MODERN AGRICULTURE TECHNIQUES

Dr. Rajeev Kumar
Praveen Kumar Singh

BOOKS ARCADE

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KRISHNA NAGAR, DELHI

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Regd. Office:
F-10/24, East Krishna Nagar, Near Vijay Chowk, Delhi-110051
Ph. No: +91-11-79669196, +91-9899073222
E-mail: info@booksarcade.co.in, booksarcade.pub@gmail.com
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CHAPTER 1
AN OVERVIEW ON MODERN AGRICULTURE

Dr. Rajeev Kumar, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id-rajeev.ag@sanskriti.edu.in

ABSTRACT:

The nation now produces more food grains thanks in large part to modern agriculture. By employing contemporary agricultural techniques, such as better seed, appropriate irrigation, a sufficient supply of plant nutrients from chemical fertilizers, and the management of pests and diseases in crop plants with pesticides, the nation could become self-sufficient in the production of food grains. Additionally, it has incorporated the use of tractor-based farming techniques, combine harvesters, and irrigation tube wells. The phrase "Green Revolution" refers to the rapid increase in food grain output that resulted from adopting high yielding variety seeds. Modern agriculture should prioritize protecting air, soil, water, and human health while providing abundant crops.

KEYWORDS:

Climate Change, Fertilizers, Modern Agriculture, Productivity, Trade.

INTRODUCTION

All economies are based on agriculture. To satisfy the demands, agriculture has to improve in a nation like India where the population is growing and there is a constant need for food. Additionally, India's current economic situation and governmental laws make the implementation of precision farming or smart farming necessary. The farmers would be able to increase agricultural production while lowering input costs and losses brought on by unpredictable rains, droughts, etc. To withstand the shifting economic circumstances in India, the agricultural industry requires a significant upgrade. Along with improvements in the tools and technology used in farming, accurate and helpful knowledge about many topics is equally important. Remote sensors, satellite photos, surveys, and other methods are being used to collect this data. The farmers should have easy access to this knowledge, together with that of topic specialists and researchers, in order to fully realize its potential value. Additionally, there is an urgent need to evaluate this data in order to draw out relevant facts and patterns since the volume of such information is steadily growing. Computer science and technology are relevant in this situation. Technology innovations need attention from a wide range of academic departments and have already produced notable advances in a number of areas. However, these developments have not had a significant impact on agriculture. The Indian economy urgently needs smart farming.

The rising spending power of middleclass populations in emerging nations, who seek higher-quality meals, will be the primary driver of future global food consumption. As agricultural resource restrictions tighten and rivalry among urban, infrastructural, and industrial users for the same resources increases, this tendency has taken on increased significance. What is modern farming? Farmers are aware of the modernity of agricultural systems, albeit it might be difficult to describe precisely. Nevertheless, despite the fact that few, if any, systems completely fit into either the modern or traditional categories, the disparities between modern and traditional systems have significant consequences for the future growth of the global food system.

Conventional methods

The perspective farmers have of themselves and their responsibilities may be the most significant distinction between the groups. For instance, traditional farmers often claim that they want to use available resources efficiently. In other words, they use their available land, rainfall, seeds, tillage techniques, and power sources to create what nature provides. Traditional methods are used to cultivate the soil, choose and sow seeds, safeguard plants from rival plants and animals, and collect the crop. Surpluses are sold via local retailers. Current manufacturers generally report having little ability to alter these procedures, and some actively resist change. Such systems' production is largely influenced by the climate and the inherent fertility of the soils, which is increased by skilled management. Lack of access to, or resistance to using, new knowledge regarding production and/or management, or governmental or commercial support, are frequent characteristics of the technology and management systems involved. Their output often increases gradually, frequently in reaction to external events that lessen producer isolation, improve access to markets, or encourage investment in water and land.

Modern agriculture

In contrast to traditional farmers, contemporary farmers see themselves as playing far more vital roles in the system and are keen to use information and technology to manage the majority of its components. Modern agriculture often sees its success as dependent on linkages access to resources, technology, management, investment, markets, and supporting government policies in contrast to the isolation inherent in older arrangements. As a result, the development and maintenance of soil fertility through the specific provision of nutrients when they are depleted; the use of machine power and technology to create the soil conditions necessary to promote plant growth with minimal disturbance and minimal soil loss; the use of improved genetics for crops and livestock to enhance yields, quality, and reliability; and, on modern genetic and other techniques to protect the environment are all crucial to the success of modern systems. This success also relies on having access to improved harvesting, handling, and storage equipment and processes to minimize losses and maximize commodity marketing, as well as efficient, effective irrigation to supplement rainfall in many regions. Access to technology, tools, information, and physical facilities must be made available throughout the whole production marketing system, and this requires on both public and private investment. Additionally, it is dependent on robust commercial and financial institutions, as well as on broad governmental policies that promote efficient markets for goods and services at all levels and provide returns on investment for the whole system. Modern agriculture in developed nations, including the United States, depends on vast, highly sophisticated systems that move, store, and process producers' output throughout a lengthy value chain that extends to food products and final consumers. Modern agriculture is far more than just farms and farmers.

Modern Agriculture's Importance

There isn't much mystery about why agriculture is crucial since it serves as the physical basis for human energy, health, and physical well-being—all crucial elements of any significant human activity. When one or more of these elements is absent, the effort required to make up for it largely determines what it means to be human. The potential of any people to invest in more fruitful employment, education, economic growth, and cultural endeavors grows when they are more broadly accessible at cheaper rates. Basic details are obvious: Modern agriculture has enabled more people to consume more and better food worldwide. The additional food that modern systems provide has enabled hundreds of millions of people to realize more of their potential and better lives, thus enhancing the accomplishments of all, from students to retirees. Increased production continues to enable steadily improving diets, reflecting increased availability of all foods, dietary diversity, and access to high-protein food products. It boosts labor productivity and generally encourages the expansion and development of people. One billion people now suffer from hunger and malnutrition, which is a result of bad policies, low productivity, and low earnings. Every facet of these issues becomes worse if new technologies aren't kept in use to increase productivity on farms and across the food chain, particularly those that are imposed on low-income persons and families. The significant hunger and malnutrition that still exist in many parts of the world would have been far worse had agricultural systems not developed as they did; Current food insecurity issues are largely a reflection of bad policies, poor infrastructure, and low economic productivity in the countries where these conditions occur; Modern agriculture has significantly reduced the physical stresses on the environment that have grown to be major public issues, which has decreased, as shown in Figure 1.

Figure 1: Illustrate the Agriculture's use of modern technologies has enhanced output and productivity.

The need to increase land area, which would lessen pressure to develop sensitive lands and forests. Successful new technologies are being used in modern agriculture, such as biotechnology, to increase yields while minimizing environmental effect. These lower the amount of land, fertilizer, and pesticides needed per unit of production. Increased pressure on crops, forested area, and grassland leads to an increase in animal habitat. Although the unintended negative environmental effects of modern agriculture are frequently noted, little attention is ever given to the negative environmental effects that frequently result from smallholder farming, particularly from the primitive "slash and burn" systems that are widely used in developing countries and where vertical rows are frequently planted up steep hillsides, resulting in some of the world's worst soil erosion, severely polluted watercourses, and many other problems of both the environmental and social variety.

These tactics are not sustainable as shown by the fact that they often result in the abandoning of new plots each year. Through pathogen reductions and significant decreases in post-harvest losses, which further boost food supply, processing technology and handling innovations provide a significant contribution to better food safety. Food-related health concerns are considerably reduced by pasteurization of milk, canning, freezing, and other processing techniques. The dangers of sickness and death are still significant, but they are far lower than they were in the past. Modern agriculture offers consumers great economic and social advantages, such as: o Improved quality of life and living standards as food prices decrease. Due to the increased buying power for other consumer items, for example, for leisure, education, and health care, this effectively increases consumer earnings. This is a trend that has been a key driver of economic development in industrialized nations as well as in some emerging ones.

Currently, Americans spend less than 10% of their disposable income on food, but many people in the developing world spend 50% or more of their income on food, which has a significant negative impact on their quality of life. It is now generally acknowledged that the development of the modern food system has played a significant role in raising the living standards currently enjoyed in a large portion of the world. When consumers spend the lion's share of their income and nearly all of their daily efforts simply to find food, little money or time is left for human investments. Most smallholder farmers, particularly those in developing nations, live on a "survival treadmill"; modern agriculture promotes political stability on a worldwide scale by increasing the quantity, quality, and accessibility of food. The surges in food prices in the middle of 2008 amply demonstrated how much more hazardous and unstable the world would be without the innovations that define contemporary agriculture. o The creation of a reliable, rules-based trading system has been crucial for enhancing food distribution and raising accessibility in places with a food shortage. The biggest danger to the advancement of modern agriculture is not a lack of enthusiasm or investment on the part of farmers, but rather the increasingly strident resistance of a group of activists who have succeeded in changing agricultural regulations in various jurisdictions.

continuous no-till, which boosts biodiversity, reduces erosion, improves soil moisture storage, and saves fuel; Cover-cropping, which may be utilized to either create biologically fixed nitrogen or scavenge excess nitrate as necessary, and no-till farming, which together result in net carbon sequestration; A few rather simple procedures are now extensively used because they have been extremely effective in preserving the quality of both soil and water. These include continuous no-till, which uses less fuel, improves soil moisture storage, prevents erosion and off-site movement of pollutants, and boosts biodiversity; cover crops, which, when used in conjunction with no-till, result in net carbon sequestration and can be used to either produce biologically fixed nitrogen or scavenge excess nitrate as needed. Evidence of agriculture's continued embrace and use of new technology comes from both large- and small-scale enterprises across the world. Plantings of biotech types are increasing; in 2009, 330 million acres were utilised, an increase of around 7% over 2008. With 158 million acres planted last year, the United States remained the greatest user of this technology, but Brazil is expected to make the biggest gains with 53 million acres planted by 150,000 farmers, largely in soybeans, a 35 percent increase from 2008. 17 Argentina, which in 2007 had the second-largest biotech acreage, is nevertheless more dependent on biotech crops than India, Canada, and China combined. Last year, China planted 9.1 million acres of biotech crops—mostly cotton—but the country's recent approval of GM rice and maize signals that plantings there could soon increase. Before being planted commercially, genetically modified maize and rice will undergo two or three years of field testing.

LITERATURE REVIEW

Suolian Wang et al. [1] studied about Eukaryotic green algae and prokaryotic blue algae are two types of common photosynthetic microalgae. They offer a tremendous deal of potential for utilization as biological resources in the production of food, fuel, health goods, and other things. Due to their capacity to improve soil nutrient absorption and macro- and micronutrient consumption, these intriguing organisms may also be utilized in contemporary agriculture. Microalgae may create plant growth hormones, antimicrobial compounds, polysaccharides, and other metabolites to support plant development in addition to enhancing soil fertility and quality. The impact of cyanobacteria and green algae as biofertilizers on enhancing the fertility and quality of soil and encouraging plant development are the main topics of this section. The future possibilities for the implementation of recent scientific advancements in contemporary agriculture are also covered.

Devlet, and Abdulgani [2] studied about the purpose of this study was to learn more about the difficulties contemporary agriculture faces and the connections between businesses in related fields. Human health is the main concern, along with the value of the industrial and agricultural sectors, including food safety, food security, and economic growth. Since demand is also evolving, while developing solutions for these three fundamental issues, humans should not only evaluate our prior planning, solve and avoid current issues, but also do more study and investigation alongside the new planning. These three subjects are significant difficulties that must be addressed immediately in one's personal, national, or worldwide relationships. Scientists work to educate farmers about the realities of contemporary agriculture and are essential to finding solutions to these problems.

Bruno Dietz et al. [3] studied about In order to meet the dietary demands and food tastes of a growing, and more wealthy, population, the globe is counting on a significant rise in food production. This necessitates the ongoing development of modern agriculture, yet modern agriculture is dependent on a limited number of very productive crops, and its growth has resulted in a large loss of biodiversity worldwide. Lower plant productivity has been shown by ecologists, and agricultural economists have connected farm-level biodiversity loss to higher crop output variability and sometimes lower mean yields. With an emphasis on how the decline in biodiversity impacts food production, this research examines the macroeconomic effects of the continuous growth of certain types of intensive, modern agriculture. They use a quantitative, structurally estimated model of the global economy, which affects land conversion, population increase, food consumption, and all other aspects of the economy. We demonstrate that even modest reductions in production caused by biodiversity loss due to agricultural expansion may be sufficient to justify a ban on further land conversion.

Bajwa et al. [4] Studied about Weeds pose a serious threat to crop output, and contemporary agriculture must control them effectively to prevent yield losses and guarantee food security. Weed dynamics are impacted by intensive agricultural practices, a changing environment, and natural catastrophes, which necessitates a shift in weed control procedures. Due to manpower constraints, manual control methods are no longer an option, and chemical control methods are constrained by ecodegradation, health risks, and the development of herbicide resistance in weeds. Therefore, they are looking at several possibly effective, viable, and non-traditional weed control methods for contemporary agriculture. Tillage regime improvement has long been recognized as a powerful weed-control strategy. Alkharabsheh et al. [5] studied about the yield of cereal crops under salt stress is a barrier to secure and sustainable food supply. Wheat and maize are only modestly adapted to salt stress, whereas barley and sorghum are the most suited. However, rice is a salt-sensitive crop, and salinity stress has a substantial influence on its growth and grain output. High soil salinity may hinder plant water absorption, cause osmotic stress, and ultimately oxidative damage in plants. Crops, especially cereals, have developed a variety of tolerance mechanisms to counteract stressful environmental factors, such as effluxing too much sodium (Na^+) or compartmentalizing Na^+ into vacuoles.

Atanu Aronson et al. [6] studied about India has implemented contemporary agricultural techniques with notable success in order to increase food production. This accomplishment was largely the consequence of a paradigm shift in agriculture, which included heavy use of agrochemicals, water, and monocultures. Bureaucratic adjustments that supported these changes also had a role. There aren't many thorough evaluations of the potentially harmful health effects that might result from these alterations. This study's goal is to uncover health concerns related to contemporary farming methods in the state of Karnataka in southern India. This research compares high-input and low-input farming techniques and examines the effects on local populations' health.

Yahya Ma, et al. [7] studied about the idea of returning to nature, leveraging technological and scientific advancement for higher living standards, people started looking for ways to reduce environmental pollution. Researchers want to create solutions that are mild yet still efficient that are economical and clean. For many years, it has been known that chitosan, a substance generated from the exoskeleton of crustaceans, cuticles of insects, cell walls of fungi, and certain algae, has biotic qualities, including anti-microbial traits. Chitosan's growth-promoting qualities include resistance to pests and diseases, control over signaling, impact on nuclear deformation, and apoptosis. Chitosan may enhance a plant's defense system by promoting photochemistry and photosynthesis-related enzymes. Furthermore, chitosan may virtually be used as a herbicide according to the electrophysiological change it causes. Chitosan is a superb plant growth stimulator that enhances soil fertility and plant development. It is concluded that chitosan can be an important factor in the production of contemporary agriculture and may be an important source for enhancing the sustainability of agricultural ecosystems. Future recommendations will be based on recent successes as well as apparent gaps. Additionally, chitosan makes a significant contribution to regulating agricultural diseases, agricultural pests, and pollution from fertilizers in contemporary agriculture.

Seleiman et al. [8] studied about There is a need for a more creative approach to fertilizer that may boost agricultural systems' production and be more ecologically responsible than synthetic fertilizers. In this post, they looked at the most recent advancements and possible advantages of using nanofertilizers (NFs) in contemporary agriculture. By improving the nitrogen usage efficiency (NUE) of field or greenhouse crops, NFs have the potential to advance sustainable agriculture and boost overall crop output. NFs have the ability to slowly and steadily release their nutrients, whether they are used alone or in conjunction with synthetic or organic fertilizers.

Yanbing Delgado et al. [9] studied Due to the idea that contract farming encourages the transition to modern agriculture, there has been a lot of interest in recent years in how contract farming affects farmers in developing nations. Using China as a specific instance of the latter, we present a complete assessment of the empirical research on contract farming in both industrialized and developing nations in this article. We carefully consider the wide economic development implications of our study. First, we discover that empirical research consistently confirms contract farming's beneficial impact on production and supply chain effectiveness. They also discover that although the majority of empirical research find contract farming to have a positive and substantial impact on farmer wellbeing, they often struggle to identify the main correlates of contract involvement.

Khoirul Anam et al. [10] studied about It has been shown that modern agriculture practices, such as intensive land cultivation and extensive fertilizer and pesticide usage, considerably boost agricultural yield. It is vital to create contemporary agricultural systems that are sustainable and ecologically sound since current agricultural systems have a significant negative influence on environmental degradation. This research attempts to define and assess initiatives that support the development of a contemporary, sustainable agricultural system by empowering farmer groups. This study's qualitative methodology was based on literature reviews from several publications and the findings of other investigations. According to the study's findings, empowering farmer groups is the best strategy to improve farmer communities' involvement in the advancement of sustainable modern agriculture. A farming group's knowledge, ability, expertise, and empowerment may all be increased via the empowerment process, giving them more power to realize their full potential. It is important to include local government, community, and farmer group leaders who may serve as drivers and motivators in the empowerment initiatives.

DISCUSSION

Benefits of Modern Agriculture

Although the term "industrial farming" is frequently used to mock contemporary farm management, it is impossible to ignore the fact that, like other industries, agriculture has increased its productivity significantly as a result of the automation of the most dangerous and labor-intensive parts of the work. The number of individuals who wish to work on farms in the traditional, labor-intensive manner is very limited, and agricultural communities have taught their children to select, in many instances, alternative vocations. Since the pool of unskilled, inexpensive farm labor on which those crops and systems have depended appears likely to continue to decline, non-mechanization is becoming an increasingly unfeasible option. The result is that hand-laborintensive crops (e.g., coffee, strawberries...), or high labor cropping systems (e.g., organic), appear to be on a collision course with demographic trends. The productivity of contemporary agriculture has increased significantly at the same time. Before the advent of better machinery, synthetic fertilizers, enhanced plant and animal breeding, pesticides, and most recently, biotechnology, and the enormous improvements these new methods brought, pre-industrial yields were low and static. Nevertheless, it is also true that the same environmental problems that caused the Dust Bowl disaster in the 1930s also resulted in the creation of the Soil Conservation Service and other significant initiatives that continue to advance farming methods through public and private programs until they have virtually eliminated risks associated with wind and water erosion. For instance, proponents of "no-till agriculture" really got their start in the early 1960s by attempting to save fuel and prevent erosion. As a result of the environmental movement of the late 1960s, the Environmental Protection Agency was established in 1969, and since that time, pesticides and pesticide control have undergone significant changes. A few rather simple procedures are now extensively used because they have been extremely effective in preserving the quality of both soil and water.

The aforementioned sections argue that the world's food challenges have grown steadily in recent years, especially since the turn of the 20th century, when there were only 1.6 billion people on the planet and the needs of everyone could be met by increasing yields and agronomic advancements. Additionally, fossil fuels became more and more crucial in the development of machines to replace animal power and to enable the production of ammonium fertilizers based on fossil fuels. The population of the world has increased significantly since the turn of the century; it was 6.1 billion in 2000 and is projected to reach 9 billion by 2050. The world's food supply will need to almost quadruple once again, but this time in within the next 40 years due to population increase and economic expansion, particularly in emerging nations. Resources are limited, which means that even if new problems related to climate change arise, the amount of arable land available will remain roughly unchanged while the amount of water and nitrogen may decrease. This conversation has also made it abundantly evident that raising the rate of innovation and productivity development is the only realistic strategy that will allow the world to satisfy the conflicting demands it confronts while more skillfully addressing its physical, economic, and social restrictions. Additionally, it has demonstrated that these objectives are attainable with the necessary public and private support, which includes support for both the continued modernization of food and agriculture systems in developed countries as well as for more efficient assistance for developing countries to modernize their agricultural sectors. It also underlined the need of including new and better protections at every step to reduce the unanticipated issues that might sometimes occur. There is a growing agreement in agriculture today and among many of the most influential organizations in the world that the industry is well positioned to satisfy anticipated 2050 demands while also tackling the poverty, hunger, and malnutrition that now affect more than one billion people. These issues have been given top priority by many prestigious international organizations, such as the G-20 group of world leaders, the Food and Agriculture Organization of the United Nations during its recent food summit, the World Bank, the Bill and Melinda Gates Foundation, and the Royal Society of London, to name just a few.

Each has argued for the need to give agriculture, food security, and the reduction of hunger, malnutrition, and poverty immediate priority. Nevertheless, overcoming these difficulties will need for constant development, building on prior achievements, and using technology. These difficulties are becoming well known within the sector. Additionally, it will need for more robust and efficient policies, the creation and implementation of which take a lot of time. At least six specific actions are currently agreed upon by the sector as being necessary to make the required progress. These actions include: Increasing public and private support for agricultural research and extension; Increasing public support for investments in agricultural infrastructure, particularly in developing countries but also in developed countries; Reduced trade barriers in agriculture; Better-organized and supported foreign aid with a focus on agriculture, agricultural productivity, and development; Systematic improvements to agricultural policies globally, with a renewed emphasis on open markets, efficient, workable safety nets for producers, and private as well as public risk management; and Renewed focus on negotiations to lower technology-related barriers and boost reliance. These promises are often supported by statements made by industry leaders. For instance, Monsanto introduced a new program in 2008 to create sustainable yields, which aim to increase production, conserve resources, and improve lives. The company is now investing in the development of seed to increase yields by twofold using traditional and advanced breeding, protected by biotechnology traits that perform well when combined with farmer innovation. The business pledges to double production while utilizing a third less resources each bushel. According to its assertions, it is willing to spend about $1 billion year, or $3 million per day, to accomplish these goals, and it presently feels that its research pipeline is producing results that are consistent with these overall promises. The Monsanto commitment, while undoubtedly one of many, reflects growing agricultural and agribusiness confidence that it will find the necessary tools to meet global needs, do so environmentally and economically, and do so in a way that is sustainable for the entire system the challenge for the next 40 years.

Designing and implementing alternatives to social security for employees in the informal sector is a significant problem for low-income nations (Jansen and Lee, 2007). In middle-income nations, formal employment is more significant, and there is often greater room for social protection for employees who are negatively impacted by trade and associated economic changes. An major trade barrier is the amount of time needed to import and export products. For businesses that can export, trade liberalization opens up new economic options, and it gives consumers access to cheaper and more varied products via imports. However, these imports could put local output in competition, putting fresh pressure on the affected local firms. Some operations will be expanded while others will be reduced due to new export prospects and greater import competition (WTO, 2008). The availability of exports and job possibilities in emerging nations has further increased the strain on agricultural commerce. Liberalizing agricultural commerce won't magically generate plenty of jobs by itself. Although these effective tactics are reliant on agricultural trade, liberalizing agricultural trade shouldn't be anticipated to have a large detrimental impact on employment. To lessen their load on social security, many farm employees need to modify their programs in a more reasonable manner. Trade liberalization aims to remove or scale down limitations on the free flow of products between nations, including non-tariff barriers like licensing requirements and quotas as well as taxes and surcharges. Some emerging nations may further specialize their agricultural output as a result of trade liberalization.

The concentrated expression of a nation's population is the movement of people from rural to urban areas. Because trade changes either generate or worsen such movement, measures that encourage urban integration may have a substantial influence. More resources and facilities for housing or job possibilities may be made available, or suburban agriculture, which includes growing crops and rearing animals in the suburbs, could be encouraged in order to provide food security for new urban inhabitants. Although moving from one employment to another or from one location to another may be very difficult for rural employees due to their high poverty rate, lowering this barrier is a lofty aim and may contribute to increased economic efficiency (Cheong et al., 2013). The United Nations Conference on Trade and Development's (UNCTAD) e-commerce and law reform initiative gives developing nations the chance to undertake expert assessments of e-commerce legislation and to provide policymakers professional recommendations on efficient e-commerce laws. Consumer protection, cybercrime, data protection and privacy, intellectual property, and electronic signature are among the topics addressed by the program (WTO, 2020b). Where is the food produced? If historical patterns hold, more trade won't be the solution. The global grain production and commerce have both increased by more than twofold since the agricultural trade liberalization. As a result, the global commerce in food still accounts for around 10% of all trade. This demonstrates that the producing nations eat, on average, 90% of the food produced worldwide. If this pattern persists, it is obvious that the production systems of the nations where new people are residing will account for the majority of the expansion in food production.

Agriculture and challenges

55% of the world's population currently lives in cities, and marginal populations have increased by approximately 7.5 billion people since the early 1960s. Rapid urbanization has given rise to innovations never seen before. In Asia and Africa, urban population growth rates are above 90%. (UN DESA, 2018). By 2050, it is estimated that 2.5 billion people will live in cities. Currently, more than half of the world's population lives in urban areas, and tremendous urban expansion is taking place everywhere. With respect to access to adequate, safe, nutritional and cash-regulated assets, urban contexts present special challenges for food security and nutrition. Actual distance between grain producing areas and consumers, lack of transportation options, fluctuating grain prices, concentration of power in global grain trade, climate change impacts, and inadequacy of safety nets for low-income urban residents, especially typically in times of crisis, there are often restrictions on access to food (FAO, 2019). To feed a growing global population, producing enough food has emerged as a primary and continuing issue for agriculture around the world. As the contribution of agriculture to total productivity and employment is declining at different rates, different places are facing different challenges. The second issue facing the sector is the development of new technologies, legislation and institutions that will allow agriculture to fully realize its potential as a growth engine. Agricultural investment and technological advances are increasing productivity, but it is catastrophically low that production growth has stalled. Productivity can be increased to reduce loss and wastage of grains in agricultural production. Degradation of natural resources, loss of biodiversity, and the cross-border spread of plant and animal diseases and pests, some of which have acquired antibiotic resistance, have all slowed the acceleration of productivity growth that is needed. The management of natural resources in developing countries, as well as the development of new technologies, incentives, and regulations to encourage them to place value on the long-term management of natural resources, are closely related to improving the productivity of small-scale farmers and profitability. The development of agronomy, agroforestry, climate intelligent agriculture and protective agriculture is a "holistic" transition process involving indigenous and traditional knowledge.

The problem of climate change affects all ecosystems and aspects of human life, thus it must be tackled by the creation of new technologies as well as the sharp reduction in economic scope and use of agricultural fossil fuels. It is also important to expand international exchanges and cooperation to fully prevent the introduction of transnational threats to agricultural and food systems, such as pests and diseases. Strengthening the innovation system based on resource conservation to enhance productivity. However, action must be taken to address the burdens and risks posed by human involvement in agricultural production systems, as well as increasing demand, climate change and soil changes. Economic activity, property values and human existence are all negatively affected by floods. Numerous studies have been conducted on the topics of prevention, mitigation, management and management of the cleanup and recovery phases. Floods are infrequent and last for a short time, but the damage they cause to homes and other property can be costly. The potential for catastrophic floods can be completely controlled and prevented by promoting integrated watershed and floodplain management, focusing on the development of efficient drainage systems, and protecting forests. The effects of climate change and drought are everywhere on the planet. It is not just a weather phenomenon. It is also a temporary condition caused by lack of water, which can occur in almost any season. In theory, drought is defined as a decrease in rainfall from the long-term average of an area, however, location is important.

It is required to significantly develop agricultural scientific research in order to promote "modern agriculture" and address "challenges." We should first prevent and avert food shortages, catastrophes, and conflicts as we travel the path of shared growth of agriculture, industry, and commerce. Second, we must discover fresh approaches to increase the competitiveness of global commerce, increase agricultural output levels, and achieve sustainable development. We should take away from the past's lessons that, no matter how many issues there are, finding solutions should always take precedence. Although the issues are not insurmountable, it employs contemporary agricultural techniques to solve them. It is the duty of all nations to make the greatest investments in resolving these issues, according to a thorough analysis of the difficulties facing modern agriculture, including COVID-19, population growth, changes in eating habits, destruction of seed resources, scarcity of water resources, air pollution, climate change, and changes in food prices. Additionally, droughts and floods continue to have an impact on the growing season of crops, diminishing agricultural yields, restricting water supplies, and promoting the development of pests, weeds, and fungus. We must radically alter all social production and consumption patterns as industry and commerce, as well as food security, expand concurrently. One of the key objectives of modern agricultural development policy is to preserve and increase the quality and efficiency of sustainable grain and modern agricultural output via the innovation and competitiveness of agricultural modernization system. Despite the potential of traditional agriculture being highlighted by several studies, the equipment and technological infrastructure in the agricultural sector, as well as the connection between supply and demand, are changing quickly. For instance, genetically engineered plants are now widely used commercially.

Artificial meat technology is becoming more and more common. I'm hoping that this product can be on sale as quickly as feasible.

The ongoing innovation process, which uses cutting-edge genes and information technology to improve agricultural productivity while balancing the economic, health, environmental, and social outcomes related to agriculture and food systems, offers the best chance of overcoming the challenge of sustainable agricultural development. In the face of agricultural modernisation, significant changes are occurring. The development of new items is accelerating thanks to conventional industries' innovation practices. People are becoming more interested in novel foods and natural goods, particularly in metropolitan settings. They are creating fresh markets and chances. One of the first commercial types of industrialisation is agriculture. Agricultural output based on cultivated land, growing plants, and rearing animals has grown into a key element of national economies in emerging nations since the start of "The Green Industrial Revolution" at the end of the 20th century. Agricultural industrialization, including the production, supply, sales, and export of agricultural goods, has accelerated since that time. In India, Africa, and other eco-friendly nations, the sector has grown in importance. The products, services, laws, regulations, and policies of an ecological nation are environmentally friendly, often referred to as eco-friendly, nature-friendly, or green, which denotes that the method is sustainable, minimizing or preventing harm to the ecosystem and the environment. Being eco-friendly helps to save water, energy, and other resources as well as to stop pollution of the air, water, and land. An approach to gauge a nation's environmental policy performance is the environmental performance index (EPI). Food safety directly relates to human safety. It has to be broken down into material and spiritual components as a human standard. An economy's growth is directly correlated with the encouragement of economic investment. The presence of interest is the sole thing preventing economic unification. Trade and industrial growth accompany agrarian economic expansion.

CONCLUSION

This chapter makes the observation that the dangers to human welfare that Thomas Malthus foresaw more than 200 years ago are still present, significant, and possibly deadly. Achieving the aims of a better-fed global population with fewer destitute people, better protected resources, and more effective techniques to cope with the changing environment is still a tremendous task, even if the world can afford more hope today than it did before. The paper discusses what modern agriculture is and the factors that could make it successful. These factors include achieving ever-more effective control over the numerous processes it uses, which can be done by utilizing knowledge and assistance from a wide range of private and public sources while avoiding the isolation present in traditional systems. The report concludes that, despite significant obstacles, future technology requirements are becoming better understood. As a result, with increased public awareness of the significance of these investments, global agriculture can reasonably be expected to meet the challenging goals set for the coming years.

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CHAPTER 2

NEW TECHNOLOGY USED IN MODERN FARMING

Dr. Manoj Kumar Mishra, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- manoj.ag@sanskriti.edu.in

ABSTRACT:

Progressions in the field of science and innovation alongside worldwide urbanization are the main considerations driving the course and advancement of horticultural examination. Ascend in per capita pay in non-industrial countries, word-related changes, and worldwide linkages have changed the food inclinations. These patterns together with the augmentation in the general population represent an assessment to horticulture for creating more and healthier food. An increase in the efficiency of horticulture by utilizing strategies of traditional agribusiness is representing a limit. The threat to the environment posed by reliance on synthetic manures and pesticides for increasing efficiency and irritation across the board is a major factor impacting global food production. These trends suggest that new farming innovations are urgently needed and that these innovations should be integrated into traditional agribusiness. Vertical cultivating and natural cultivating are the exploration territories to battle these requirements. Vertical cultivating utilizes vertical stacking of the ranches and little land can be used for more creation. This strategy is appropriate for the quickly developing worldwide metropolitan population can be met food supply from inside the urban communities and along these lines decreasing the transportation cost and climate weakening brought about by energizes all the while. Natural cultivating again depends on of minimization of the synthetic contributions to the horticulture and henceforth is climate cordial. As a result, these processes can be employed to increase production and profitability in order to meet the growing food demand.

KEYWORDS:

Agribusiness, Climate Change, Economy, Organic Farming, Sustainability.

INTRODUCTION

The importance of advancement in farming now is greater than at any previous period in recent memory. The industry as a whole is experiencing severe challenges because to rising provisional costs, a labor shortage, and shifting customer preferences for honesty and supportability. Agribusiness firms are increasingly acknowledging the need for solutions to these problems. Farming innovation has had a remarkable growth in speculation over the last ten years, with $6.7 billion invested in the last five years and $1.9 billion in the most recent year alone. Zones such indoor vertical farming, automation and mechanical technology, domesticated animal innovation, contemporary nursery practices, precision farming and man-made awareness, and square chain have seen significant innovation improvements. According to the paper, despite the fact that demand is steadily growing, we should produce 70% more food by 2050. However, a significant portion of the GDP as a whole has decreased to only 3% from 33% just a few years ago. Approximately 800 million individuals worldwide normally suffer from craving's negative effects.

In addition, under current conditions, 650 million people, or 8% of the total population, would still be undernourished by 2030. There hasn't been much progress in recent years, and nothing indicates that there won't be a problem with food insecurity and hunger in the years to come. Governments will need to make a concerted effort, together with financial backers and innovative agriculture developments, to solve these problems. After consistently administering water, compost, and pesticides over whole fields, agriculture 4.0 won't rely on these practices in the future.

Farmers will employ the basic amounts needed after taking everything into consideration and focus on very specific domains. According to the research, farms and agricultural projects should be managed in an innovative way, mostly because of technological developments like sensors, machinery, and information development. Current innovations like robotics, temperature and moisture sensors, aerial images, and GPS technology will be used in future agriculture. These broad contraptions, precision farming techniques, and mechanical constructions will make farming more beneficial, profitable, secure, and environmentally friendly.

Technological advances have changed our everyday lives over the last several decades. Engineers and scientists have found methods to improve our lives, from cellphones to smart houses. This technological revolution has also benefitted the agriculture sector. Modern farming is now possible because to advancements in robotics, aerial imagery, and sensor technology. At BTC Bank, commercial agriculture enterprises like yours are at the center of our neighborhood. To assist you in modernizing your farming practice, we've selected the best emerging new agricultural technologies and approaches.

What is AgTech?

Technology used in agriculture is referred to as AgTech. Technology advancements are being incorporated into conventional agricultural practices to benefit both farmers and the environment. New AgTech has being embraced by farmers all throughout the nation to help them organize their labor, decrease costs, minimize waste, and fight the consequences of climate change. Instead of needing to concentrate on their fields as a whole, farmers can now more precisely tend to each of their specific crops thanks to smart farming technology. Numerous advantages have come from agricultural advancements, including:

- Enhanced worker safety
- More crops produced.
- Less need for herbicides.
- Fertilizer, and irrigation.
- Less negative environmental effects

GIS applications and GPS Farmers can track temperature, rainfall, crop yields, and other factors throughout their acreages thanks to GIS software for agriculture. By examining the historical circumstances of their various areas, this data might assist company leaders in making future plans. These technologies, when combined with GPS, direct autonomous tractors, seeders, and combine harvesters to work the fields in accordance with a precise plan. Drones and satellites are also used in agriculture thanks to GIS software, which enables an airborne evaluation of crop biomass and height, weed presence, topography, and weather.

Water and Soil Sensors

Humans have traditionally made sense of the world using just a few of their senses. Do you notice any issues with your crops? Does your food have a bad flavor or odor? Robotic sensors give information much beyond what the human eye can observe. Sensors keep tabs on the soil's temperature, pH, humidity, plant health, and stress from pests. Robotic sensors may be used on farms to eliminate human error and manage labor time more effectively. These sensors provide reliable information that is rapidly and remotely sent to the farmer.

Algorithms are developed by remote sensors using the data they collect. As with any computer program, accuracy increases as more data is handled. Remote sensors may eventually contribute to the development of a farming algorithm that will precisely forecast a range of crop outcomes depending on the current field circumstances. Farmers may use this information to plan and adjust in order to minimize crop losses and increase revenues.

Satellite Imaging It should come as no surprise that scientists have found a method to use satellites as AgTech as they have been employed for a variety of purposes throughout the years. In order to perform precision agriculture, modern satellite photos enable farmers to combine information from applicable spectrum indices. The quantity of chlorophyll in crops is analyzed by the NDVI, NDRE, and CCCI. Low chlorophyll may indicate nitrogen shortage before the damage becomes irreversible and enable the farmer to apply fertilizer precisely. The MSAVI has been particularly tuned to detect vegetation in newly planted or very barren soil-covered regions. This measure may demonstrate the effectiveness of seeding or the condition of crops in relatively barren areas.

Figure 1: Illustrate the water management with automated irrigation.

Precision farming methods supported by the Internet of Things provide farmers useful tools to maximize every agricultural operation. The goal of these technologically advanced farming methods is to boost agricultural yields and profitability while using less of the conventional inputs (water, fertilizer, pesticides, and herbicides) required to produce crops, as shown in Figure 1.

In order to sow crops more effectively and to optimize travel over and between their fields, for instance, farmers may use GPS devices mounted on tractors. This reduces travel time and fuel costs. The weather, soil, pest, and hydration conditions may also be tracked using sensors put on agricultural equipment. This data is then sent to a central smart farm platform for analysis and the use of predictive farming techniques. To apply water more effectively and with less liquid waste draining into nearby streams and rivers, fields may be leveled using IoT-controlled lasers.

AI may also be used to forecast pest behavior, which is useful for early planning of pest treatment. Less agricultural and environmental harm results from effective insect control. To identify the weed from the crop, a combination of remotely sensed data, effective picture classification methods, meteorological information, and other pertinent data points may be employed. This will limit the use of weedicide to those areas that need it. Remote satellites can keep an eye on crop health and provide insect assault alerts.

Automated drones can replace crop dusters when it's time to spray fields with crop protection chemicals, saving money and eliminating the danger of manned aircraft flying at high speeds so close to the ground. Crop dusting drones have the ability to continuously capture images and video of fields while in the air, allowing farmers to check on plant health without dispatching scouts.

RFID Technology

Technology using radio frequency identification (RFID) is not only used in agriculture. RFID integration with AgTech is improving crop monitoring, according to farmers. Similar to a barcode, RFID can also be read through dirt and at distances of up to several feet. RFID tags are useful for marking crop name, location, and planting date since they can be programmed with up to 2 KB of data. RFID will make it easier to monitor agricultural items as they are transported. The product's origin and the date and time of processing may both be determined by a quick scan.

Because the data is securely stored on the product, RFID technology may decrease human mistake. When RFID technology is used, retailers and customers may be certain of the farm and manufacturing date of food goods.

Technology behind block chain

In the past, if a foodborne illness was discovered on produce from a particular area, the whole region would be subject to a financially devastating recall to safeguard the public. By precisely tracing the supply chain journey of all items in our food system, blockchain technology seeks to lessen the widespread consequences of such problems. The precise source of food contamination might be identified using blockchain technology. Each producer would need to provide a digital record of their food's journey in real-time for blockchain technology to succeed.

It is challenging to immediately determine a product's origins since some firms still preserve paper records of their sales and shipments. A completely digitized blockchain would increase market openness and enable precise supply and demand estimates for agricultural goods. Producers may be able to set better prices for their goods and organize production using this real-time market information.

Using minichromosomes

The development of genetically modified crops is being studied. Scientists are enhancing the nutritional value and crop-resistant features of produce via genetic engineering, starting with a very little quantity of genetic material (minichromosomes). This new technique is more socially acceptable than previous forms of genetic alteration since it preserves the plant's native chromosomes. Although this new AgTech has not yet reached its full potential, interesting new breakthroughs are likely to occur soon.

Contemporary greenhouses

Modern greenhouses today provide year-round crop production, unlike the past when they were mainly utilized for early-season seedlings. The LED lighting and automated control systems required to set up an indoor growing environment for farmers have been made available thanks to technological advancements. For indoor crop production, robotic devices can provide just the right quantity of irrigation, light, and humidity. Growing techniques that make advantage of the contemporary greenhouse include vertical farming, hydroponic farming, and aeroponic farming.

Automated Agriculture

A new style of farming has been made possible by developments in robotics and drone usage. Today's technology enables robotic sowing and weeding as well as self-navigating harvesting combines. The farm uses less labor as a result of automating these repetitious chores. Scheduled irrigation is one example of automatic watering, although soil monitoring around specific plants is more involved. Automation of agricultural machinery is reducing stress on farm workers and solving the labor deficit. As self-driving machines can operate around the clock, higher yields are observed. Farmers may concentrate on planning and problem-solving to increase the long-term viability of their companies when physical work is transferred to equipment.

Precision farming

Most farmers used to regard their fields as a single entity in the past. To fulfill the demands of all of their crops, they irrigated and used fertilizer or insecticides. Farmers can now more precisely monitor the demands of their plants thanks to technological advancements. Precision action on tiny, targeted sections of the fields is made possible by technologically advanced monitoring of moisture levels, soil conditions, and insect damage. Precision farming lowers agricultural costs by reducing the amount of money farmers spend on irrigation, herbicides, and fertilizers. Farmers are treating particular requirements rather than the farm as a whole, which makes farming more efficient.

Recent Trends in Agricultural Growth Technology

Indoor Vertical Farming

By reducing the distance traveled in the production network, indoor vertical cultivation may increase crop yields, overcome the limitations of limited land, and even minimize the impact of cultivation on the environment. Growing produce that is piled on top of one another within in a closed environment is known as indoor vertical cultivation. The amount of area needed to grow plants is much less with the use of vertically mounted growing racks than with conventional cultivating techniques.

Due of its ability to thrive in constrained spaces, this kind of development is frequently associated with urban and metropolitan farming. Vertical ranches are unique in that certain configurations don't need soil for plants to grow. Most are either aquaculture, where vegetables are placed in a bowl of water with additional nutrients, or aerologic, where plant roots are purposefully doused in water and other nutrients. Artificial develop lights are used in place of natural daylight.

The advantages of indoor vertical cultivation are obvious, ranging from sustainable urban development to increasing agricultural output with reduced labor expenses. Vertical farming can effectively assess year-round conditions such as light, stickiness, and water, increasing food production with reliable harvests. Energy conservation is improved by the lower water and energy use of vertical homesteads, which use around 70% less water than traditional ranches. Using robots to handle harvesting, planting, and coordinating tasks also significantly reduces labour, helping test farms deal with the present labor shortage in the agricultural industry. In the 1950s and maybe earlier, vertical farming was a sci-fi concept. Today, it is experimentally possible and will be commercially viable within the next ten years.

Innovation in vertical ranching

The process of growing food in layers that are vertically stacked is known as vertical cultivation and is a subset of urban gardening. This presents a number of advantageous scenarios. Perhaps the most obvious is the ability to grow in urban settings, making fresher food more readily available and more reasonably priced. However, contrary to what was once believed, vertical farming is not only limited to urban settings. It may be used by ranchers in all places to make use of available land and to grow crops that aren't typically appropriate there.

Agriculture Automation

Ranch mechanization, also referred to as "shrewd cultivating," is a development that increases cultivators' efficiency and automates the cycle of harvest or animal production. As mechanical technology advances, an increasing number of businesses are working to develop drones, self-driving farm tractors, automated garbage collectors, programmable irrigation systems, and cultivating robots. Even though these innovations are very new, an increasing number of traditional horticultural businesses have begun incorporating ranch robotization into their workflows. Modern agriculture has been completely transformed by new technological advances that have moved from mechanical technology and robotics to PC vision programming. The primary goal of ranch robotization innovation is to handle routine, uncomplicated tasks. Drones, independent farm transporters, cultivating and weeding equipment, and collect mechanization are a few key innovations that ranches are often using. Ranch mechanization innovation addresses important concerns such a growing global population, ranch employment shortages, and changing consumer preferences. Mechanizing traditional farming practices has great benefits since it addresses concerns with consumer preferences, labor shortages, and the environmental impact of farming.

Animal Agriculture Technology

Despite seeming to be the most essential, the traditional animals sector is one that is often disregarded and under-resourced. We continually rely on the genuinely essential, non-depletable resources that domesticated animals provide. The CEOs of agribusinesses that are linked to animals are often recognized for managing poultry farms, dairy farms, cow farms, and other similar agribusinesses. Supervisors of domesticated animals must maintain accurate financial records, supervise staff, and ensure that animals are given the proper attention and care. Despite this, recent trends have shown that innovation is changing the world of domesticated animals and the CEOs. The industry has seen significant improvements over the last 8–10 years that have made monitoring and managing animals more easier and more data-driven. The possibilities for this invention are endless and may include healthy advancements, inherited traits, computerized innovation, and so on. Animal innovation may enhance or update the profit cap, public aid, or the managers of wild and domesticated animals. The efficiency cap, government support, or the board of creatures and animals may all be upgraded or improved by animals. The concept of the "associated cow" emerged from an increase in the number of dairy companies installing sensors to monitor well-being and boost profitability.

Dairy cattle with individual wearable sensors may be used to track regular movement patterns and health-related concerns while providing the general public with information-driven nuggets of knowledge. Additionally, this information is being turned into substantial, notable pieces of knowledge so that decision-makers may search quickly and efficiently to make quick administrative decisions. The study of looking at a living thing's whole quality scene and how those components interact with one another to influence the organism's growth and progress is known as "creature genomics." The understanding of the inherited risks posed by their herds and the determination of the animals' long-term welfare are both made possible by genomics. Dairy cow genetics enables producers to increase productivity and yields of animal populations by being crucial with regard to creature determination and reproductive options. The contemporary livestock sector has a lot to gain from sensor and information advancements. By identifying extinct species and seeing opportunities for improvement, it may increase the effectiveness of domesticated animals and the help provided by the government. PC vision enables us to access a large variety of accurate information that is combined into meaningful, remarkable experiences. A dynamic driven by information encourages better, more effective, and timely decisions that will increase the profitability of populations of domesticated animals.

Contemporary greenhouses

In recent years, the greenhouse industry has evolved from small-scale operations used primarily for research and aesthetic considerations (i.e., botanic nurseries) to much larger-scale operations that directly compete with land-based conventional food production. Currently, the global nursery market as a whole produces over $350 billion worth of vegetables annually, with less than 1% of those veggies coming from the United States. These days, the firm is seeing a blossoming unlike any other moment, in large part due to the significant continual improvements in generating innovation. Today, nurseries with a large scope, capital investment, and an urban orientation are steadily emerging. Currently, the global nursery industry generates almost $350 billion in veggies annually. The market has recently undergone unmistakable trends in addition to its rapid development. Modern day nurseries are becoming more technologically advanced, using computerized control systems and LED lighting to perfectly adjust the environment for growing children. Effective nursery businesses are spreading across the board and have discovered that their developing offices near to metropolitan center points may benefit from the continually rising demand for local food, regardless of the season. The nursery industry is also becoming more capital-imbued to achieve these successes, leveraging venture funding and other sources to build the foundation necessary to compete in the present market.

LITERATURE REVIEW

Odintsov Vaintrub, et al. [1] studied about Precision livestock farming (PLF) methods are becoming used in contemporary agriculture. They are commonly incorporated with other emerging technologies to enhance connections between people and animals, agricultural output, and financial stability. For both vast and pasture-based agricultural systems as well as condensed farming operations, new systems are continually being created. The huge sheep farming industry in the Mediterranean region is particularly interested in the development of technology for grazing animals. A characteristic agricultural method of the region connected to its cultural and historical roots is dairy sheep farming.

Groher et al. [2] studied about Agriculture in the present day is completely digital. Precision livestock husbandry is based on a number of digital technologies that may be used for various animal species. Which digital technologies are now applied in agricultural practice, however, is not entirely clear. This book intends to offer the Swiss cattle agricultural status quo as an example of a highly developed, small-scale, and varied organised agriculture for the first time. The article in this context focuses on the use of robotics in ruminant farming, specifically for dairy cattle, suckler cows, dairy goats, beef cattle, as well as meat sheep. It also discusses the adoption of electronic sensors and measuring devices, electronic controls, and electronic data-processing options. In addition, the effectiveness of using smartphones for barn monitoring on chicken farms and electronic ear tags for pigs was evaluated.

Kwakye et al. [3] studied about the degree to which young people are involved in farming is increasingly considered as the contemporary solution to sustainability and the alleviation of food poverty. However, this youth-led plodding change has created new opportunities for a distinct issue that requires an effective agricultural solution. Using information gathered from young people in Ghana, the research investigates the relationship between youth farming and the many variables that motivate young people to pursue careers in agriculture. They used principle component factoring in our Explanatory Factor Analysis (EFA) of the paradigms. The findings indicated that technology greatly influences young people attitudes regarding farming more than motivation, economics, and governmental policies. Additionally, it was shown that knowledge and attitude indirectly affect youth farming.

De Bont et al. [4] studied about Irrigation strategies and development in the Global South are still shaped by the argument over whether kind of irrigation, large- or small-scale, contemporary or traditional, best contributes to food security and rural development. The terms "modern" and "traditional" irrigation dominate irrigation policy and influence actions in Tanzania. In this essay, we examine what these ideas really mean in the context of Tanzania and how they apply to the development of farmer-led groundwater irrigation in Kahe ward, Kilimanjaro Region. This has produced a new, distinctive environment where several agricultural production methods coexist. The development of various kinds of farmers, from those practicing capitalist farming to those participating in subsistence farming, has been made possible by the same set of groundwater irrigation technology. Crop selection, input intensity, and market integration all differ. As a result, some farms closely resemble the "modern" model of industrial farming that the government has encouraged, while others do not, or do so to a lesser level. At the local level, where interventions are heavily influenced by prioritizing based on conflict and financing, they also find that national policy discourses on irrigation are not always reproduced.

Rizov, and Marian [5] studied about Modern farming is more efficient than ever and is becoming more independent from nature than ever thanks to recent technology developments on the field and in the lab. With the development of more accessible and inexpensive new technology, we are better able to comprehend and "control" nature. As a result, for the first time in history, agriculture is beginning to function like any other business, subject to specialization and economies of scale. In turn, this leads to significant organizational shift away from traditional family farms and more towards corporate forms, which has ramifications for employment and rural lives in addition to productivity gains and the minimum effective scale. Recent data from the digitalization of agriculture points to the need to acquire capabilities in abstract and analytical skills to replace skills in everyday jobs while using new technology. However, as digitalization and connectivity become a strategic concern, new alliances between technology providers and agriculture businesses start to arise.

Yongfeng Qian, et al. [6] studied This study aims to assess farmers' propensity to accept drought shock, risk-taking networks, and contemporary irrigation technology. Design/methodology/approach: Based on this supposition, the binary probit model was used in this study to assess the data obtained from 498 household surveys conducted in Zhangye, Gansu province, PRC. The influence of drought stress and risk-taking attitudes on farmers' adoption of contemporary irrigation equipment was first evaluated via the analysis of empirical data. Second, the writers included unofficial networks that carry formal hazards. In conclusion, the sustainability test, marginal effect analysis, and degree of impact were performed based on the empirical data.

Semenov et al. [7] studied In this research, the conventional (intense) agricultural system and the organic farming system are compared and discussed. In this respect, a contemporary definition of soil content is put out, using the "soil ecosystem" notion to replace the conventional view of what the soil is. Several aspects of how soil ecosystems work in the conventional and organic agricultural systems are looked at. These two alternate land-use regimes' internal workings and outside performance are made clear. The papers of international organizations underline the significance of the development of organic agriculture (IFOAM). The following is a quick list of the activities that must be completed as part of the transition to a knowledge-intensive system of producing environmentally friendly agricultural goods under organic farming circumstances.

Armanveer Singh Arora et al. [8] studied about Population needs are progressively rising quickly. The majority of manufacturing and processing sectors encounter challenges or issues in meeting this daily growth in demand. The spread of illnesses via these industries is a major problem even if the demand can be controlled. In order to prevent the terrible repercussions that result from human-to-human touch or connection, several innovative technologies are being deployed. To solve these issues, larger businesses use a lot of computer software and other contemporary technology. One of the most important vocations, farming, is also being affected, although humans have gone a long way since they first began farming. This study looks at how artificial intelligence, one of the newest technologies, has enhanced farming, agriculture, and associated operations to boost production and output.

Wei Sun et al. [9] studied about Population needs are progressively rising quickly. The majority of manufacturing and processing sectors encounter challenges or issues in meeting this daily growth in demand. The spread of illnesses via these industries is a major problem even if the demand can be controlled. In order to prevent the terrible repercussions that result from human-to-human touch or connection, several innovative technologies are being deployed. To solve these issues, larger businesses use a lot of computer software and other contemporary technology. One of the most important vocations, farming, is also being affected, although humans have gone a long way since they first began farming. This study looks at how artificial intelligence, one of the newest technologies, has enhanced farming, agriculture, and associated operations to boost production and output.

Kamyshova, et al. [10] studied about Modern methods of precision farming, which are based on the specifications of the spatiotemporal optimality of irrigation of agricultural crops, call for novel strategies since it is difficult to achieve the necessary accuracy without using cutting-edge digital technology and clever techniques. An artificial neural network-based operational irrigation management model is presented in the paper. Compared to previous approaches, the neural network algorithm has the benefit of a minimal error and the flexibility to adapt to changing circumstances, allowing it to provide the best results for various soil types and crop varieties.

DISCUSSION

Artificial Intelligence

A wealth of new information opportunities have been created by the rise of computerized agriculture and its related improvements. Remote sensors, satellites, and UAVs may gather data across a whole area continuously. These may monitor factors such as soil quality, plant health, temperature, moisture, and more. The enormous volume of data that these sensors are capable of producing makes it difficult to understand the significance of the numbers. By using cutting-edge technology, such as far-off detection, which may disclose more about a scenario than the human eye can see, ranchers will be able to better grasp the situation on the ground. Moreover, it moved more quickly and accurately than I could have imagined it moving across the fields as it walked or ran. Remote sensors enable computations to interpret the present state of a field into measured data that ranchers may understand and find useful for dynamic. Calculations are used to measure information and adapt and learn based on it. The formula will be more accurate at predicting a range of outcomes the more data sources and quantifiable facts it has access to. Additionally, the idea is that ranchers may use this artificial intelligence to achieve their goal of a superior gather by making wiser decisions in the field. The use of digital technology to enhance agricultural operations in order to raise crop yields is known as precision farming, and experts estimate that 25 to 50 percent of farms are investing in this practice. Farmers may benefit from automation, artificial intelligence, and special monitoring devices housed in waterproof enclosures for tasks like:

- Plant seeding and spacing
- Growth management
- Plant packing and preparation
- Energy efficiency
- Grafting and harvesting
- Water distribution

Urbanized digital agricultural technologies, including drones, cameras, and sensors, have been developed by businesses like Climate Corporation to track the growth and health of crops in tiny greenhouses as well as bigger indoor facilities the size of small fields. A variety of reports on the environment, plant life, and overall growth progress are produced by the tracking device.

Water and Soil Sensors

Soil and water sensors may be the technology that makes an effect the fastest. These sensors are robust, discrete, and somewhat acceptable. In fact, even family cultivates believe that it is appropriate to spread them around their region since they provide a number of benefits. These sensors, for instance, can discriminate between nitrogen and wetness levels, and the ranch may use this information to decide when to treat and water rather than relying on a predetermined schedule. This leads to a more efficient use of resources, which lowers costs. However, it also helps the farm be less harmful to the ecology by saving water, limiting decomposition, and lowering manure levels in neighboring streams and lakes.

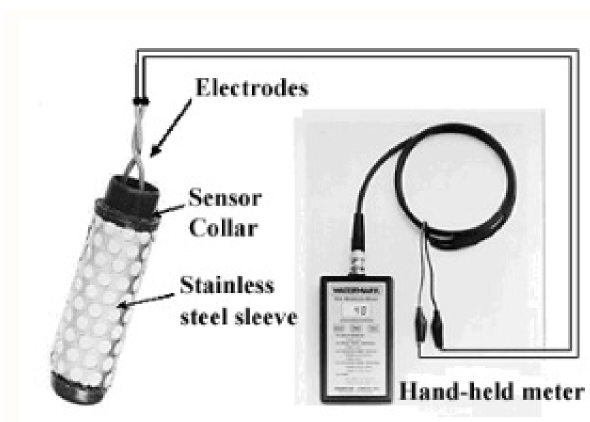

Figure 2: Illustrate the Stainless steel sleeve with hand-held mete for the Model 200SS Watermark® sensor.

The sensor's novel transmission medium, sand, was created to react more swiftly to soil wetting and drying cycles. As a result, the sensor's reaction to changes in the state of the soil's water is quicker than it would be with gypsum blocks. Unlike a gypsum block, which often dissolves in the soil over time, the Watermark sensor does not. Across a range of soil types, the sensor has been shown to be reliable and provide a decent indicator of soil matric potential. The soil water content of the matric potential may be converted, and its availability or depletion per foot of soil layer can be calculated. The sensors should be put in place as early as feasible in the growing season so that crop roots may envelop them and the sensors can accurately depict crop water uptake, as shown in Figure 2.

Weather Monitoring

Even though we often make fun of the local meteorologists, completely automated climate presentation is becoming more and more sophisticated. There are online climate services that focus only on horticulture, and farmers may get these services on dedicated installed and portable farm technology as well as via mobile apps that unexpectedly increase in demand for just about every buyer Smartphone. This invention may provide ranchers with sufficient early warning of ice, hail, and other weather conditions so they can minimize possible danger to assure the yields or, at the very least, greatly lessen unfortunate events.

Satellite photography

As distant satellite imagery has become more accurate, it has included continuous yield symbols. This includes images with targets of 5 meter-pixels and above, not only bird's-eye-view renderings. Yield symbolism enables a rancher to see crops as if they were still there even when they are not. In any case, regularly glancing at photos may help a homestead save a lot of time and money. Additionally, this invention may work with yield, soil, and water sensors to provide alerts and appropriate satellite images to ranchers when hazard boundaries are reached.

Omnipresent automation

In the agricultural technology sector, the phrase "inescapable mechanization" refers to any breakthrough that reduces manager responsibilities. Models include self-driving cars confined by mechanical technology or remotely controlled by terminals, as well as hyper-exactness features like RTK route frameworks that provide the best possible conditions for growing and preparing food. The majority of farming equipment now adheres to the ISOBUS standard, which contributes to a farming environment where balers, combines, work trucks, and other farming equipment share and even function in a suitable and appropriate manner.

Minichromosomal

Technology the most inspiring methods in agriculture innovation may come in the form of a little package. A minichromosome is a tiny structure within a cell that has very little genetic material but may, to put it simply, store a lot of information. Geneticists working in agriculture may give plants a variety of traits by using minichromosomes. These characteristics, like as nitrogen consumption and dry season resistance, may be quite baffling. The fact that a plant's unique chromosomes remain completely unaltered is what makes minichromosomal innovation so intriguing in general. These results lead to speedier administrative approval and quicker customer acknowledgement.

Technology RF

The setup has been configured for discernibility by the previously mentioned dirt and water sensors. The firm has only just begun to comprehend this base, but it is already bearing fruit. These sensors provide information that is relevant to crop yields. Although it may sound science fiction, we live in a world when a bag of potatoes could have a standard tag that you can use your smartphone to get information on the soil that produced them. It's not impossible to imagine a day in the future when ranches may advertise themselves and have devoted customers watch their yields for purchases.

CONCLUSION

The important goals of the agricultural sector in the long run are to produce enough food while maintaining the environment. The constraints on space and water resources, as well as the degradation of ecological wellness caused by the excessive use of synthetic nutrients and pesticides in horticulture, are essential to complete this project. Anthropogenic efforts to progress humanity have accelerated environmental change and further deteriorated the climate. When everything is said and done, efforts have been made globally to lessen the effects of environmental change, particularly on farming. These strategies should be commended given the current methods used in agriculture and moreover the rational exploitation of the local information, which is shown to be more controllable. The two distinct horticultural practices described above may be combined in the existing agribusiness framework without much difficulty and can be used on a global scale. Given the shrinking farmland assets owing to widespread urbanization and the rise in per capita income of the agricultural nations, vertical cultivation, a novel concept in agribusiness, has tremendous promise.

The process, however, is still another suggestion for the agricultural nation that offers remarkable assurance and may successfully handle the problem with respect to quantity, quality, and variety. Natural farming, on the other hand, is a commendable concept in horticulture, but it needs more research and logical information reconciliation for consolidation in the mainstream agribusiness to meet the expanding demands. These two distinct approaches, each with its own standards, provide potential new directions for global agriculture, but they still need further research in the areas of phrase discovery and standard combination for improved global climate and environmental care. This is bringing about fresh breakthroughs in the area of horticulture while taking into consideration shifting sector patterns and mechanical headways. To meet the evolving demands of the present agriculture, these emerging innovations must be used responsibly. To meet the evolving demands of mankind, vertical cultivation and natural cultivation may be accepted as viable alternatives to conventional farming. Additionally, regulations for adopting such techniques should be taken care of, and connections between experts and ranchers should be established for suitable measures.

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CHAPTER 3

AGRICULTURAL TECHNOLOGIES IN INDIA

Dr. Umesh Kumar Tripathi, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- umesh.ag@sanskriti.edu.in

ABSTRACT:

Science and technological advancements, as well as urbanization on a worldwide scale, are the main elements promoting the growth of horticulture examination. Increased per capita income in emerging countries; changes in gastronomic tastes due to globalization and linguistic improvements. With the population growing, these developments put horticulture to the test in terms of generating more and better food. When conventional (twentieth-century) agribusiness methods are applied to boost horticulture's effectiveness, a limit is reached. A significant aspect affecting the production of food internationally is the threat to the environment presented by the reliance on synthetic fertilizers and pesticides for boosting productivity and irritability across the board. These trends imply that new agricultural innovations are definitely required, and that these advancements should be included into the current agribusiness.

KEYWORDS:

Climate Change, Sustainability, Organic Farming, Vertical Crop Growing, Urban Agriculture.

INTRODUCTION

India, which has 1.3 billion inhabitants, is second in the world in terms of agricultural production. In 2021, the sector that included agriculture, forestry, and fisheries represented for 16.4% of the total gross value added (GVA). On the other hand, the industry is acting as a major source of income for more than 50% of the population of the nation. The issue of low and stagnant income in all of these areas continues to dominate India's policy discussions. The bulk of the impoverished in the nation are concentrated in these industries. According to recent estimates, there are 220 million impoverished people in India. Adopting more advanced agricultural technology is one of the most common strategies to increase farmers' revenue. According to the literature, adoption of better technology is the key to raising agricultural output and farmers' income.

The adoption of upgraded technologies remains modest, particularly in the context of emerging areas and nations, despite the fact that they have a significant positive influence on the wellbeing of farmers. The acceptance and spread of better agricultural technology depends critically on elements on the supply and demand sides. Access to finance and necessary inputs, risk considerations, and marginal returns are some examples of demand side issues. Policy support, investments in the agricultural research and extension system, the accessibility of infrastructure, and institutional structures for the distribution and benefit sharing of technology are all supply-side issues. The penetration rate of upgraded technologies for obtaining desired results is accelerated by a perfect balancing of supply and demand side elements. Improved technologies are developed and disseminated predominantly in India via the public sector agricultural research system. As time goes on, the private sector steadily makes a contribution to the creation and promotion of better technology. The up-scaling and out-scaling of better technologies depends heavily on the delivery of such innovations via agricultural extension channels. In actuality, the agricultural extension system targets demand-side variables including raising awareness, lowering risks, and improving efficiency. All of these elements have a big role in the broad acceptance and diffusion of new technology.

Impact on Sustainability and Inequality

Without a doubt, the upgraded and HYVs gained widespread use and considerably raised agricultural output. According to the adoption patterns, the effects varied depending on the size of the farm and the agro-ecoregions. According to several research, the Green Revolution led to a widening of economic gaps and made impoverished farmers further destitute. Although have recognized the disparity in adoption trends for the recent time, it is still important to evaluate the role that technologies play in explaining the degree of regional disparity in agricultural output and farm incomes.

The sustainability of natural resources is a major problem. Adoption of improved and HYVs has resulted in the inappropriate application of fertilizers, pesticides, and irrigation that has negatively impacted soil health, nutritional imbalance, and natural hydrology, according to the majority of studies on the impact of improved technologies on the sustainability of natural resources. Soil and water resources degraded as a result of inadequate institutional systems for managing natural resources. According to studies, the Green Revolution belt, which overused ground water, is now displaying second-generation issues as a result of resource overuse and poor management. These harmful externalities can be divided into three main categories: I affecting soil health due to an imbalance and excessive use of organic fertilizers; (ii) depleting groundwater due to an excessive and careless use of groundwater; and (iii) polluting air quality as a result of burning crop residue.

Numerous studies have shown that excessive inorganic fertilizer usage and inadequate organic manure application have led to a decline in soil health. Between 1970 and 1971 and 2007 and 2008, the partial factor productivity of fertilizers exhibited a dramatic decline, dropping from 48 kg of foodgrains per kilogram of nitrogen, phosphorous, and potassium (NPK) in 1970–1971. If properly implemented, the newly announced "Soil Health Card Scheme"5 will play a significant role in preserving inorganic fertilizers and enhancing soil health, which will ultimately result in a significant reduction in the burden of fertilizer subsidies.

Crop residue burning is a recent occurrence that has emerged as a severe environmental issue in the Green Revolution area. According to estimates, 92 mt of agricultural waste would otherwise be burned in India. Over time, residue burning has grown in scope and has expanded to other regions of India. According to the following factors contribute to crop residue burning: an increase in crop yield, a lack of labor, a short window between harvesting the monsoon (Kharif) crop and sowing the winter (Rabi) crop, a lack of space to stock or store crop residue, an absence of suitable crop residue management technologies, nutritionally deficient rice crop residues, a lack of financial resources, social pressures, and a lack of public awareness Burning agricultural waste has relatively little personal financial cost, but it has a very large societal cost owing to air pollution, which worsens human health and contributes to global warming. According to there is a three-fold increased risk of acute respiratory infection (ARI) for those who reside in locations where agricultural waste is burned. The value of each adjusted life year lost during a five-year period was assessed by the authors to be worth $1.529 billion. The efficient application of sustainable management methods together with appropriate government actions and policies is the answer to agricultural residue burning. The government created a "National Policy for Management of Crop Residue," which includes

- Organizing awareness campaigns,
- Conducting demonstrations of technologies to manage and use crop residue,

- Extending subsidies on implements for managing crop residue, and
- Making residue burning illegal.

Despite the government's diligent efforts, the issue has grown over time and is now hurting both soil quality and human health. As a consequence of advanced technology, there has been discussion over the root causes of negative externalities. Some claim that the enhanced cultivars degrade natural resources and the environment since they demand more water and inorganic fertilizers environment. The others contend that government policies, particularly subsidies on inputs (fertilizer, irrigation, and electricity), are pushing farmers to utilize modern inputs carelessly and excessively in an effort to maximize their earnings. A need for sustainable transformation and agricultural growth is the correction of government policies and incentives, as well as the promotion of agricultural diversification toward input-saving (particularly water-saving) and more lucrative agricultural commodities.

- The review above may be summarized as conveying the following messages:
- The influence of improved varieties in altering Indian agriculture, raising agricultural output, and assuring food security was substantial. India's position on the world map was therefore improved from one of food deficit to one of food abundance.
- Geographical location and product category affected the adoption trends of improved cultivars.
- The use of improved cultivars has a clear influence on agricultural productivity, output, and farmer revenue.
- The adoption of better cultivars has an impact on poverty, equality, and employment.
- Negative externalities are becoming more visible, particularly those that have a negative influence on the environment's sustainability and natural resources. These externalities need to be effectively handled using the right technology and effective regulations.
- A targeted strategy is essential for accelerating and expanding the dissemination of better cultivars.

Management of Natural Resources

Improving water usage efficiency, boosting input utilization, particularly of fertilizer, and protecting soil and water resources are all examples of promising innovations in the field of natural resource management.

Water use

A crucial component of agriculture and related operations is water. India is home to 17% of the world's population and 4% of the world's freshwater. The irrigation zone has been attained through ground, surface, and other sources to more than 40%. India was categorized by the World Resource Institute as having significant water stress despite having plenty of water available. It is primarily caused by the fact that ground water levels are drastically declining in India, and their situation is quite frightening in states like Punjab and Haryana. For agriculture to be sustainable in such a circumstance, saving groundwater and increasing water usage efficiency must be given top attention. About 22 million hectares of India's cultivable land is irrigated by canals, 39 million ha by groundwater, and about two-thirds of the country's cultivable land is rainfed. One of the most notable strategies to address the sustainability of agriculture is to use water-efficient technology. In order to better comprehend how significant innovations affected the viability of agriculture and farmers' income, this section offers a succinct assessment of these technologies. To comprehend adoption hurdles and possible effects, the study takes into account diverse water usage systems, land-leveling technology, agronomic techniques, and micro-irrigation technologies.

The adoption of micro-irrigation technologies like sprinkler and drip irrigation has a significant potential to increase agricultural productivity and increase water use efficiency. According to these findings, the adoption patterns of micro-irrigation technologies are growing at a substantial pace over time. The area covered by micro-irrigation for the largest states in 2020. According to the findings, the top 5 states in terms of gross irrigated area are Andhra Pradesh (51%), Karnataka (49%), Maharashtra (34%), Tamil Nadu (29%) and Gujarat (22%).

Surprisingly, despite the rapidly declining ground water table, just 1% of Punjab is irrigated with micro irrigation. In contrast, the neighboring state of Haryana has 10% of its land under micro-irrigation, particularly in regions where the quality of the groundwater is poor. The fact that rice farming is so prevalent in Punjab and Haryana is the fundamental reason for the limited adoption of micro-irrigation technology. It should be noted, nevertheless, that research into the use of micro-irrigation to rice crops is currently ongoing.

Artificial fertilizer

The improvement in agricultural production and farmers' revenue has been largely attributed to the use of inorganic fertilizers and pesticides in the authorized proportions. Their adoption, in conjunction with better cultivars and -irrigation, has\ssignificantly enhanced agricultural yield. But there is a significant discrepancy. There are several sources for fertilizers. Minerals, airborne gases, and inorganic waste are used to make fertilizers that are synthetically generated as shown in Figure 1. The use of fertilizers and pesticides varies among states and farm size while rainfed regions and small and marginal farmers use less than the recommended dosages, better-off states and big farms use excessive amounts of fertilizers and pesticides. The best use of fertilizers and pesticides faces three challenges:

- Affordability of fertilizers and pesticides.
- Balance and judicious use of fertilizers and pesticides.
- Environmental degradation as a consequence of injudicious and indiscriminate use of fertilizers and pesticides.

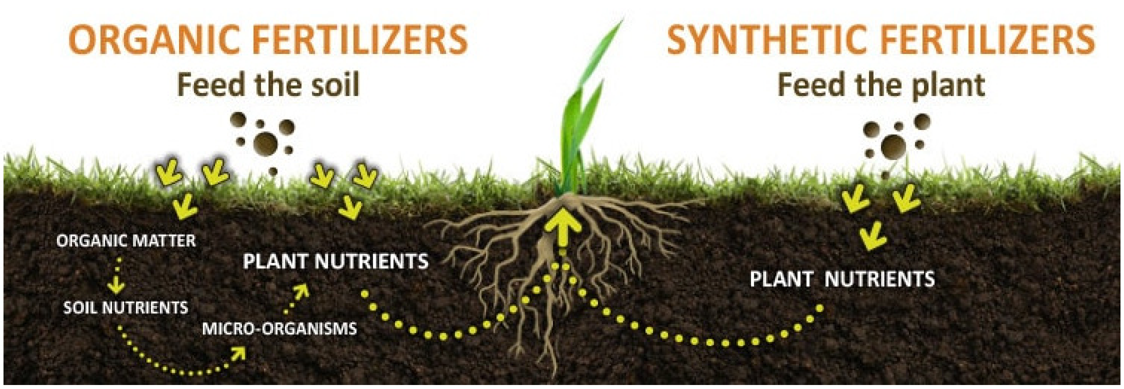

Figure 1: Illustrate the Organic fertilizers get their nutrients from natural sources like microorganisms, organic waste, as well as other similar substances.

The Government of India offers a large subsidy to make fertilizers cheap; in 2020–21, according to the government webpage, bought fertilizers, indicating that barely 70% of farmers use fertilizers and pesticides for agriculture operations. To further understand the major reasons why the remaining 30% of farmers don't use fertilizers, more thorough research will need to be done. Is it due to cost or lack of accessibility? It would be helpful to define these farmers and create a typology of them so that the right institutional and regulatory decisions could be made.

Many farmers in areas with more resources are abusing these inputs. The Government of India launched a "Soil HealthCardScheme" in 2014 to combat the improper use of fertilizers, allowing farmers to apply soil-test based nutrients and fertilizer to maximize their profit. The most effective use of nutrient management has an impact on input costs, productivity, and profitability. Micronutrients have a crucial role, particularly Zn and Mn. The government of Karnataka started a campaign called Bhoochetna to increase micronutrient consumption. The negative impacts of excessive and careless fertilizer usage have led to the loss of microflora and other species, deterioration in groundwater quality, and degradation of soil health. As previously mentioned, during the last three and a half decades, fertilizers' partial factor productivity has dramatically decreased. Experiments conducted on farms also show that the existing fertilizer

Management practices are reducing the availability of carbon and micronutrients, negatively impacting agricultural productivity and income, and destroying soil health and water quality. - Due to their excessive usage of fertilizer, smallholder farmers are more susceptible to these negative impacts. Compared to phosphorus, potash, and other micronutrients, higher subsidies on nitrogenous fertilizer encourage more urea usage (like manganese, zinc and boron). Due to their high number, smallholders only get a tiny portion of the fertiliser subsidy. According to data from the Government of India (2016), smallholder farmers get around 14 times less in fertiliser subsidies per holding than big farmers do. 2015 saw the introduction of whole urea with neem covering. Neem-coated urea provides a number of advantages, including conserving urea, enhancing nitrogen usage effectiveness, and raising crop yields. Additionally, it reduces fertilizer leakages from agriculture to nonagricultural sectors, which lowers the fertilizer subsidy burden. To evaluate the acceptance and effects of neem coated urea on all facets of agriculture, further study is required.

The development of watershed technology is seen as beneficial for rainfed regions. It entails rainwater conservation and smart usage to boost agricultural output and stop soil erosion. Based on research efforts undertaken in eight places by the Indian Council of Agricultural Research, the Watershed program in India was created (ICAR). The initiative entails integrating technological advancements with institutional frameworks, budgetary plans, capacity building for increased public engagement, and efficient governance for watershed management. The program was created for rainfed regions with many goals in mind, including raising farmer income, reducing soil erosion, and preserving rainwater.

An essential instrument for the development of water resources, groundwater recharge, and socioeconomic advancement is the watershed program in rainfed regions. Raised bed planting, the ridge-furrow method of sowing, sub-surface irrigation, and precision farming are some of the structures and agronomic techniques used in the watershed program. All of these have a significant potential to increase water usage efficiency. According to author improved availability to irrigation water as a consequence of rainwater gathering has a number of advantages, including

- Raising agricultural output.
- Increasing agricultural intensity to allow for two to three harvests each year.
- Increasing the accessibility of groundwater.
- Making it easier to diversify crops in favor of high-value crops.

- Creating job opportunities
- Increasing agricultural earnings.
- Increasing the soil and water resources' sustainability.

A significant number of watersheds were subjected to a meta-analysis by Joshi et al. (2008) to measure the effect on rainfed agriculture. The outcome show that watershed programs enhance equality and the sustainability of natural resources in rainfed regions in addition to raising farmers' income. Additionally, by integrating fish, poultry, and other businesses into the agricultural system, crop diversification enhances the possibility of increasing farm revenue.

LITERATURE REVIEW

Demestichas et al. [1] studied about a lengthy and contentious discussion has centered on how agriculture contributes to environmental deterioration and climate change. This circumstance, together with the anticipated expansion in crop demand, rising fertilizer and pesticide costs, and the need for a more resource-efficient and ecologically friendly agriculture, have all contributed to highlighting this need more than ever. By employing data on the temporal and geographical variability of crops, precision agriculture (PA), a relatively new agricultural management concept, seeks to increase crop performance while also reducing environmental impact. Every aspect of contemporary life has been altered and impacted by information and communication technology (ICT) systems, and PA is no exception. The present research undertakes a review of the literature on well-known ICT solutions, emphasizing their function in assisting various stages of the lifecycle of data connected to PA.

Feyisa, and Bekele W [2] studied Promoting the use of agricultural technology is one strategy to increase the productivity of smallholder farmers. Ethiopia still has a relatively low adoption rate for agricultural technologies. As a result, the reasons why agricultural technology adoption remained low have been the subject of several studies. However, there is only a limited amount of data on the general variables impacting the adoption of agricultural technology in Ethiopia. As a result, little is known about the common variables influencing Ethiopia's adoption of agricultural technology. Therefore, this meta-analysis sought to quantify the factors that influence the adoption of agricultural technology from adoption research.

Damba et al. [3] Studied Growing agricultural production is seen as an important step toward addressing the problems of food insecurity and poverty in developing Africa. The adoption and use of technology is one such route to increasing agricultural output. The manner in which more advanced agricultural technologies are disseminated is a significant limiting factor for technological adoption and use. It is well established that the techniques used for educating farmers about agricultural technology affect the replication impact on productivity improvement among target and non-target farmers. Data from 1009 farmers in the (former) three northern areas were gathered using a multi-stage sampling procedure. Count data and binary regression techniques were then utilized to evaluate the impact of the different distribution strategies on technology adoption and usage. The findings show that a carefully planned mix of technology diffusion strategies would be most efficient and have the potential for long-term adoption in Northern Ghana. Lessons learned from this exercise may be useful in encouraging the adoption of productivity-enhancing technologies in other agricultural communities with comparable demographics.

Nonvide et al. [4] studied about adoption of agricultural technology is still quite low. The elements that affect rice growers in Benin's adoption of agricultural technology are examined in this essay. To account for the unobserved interaction between technology adoption choices, it uses a multivariate probit model, a simple probit model, and Poisson regression models. The findings show that factors including education, access to extension services, participation in a farmers-based organization, access to financing, usage of a mobile phone, and media are crucial in the process of boosting adoption of agricultural technology. When formulating the agricultural modernization strategy, these factors must be taken into account.

Okello et al. [5] studied Smallholder dairy producers' production and revenue may be significantly increased by using agricultural technology. However, the majority of smallholder farmers, particularly in developing nations, have a poor adoption rate for these technology. . For the simultaneous multiple utilization choices, we used a multivariate probit model, and ordered probit models were used to gauge the intensity of use. The study's findings showed that the household head's education level, the number of cows owned, the type of livestock, milk yield, the size of the land, the availability of contracts, the cost of milk, the availability of credit, the availability of business plan training, membership in dairy cooperatives, the nature of the service providers, the receipt of remittances, the distance to veterinary services, and the location of the output market were the main factors that affected the likelihood of using dairy agricultural technologies among smallholder farmers in The number of cows in the home, the kind of animals, the size of the land, the availability of contracts and finance, participation in dairy cooperatives, and the kind of service providers all had an impact on how intensively dairy technologies were used. In conclusion, varied family, farm, market, and transaction cost variables determine how agricultural technologies are used, which may either limit or promote the adoption of these technologies.

DISCUSSION

Conservation farming

The loss of natural resources, particularly soil and water, is a severe problem for the upper Indo-Gangetic plain. These are a result of increasing manufacturing costs and deteriorating profitability, mostly due to (a) reducing soil organic matter and carbon content, (b) intensive tillage and unbalanced fertilizer usage, (c) increased threat of residue burning, (d) steadily lowering ground water table, (e) rising wages and labor shortages, and (f) rising fuel costs. These elements are having a negative impact on the land, water, and air, which has an impact on agricultural production, farm revenue, and human health. The idea of conservation agriculture is pushed as a solution to these issues brought on by conventional agriculture. A variety of soil management techniques are used to minimize the impact on soil composition, structure, and natural biodiversity as well as to minimize erosion and degradation. Direct sowing, no, little, or little tillage, surface integration of crop wastes, and establishment of cover crops in both annual and perennial crops are all examples of conservation agricultural methods.

The Food and Agriculture Organization (FAO) of the United Nations has concentrated on the idea as resource-saving agricultural crop production in order to combine farm revenue and soil health via conservation agriculture. The goals of conservation agriculture, according to the FAO, are to (a) generate acceptable profitability, (b) maintain high and sustained production levels, and (c) protect the environment. The direct-seeding of rice, zero tillage, and laser field leveling are the three most crucial elements of conservation agriculture. In India, conservation agriculture is just slowly being adopted, although it is becoming more significant in Punjab and Haryana. Adopting conservation agricultural methods results in a number of economic and environmental advantages. The following are some of them: I yield increase (10%–17%); (ii) water savings (20%–35%); (iii) energy and oil savings (approximately one million barrels if implemented in 3.5 million ha); (iv) high internal rate of return (57%); and (v) improved carbon sequestration and decreased greenhouse gas emissions (Erenstein and Pandey 2006).

The barriers to adoption include me a lack of knowledge of the idea, (ii) the absence of laser land leveling and zero tillage equipment and/or services, (iii) the expensive cost of machines, and (iv) a lack of maintenance expertise for machinery used in conservation agriculture. The farmers also gradually adopt and modify the conservation agriculture components to fit their abilities and resource endowment. The use of laser land leveling is becoming more popular in Punjab and Haryana than the other components. Zero tillage and direct seeded rice come next. The substantial link between the use of laser land leveling and zero tillage (Joshi 2016) is noteworthy to notice. If the field is laser leveled, zero tillage is more likely to be used. To increase the use of conservation agriculture, more research is required in various agro-ecologies and for alternative production methods.

Technologies That Are Climate Smart

The fact of climate change has finally emerged. It has a negative impact on agricultural productivity and lowers the incomes of the poor. One of the Inter-Governmental Panel on Climate Change's (IPCC) most recent studies, which asserts that human activity is to blame for climate change, is very ominous. It goes on to explain that the harm would be worse than anticipated in the absence of effective climate change mitigation efforts. More people who own small farms are susceptible to climate change. This group of individuals is least equipped to deal with the effects since they lack the resources to change their social and technological environments. The Consultative Group on International Agricultural Research (CGIAR) initiative on Climate Change, Agriculture, and Food Security has supported Climate Smart Agriculture (CSA) at the global level to battle the effects of climate change (CCAFS). The CSA is "an approach that helps lead efforts required to change and reorient agricultural systems to successfully promote development and assure food security in a changing environment," according to the FAO. It is a win-win situation in the short and long terms, contributing to I increased agricultural output and farmer incomes, (ii) climate change adaptation and risk reduction, and (iii) improved carbon sequestration and/or decreased greenhouse gas emissions. The CSA uses a thorough approach that takes into account the social, economic, and environmental circumstances. The CSA is a collection of procedures designed to boost productivity, lower hazards, and increase the sustainability of the environment and natural resources. The efficacy of CSA activities in reducing the negative effects of climate change. The research shows that CSA activities have a significant potential to alleviate the negative consequences of climate change.

The CSA technologies are made up of a number of parts. These include crop diversification, energy management, site-specific fertilizer management, weather advisory, low tillage, and stress-tolerant cultivars. The adoption of these components is location-specific since the majority of them deal with resource management. Depending on the resources and abilities of the farmers, their adoption may be gradual or step-by-step. The implementation of various CSA procedures is connected. According to their convenience, farmers often alter the suggestions. Depending on resource endowments, access to expertise, and agro-ecoregion, different CSA practice adoption levels have been observed. Poorer agro-ecoregions were shown to have lower adoption rates when compared to the areas with more resources. Laser land leveling, direct seeded rice, zero tillage, stress-tolerant cultivars, irrigation scheduling, weather advisory, and agricultural insurance are significant factors that are given precedence for adoption. However, their level and rate of adoption varied amongst various agro-ecoregions.

One of the key economic areas in India is the agricultural industry, which is presently worth US$ 370 billion. The Economic Survey 2020-21 estimates that the agricultural sector will contribute 19.9% of GDP in 2020–21, up from the 17.8% reported in 2019–20. The government has made significant efforts over the years to assist and advance the agricultural industry with tried-and-true farming technology and encouraging legislation. The current advancements in digital farming technology will hasten expansion by providing greater agricultural yields and enhancing sustainability by lowering water usage and pesticide use.

Artificial intelligence (AI) and machine learning (ML), remote sensing, big data, block chain, and the internet of things (IoT) are among the digital technologies that are upgrading agricultural value chains. While several nations, like the US, Israel, Australia, and the Netherlands, have effectively accepted and used digital technologies to revolutionize agriculture, India is still in the early stages of this process. India is expected to foster the use of digital agriculture via Public-Private Partnerships (PPP).

Current Digital Agriculture Projects in India

Efforts have also been undertaken to digitise the current value chain. It is clearly accepted and acknowledged that Indian agriculture has to become more digital. The launch of the Digital Agriculture Mission 2021–2025 was announced in September 2021 by the Union Minister of Agriculture & Farmers Welfare, Mr. Narendra Singh Tomar, who also inked five Memorandum of Understandings (MoUs) to advance digital agriculture through pilot projects with CISCO, Ninjacart, Jio Platforms Limited, ITC Limited, and NCDEX e-Markets Limited (NeML). The goal of the Digital Agriculture Mission 2021–2025 is to encourage and speed up initiatives based on cutting-edge technologies including artificial intelligence (AI), blockchain, remote sensing and GIS, and usage of robots and drones.

In August 2019, Cisco created an Agricultural Digital Infrastructure (ADI) solution to improve farming and information exchange. This ADI is probably going to be quite important in the data pool that the Department of Agriculture will develop for the National Agri Stack. At Kaithal (Haryana) and Morena (Mexico), this initiative's pilot experiment will be conducted (Madhya Pradesh).

In order to empower farmers, the Jio Agri (JioKrishi) platform, which was introduced in February 2020, digitizes the agricultural ecosystem throughout the full value chain. The platform's primary function leverages data from standalone applications to provide counsel; the advanced features use data from a variety of sources, input it into AI/ML algorithms, and then deliver precise, individualized advice. Jalna and Nashik will host this initiative's pilot project (Maharashtra).

Using a digital crop monitoring platform housed on ITC's e-Choupal 4.0 digital platform, ITC has proposed to develop a customized "Site Specific Crop Advise" service to transform traditional crop-level generic counsel into a personalized site-specific crop advisory for farmers. At Sehore and Vidisha, this initiative's pilot project will be implemented (Madhya Pradesh). Major digital tools have been created by the Ministry of Agriculture & Farmers Welfare to encourage farmers to utilize technology, including: -

Agricultural Produce Market Committee (APMC) mandis are connected through the pan-Indian electronic trading platform known as the National Agriculture Market (eNAM), which was introduced in April 2016, to establish a single national market for agricultural commodities. By offering farmers reasonable returns on their investment, eNAM enables farmers to sell goods directly to consumers without the involvement of brokers or middlemen.

Transfer of Direct Benefits (DBT) Central Agricultural Portal: The DBT Agri Portal, which was introduced in January 2013, serves as a centralized hub for all agricultural programmes in the nation. The site provides government incentives to assist farmers in acquiring new agricultural equipment.

The Ministry of Agriculture and Farmers Welfare and Microsoft signed a Memorandum of Understanding in June 2021 to operate a pilot program in 100 communities across six states. In accordance with the MoU, Microsoft will use its cloud computing capabilities to develop a "Unified Farmer Services Interface." This is a key component of the ministry's long-term strategy to develop "AgriStack," a single platform that will provide farmers end-to-end services along the agricultural and food value chain. To do this, the government intends to issue special farmer IDs to each farmer in the nation in order to link them with other government programs and develop digital agricultural ecosystems.

India's future in digital agriculture

Agriculture using digital technology

Remote sensing, soil sensors, unmanned aerial surveys, market insights, and other technological interventions enable farmers to collect, visualize, and evaluate crop and soil health conditions at various phases of production in a practical and economical manner. They may serve as a first signal to spot possible problems and provide solutions to address them quickly.

Artificial intelligence/machine learning (AI/ML) algorithms may provide in-the-moment actionable insights to aid in soil screening, increase crop production, manage pests, and lessen farmer burden. With the use of blockchain technology, you can monitor your food and track tamper-proof, accurate data about farms, inventory, and transactions. As a result, farmers no longer need to rely on files or papers to capture and save crucial information.

Digital agriculture advantages

By putting these technology solutions into practice, farms may be managed and monitored effectively. Farmers can respond appropriately and avoid using excessive amounts of pesticides, fertilizers, and water since they have access to a comprehensive computerized study of their crops in real-time.

Additional advantages include:

- decreases the cost of production while increasing agricultural productivity
- prevents soil deterioration
- Reduces the use of chemicals in agricultural production and encourages effective and efficient water usage
- improves the socioeconomic circumstances of farmers
- lessens adverse effects on the environment and ecology
- improves workplace safety

India's use of digital agriculture

The prevalence of segregated small-holder farms in India is a major reason for the slow adoption of digital farming in that nation since it makes data collection more difficult. The sector's use of digital solutions has also been significantly influenced by the low penetration of mechanization equipment and frequent natural disasters including droughts, floods, and heavy monsoon rains. In order to deploy digital agriculture on a typical Indian small farm, a customized strategy is thus required; this may then be scaled up and made accessible to many

Indian farmers. The following actions might be taken in India to make digital agriculture successful: -

Cost-effective technology: An Indian farmer often makes over $1,000 per year. The difficult financial situations that a typical farmer in India faces are explained by their poor revenue. Reduced technological costs will thus be beneficial. Plug-and-play hardware has a greater chance in the Indian market since typical Indian farms are tiny. Additionally, agricultural land leasing is quite common under different farming arrangements, so a farmer may transfer to another farm plot the next season. For farmers in such situations, purchasing portable equipment is preferable.

Platforms for renting and sharing agricultural gear and equipment include: Small agricultural plots and limited financial resources provide an opportunity for online platforms that provide equipment rental and sharing services rather than outright purchases. Several agritech startups currently provide equipment rental services, including Farmkart (rent4farm), EM3 AgriServices, and Trringo. Academic support: Through different locally run programs and government initiatives, the local agricultural organization and academic institutions often engage with farmers. The availability of training resources from different academic institutions and agricultural organizations will increase farmers' use of digital technology.

CONCLUSION

For the area, the agriculture industry is crucial. Similar to all other economic sectors, it is transitioning to a market economy and experiencing significant changes to its social, legal, structural, productive, and supply setups. For the majority of the nations, these changes have been followed by a reduction in agricultural productivity, which has also had an impact on the national seed supply sectors in the area. The area has seen food security issues, and some nations have required food help for IDPs and refugees. It should be possible to overcome issues with food insecurity in the region as a whole and even use this region to provide food to other food-deficient regions due to the relatively low demographic pressure projected for the future, the presence of some favorable types of climates, and other positive factors, including a very wide formal seed supply sector. Therefore, opportunities must be established in order to achieve these goals.

The region needs integrated efforts from all national and international stakeholders and institutions involved in seed supply and plant genetic resource management in order to address the primary constraints affecting the development of the national and regional seed supplies that are mentioned here. Lessons learnt on practical matters might be imparted to other nations, such as how to go forward with the transition or how to identify farmers' most pressing needs. In order to promote initial investment and regional growth, appropriate policies should be implemented at different levels.

Indian and international agritech businesses can play a crucial role in providing farmers with these cutting-edge technologies since the Indian Agriculture and Allied sector is on the brink of embracing contemporary technology, such as IoT, AI/ML, and agri-drones for unmanned aerial surveys. There are currently few competitors in the sector, but serving the nation's 267 million farmers presents a significant potential for private and international businesses to increase their presence in the nation. The success of digital agriculture in India will, however, be determined by a number of important aspects, including government policies that are supportive, low-cost technology, simple operations and access, and simple system maintenance. In order to reach goals like doubling farmer incomes and sustainable growth, it is in the national interest to take a comprehensive ecosystem approach to solving the problems the Indian agricultural industry faces. The widespread adoption of digital agriculture in India would thus need a multi-stakeholder strategy, with the government playing a major enabler's role in the ecosystem.

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CHAPTER 4

DEVELOPMENT OF AGRICULTURE

Dr. Vinaya Kumar Yadav, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- vinay.ag@sanskriti.edu.in

ABSTRACT:

This chapter discusses the significant changes in the agricultural sector in India, including productivity gains and integration with international food markets, before going over some of the challenges for future development, such as land distribution policies, access to credit, water management, and food distribution. The primary source of revenue for the federal and state governments is agriculture. The country's government receives significant funding from increasing land income. Additionally, the transportation of agricultural products helps the Indian Railways make money, which aids the government in making money. India has a fairly high labor share (55%) but a lower contribution to agriculture mechanization (40%) than other countries. India reduces the profitability of farming and makes farmers poor. While the labor share in the USA (2.5%) and Western Europe (3.9%) is quite low compared to the mechanization share of 95%.

KEYWORDS:

Agriculture, Climate Change, Sustainability, Organic Farming, Vertical Crop Growing.

INTRODUCTION

For food to be available to the average person, agriculture has to increase output. The Food and Agriculture Organization (FAO) of the United Nations reports that 8.68 billion people worldwide, or 12.5% of the population, are undernourished in terms of calorie consumption. It was estimated that 852 million of these individuals were residents of developing nations. The Food and Agricultural Organization (FAO) predicts that in order to feed the expanding population alone, agricultural output would need to increase overall by 70% by 2050, and especially by nearly 100% in emerging nations. Technology should be introduced at a rapid rate. According to the report, lost productivity and treatment costs caused by malnutrition cost the global Gross domestic product (GDP) 5% of its value. Contrarily, spending money to fight malnutrition increases income with a benefit-to-cost ratio of over 13 to 1.

Productivity

Although agriculture in our country has improved, the yield of our main horticultural and agricultural crops is still quite poor when compared to other nations. Our agricultural sector still lacks in technology. In our nation, food grain, fruit, and vegetable yields per acre are much below average globally. Our rice output is around half that of Vietnam and Indonesia, and it is just a third of China's. Even the most productive regions of India underperform the world. Similar to this, by paying attention to seeds, soil health, pest control, crop lifesaving irrigation, and post-harvest technologies, the production of pulses and oilseeds may be raised by 2.3 to 2.5 times. By 2025, India's population is predicted to exceed 1.5 billion, making food security the most pressing societal problem and necessitating a significant increase in food production to accommodate the expanding population. To increase agricultural productivity, it is necessary to use new technologies including biotechnology, nanotechnology, high-tech protected cultivation, and contemporary irrigation techniques.

The use of biotechnological techniques in agriculture might increase the productivity and resistance to biotic and abiotic challenges of food crops. Given the rising food demand, the effects of climate change, and the shortage of both land and water, this might stabilize and grow food supply. More than 17 million farmers planted genetically modified (GM) crops such soybean, maize, cotton, and canola on 170 million hectares (ha), or around 12% of the world's arable land, in 2012. However, the majority of these crops were not cultivated mainly for direct food consumption. Genetically modified cotton, or Bt cotton, was first marketed in India in 2002. By 2012, nearly 7 million farmers have embraced this technique over 10.8 million acres, or 93% of the nation's cotton-growing land. The farmers' profitability has undoubtedly grown thanks to bt cotton, which has also significantly decreased the usage of chemical pesticides on this crop. According to studies, food insecurity among Indian cotton producers has decreased by 15% to 20% as a result of the adoption of Bt technology. But because of concerns expressed by several ecological organizations, the usage of genetically modified crops was limited to cotton exclusively. However, the Central Government has recently permitted the testing of other GM crops as well, which will encourage the use of additional GM crops. In 2012, the government authorized 17 GM crops with 8 characteristics for bacterial and viral resistance. Additionally, ß-carotene-rich golden rice has been created in the nation. Since ß-carotene shortage causes over 5,000 children in India to become blind every year, this is a fantastic remedy.

Nanotechnology

Numerous applications of nanotechnology are possible in agriculture. The distribution of agricultural pesticides, field-sensing devices to monitor the environmental pressures and crop conditions, and development of plant characteristics against environmental stresses and diseases are all possible benefits. It can also help to promote soil fertility and balanced crop nutrition. Applications in animal husbandry might improve farmed animals' nutrition and feeding efficiency, reduce animal disease-related losses, and create value-added goods from animal waste and by-products. The use of nanotechnology may have advantages for farmers, the food industry, and consumers alike. Nanotechnology provides significant opportunity for the creation of novel products and uses for agriculture, water treatment, food production, processing, preservation, and packaging. At certain nations, people may already purchase food, health food items, and food packaging materials based on nanotechnology. Additional goods and uses are now in the research and development stage and some might soon hit the market. Given this development, it is anticipated that in the next years, customers all over the globe will have more access to food items made using nanotechnology. With the development of technology, the usage of nano size silver particles as antibacterial agents has increased. This has also made their manufacture more affordable.

In comparison to commonly used fungicides, silver may be utilized to manage a variety of plant infections since it exhibits multiple ways of inhibitory action against microorganisms. Numerous metabolic activities in bacteria, including modifications to the plasma membrane and regular operations, are known to be impacted by silver. Insect and pest control may also be accomplished using nanoparticles. New formulations of herbicides, insecticides, and insect repellents may be made using nanoparticles. DNA and other desirable compounds may be delivered into plant tissues to protect host plants from insect infestations. Validamycin-loaded porous hollow silica nanoparticles (PHSNs) may effectively deliver water-soluble pesticides for their controlled release. In particular, for the regulated delivery of pesticides, whose immediate as well as delayed release is required for plants, PHSNs' controlled release behavior makes them a viable carrier in agriculture. The packaging of food has a great deal of potential to be transformed by nanotechnology. When functionalized, nanoparticles like titanium dioxide, zinc oxide, and magnesium oxide or a mixture of them can be effective in killing microbes and are less expensive and risky to employ than metal-based nanoparticles.

Safeguarded Cultivation

The most promising area where horticultural crop output has increased globally, both qualitatively and quantitatively, in recent decades is protected culture, or greenhouse cultivation. The countries that are now leading in crop growing in polyhouses and greenhouses include Spain, the Netherlands, and Israel. Around 70.000 acres are planted in protected agriculture in Spain. The use of plasticulture may significantly reduce expenses, which can result in increased crop quality and yield. In India, there are now roughly 25,000 hectares of land under protected agriculture, compared to about 2,000 ha for greenhouse vegetable farming. The Netherlands and India both have almost the same amount of area used for flower farming, but because to the Netherlands' sophisticated poly house technology, the Netherlands contributes 70% of the world's flower exports while India only contributes 1% or less. In the Netherlands, fewer than 1% of agricultural land is used for glasshouse production, which generates 40% of the industry's yearly gross income and up to €600,000 per hectare in crop revenue. Protected cultivation has provided a new way to produce more in a small space as a result of land holding restrictions, rapid urbanization, declining crop production, declining biodiversity, and an ever-increasing population. Demand for food, particularly vegetables, has increased significantly as a result of these factors. Rainwater collection may also be done in polyhouses. A 175 square meter polyhouse would use around 52,000 liters of water per year. Water consumption for a crop with a six-month life cycle is 26,000 liters per half-year. The amount of rainwater that falls on the roof of the polyhouse at a location with a 400 mm annual rainfall is on the order of 70,000 liters. The amount of rainwater that can be collected, 56,000 liters, is more than the amount needed annually, assuming an 80 percent collection efficiency.

Machine farming

India has a fairly high labor share (55%) but a lower contribution to agriculture mechanization (40%) than other countries. India reduces the profitability of farming and makes farmers poor. While the labor share in the USA (2.5%) and Western Europe (3.9%) is quite low compared to the mechanization share of 95%, Only 1.36 kw/ha of electricity is consumed in India, compared to 8.75 kw/ha in Japan, which highlights the huge power shortage in mechanization. With 461.2 tractors and 236.9 combine harvesters per hectare as opposed to 15.75 tractors and 0.026 combine harvesters per hectare, our nation lags considerably behind Japan. With 138 million land holdings, India has one of the biggest barriers in agricultural mechanization compared to the USA, where just 2 to 3 percent of the population owns land. Indian agriculture utilizes 263 million farm laborers to cultivate 140 million hectares of land, despite the country's fast agricultural automation (149 million pieces of farm equipment). One of the most crucial elements for increasing profitability is farm mechanization and the use of sophisticated devices, machinery, equipment, and instruments to do various tasks in the agricultural field quickly and effectively. The efficacy of operations and farm revenue will both be improved by smaller machinery designed for horticulture activities in the hills and mountains. Farm mechanization will contribute to increased output and productivity overall at the lowest possible cost. Farm mechanization may reduce manual labor by 20 to 30 percent, save 15 to 20 percent on fertilizer costs, boost crop production by 5 to 20 percent, save 20 to 30 percent on time, and enhance farm productivity by 10 to 15 percent overall.

Use of Contemporary Irrigation Techniques

The availability of water is of utmost importance for boosting agricultural output. In India, the agricultural sector uses around 78% of the country's water supply, with the remainder going to drinking, industrial, and other uses. As a result, by 2050, the nation's water storage capacity must be doubled to 450 million cubic meters. More than 60% of the country's arable land lacks irrigation, thus dry land agriculture should be the major area of concentration. Due to significant conveyance and distribution losses, the traditional flood technique of irrigation, which is mostly used in Indian agriculture, has a relatively poor water usage efficiency. In order to save water and improve the current water usage efficiency in Indian agriculture, a variety of demand management methods and programs have been established in response to the rapidly declining irrigation water potential and rising demand for water from other sectors. Since 40% of the world's food is produced on the 18% of irrigated farmland, irrigation is essential to the world's food supply. Nevertheless, fewer than 4% of the irrigated land on the planet has micro-irrigation systems in place. Modern irrigation techniques like drip and sprinkler irrigation must be used.

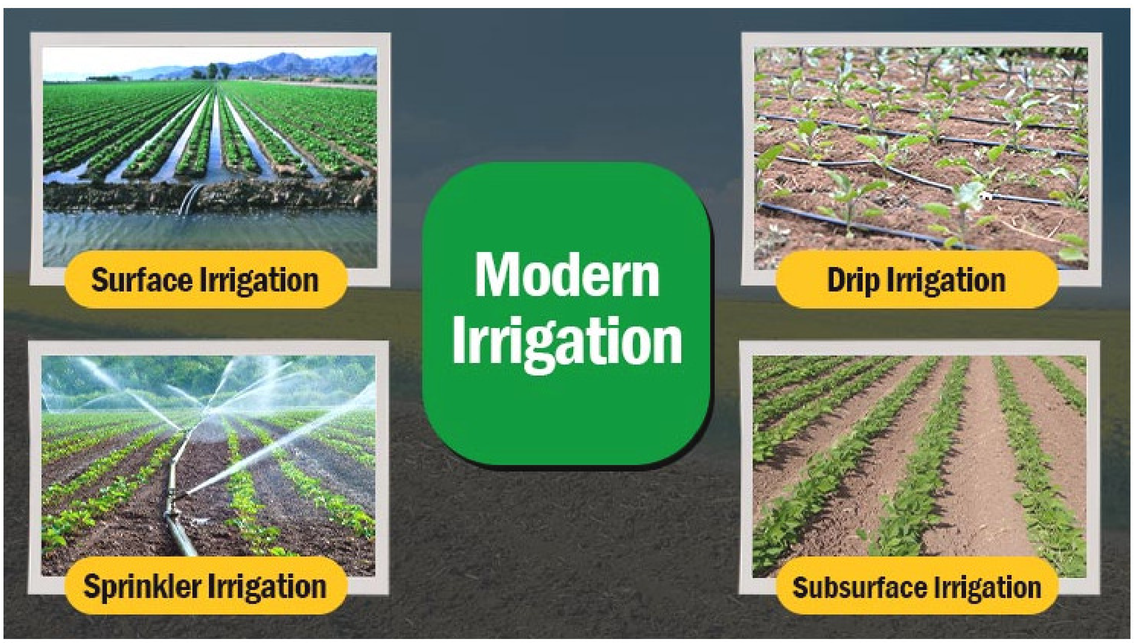

Figure 1: Illustrate the modern irrigation techniques.

The modern irrigation system is a method of artificial irrigation used in regions with limited rainfall. It involves the delivery of water via pumps, tubes, and sprays. In areas with inconsistent rainfall or frequent droughts, irrigation is often used. Using different irrigation system techniques, water is distributed evenly throughout the area, as shown in Figure 1. This water supply method may originate from a number of different places. Surface water sources like lakes, rivers, or reservoirs, treated wastewater, or groundwater springs or wells are all included.

Drip irrigation techniques may lower the amount of water delivered to fields by up to 70% while boosting crop yields by 20% to 90% compared to traditional flood or furrow irrigation. In China and India, where the area under micro-irrigation increased 88-fold and 111-fold, respectively, during the previous two decades, significant benefits have been made. With approximately 2 million hectares (about 5 million acres) using micro-irrigation techniques, India now leads the globe. However, by using the enormous potential of rainfall, it is still possible to transition from the use of subsurface water to the use of such approaches. Water for irrigation must be administered at the proper time and volume, but climate change will have an impact on both irrigation demand and the amount and timing of water availability, with implications for reservoir, tube well, and other on-farm irrigation infrastructure performance. In order to fulfill the increasing demand for agriculture, industry, and home usage, this vitally essential resource must be developed, conserved, used, and economically managed on an integrated basis. Modern irrigation methods will boost irrigation potential and extend in the direction of the best use of water resources via ideal irrigation scheduling, i.e., determining the precise amount of water that crops will need through micro irrigation. Micro irrigation is a cutting-edge method of irrigation that will boost agricultural output and water usage efficiency.

Modernize Technology Transfer

Tools Agriculture technology transfer should concentrate on important crop-stage interventions, such as seed planting, crop protection and harvest, post-harvest management, and marketing. Effective interactive organizations like Self Help Groups and Farmers Clubs are needed to transfer technology. These organizations should serve as tools for disseminating information about various government-sponsored programs and will assist in liaising with various government departments for developmental activities. Given that the national government has an ambitious plan to provide internet access to every Gram Panchayat in the nation. These Gram Panchayats need to serve as centers for farmers to access technology. The internet and mobile devices are promising instruments for disseminating information about recent advancements, better growing techniques, and agricultural technology. These technologies may also be helpful in providing farmers with the most recent information on pricing of agricultural products as well as meteorological data and agroclimatic conditions. The foundation for the diffusion of technology in our nation. There are 637 KVKs around the nation with the responsibility of serving as district-level knowledge and resource centers for agricultural technology, which might accelerate the adoption of new technologies. To ensure that technology and inputs are delivered effectively in the district, these KVKs should serve as the district's technological umbrella and collaborate with the state departments of agriculture, horticulture, and other sister agencies. It should be possible to access local language internet databases and village knowledge centers. Rapid technological distribution will undoubtedly help close the knowledge gap between farmers and the general public, accelerate agriculture's stagnating development, and unlock the full potential of our land and the labor of our farmers.

LITERATURE REVIEW

Rudnick, et al. [1]studied In order to achieve the objectives of food security and climate resilience, several public and private organizations are cooperating across sectors and scales in agricultural development programs. Although very little comparative empirical data has been gathered to evaluate where and how these networks operate, policy networks are thought to be an essential component of the learning and collaboration required to successfully implement agricultural development projects and increase community resiliency. In order to examine network structures and comprehend the roles of different players cooperating toward agricultural development objectives, they combine theories of network governance and leadership in contexts of international development with social network research techniques. We offer two important discoveries that extend network governance theory and have repercussions for global agricultural development policies. First, we discover evidence for three different network types, including shared and brokered networks, which are expected by the literature on network governance, as well as a class of fragmented networks with very low levels of coordination at their core.

Mauricio R. Kotu, et al. [2] Studied Crop variety as well as its impact on each household's cash income and self-consumption (calculated as imputed monetary value). They calculated a system of three simultaneous equations using this data. The findings demonstrate that families maintained significant levels of agricultural variety, growing up to eight different crops on average, with 3.2 crops cultivated per family, and fewer than 5% having no or very little crop diversity. On average, the value of crop species grown for personal use was 55% greater than the value of crop species sold. According to the findings of the regression analysis, crop diversification is favorably correlated with both monetary revenue from crop sales and self-consumption of food crops. According to this research, a rise in crop variety creates new market options for families while maintaining a positive impact on self-consumption.

Djokoto et al. [3] studied Estimates of the extent of foreign divestment on agricultural development and policy options for reducing this effect were obtained. These effects included the loss of employment, revenue, foreign exchange, and the negative impact on overall agricultural development as a result of foreign divestment. OLS was used to estimate a cross-sectional dataset of 159 observations that was fitted to a derived model. Foreign divestment decreases agricultural development by $0.04 for every $1 increase. In reaction to foreign divestment in agricultural, policy combinations combining domestic investment, assistance, and trade have been advocated. To counteract foreign agricultural divestment, the ideal policy mix is a mix of domestic investment, assistance, and trade. Agriculture aid alone had little influence on advancing agricultural growth; rather, other factors had a synergistic impact.

Pradiana et al. [4] studied about The agricultural extension office plays a vital role in coordinating subdistrict-level agricultural development. In addition to formulating a strategy for the development of the Agricultural Extension Office as the knot to coordinate agricultural development in the subdistrict, the study's objectives included describing and analyzing the factors that have an impact on the implementation of task, function, and work coordination. From May to October 2018, this study was carried out in Sukabumi Regency, Province of West Java, Indonesia. In this research, 186 agricultural extension officers from Sukabumi Regency were chosen as responders. Institutional Support (X1), Human Resource Management (X3), Facility Management (X2), and Quality Management were among the variables examined in this research (X4). A questionnaire was used to gather research data. The method of data analysis used in this research includes a SWOT analysis, path analysis, and analysis of descriptive statistics in order to design a plan for the establishment of an agricultural extension office. The study's findings demonstrated how institutional support, facility management, and human resource management all had an impact on quality management when tasks and functions were carried out.

Naumov et al. [5] studied about Farming is practiced on Arctic margins all around the globe despite the extreme environmental conditions and isolation. Russia is the largest nation using the arctic regions for agricultural purposes. Traditional agricultural practices like semi-nomadic reindeer rearing and technologically advanced urban agriculture are both practiced in the northern areas. Due to the uneven spatial representation of these activities, there are large regional variations in the labor and agricultural land productivity. By comparing these fundamental characteristics across Northern Russian areas, Northern European nations, and North American regions, we may pinpoint distinct patterns of contemporary agricultural growth and their dynamics.

Jihong Liu et al. [6] A crucial and fundamental component of sustainable agricultural growth is soil and water conservation. However, it has become difficult to determine the actual state of the quality assessment system of soil and water conservation for sustainable agricultural growth. In this study, an assessment system and approach based on the induced ordered weighted averaging (IOWA) operator and insufficient data provide effective tools for soil and water conservation. First, a new multi-attribute quality assessment methodology for soil and water conservation for sustainable agricultural growth is developed. In order to calculate the overall evaluation weights and determine the variation coefficient, the technique of multiple attribute comprehensive assessment with partial information is provided. Then, using the calculated weight of an acceptable degree, the priorities of quality assessment are determined. The outcome of the quality evaluation also exposes the internal variations in sustainable agricultural growth. Finally, the case study from China illustrates the logic and viability of the new quality rating method.

Huiru Zhang et al. [7] Studied Environmental protection, rural revival, and natural resource conservation are all facilitated by sustainable agricultural growth. According to experts, industrial structure upgrading and the implementation of agricultural industrial agglomerations are necessary to support agricultural growth. However, the conflict between them is also becoming more apparent, and the industry's explosive growth has put tremendous pressure on agricultural development by altering the environment and resources. Therefore, further clarity is needed about the complex nonlinear interaction between agricultural industrial agglomeration, industrial structure upgrading, and sustainable agricultural growth.

Sipa Gong et al. [8] studied As a big agricultural country, China places a high value on agricultural growth since it has an impact on the country's long-term development. This paper uses Chengdu, Sichuan Province as an example, and uses indicators and data from the Chengdu Statistical Yearbook from the past 15 years. It then applies the dissipative structure theory to create an evaluation system for sustainable, regional agricultural development based on five key factors: economy, society, environment, education, and population. Each indicator was given weight using the entropy weight technique, and the 15-year evolution of Chengdu's sustainable agricultural growth was estimated. It was discovered that Chengdu's sustainable agricultural development has been rising every year, with the economic and educational subsystems providing the most assistance. The overall entropy of the Chengdu agricultural sustainable development system steadily declined from 2003 to 2017, and the entropy change was negative.

Bratovcic et al. [9] studied because a significant portion of pesticides and fertilizers used in agriculture go unused and have detrimental impacts on the environment and human health, their excessive usage to boost yields has shown to be wasteful. Therefore, it is a significant task for farmers to switch over to the use of nanopesticides and nanofertilizers in order to increase yields, decrease the need for mineral fertilizers, and boost agricultural growth. The categorization of pesticides, common agricultural nanoparticles and their uses, the effects of nanopesticides and nanofertilizers on the environment, and more are all covered in depth in this paper. Review and description of the use of nanopesticides, nanofertilizers, and innovative delivery systems to increase agricultural yield.

The benefit of the nanoencapsulation procedure is highlighted in particular for both insecticides and fertilizers. It might be a method to boost stability, dispersion in aqueous environments, and enable a controlled release of the active ingredient in hydrophobic pesticides, increasing their efficiency.

Villanueva-Mejía et al. [10] studied Regarding its potential for agricultural growth and for producing food supplies for both the present and future human generations, Colombia is now one of the most promising nations. This is due to elements including political considerations, geographical variety, and the availability of land and water. However, Colombia won't realize its full potential unless it uses the technologies currently in use to address the current global challenges facing agriculture in the twenty-first century, including, among others, the growing global population, an increase in the average life expectancy, a high level of malnutrition, climate change, and poor agricultural practices. This article demonstrates how contemporary biotechnology may be a valuable ally by using a broad variety of cutting-edge technologies and systems where they are most needed: to boost crop output, withstand both biotic and abiotic influences, and guarantee food safety. This research provided evidence for the enormous advantages of using biotechnology crops to improve food safety, and it described how these crops are currently being used in both industrialized and developing nations. With the use of contemporary technologies, the nation can enhance its food sovereignty, move toward a circular bio-based economy, and act as a global agricultural hub for Latin America.

DISCUSSION

The Agriculture Revolution

Agriculture, which first appeared some 12,000 years ago, caused such a shift in society and lifestyle that its advancement is known as the "Neolithic Revolution." Humans have lived traditionally as hunters and gatherers from the beginning of time, but permanent settlements and a steady source of food have replaced them. Cities and civilizations sprang from agriculture, and since it was now possible to raise food and animals to fulfill demand, the world's population exploded from around five million people 10,000 years ago to more than seven billion now.

In diverse places of the globe, people didn't start farming for any one reason or set of reasons. For instance, it is believed that seasonal circumstances that benefited annual plants like wild grains were brought about by climatic shifts at the end of the last ice age in the Near East. Increased strain on natural food supplies in other places, such East Asia, may have compelled individuals to come up with their own remedies. But farming planted the seeds for the modern era regardless of the causes of its autonomous beginnings.

Domestication of plants

Wheat, barley, and peas are among the crops whose wild ancestors may be found throughout the Near East. Cereals were first farmed in Syria 9,000 years ago, and figs even earlier; evidence from ancient seedless fruits found in the Jordan Valley suggests that fig trees were first planted 11,300 years ago. The advent of early Neolithic communities with residences outfitted with grinding stones for processing grain marks the move from a nomadic to established mode of life, notwithstanding the slow change from wild gathering. Rice and millet cultivation both have their roots in China's Neolithic era. The earliest known rice paddy fields in the world were found in eastern China in 2007, and they provide proof of early farming methods including flood and fire control. While corn (maize) had to wait for spontaneous genetic alterations to be chosen for in its wild predecessor, teosinte, squash cultivation in Mexico started roughly 10,000 years ago. The earliest properly dated corn cob only seems to have existed approximately 5,500 years ago, however maize-like plants descended from teosinte appear to have been farmed at least 9,000 years ago. Later, corn made its way to North America, where domesticated sunflowers had already begun to blossom some 5,000 years earlier. Additionally, this was the start of potato cultivation in South America's Andes area.

Animals from farms

The so-called Fertile Crescent, which is an area including eastern Turkey, Iraq, and southern Iran, is where cattle, goats, sheep, and pigs all had their start as domesticated animals. The Neolithic Revolution began in this area. Between 13,000 and 10,000 years ago, these animals were first domesticated. According to genetic research, goats and other animals helped transform Stone Age life when agriculture moved into Europe from the west. While it is debatable to what degree farmers themselves moved west, the profound influence of dairy farming on Europeans is indelible in their DNA. People living in ancient times in Europe were unable to tolerate raw cow milk until domestic cattle were introduced there. However, at some time during the expansion of agriculture into southeastern Europe, a mutation for lactose tolerance appeared, which via natural selection grew in frequency due to the nutritious properties of milk. The majority of Europeans today are descended from cow herders, as shown by the high frequency of the milk-drinking gene up to 90% in populations of northern nations like Sweden.

To meet the global development objectives, we need food systems that are wholesome, sustainable, and inclusive. One of the most effective strategies for reducing extreme poverty, fostering shared prosperity, and feeding the estimated 9.7 billion people by 2050 is agricultural development. Compared to other sectors, the agricultural sector's growth is two to four times more successful in increasing the incomes of the poorest people. Another important factor in economic development is agriculture, which accounts for 4% of global GDP and up to more than 25% of GDP in the least developed nations.

However, food security, poverty alleviation, and growth generated by agriculture are all at risk: Multiple shocks are affecting agricultural systems, driving rising food prices and escalating famine. These shocks range from COVID-19-related disruptions to harsh weather, pests, and wars. Millions more people are falling into severe poverty as a result of the worldwide food crisis that the conflict in Ukraine has sparked. A $30 billion fund will be made accessible by the World Bank as part of a worldwide effort to address the food crisis.

Crop yields might be further reduced by accelerating climate change, particularly in areas with the greatest food insecurity in the globe. Approximately 25% of greenhouse gas emissions are attributable to agriculture, forestry, and changes in land use. One way to combat climate change is via agricultural mitigation. In addition to endangering human and environmental health, current food systems also produce unacceptably high amounts of waste and pollution. Global food production wastes or is lost in one-third of cases. Improving food and nutrition security, as well as achieving climate objectives and lowering environmental stress, depend on addressing food loss and waste. The main cause of mortality globally is also risks related to inadequate nutrition. There is a double burden of malnutrition that may result in sicknesses and health crises since millions of individuals are either not eating enough or consuming the improper kinds of food. According to a research from 2021, more than 10% of the world's population between 720 and 811 million people were food insecure in 2020.Food insecurity may deteriorate the quality of diets and raise the danger of different types of malnutrition, which may result in undernutrition as well as overweight and obese persons. Around 3 billion people worldwide are thought to be unable to afford a balanced meal.

To meet the global development objectives, we need food systems that are wholesome, sustainable, and inclusive. One of the most effective strategies for reducing extreme poverty, fostering shared prosperity, and feeding the estimated 9.7 billion people by 2050 is agricultural development. Compared to other sectors, the agricultural sector's growth is two to four times more successful in increasing the incomes of the poorest people. Another important factor in

economic development is agriculture, which accounts for 4% of global GDP and up to more than 25% of GDP in the least developed nations. However, food security, poverty alleviation, and growth generated by agriculture are all at risk: Multiple shocks are affecting agricultural systems, driving rising food prices and escalating famine. These shocks range from COVID-19-related disruptions to harsh weather, pests, and wars. Millions more people are falling into severe poverty as a result of the worldwide food crisis that the conflict in Ukraine has sparked. A $30 billion fund will be made accessible by the World Bank as part of a worldwide effort to address the food crisis.

Crop yields might be further reduced by accelerating climate change, particularly in areas with the greatest food insecurity in the globe. Approximately 25% of greenhouse gas emissions are attributable to agriculture, forestry, and changes in land use. One way to combat climate change is via agricultural mitigation. In addition to endangering human and environmental health, current food systems also produce unacceptably high amounts of waste and pollution. Global food production wastes or is lost in one-third of cases. Improving food and nutrition security, as well as achieving climate objectives and lowering environmental stress, depend on addressing food loss and waste. The main cause of mortality globally is also risks related to inadequate nutrition. There is a double burden of malnutrition that may result in sicknesses and health crises since millions of individuals are either not eating enough or consuming the improper kinds of food. According to a research from 2021, more than 10% of the world's population between 720 and 811 million people were food insecure in 2020. Food insecurity may deteriorate the quality of diets and raise the danger of different types of malnutrition, which may result in undernutrition as well as overweight and obese persons. Around 3 billion people worldwide are reportedly unable to afford a balanced diet.

CONCLUSION

The future of Indian planning is thus highly dependent on the agricultural industry. A successful harvest always gives the nation's anticipated economic development energy by enhancing the business environment for the transportation system, internal trade, manufacturing sectors, and other areas. The government will have enough money to pay for its planned expenses if the harvest is good. Similar to a bad crop, poor business conditions throughout the nation ultimately result in the breakdown of economic planning. As a result, in a nation like India, the agricultural sector is crucial, and the success of the Indian economy is still largely dependent on it. The analysis mentioned above makes it very evident that sectoral variety and economic development need agricultural expansion as a prerequisite.

Agro-economies like that of India heavily rely on the agriculture industry. The agriculture sector not only helps the Indian economy but also the industrial sector, as well as import and export commerce internationally. Although the agricultural sector's contribution to the Indian economy is declining, it still employs the greatest number of people nationwide. Although its percentage of the GDP has declined over the last 50 years, India's agriculture industry is nevertheless vital to the country's economy. In the last several decades, India has achieved great strides in agricultural productivity, including the introduction of high-yield seed types, increased fertilizer usage, and enhanced water management techniques. Improvements to the infrastructure for distributing land, managing water, and distributing food would increase production even more and help India fulfill its rising food demand.

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CHAPTER 5

MODERN AGRICULTURE AND ITS IMPACT ON THE ENVIRONMENT

Dr. Kaushal Kishor, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- kaushal.ag@sanskriti.edu.in

ABSTRACT:

Modern agriculture faces several issues, such as the urbanization of farmland, water rights and utilization, environmental issues, and the acquisition of government subsidies. Cycles of trash, water, energy, and nutrients have changed from being closed as in a natural environment to being more open. Although farms generate a lot of crop waste and manure, it is becoming more and harder to recycle nutrients even within agricultural systems. Because production systems are geographically separated from other systems that would complete the cycle, it is not feasible to economically return animal feces to the soil in a nutrient-recycling process. Agricultural waste no longer serves as a resource but rather a problem in many places. It is also challenging to recycle nutrients from cities back to the countryside. Because to the specialization of production processes, agriculture is seen as a contemporary marvel of food production. In order to fulfill the world's demands for food, fuel, and fiber, farmers must use less natural resources, such as water, land, and energy, via the use of agricultural advances and modern farming techniques. Other names for contemporary agriculture include agribusiness, organic farming, intensive farming, and sustainable agriculture.

KEYWORDS:

Climate Change, Environmental impact, Modern agriculture, Sustainable agriculture, Vertical Crop Growing.

INTRODUCTION

The effect that various agricultural techniques have on the ecosystems around them or how those impacts may be attributed to those practices is the environmental impact of agriculture. Based on farmer techniques and the scope of operation, the environmental effect of agriculture varies greatly. Sustainable agriculture is practiced by farming communities that make an effort to lessen their negative effects on the environment by changing their methods. Even as professionals develop creative ways to lessen harm and increase eco-efficiency, the negative effects of agriculture are a long-standing problem that still causes worry. Although certain forms of pastoralism are ecologically friendly, contemporary animal agriculture tends to be more harmful to the environment than agriculture that focuses on producing fruits, vegetables, as well as other biomass. Concerns about environmental contamination are still being raised by the ammonia emissions from cow feces [1].

Experts use two different types of indicators when assessing environmental impact: "means-based" indicators, which are based on the farmer's production techniques, and "effect-based" indicators, which are based on the effects that farming techniques have on the farming system or emissions to the environment. The quality of groundwater, which is influenced by the quantity of nitrogen given to the land, is an example of a means-based indicator. Effect-based indicators would show how much nitrate is being lost to groundwater. The means-based assessment examines farmers' agricultural practices, whereas the effect-based assessment takes into account the actual impacts of the agricultural system. For instance, a means-based analysis may examine the pesticides or fertilization techniques that farmers use, whereas an effect-based analysis might look at the amount of CO2 being released or the soil's nitrogen level [2].

Agriculture's effects on the environment may be seen in the soil, water, air, diversity of soil and animal life, humans, plants, as well as the food itself. Climate change, genetic engineering, biodiversity loss, deforestation, dead zones, irrigation concerns, pollution, soil degradation, and waste are only a few of the broader environmental issues that agriculture contributes to [3].

Principles of Contemporary Agricultural Systems

The need for advanced agricultural systems is driven by the desire to provide the most essential items while making a fair financial return. The foundation of manufacturing has evolved into six fundamental processes. The following are some contemporary agricultural techniques. A monoculture, intensive tillage, the use of artificial fertilizer, chemical pest control, irrigation, or crop plant genetic engineering.

Tillage Intensive

Most current agricultural techniques plow the soil thoroughly, fully, and often, and a wide range of tractors and farm equipment have been created to make this process easier. A looser soil allows for greater water drainage, quicker root growth, and easier seed planting. Additionally, weeds are managed by cultivation, and dead plant debris is incorporated into the soil. Intensive agriculture is a kind of farming that produces more crops and livestock per cubic meter of land than other types of farming [4], [5].

Monoculturalism

A monoculture is when just one crop is planted in a field. Expanding the scale of the agricultural business, as well as improving elements of profitability and cost, are all made possible by monoculture. It also makes it simpler to cultivate, sow seeds, manage weeds, and harvest.

Artificial fertilizers

When synthetic chemical fertilizers are used, the yield is dramatically increased. It is simple to produce, mine, transport, and use. The amount of fertilizer used now is five to 10 times more than it was after World War II (1939-45). Fertilizers, which may be used in liquid or granular form, can provide crops with easily accessible and consistent levels of several important plant nutrients.

Water Management Techniques

By providing crops with water during dry spells or in regions of the globe where natural rainfall is insufficient for the growth of most crops, irrigation has enhanced the world's food supply. Farmland availability has grown and yields have improved as a result of the construction distribution of canals, reservoirs, and reservoirs, as well as river diversion. The effectiveness of applying water has also been significantly increased thanks to specialized sprinklers, pumps, or drip systems.

Pest Control Using Chemicals

Pests in contemporary agriculture's vast monoculture fields include things like insects that consume plants, weeds that hinder crop growth, or illnesses that either kill or severely retard the growth of plants and animals. Synthetic chemicals have offered an efficient, comparatively simple method to give such control when utilized appropriately. Pest outbreaks may be promptly controlled with chemical sprays.

Genetic Manipulation

Modern agriculture has taken advantage of several more recent crop breeding techniques. The development of hybrid seed, where two or more strains of a crop are combined to produce a more productive offspring, has been one of the most significant strategies. Genetic engineering has begun to develop molecular techniques that selectively introduce genetic information from one organism to another, oftentimes from much unrelated organisms, to capitalize on specific useful traits.

LITERATURE REVIEW

Sławomir Perez-Piza et al. [6] studied about Agriculture now has a significant negative influence on the environment. The extensive search for preparations based on natural ingredients is what has sparked agriculture's interest in the field of novel bio-stimulants. Without creating and deploying cutting-edge technologies, like cold plasma, and supporting technologies for farmers, this is not conceivable. Therefore, plant production and protection must be aimed at combining the promotion of crop development and the eradication of hazards to people and the environment in order to avoid environmental harm brought on by intensive agriculture. Future approaches to this problem seem to need an examination of how the creation of organic bio-stimulants may be influenced by cold plasma. Due to the fact that allelopathic plants are a source of numerous chemicals that aid in crop growth and development, combining the extraction of biologically active compounds with plasma activation of allelopathic extracts has intriguing potential to provide the most cutting-edge alternative to traditional agriculture. However, its practical use won't be possible until a thorough and careful analysis of the processes behind crops' reactions to such bio-stimulants has been conducted.

Schmidt et al. [7] studied Modern agriculture has concentrated on choosing characteristics that produced the highest aboveground productivity with increasing degrees of crop management and fertilizer inputs throughout the shift from natural environments. The significant environmental and genetic changes related to this transition may have had an impact on root shape, anatomy, and Eco physiological processes. As a consequence, it's possible that root and rhizosphere features that enable more effective foraging and absorption in situations with lower synthetic input were lost. There has been a change in the microbiome community composition as a result of the evolution of modern maize, but questions remain regarding the dynamics and causes of this change over the course of maize evolution as well as its effects on resource acquisition and agroecosystem performance under various management strategies. Greater integration of root development and ecophysiology with agroecosystem functioning might increase resource use efficiency via improved knowledge of how domestication and breeding affects root and rhizosphere microbial features, breeding methods, and the sourcing of beneficial alleles.

Selvaraj et al. [8] studied In India, agricultural modernization is continually expanding to suit the country's increasing population's increased need for food. However, owing to extensive pesticide usage and emission-intensive farming, contemporary agriculture also affects the ecology, human health, and resources in addition to alleviating hunger, which calls for a sustainable evaluation. India, the second-largest agricultural producer in the world, has not yet been the subject of any impact assessments. This study is the first of its kind to assess the effects of growing 21 widely used crops in India that have high output and emissions. The findings were presented together with potential reasons and corrective actions in the order of impact parameters for the relevant years. According to the findings, rice has the highest indexes, followed by sugarcane, wheat, and banana.

Qing Xiong Lu et al. [9] studied The current research used the indigenous community of Wutai in Taiwan as a case study to investigate traditional farming and its significance in the sustainable development of the hilly environment. As a crucial part of the public participation geographic information system (PPGIS), it adopted qualitative methods with an ethnographic orientation to conduct in-depth interviews, participant observation, and focus groups. Aerial photo analysis was also used to gather and analyze field data, primarily in 2013 and 2017. The findings showed that traditional farming methods, such as mixed cropping, intercropping, and rotation, which maximized the utilization of the region's few arable lands, are still being used. These methods are regulated by the traditional agricultural calendar. Additionally, these approaches helped to maximize and secure the local food supply and preserve native crop kinds.

Rharrhour et al. [10] studied the potential for growth of aquaponics in Morocco, an emerging technique that combines aquaculture with hydroponics and uses aquaculture waste to fertilize hydroponic plants. A different approach to solving contemporary issues on earth related to climate change, including such drought, soil degradation, food and water availability, adverse effects of aquaculture on the environment, and the usage of pesticides and medicines, is aquaponics. Although Morocco's economy is founded on two major areas, agriculture and fisheries, there have been no successful experiences or scientific papers in Morocco about this food production system in the previous five years.

Hiranandani et al. [11] studied agriculture and climate change have mostly centered on how the environment affects agriculture and what it can mean for regional and global food security. But from a policy perspective, it's equally critical to examine how agriculture and other associated industries are affecting the environment. Most of the world's agriculture has changed during the last 50 years to become industrial agriculture, requiring higher inputs of fossil fuel electricity, synthetic pesticides, water, and fertilizers. This has had significant negative consequences on the air, soil, water, and biodiversity. Modern agriculture has come to be seen as an environmentally unfriendly alternative to sustainable farming, which stresses localized production and consumption while using less chemicals and fossil fuels.

Mihailovic et al. [12] studied Major changes in how people work and conduct business have been brought about by the growth of modern industry and the factory system, as well as widespread migration across oceans and continents, particularly throughout the nineteenth and early twentieth centuries. Agriculture and family cooperatives were replaced by urban, industrialized economies. As a result of these developments' effects on people, professions, families, communities, and the environment as well as the emergence of a new class of affluent corporate executives and new pockets of poverty, there has been an increase in the reporting of ethical discussion. At the same time, if someone has a definite interest in a certain business, they should also be interested in its workers, whose personal and professional life are strongly related to it.

Hansen et al. [13] studied As the environmental effects of intensive agricultural techniques come under more and more scrutiny, organic farming is emerging as a more eco-friendly production method. Organic farming practices often have a lesser risk of negative environmental consequences than conventional farming practices, however this is not always the case. This paper analyzes organic farming in the context of European settings, paying particular attention to current Danish research results. It outlines the environmental issues brought on by contemporary agricultural methods and proposes suitable metrics for gauging their effects. To organize and comprehend the processes and mechanisms behind the influence of agriculture on nature and the environment, a driving force-state-response (DSR) paradigm is used. The publication examines a number of empirical investigations as well. Due to its diverse crop rotations, sparing use of nutrients, and prohibition on pesticides, organic farming is typically associated with a significantly higher level of biological activity in the soil (bacteria (Monera), springtails (Collembola), fungi (Mycota), mites (Arachnida), and earthworms (Lumbricus terrestris). Additionally, organic farming often has fewer nutrient surpluses and less leaching than conventional farming.

Yusuf et al. [14] studied Natural resource wealth has dominated wealth production throughout the last century, but today more than ever, intellectualism, knowledge, and skills are the key drivers of modern wealth generation on a global scale. The countries that have progressed their science and technology systems and embraced new technologies serve as examples of this truth. The application of modern biotechnology has highlighted its positive impact on agriculture, human health, and the environment through increased crop yields, decreased use of pesticides and herbicides, production of nutritionally enhanced foods, and low-cost vaccines. Biotechnology, like any new technology, has advantages and limitations. In fact, it is a crucial solution to Nigeria's endemic problems with food security and poverty. With no difference being made between biotechnology as a technique and genetically modified (GM) crops and foods as products, the argument regarding biotechnology is still in the public eye. This has resulted in a heated debate about the alleged threats to human health and the environment. This underlines how crucial it is to have biosafety laws in place and to make sure that the government has the resources to take all required safeguards.

Brodeur et al. [15] studied Through habitat loss and the direct and indirect impacts of the pesticides it depends on, modern agriculture's intensification may have an adverse influence on amphibian populations. As refuge quantity and habitat connection decline, the increasing homogeneity of contemporary agricultural landscapes may be harmful during periods of severe low and high temperatures brought on by climate change. In this investigation, we assessed how the herbicide glyphosate and the ensuing severe drought affected the common tree frog, Hypsiboas pulchellus, which lives in an agricultural setting. Organismic indices included the stomach content index, hepatosomatic index, body fat index, gonadosomatic index, and condition factor (frequency of micronuclei). An increase in hepatic catalase activity, hepatic GSH content, and the frequency of micronuclei in peripheral circulating erythrocytes were seen in anurans collected in the same location two months later, when a drought was at its worst.

DISCUSSION

Since the Industrial Revolution, agricultural practices have continued to advance, and this trend has accelerated since the "green revolution" in the middle of the 20th century. At every step, improvements in agricultural methods led to enormous gains in crop yields per unit of arable land. Over the course of a century, the world's population has doubled, yet it has survived because to this incredible increase in food production. The area devoted to feeding people has expanded along with the human population. According to data from the World Bank, more than 700 million hectares (1.7 billion acres) of the planet's arable land nearly half of all cultivated land was used to produce maize, wheat, rice, and other major cereal grains in 2016.

But it's going to be harder than it has been up to this point to fulfill the need for increased agricultural production in the decades to come. This is due to a number of ecological variables. A large number of the natural mechanisms that enable modern agriculture are becoming unstable due to global climate change. However, the sustainability dilemma is also partially a result of contemporary agriculture. Many of the methods and adjustments that farmers use to increase productivity are environmentally harmful. The three ways that extensive agriculture jeopardizes the fragile balance of non-agricultural ecosystems are briefly described here.

Irrigation 70% of the freshwater used by people worldwide comes from agriculture. Several different types of irrigation plans are used to shift a significant amount of this water onto agriculture. By 2050, experts project that water extraction may have increased by another 15% or more in order to feed a burgeoning population. The high harvest yields needed by such a big population are supported by irrigation. From California's Central Valley to Southern Europe's dry Mediterranean basin, many of the world's most productive agricultural areas have grown to rely heavily on irrigation for economic survival.

The effects of this extensive freshwater diversion are coming to the attention of both scientists and farmers. The loss of aquifers, river systems, and downstream ground water are some of the most evident effects. Irrigation does, however, have a variety of additional unfavorable impacts. Waterlogging may occur in areas that have received excessive irrigation, which results in soil conditions that harm plant roots via anaerobic decomposition. In areas where water has been diverted, soils may become oversalted, which may hinder plant development. Increases in water evaporation brought on by irrigation have an effect on the temperature, pressure, and moisture content of the atmosphere. Recent investigations have demonstrated that farmland irrigation may affect rainfall patterns hundreds of kilometres distant as well as over the irrigated region. Coastal erosion and other forms of long-term ecological and habitat degradation have also been linked to irrigation.

Animals Grazing

The primary use of a sizable portion of agricultural land is as a pasture for cattle and other animals. There are hundreds of millions of acres set aside for this use in the western United States, more than for any other kind of land use, if one includes both government controlled and privately held grazing grounds. Most notably, methane emissions from agricultural animals make up a significant fraction of the world's total greenhouse gas emissions. Overgrazing is a significant issue for environmental sustainability as well.

In certain locations, swaths of pasture land are depleted to the point that grasses cannot recover. Native plants' root systems may suffer so severe damage that the species may become extinct. The interaction of overgrazing and fecal wastes may pollute or jeopardize water supplies close to streambeds and in other riparian regions where cattle congregate. Even soil may be harmed by trampling by cattle and other big grazing animals.

Due to nutrient runoff, bare, compacted terrain may cause soil erosion and topsoil quality deterioration. Numerous delicate ecosystems and animal habitats may become unstable as a result of these and other disturbances.

Synthetic fertilizers

Since World War II till the present, nitrogen and phosphorus-containing synthetic fertilizers have been at the core of increased farming. These chemical inputs have become essential to modern agriculture, increasing the number of people that can be fed by global farms. They are very useful for producing maize, wheat, and rice, and they are primarily to blame for the current explosion in grain agriculture. Due to its rapidly expanding population, China is now the top producer of nitrogen fertilizers in the world. The biggest industry in the world is agriculture. It creates approximately $1.3 trillion worth of food yearly and employs over one billion people. Around 50% of the livable land on Earth is made up of pasture and crops, which provide as both habitat and food for a wide variety of species.

When agricultural activities are managed sustainably, they may protect watersheds, restore important ecosystems, and enhance the health of the soil and the water supply. However, unsustainable behaviors have negative effects on both the environment and humans. Sustainable resource management is becoming more and more critical. With an increasing global population comes a significant increase in demand for agricultural products. Agriculture is one of the most crucial frontiers for conservation worldwide because of its close relationships to the global economy, human communities, and biodiversity.

While these compounds have assisted in doubling the pace of food production, they have also contributed to a massive rise in the amount of reactive nitrogen in the environment, perhaps by up to 600%.

The once-beneficial nutrients have turned into contaminants as a result of the excess nitrogen and phosphorus present. In synthetic fertilizers, around half of the nitrogen escapes from the areas where it is used and into the soil, air, water, and rainfall. Rainstorms or irrigation systems transport these pollutants into groundwater and river systems after soil microbes transform nitrogen from fertilizer into nitrates.

The buildup of nitrogen and phosphorus causes eutrophication, which damages terrestrial and aquatic ecosystems by overloading them with nutrients. Lakes in China, the US, and other countries are affected by harmful algal blooms because of nutrient pollution. In aquatic settings, high concentrations of organic matter may lead to oxygen depletion and the creation of "dead zones" where nothing can exist. Instances like this occur often in the Gulf of Mexico. The health of native plant species, natural ecosystems, and biodiversity are all at risk due to nitrogen buildup in water and on land.

Nitrous oxide, one of the most dangerous greenhouse gases, is also formed and released when fertilizer is applied to soil. The conflict between sustained agricultural expansion and the ecological soundness of the land on which people rely will only worsen as the world population continues to soar.

Environmental effects of modern agriculture

As is well known, modern agriculture has made food more accessible and affordable while also increasing food production, sustainability, and the production of biofuels. However, since it is based on a high input-high output technology that uses hybrid seeds of high-yielding varieties together with copious amounts of irrigation water, fertilizer, and pesticides, it also contributes to environmental issues. The following is a discussion of how modern agriculture affects the environment:

Soil Erosion

Due to the overabundance of water, cropland loses its top layer of rich soil. As a result, nutrient-rich soil that hindered production is lost. Additionally, it contributes to global warming because soil carbon is released from particle organic matter in water bodies due to silt.

What impact has climate change had on human life?

Water contamination in the earth

One of the major sources of water for irrigation is groundwater. Nitrogenous fertilizers from agricultural areas eventually pollute groundwater after leaching into the soil. Groundwater nitrate levels above 25 mg/l may result in "Blue Baby Syndrome," a major health risk that mostly affects babies and can even be fatal.

Salinity and standing water

Due to poor farm drainage management, one of the causes of low production is the salt of the soil. As a result of the plants' roots not receiving enough oxygen to breathe in this scenario, the crop yield and mechanical strength are both poor.

Eutrophication

It describes the addition of synthetic or natural materials, such as nitrates and phosphate, to a freshwater system via fertilizers or sewage. It causes the phytoplankton to "bloom," or improve the water body's primary production. The phenomena of eutrophication (EU = more, trophication = nutrition) is brought on by an over-nourishment of lakes and other bodies of water caused by the excessive use of fertilizers that include nitrogen and phosphorus.

Excessive pesticide usage

Numerous insecticides are used to eradicate pests and increase agricultural yields. In the past, bugs were killed with arsenic, sulfur, lead, and mercury. For instance, insecticides like Dichloro Diphenyl Trichloroethane (DDT) were utilized, but sadly they also affected beneficial pests. The fact that many pesticides are non-biodegradable and connected to food chains that are detrimental to people is most essential. Since the start of industrialization, agriculture's relative importance has decreased progressively, and in 2006, the services sector surpassed agriculture as the economic sector with the most people employed globally for the first time in history. But we fail to recognize the need of agriculture if we are to exist.

CONCLUSION

Agriculture has the potential to be a renewable industry, despite the list of environmental catastrophes that accompany it in the paragraph above. There isn't really much new here, in a way. Ecological capital has been lost to the sea from its home in the wilderness over the course of 10,000 years on practically every agricultural acre in the globe or has been harmed by poisonous substances. However, agriculture is still seen as potentially renewable on a global scale and, as a result, as fundamentally distinct from the industrial sector of society. The intrinsically extractive economy has only operated as if the renewable resources that underpin agriculture are justifiable targets for industrial exploitation in the past 50 years as a result of the growth of industry and the chemicalization of agriculture.

That is what distinguishes the contemporary period. The agricultural economy of today is more fragile than practically any agricultural economy in history because of this. Perhaps the reason it is difficult for us to see our energy and aquifer mines being empty is because it is difficult for us to perceive this. We find it difficult to imagine that our well water, clean air, aesthetically beautiful meals, and flawless produce could all contain unseen toxins. We struggle to understand the importance of genetic variety and to predict the effects of widespread extinctions. It is difficult for us to accept that our miraculous power to grow crops with ever-increasing yields may eventually run out. When the earth's belly is covered with sterile, barren soils rather than lush, green flora, it is difficult for us to fathom the complete loss of our enormous tropical forests or to predict the climatic changes. It is difficult for us to conceive a future in which modern chemical pesticides and fertilizers lurk under our agricultural surfaces like devils in peaceful prisons of deteriorated soil while old salts sterilize the land.

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CHAPTER 6

ASSOCIATION BETWEEN ENVIRONMENTAL IMPACTS AND MODERN AGRICULTURE

Dr. Umesh Kumar Tripathi, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- umesh.ag@sanskriti.edu.in

ABSTRACT:

Agricultural waste no longer serves as a resource but rather a problem in many places. It is also challenging to recycle nutrients from cities back to the countryside. Because to the specialization of production processes, agriculture is seen as a contemporary marvel of food production. The increase of food production has been linked to the environmental effects of ecological illnesses. They can be categorized into the following categories: erosive processes, loss of soil fertility, depletion of nutrient reserves, salinization as well as alkalinization, pollution of soil and water systems, urbanization of fertile field lands, loss of crop, wild plant, and animal genetic resources, eradication of natural enemies, resurgence of pests, development of genetic pesticide resistance, chemical contamination, and destruction of natural control mechanisms. New criteria must be taken into account when developing agricultural policy, such as the huge reallocation of agricultural land use, the replacement of present food crops with energy crops, and the potential contributions of agriculture to the growth of the global economy. There is obviously no other option than to create more with less. Agriculture must now prioritize environmental sustainability above all other considerations. The agricultural industry has three major environmental challenges: preserving biodiversity, reducing climate change, and the worldwide transition to bioenergy.

KEYWORDS:

Arthopogenic Activities, Climate change, Environmental Impacts, Modern Agriculture, Pollution.

INTRODUCTION

In 2050, the population of the world is expected to increase further and reach roughly nine billion people. Due to population expansion and a shifting food supply, the demand for agricultural products will continue to increase, necessitating a doubling of output by the year 2050. According to the FAO, "the future may witness a severe drop in the growth of aggregate world output, to 1.5 percent per year in the next three decades and on to 0.9% per year in the following 20 years to 2050." 6. Increased demand for biofuels might put further pressure on input costs, agricultural product prices, land prices, and water prices.

Agriculture's Environmental Issues

Agriculture's environmental issues with regard to water are among the most significant. One may say that water is an ecosystem's lifeblood. Water has a crucial role in the transport of nutrients, among other things, in soils, in addition to influencing plant development on a set basis. It affects the physical characteristics of the soil both directly and indirectly as a result of metabolic activities.

The regional heterogeneity and temporal unpredictability inherent to agriculture make it challenging to manage environmental issues. Agriculture is primarily a war against nature; as a result, its sustainability and the chances of simultaneously increasing farm revenue and environmental performance are constrained. Direct control is ineffective in agriculture because of the high level of unpredictability. Due primarily to bureaucratic culture, subsidies for enhancing environmental performance may have unfavorable outcomes and have historically shown to be unsuccessful in reality. The most effective and efficient type of policy should be pollution taxes.

It takes interdisciplinary research to develop performance assessment models. The demand for more food production across the globe has a variety of effects on the environment, some of which are directly tied to water systems. Water is used to move materials both within and outside the specific agroecosystem. Agriculture's water-related environmental issues are inherently linked to irrigation and are caused by the mechanical preparation of soil, the use of fertilizers, pesticides, and other chemicals. Soil and water contamination are the environmental factors that agricultural activities affect the most. Through the use of simulation models, the water-related environmental issues in agriculture at the field level will be investigated. In this paper, the most significant water-related environmental issues relating to agriculture are briefly described in sets**.**

Modern farming is a growing method of agricultural innovation and farming techniques that aids farmers in increasing productivity and lowering the number of natural resources, including water, land, and power, needed to fulfill the world's demands for food, fuel, and fiber. People now understand that modern agriculture has made food more accessible, viable, safe, and sustainable, and has boosted the production of biofuels. It also contributes to some environmental problems that have an impact on the climate, including soil erosion, groundwater contamination, waterlogging but also salinity, and occasionally eutrophication, because it is based on a high input-high output technique using hybrid seeds of high-yielding varieties and ample irrigation water, fertilizers, and pesticides. However, these effects may also be mitigated.

Types of Modern Farming

Agribusiness

The agricultural production sector known as agribusiness covers the production, selling, safety, and marketing of the product to suit consumer demands. The term was created in 1957 by John Davis and Ray Goldberg and is a combination of farming and business. This comprises breeding, crop production, agricultural equipment, distribution, seed production and supply, marketing, and retail sales. It also covers contemporary farming.

All participants in the food and fiber value chain as well as the organizations in charge of it are a part of the agribusiness system. The word "agribusiness" refers to the broad range of tasks and specialties involved in contemporary food production in the agricultural sector. There are university degrees with agribusiness concentrations, agribusiness organizations, agribusiness trade groups, and agribusiness periodicals. The agriculture industry, which is essential to the expansion of the economy, is encouraged to flourish by the agribusiness sector.

It still plays a significant part in the development of industrialized nations. Governments also provide subsidies to agricultural firms since agribusiness has the potential to improve agricultural productivity. Agricultural methods also help to raise the income of the vast majority of the poor in emerging nations and improve the food security system and sustainable food development. However, the activities raise greenhouse gas emissions and contribute to global warming, thus innovation is essential for the industry to address these issues.

The drive for innovation by agribusinesses is ongoing as the sector looks for more effective and efficient production and processing techniques. For instance, several companies now provide drone monitoring of farms, giving farmers and owners information about the condition of their crops and enabling them to create stock projections and plan for the future.

Additionally, a lot of new and enhanced types of equipment are being developed and manufactured, including autonomous tractors, robotic harvesters, and automated pesticide sprayers. The ultimate goal of agribusiness innovation is to boost farmer production and support their agricultural endeavors. For farmers, who often face unexpected market circumstances as crop prices change in response to changing economic conditions, the objective is to lower production costs and increase profitability.

Intensive Farming

Intensive farming sometimes referred to as industrial farming and intensive farming (as opposed to extensive farming), is a kind of contemporary farming that raises input and output levels per cubic unit of agricultural land. It involves both crops and animals. The characteristics include a low fallow ratio, more reliance on labor and other inputs, and higher crop yields per unit of land area. The majority of commercial agriculture is intense in one or more ways. Forms of agriculture that extensively depend on industrial techniques, sometimes known as industrial agriculture, are characterized by innovations intended to boost production. The development of cultivars, reducing the frequency of fallow years, and planting several crops each year are examples of techniques. Improved and more thorough growing conditions research, including weather, water, soil, weeds, or pests, regulates the use of fertilizers, plant growth regulators, and pesticides as well as automated contemporary farming. Intensive farming is widespread and becoming more so in developing countries worldwide.

A large portion of the meat, dairy, eggs, fruits, and vegetables sold in stores are produced on these farms. Some intensive farms may use sustainable practices, although this may result in greater labor costs or poorer yields. A key strategy for reducing the quantity of land needed for agriculture and reducing the rate of environmental deterioration due to processes like deforestation is to sustainably increase contemporary agricultural productivity, particularly among smallholder farms. Utilizing sustainable agricultural practices can help reduce the changes as contemporary farming has such significant effects on climate change. Numerous animals are kept on limited plots of land using intensive farming techniques, such as rotational grazing or, in the West, concentrated animal feeding facilities. These methods, as compared to intensive animal husbandry, optimize food and fiber production per acre; the concentrated feed is supplied to cattle that are seldom moved, or the animals are frequently moved to new forage using rotational grazing.

Climate Change

Both agriculture and climate change are global phenomena that interact with one another. The estimated effects of global warming on factors that influence agriculture, such as temperature, precipitation, and glacier run-off, are expected to be considerable. These factors influence the biosphere's ability to sustainably generate food for both people and domesticated animals. Crop production would also be affected by rising carbon dioxide levels, both favorably and unfavorably. Analyzing how global climate change will affect agriculture may assist in correctly foreseeing and modifying farming to increase agricultural output. Although the overall effects of climate change on agricultural output are unknown, these effects will probably result in a shift in the ideal growing regions for certain crops. Adjusting to this spatial change will have a significant financial and social cost [1], [2].

The production and emission of greenhouse gases including carbon dioxide, methane, or nitrous oxide have been proven to be a major way that agriculture contributes to climate change.

Additionally, agriculture that uses plowing, fertilizer, and pesticide application emit ammonia, phosphorus, nitrate, and several other chemicals that have an impact on biodiversity as well as the quality of the water, air, or soil. Agriculture also changes the land cover of the planet, which may affect how well it can reflect or absorb heat, adding to radiative forcing. The main human sources of carbon dioxide are land use change, including deforestation or desertification, as well as the burning of fossil fuels; agriculture itself is the main driver of rising methane or nitrous oxide concentrations in the earth's atmosphere [3].

The use of livestock, particularly ruminants like cattle and pigs, is the main cause of methane emissions. Fish and other aquatic life have far less of an effect than other livestock. The ruminant emissions are being addressed in a few ways. Utilizing biogas made from dung, genetic selection, immunization, and rumen defaunation are a few strategies. Others include introducing methanotrophic bacteria into the rumen, modifying food, and managing to graze. Several dietary modifications may reduce ruminant greenhouse gas emissions by up to 99%. One example is the usage of Asparagopsis taxiformis. One forecast suggests a significant drop in livestock at least certain animals (i.e. cattle) in certain nations by 2030 due to these negative effects as well as agricultural efficiency reasons.

Deforestation

A major portion of the world's forests is being cleared due to deforestation, which also causes significant land degradation. Land clearance for crops or grazing is one of the factors that contribute to deforestation. 5.00% of deforestation is attributed to cattle ranching, 19.1% to excessive logging, 22% to the expanding industry of palm oil plantations, as well as 54.00% to slash-and-burn farming, according to British ecologist Norman Myers.

Millions of species lose their habitat due to deforestation, which also contributes to climate change. By absorbing carbon dioxide, an unwelcome greenhouse gas, from the atmosphere, trees operate as carbon sinks. When trees are cut down, carbon dioxide is released into the sky and fewer trees are left to absorb the rising levels of carbon dioxide in the atmosphere. Deforestation exacerbates climate change in this manner. Because there is no longer any shade in forests, and there aren't enough trees to help with the water cycle by releasing water vapor back into the air, the soils tend to dry up. Landscapes that were formerly forested may eventually turn into arid deserts without trees. Because the tree's roots also function to keep the soil in place, its removal may potentially cause mudslides. The loss of trees also results in dramatic temperature changes [4].

Sustainable Farming

The concept of sustainable agriculture holds that agriculture should be practiced in a manner that allows us to produce what is required without compromising the capacity of future generations to do the same. The practice of converting agricultural land to supply the need for food has expanded due to the exponential population growth in recent decades, which has also worsened the environmental impacts. Although some opponents question if food production can feed the world's population due to decreasing yields brought on by global warming, the global population is still growing and will ultimately stabilize.

Biodiversity may also be negatively impacted by agriculture

Organic farming is a broad category of sustainable agricultural methods that, on a small scale, may lessen its environmental effect. However, organic farming often delivers lower returns in terms of output per area. Because of this, expanding the use of organic farming will need more land clearing and water resource extraction to produce at the same level. In a European meta-analysis, it was discovered that organic farms typically had higher soil organic matter content but also lower nutrient losses nitrous oxide emissions, nitrogen leaching, or ammonia emissions per unit of a field area, but higher nitrous oxide emission levels, ammonia emissions, or nitrogen leaching per product unit. Many people think that organic agricultural methods produce more biodiversity than conventional farming systems. According to studies, organic farming has a 30% more diversity of species overall than conventional farming [5]. On average, organic systems include 50% more organisms. This data has some problems since various findings indicated that these products suffer when grown in an organic agricultural method. These drawbacks, according to some who oppose organic farming, constitute a problem with the organic agricultural system. What was formerly a small-scale, ecologically sensitive activity has now equaled conventional agriculture in terms of industrialization. The problems mentioned above, including climate change and deforestation, may be brought on by this industrialization.

LITERATURE REVIEW

Lopez-Raez et al. [6] studied about The relevance of strigolactones is highlighted in this paper's evaluation of the value of AM symbiosis in reducing plant stress in unfavorable environmental situations. Its potential utility as a novel and sustainable method in contemporary agriculture will grow as we get a deeper knowledge of the systems that govern this advantageous connection. Plants are very dynamic systems with a high ability for environmental adaptation. In places that have been degraded or exposed to intense agriculture, this phenotypic flexibility is very helpful.

The effect of modern agricultural production practices on natural resources, such as water availability, is becoming worse. Therefore, it is crucial to quickly identify more environmentally friendly substitutes. Establishing mutualistic beneficial connections with soil microorganisms, such as the arbuscular mycorrhizal (AM) fungus, is one of the tactics used by plants to increase phenotypic flexibility. Phytohormones are important players in the intricate network of interrelated signaling pathways needed to develop AM symbiosis. Plant hormones known as strigolactones (SLs) modulate the coordinated development under nutrient scarcity. Additionally, SLs serve as host detecting signals for AM fungus, which favors the development of symbioses.

Rizwan et al. [7] studied A balanced use of inorganic, organic, and biofertilizer sources of plant nutrients is required for sustainable improvement in the bioactive production of medicinal plants in order to increase and maintain soil fertility, productivity, and quantity. This calls for a complex examination of the interactions between microbial populations and their bearing on the productivity of the host plant. In the phyllosphere, endosphere, and rhizosphere of medicinal plants, a wide range of fungus and bacteria have been identified. These organisms have a substantial impact on the change of secondary metabolites and nutrient intake. The production of important phytotherapeutic chemicals by related microorganisms as a result of their interactions with their host plants helped to establish the link between bacteria and plants. Although medicinal plants are regarded as rich bioresources in agriculture and contemporary medicine, the ecological importance of their microbiome is yet unknown. By preserving host plant fitness, health, and nutrition as well as increasing tolerance to abiotic stresses and environmental variations, plant-associated microbes form a holobiont that is responsible for the beneficial interaction of the host and its microbiome. This holobiont also promotes the establishment of mycorrhizal associations.

Yearly et al.[8] Studied the perspectives on social change-oriented actors are constrained by traditional social movement theories like Resource Mobilization Theory and New Social

Movement Theory. Conventional theories have failed to evaluate the influence of the green movement outside and independent of the framework of contemporary industrial societies because they are constrained by the worldview and truth regime of modern industrial cultures. These methods thus provide a poor representation of the goals and outcomes of the ecological and environmental movements. In actuality, rather than serving those who want to harmonize human connections with Nature, the explanation offered by traditional theories on these drivers of social change works as a tool to maintain the status quo. This thesis suggests a novel approach to the study of social movements in an effort to redress the balance and give an explanation of social movements that serves the interests of people who desire to effect change. This method's emphasis on knowledge's function in the study of the politics of social change and status quo maintenance, as well as Gandhian forms of political engagement like non-cooperation and self-reliance, are at the core of the approach. The instance of UK agriculture, and specifically the conflict between proponents of a contemporary industrial and an alternative ecological agricultural paradigm, is then examined using the new viewpoint in order to study the dynamics and processes that lead to reform or genuine change.

Y. Ulusoy [9] studied This research makes the case that traditional social movement theories, such Resource Mobilization Theory and New Social Movement Theory, have a limited understanding of actors who are motivated by social change. Conventional theories have failed to evaluate the influence of the green movement outside and independent of the framework of contemporary industrial societies because they are constrained by the worldview and truth regime of modern industrial cultures. These methods thus provide a poor representation of the goals and outcomes of the ecological and environmental movements. In actuality, rather than serving those who want to harmonize human connections with Nature, the explanation offered by traditional theories on these drivers of social change works as a tool to maintain the status quo.

Si Yuan Wang [10] It was important to study the distribution patterns of organic carbon (Corg) in coastal wetlands in order to understand carbon sequestration and adapt to environmental change and global climate change. The shape that this carbon takes may be more significant than total soil carbon, which is an essential measure of soil's ability to sequester carbon. One existing form of Corg, globalin-related soil protein (GRSP), may reflect and carry out the important Corg effects on carbon sequestration in coastal wetlands. After hyphal death/turnover, the newly characterized glycoprotein known as GRSP, which is produced by arbuscular mycorrhizal fungus (AMF), was released into the soil. The projected GRSP residence period in an anaerobic environment in a coastal location ranged from 6 to 42 years, and even thousands of years.

DISCUSSION

Biological Environmental Factors

Farmers used a number of supplementary technologies to more fully utilize these high-yield crop types. Yes, they did contribute to environmental issues. Nevertheless, they raised output while decreasing the quantity of land used for cultivation.

Irrigation

Many aquatic animals face serious issues as a result of water diversions for agriculture. However, irrigating the land often triples it. Currently, irrigation is used on 18% of the world's crops. A minimum of 1.31 billion more acres of land would be required to make up for the lost productivity if all irrigation were stopped.

Fertilizers

The main cause of nutrient loading in the oceans is the usage of fertilizers. However, in other circumstances, the application of fertilizer has increased harvests. Mechanization: Between 1961 and 1998, the use of tractors rose 2.3-fold. It increased society's reliance on fossil fuels while reducing the need for agricultural labor, both human and animal. As a result, it was easier to afford food and required less area to be farmed for labor animals.

Pest Control Systems

Instead of the existing 42%, an estimated 70% of the world's crop may be lost in the absence of pesticides and other pest treatments. In order to make up for the productivity loss without them, at least 90% additional farmland would be needed. A whopping 99% of pesticides are really wasted and end up in the environment. Nevertheless, a number of cost-benefit evaluations suggest that the overall advantages of pesticide usage in terms of the economy, public health, and the environment may surpass the overall costs. The environmental advantages of less habitat modification are not included in these research.

Environmental effects and modern agriculture are related

Innovations in animal husbandry, technology for storage, handling, and processing, and a larger global infrastructure for the effective transportation, storage, distribution, and exchange of agricultural inputs and outputs are further elements that have contributed to farm productivity. Although these technologies have many advantages, it does not imply that we should disregard the propensity for inputs like water, fertilizer, pesticides, and energy to be used excessively. This tendency is caused in part by subsidies and, in the case of water, a lack of property rights.

Therefore, although marginal costs may occasionally outweigh marginal gains even while overall advantages of various technologies often outweigh total costs. In order to concentrate on the long-term environmental benefits and drawbacks of agricultural technology, it is important to note that many impacts of agricultural pollution seem to be reversible, but not necessarily quickly and sometimes at great expense. Many freshwater systems, aquatic animals, and bird species have recovered from decades, if not generations, of abuse in the wealthier countries thanks to new regulations and significant expenditures in cutting-edge, environmentally friendly technology.

The foundation of the life-support system for humankind is agrobiodiversity. The destruction of biodiversity and habitats, the extinction of wild species, the acceleration of the loss of environmental production services, and the erosion of agricultural genetic resources necessary for long-term food security are all results of agricultural intensification and growth. It is anticipated that climate change would alter biodiversity at all scales, including ecosystems, species, and genes.

Agro-ecosystems are under risk of extinction due to the rising frequency of storms, droughts, and floods brought on by climate change. As a result, it seems that the direct consequences of agricultural pollution are no more lasting or permanent than the indirect ecological and biodiversity implications of greater land clearing that would have happened in the absence of such technologies. Therefore, the environment for the rest of nature would not necessarily have been protected if there had been insufficient food production. Population surged by 117% between 1961 and 1998, while per capita food supply climbed by 19%. However, agricultural barely rose by 5%, reaching 420 million acres. From 141 to 170 million acres, the area covered by forests and woodlands increased by 21% between 1961 and 1994.

Agriculture has made it simpler to regard the rest of nature as a source of wonder rather than just one's next meal or the fire to cook it with, which has boosted human wellbeing and decreased habitat loss. The socioeconomic cost of conservation was also reduced. These elements contributed to the development of the circumstances required for political support for conservation.

CONCLUSION

Rethinking the food processing chain: Infrastructure distribution, energy, agro-ecological practices, aquaculture, and molecular biology, reforming the food production system: Moving towards economic incentives, greater governance, and full costing: Institutions earmarking of payment, green taxes, ecological services, market-orientation, and policy changes. A sustainable and fair global food system may be successfully supported by the appropriate technical solutions and future governmental initiatives. A new global food system should guarantee that everyone has access to enough food and that poverty is greatly eliminated without endangering the environment. Agriculture has the potential to be a renewable industry despite the environmental catastrophes that often surround it. Agriculture is seen as potentially renewable and essentially distinct from the industrial sector of society in every century on a global scale.

The intrinsically extractive economy has only operated as if the renewable resources that underpin agriculture are justifiable targets for industrial exploitation in the past 50 years as a result of the growth of industry and the chemicalization of agriculture. That is what distinguishes the contemporary period.

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CHAPTER 7

ADOPTING TECHNOLOGIES FOR SUSTAINABLE FARMING SYSTEMS: THE FARMER'S PERSPECTIVE

Dr. Dinesh Singh, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- dinesh.ag@sanskriti.edu.in

ABSTRACT:

To increase agricultural sustainability, sustainable agriculture practices (SAPs) must be used. The goal of SAP marketing is to promote voluntary adoption of these systems. Show that farmers were six times more likely to embrace further sustainable practices if they had already implemented one sustainable practice in this respect. Farmers that use sustainable methods may also have an impact. To encourage adoption among the local farmers. In supplying this network of knowledge regarding sustainable agricultural education, the extension services may play a critical role. Therefore, extension plays a crucial role in promoting sustainable agriculture, which is shifting from a focus on productivity to a broader range of sustainability and environmental goals, and may need to adapt their extension strategy.

KEYWORDS:

Climate Change, Modern agriculture, Management, Sociopsychological, Sustainable Agricultural.

INTRODUCTION

Innovations in sustainable agriculture are known to address issues facing agriculture, such as pests, drought, natural disasters, and food insecurity. The low rate of acceptance of these improvements, however, necessitates more research into the factors that influence adoption using models. Models may provide a t o explain adoption, complicated connections between variables are shown. The incorporation of sociopsychological variables in the modeling of the farmer's choice to embrace or not adopt agricultural innovations was recommended by many research. People are unaware of any research that have evaluated the implementation of this integration of sociopsychological aspects in modeling, but. In order to fill this research gap, the publication blends traditional bibliometric analysis with the vote-count approach. There are various reasons to perform this study despite the extensive body of literature accessible to comprehend the practice of modeling the adoption of innovations in agriculture.

In terms of the use of technology for farming system automation and control, the agricultural industry is still far behind other industries. Due to the fact that most old or traditional agricultural methods seldom ever provide the intended results in terms of maximum output or low production costs. These systems use modern, creative technologies to help apply fertilizer and insecticides as inputs for higher output levels. The economic and social viability of farming is impacted by technology and advances. As a result, academics have been more interested in examining how agricultural technology gets adopted during the previous several decades. There have been several worldwide studies on adoption choices in the agricultural industry. For instance, if we look at various technology from the standpoint of industrialized countries, acceptability criteria have been established. Understanding the phenomena is necessary to optimize farmers' adoption decisions. The major focus of Malaysian agricultural economics is to thoughtfully handle all of these concerns and gauge the effects of farmer decision-making.

Over the last several years, a great deal of research has been done on how Malaysian farmers decide whether to accept any innovations.

The primary driving force behind this study is the discovery that, despite the existence of several literature reviews on this subject, none of them specifically examined how sociopsychological constructs were chosen in relation to the adoption of innovations in sustainable agriculture. This knowledge gap supports the need for more study to learn how academics can communicate clearly with policymakers to support the implementation of sustainable agricultural advances. This is due to the fact that the introduction of these agricultural advances has only met with limited success and that the adoption rate is still low, especially in the Global South. As a result, the emphasis of this research is on a critical review of the information that is currently available with regard to the common models and variables used in studies looking at the adoption of sustainable agricultural technologies.

Adoption study is required to look at how inconsistent variable definitions have been employed in conceptual models and empirical studies related to the theme of innovations in sustainable agriculture. Focused on the importance of intrinsic and extrinsic factors for the adoption of agricultural innovations in the decision-making process, contending that intrinsic factors such as the potential adopter's knowledge, perceptions, and attitudes toward innovation play a critical role. In order to comprehend the factors that affect the adoption of a variety of sustainability agriculture innovations, including agroforestry systems fertilizer tree systems, conservation agriculture, organic farming, green pesticides, and other agricultural practices that promote sustainability, several studies using various conceptual models have been conducted.

A mathematical framework to describe how agricultural innovation spread, gave rise to decision-making models and analytical techniques on the subject of adoption. After fifteen years, developed regression modeling and showed how economic analysis could be used to understand how innovation decisions are made and how it is accepted. The diffusion of innovations (DOI) theory was developed and proposes that the compatibility and complexity of the new technology, the characteristics of the potential end-user, the individual's perception and knowledge of the technology, as well as the type of communication channels—mass, group, and individual will determine the diffusion and adoption of innovative technologies. Introduced the theory of reasoned action (TRA) and the theory of planned behavior (TPB) into the agricultural area in addition to the specialized theories of innovation in agriculture in order to better understand the sociopsychological components of farmers' adoption. All of these theories have frequently and extensively been applied in empirical studies relating to consumer behavior, manufacturing industries, information technologies, advertising campaigns, and software sciences. According to Burton, decomposed TPB appears to be more all-inclusive.

However, it still only has a little amount of application in agriculture. The incorporation of sociopsychological elements to model farmers' decisions to embrace sustainable agricultural techniques was found to be rare, the empirical material that is currently available. However, this analysis concentrated on UM, TPB, and TRA and excluded other sociopsychological models, which probably explains why the constructs in the papers the authors analyzed were not well quantified. The factors encouraging farmers to embrace agricultural technologies were examined by to this study, the utility maximization (UM) theoretical framework-based research revealed that explanatory variables had a negligible impact on the adoption of innovations, whereas the results of the TPB study revealed that correlations between sociopsychological constructs were quite positive but poorly measured. Other adoption models were not included in these earlier review studies, which were primarily focused on TPB and UM theory. These methods have not enabled a thorough examination of the limits of various models. All of these studies, however, made a substantial contribution to the body of literature on this subject and were pertinent to identifying the research gap that needed to be filled in this review. The fundamental idea behind sustainability innovations is the development of new or enhanced goods, services, technologies, procedures, and management strategies that have both economic and environmental advantages.

Innovations in sustainable agriculture can take place on a farmer's level, such as the adoption of compost, conservation tillage, fallow, legume crop rotations, better seed varieties, and the use of animal manure, or outside the farm, such as the adoption of short distribution chains and cooperatives. This is described as a process where sustainability concerns, such as environmental, social, and financial ones, are applied to new products, services, and technologies as well as new business and organizational models and integrated into agricultural systems from idea generation through research and development (R&D) and commercialization. This research helps provide relevant information that policymakers may use to craft more effective policies to support innovations in sustainable agriculture. The review's main contribution is to increase researchers' awareness of the need to broaden the dimensions that should be included in models that analyze the decision-making process for adopting innovations in sustainable agriculture rather than concentrating only on those already investigated by the established models, which frequently overlap in the constructs included. It is stated in the present research that sociopsychological dimensions like effectiveness, trust, awareness, and knowledge should be included since they have the potential to be useful in the analysis of adoption modeling in the context of agriculture.

ORGANIC FARMING

Early in the 20th century, organic farming emerged as a farming technique in reaction to constantly changing agricultural methods. 70 million hectares are used for organic farming worldwide. Various groups are still working to improve organic farming today. It is established to utilize organic fertilizers like green manure, compost, as well as bone meal, and emphasis is placed on practices like crop rotation or companion planting. The development of insect predators, mixed production, or biological pest control is all advocated. The goal of organic requirements is to promote the use of naturally occurring compounds while outlawing or severely regulating the usage of manufactured substances. Synthetic fertilizers and insecticides are often forbidden, but naturally occurring pesticides like pyrethrin and rotenone are needed. Ivermectin, copper sulfate, and elemental sulfur are a few examples of synthetic chemicals that are acceptable. In the care of cattle, it is prohibited to employ hormones, antibiotics, plant growth regulators, nanomaterials, human waste sludge, or genetically modified organisms. The advantages of transparency, self-sufficiency, autonomy and independence, health, food safety, and sustainability are cited by proponents of organic farming. Several countries throughout the world have laws enforcing and regulating organic agricultural practices. Simply described, organic farming is an integrated agricultural system free of synthetic pesticides, genetically modified organisms, antibiotics, synthetic fertilizers, and growth hormones, with rare exceptions, to boost soil fertility and biological variety. Organic farming is still in its infancy in India [1].

As of March 2020, 2.78 million hectares of agricultural land were being farmed organically, according to the Union Ministry of Agriculture and Farmers' Welfare. This equates to 2% of the 140.1 million hectares of net planted land in the nation. Given that the majority of this area is concentrated in a small number of states, several of them have taken the initiative to increase the scope of organic farming. With 0.76 million acres under organic agriculture, Madhya Pradesh leads the list and accounts for approximately 27% of all Indian land used for organic farming. The top three states, Madhya Pradesh, Rajasthan, and Maharashtra, make up roughly half of the land used for organic farming. The top 10 states account for almost 80% of all land used for organic farming [2].

Advanced Agriculture

A management approach in agriculture known as “precision farming” (PA), “satellite farming,” or “site-specific crop management” (SSCM) is centered on the observation, estimation, and reaction to crop inter- and intra-field variability. Establishing a decision support system (DSS) for whole farm management to increase input returns while preserving resources is the goal of precision agriculture research. A Phyto geomorphological strategy, which connects stability/characteristics of multi-year crop development to topological terrain properties, is one of the several ways. The interest in the phytogeomorphological approach comes from the fact that the geomorphology component typically determines the hydrology of the farmland. Precision agriculture is now possible because of the development of GPS and GNSS systems. The creation of spatial variability maps of as many variables as can be calculated (such as crop yield, landscape features/topography, organic matter content, moisture levels, nitrogen levels, pH, EC, Mg, K, and others) is made possible by the farmer's and/or researcher's ability to pinpoint their exact location in a field.

Sensor arrays mounted on a GPS-equipped combined harvest gather comparable data. These arrays include multispectral imaging and real-time sensors that track everything from plant water status to chlorophyll levels. In line with variable rate technology (VRT) satellite images, this information is utilized to distribute resources, like seeders and sprayers, in the most efficient way possible. However, recent technology developments have made it possible to deploy real-time sensors that can broadcast data wirelessly without the need for human intervention directly in the soil. These topographic maps may be used to link topography and crop health, and variable rate applications can take advantage of those effects to maximize crop inputs like water, fertilizer, or chemicals like herbicides and growth regulators [3], [4].

Sustainable Agriculture

- To satisfy society's current food and textile demands without compromising the ability of current or future generations to meet their own needs, agriculture must be sustainable. It could be based on knowledge of ecosystem services. There are various ways to increase agriculture's sustainability.
- Establishing adaptable business procedures and agricultural methods is crucial when agriculture is developed in the context of sustainable food systems. A key contributor to climate change, water scarcity, land degradation, deforestation, and other processes, agriculture has a significant negative impact on the environment and is both creating and being impacted by these changes [5].
- The survival of the human population is facilitated by the development of sustainable food systems. One of the greatest methods to combat climate change, for instance, is to build sustainable food systems based on sustainable agriculture. A potential answer to enabling agricultural systems to feed an expanding population in the face of changing environmental circumstances is provided by sustainable agriculture.

LITERATURE REVIEW

Pimentel et al. [6] studied about for around 6000 years, several organic methods have been used to make agriculture sustainable while preserving soil, energy, water, and biological resources. Higher soil organic matter and nitrogen content, fewer fossil energy inputs, yields comparable to those of conventional systems, and preservation of soil moisture and water resources are only a few advantages of organic technology (especially advantageous under drought conditions). By using certain traditional organic farming techniques, conventional agriculture may become more environmentally friendly and sustainable.

Adegbeye et al. [7] studied about Human health, food security, and the climate are all being impacted by environmental degradation caused by previous and present agricultural practices. Agriculture, however, cannot be abandoned due to its potential to help low- and middle-income nations end hunger, eradicate poverty, boost nutrition, and achieve food security. Therefore, a move from "unclean" to sustainable methods is required. Similar to this, national variances in pollution need regional adjustments or intervention in agri-food practices in order to lower global pollution. These procedures are crucial for the nations of Asia and Africa. Localized technological development and worldwide sustainable intensification are two of the numerous techniques suggested in this analysis that have the potential to have a substantial effect and reduce greenhouse gas emissions by up to 30%. There are numerous ways to implement these measures, including changing crop and livestock production management systems, encouraging environmentally friendly and highly adaptable agricultural and veterinary practices, empowering nutrient recycling or recovery, resource-use efficiency, reducing nitrous oxide and methane emissions from soil, implementing integrated farming systems, and insect farming.

Dumont et al. [8] studied about Humans benefit from livestock farming systems in many ways, including: protein-rich diets that improve food security; employment and rural economies; capital stock and draught power in many emerging nations; and a diverse cultural environment. Despite these beneficial effects on society, livestock is nevertheless the subject of heated debates regarding its effects on the environment, animal welfare, and the health effects of excessive meat consumption. Here, they examine the potentials of agroecology (AE) and sustainable intensification (SI) in the development of sustainable ruminant farming systems. They examine the two frameworks from a historical standpoint and demonstrate how they are based on various moral standards and worldviews on dietary habits, the use of technology, and our interaction with the natural world. They consider the growth in animal protein consumption as unavoidable. Thus, sustainable intensification may be seen as a framework focused on efficiency that takes use of all technological advancements. Supporters of AE seem more receptive to dietary changes that would reduce consumption of animal protein and restore the balance to the whole food chain. Agroecology seeks to provide regulatory and cultural functions, encourages system redesign, and profits from functional variety.

Malik et al. [9] studied The idea of "smart farming" has sparked interest in using technology to improve agricultural output. In order to achieve sustainable development, more farmers are using this technology thanks to the availability of inexpensive sensors and management systems. However, there are no simulation systems described in the literature to aid users and researchers in understanding sensor placement, data collecting, and processing. In this piece, we provide a framework that is intended to offer a whole agricultural ecology. Additionally, the majority of current works overlook network characteristics, which might affect the overall performance of any deployed system. As a result, the suggested framework also offers a baseline for the utilization of system resources, energy consumption, and packet delivery ratio.

Jara-Rojas et al. [10] studied about Cattle farming, which is one of the primary causes of deforestation, loss of biodiversity, land degradation, and greenhouse gas emissions, occupies one-third of the land in Colombia. Agroforestry methods have been vigorously advocated with varying degrees of success to reduce the negative environmental effects of livestock ranching. They use a double hurdle regression to capture the choice to adopt and the intensity of adoption as a combined decision of such activities in order to investigate the factors that influence cattle producers' behavior with respect to implementing agroforestry methods.

Gourav Shrestha et al. [11] studied Any agricultural production system is significantly hampered by weeds, which also affect productivity and profitability. Since the introduction of crops that are resistant to herbicides, there has been a considerable rise in the use of herbicides, which are among the most effective ways to manage weeds. Unfortunately, an over dependence on herbicides results in ecological problems and weeds that are resistant to them, endangering both human health and the environment. In important agricultural production systems, crop diversity may aid in the sustainable management of weeds. It serves as a guiding concept for integrating ecological knowledge and technology advancements to control weeds sustainably. Vunnava et al. [12] studied about a macroscale assessment of the possibilities and effects of implementing new technologies in an area is necessary for a sustainable transition to a low carbon and zero waste economy. However, a thorough analysis of the present physical flow and waste is a time-consuming operation, thus there is a lack of thorough analysis before scaling up and adopting innovative technology. They offer a revolutionary integrated technique to comprehensively map the physical economy that automates the process of mapping industrial flows and wastes in an area. It combines the mechanistic models created for engineering and biological systems with the macroeconomic framework of Input-Output models. The method is shown by visualizing the status of Illinois' agro-based physical economy using mechanistic models for 10 of those sectors, which have a significant influence on waste creation.

Day, W. et al. [13] studied about A more favorable effect on local and global environments, enabling the integration of sustainable biodiversity goals with production performance; improved methods for balancing global supply and demand, enabling the achievement of the internationally agreed-upon goals for biosphere stability; and higher production efficiencies per unit land area or per unit input of crucial ingredients like water or fertilizer Each stage will provide significant improvements over current agriculture methods. Modern engineering methods and technology developments have enhanced productivity across all major industries, but farming has not yet made substantial progress in creating and using these technologies.

Soulama et al. [14] studied In the Sahel, agroecosystem degradation is a significant socio-environmental issue. Populations are using a variety of adaptation tactics in response to the falling yields from cultivated soils. The goal of this research was to evaluate the effects of three agricultural methods on the development of soil fertility in Burkina Faso's Sahel region. Agro-system soil was taken and subjected to laboratory physical, chemical, and biological analyses. We measured the soil's ability to absorb water as well as the amount of herbaceous growth. Grass biomass was also assessed, and grains and millet straw were weighed in the field. Neville Bizimana et al. [15] studied using an integrated decision support system, this research examines the multifaceted effects of implementing new agricultural technology in sub-Saharan Africa at the farm/village and watershed scales (IDSS). By evaluating the production, economic, environmental, and nutritional effects of adopting farming techniques for sustainable improvements in food production and use of finite natural resources, IDSS application as an integrated modeling tool aids in the resolution of complex issues in agricultural systems. In order to assess the effects of alternative agricultural technology interventions in the Amhara area of Ethiopia, where resource scarcity and agro-environmental repercussions are crucial to agricultural production of small farms, the IDSS technique was used.

DISCUSSION

Critical Analysis

The suggested works provide insight but do not explicitly describe how TRA, TPB, TAM, and are used in conjunction with communication channels. TRA, TPB, TAM, and DOI were used to analyze diverse innovation types globally from an agricultural viewpoint, according to Table 1. Since one of the fundamental premises of DOI is that farmers want to maximize their profits, it stands to reason that the theory would be used to research innovation that is anticipated to boost profitability while using innovative qualities. In addition to explaining the adoption of sustainable and conversational practices, DOI is used to embrace innovations that are anticipated to boost profitability. Additionally, this table states that TRA, TPB, and TAM have been utilized in agricultural perspectives with at least two goals in mind: to define general behavior and governmental agency conduct. For instance, examined the variables that affect the acceptance of agricultural innovation in China using TAM variables like perceived usefulness and ease of use as well as other variables like trust, social influence, perceived enjoyment, and perceived behavioral control. The construct belongs to the following category: beliefs, perceptions of the innovation's qualities, and psychological concepts that comprise behavioral intention, attitude, subjective standards, and perceived behavioral control.

The conceptual framework

An important subject in the field of agricultural research has been the acceptance of innovation in agriculture. By developing key sets of theoretical frameworks, several research investigations have attempted to forecast as well as explain the crucial aspects of technology adoption and the process of dissemination. The "innovation diffusion model," which succeeded Rogers' early investigations, is one of the most well-known models discussing the uptake of technology. According to this particular model, the diffusion and adoption of novel new technologies are influenced by the compatibility and complexity of the new technology, the characteristics of the potential end users, the individual's perception of and familiarity with the technology, and the communication channels. A further hypothesis put out by the Theory of Reasoned Action (TRA) is that the attitude clarifies the behavioral goal. Based on TRA, the Technology Acceptance Model (TAM) is a paradigm for predicting the adoption of new technologies based on user knowledge and attitudes.

These theories all represent the understanding and attitude that prospective technology users have about the characteristics of the technology as important factors affecting adoption choices. From an empirical standpoint, it has often been assumed that the adoption depends on the traits of the farmer, the farm, as well as the particular structures of the particular technology. The age of the farmer has often been considered by researchers who study adoption, and it is typically anticipated that the farmer's age is unfavorably related to the adoption. It has been discovered that the farmer's education and experience have a favorable impact on the adoption.

Building blocks of interest

According to this study, the success of paddy farmers' interest in adopting GFT Malaysia rests on their acceptance and adoption. Consequently, this study will examine the main factors influencing a farmer's decision to use GFT. Perceived usefulness, communication, mass media, interpersonal, attitude, subjective norm, intention, perceived behavior control, and traceability compatibility are the elements that were identified for this study. Each factor's definition in relation to the study's setting is provided.

Selection Green fertilizer technology adoption

The real adoption choice is based on how much a person is willing to employ innovation in the future and suggest it to other farmers. According to ideas on technology acceptance, technological adoption among farmers is predicted by how paddy farmers see the actual usage of the innovation. Numerous research have looked at adoption decision-making as well as economic, sociological, psychological, and communicative variables. A broader variety of disciplines, including farm management, rural development, and farmer attitudes toward the use of GFT, are where the application is found. Decision-making in the subject of business management has often been examined in terms of the conventional classical economic theory, which proposed that individuals make decisions in order to maximize the utility. Additionally, according to most economists typically cite pro fit as a substitute for utility since it justifies the choice to maximize profits and minimize expenses. The choice to implement GFT into its communication approach is discussed in this study. As a result, the fundamental construct in this study a dependent variable is the choice to adopt.

It is acknowledged that embracing innovations in sustainable agriculture is an effective solution to agro-ecological issues such food shortages, insect infestations, drought, and climate change. However, it is still not evenly distributed around the world, particularly in the global south. A greater knowledge of the variables affecting acceptability is needed to enhance these technologies. In order to provide a thorough review of the literature on the use of sociopsychological factors to explain the adoption of sustainable agriculture technology, this research combines standard bibliometric analysis with the method of vote-counting. With the aid of this method, it was feasible to evaluate how well the variables accounted for by the models and related sociopsychological characteristics explained the adoption of innovations. Our results show a significant increase of study into the decision-making processes employed by farmers when embracing innovations in sustainable agriculture. This research combines theory and models based on sociopsychological factors. Thanks to the development of statistical models and procedures like the structural equation model, a growing number of sociopsychological aspects may now be incorporated (SEM). However, as highlighted in our review, the choice of sociopsychological constructs used in research to explain farmers' adoption of sustainability innovations frequently depends on constructs created for other decision-making settings, such as the adoption of innovations by businesses in other sectors. Due to the models' inadequate choice of constructs, they are unable to adequately represent farmers' adoption behavior.

This research focused on the elements that affect a farmer's choice to implement GFT. Examining innovation qualities and sociopsychological communication channels is the primary goal of this review research. GFT has been urged to increase the effectiveness of on-farm resource use in order to meet the entwined goals of enhancing food security and sustainability. Many nations throughout the globe have thought about funding these sustainable technology. Despite the fact that GFTs are becoming economically feasible in many industrialized countries, the adoption decision-making process is only expanding at a moderate pace. These farmers have been known to profit from the advantages of GFT, which have been found to provide them a competitive edge over traditional fertilizer, increase their paddy yield while lowering operating expenses. The remaining difficulty, however, is figuring out what obstacles these farmers experience that keep them from using GFT. Therefore, the goal of this research is to concentrate on the farmer's choice to adopt GFT and the variables that influenced that choice. The study's main objective is to evaluate sociopsychological elements, communication pathways, innovation characteristics, and environmental aspects that are all connected to farmers' decision-making processes.

CONCLUSION

The numerous strategies that agricultural extension may use to support the creation, advancement, and acceptance of sustainable farming methods used by families. If the agricultural extension system's efforts are effective in disseminating knowledge, farmers will be encouraged to use the right technology for sustainable farming systems. Because the goals of extension might include anything from the efficient transmission of technology to the development of strong rural organizations that can influence future research and policy agendas to the adoption and enforcement of group choices about natural resource management.

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CHAPTER 8

INFLUENCING INNOVATION AND UPTAKE OF TECHNOLOGIES FOR SUSTAINABLE FARMING SYSTEMS

Dr. Kuldeep Maurya, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- kuldeep.ag@sanskriti.edu.in

ABSTRACT:

The most important laws and regulations promote trade liberalization and the modification of the Common Agricultural Policy, as well as biodiversity preservation, environmental protection, or technological innovation. While certain policy initiatives are encouraging the industry to create new technologies, it is more common to find that policies from several government agencies clash and produce less than desirable outcomes. More cross-functional integration and familiarity with topics outside of their areas of competence are required of policymakers.

KEYWORDS:

Adoption, Sustainable Agriculture, Environmental Protection, Sociopsychological, Vertical Crop Growing.

INTRODUCTION

Innovations in sustainable agriculture are known to address issues facing agriculture, such as pests, drought, natural disasters, and food poverty. The low rate of acceptance of these improvements, however, necessitates more research into the factors that influence adoption using models. Models may provide a t o explain adoption, complicated connections between variables are shown. The incorporation of sociopsychological variables in the modeling of the farmer's choice to embrace or not adopt agricultural innovations was recommended by many research. We are unaware of any research that have evaluated the implementation of this integration of sociopsychological aspects in modeling, but. This article fills a research hole in the literature caused by the poor choice of determinants.

In the models describing the adoption of sustainable agricultural advances. In order to fill this research gap, the publication blends traditional bibliometric analysis with the vote-count approach. There are various reasons to perform this study despite the extensive body of literature accessible to comprehend the practice of modeling the adoption of innovations in agriculture. The primary driving force behind this study is the discovery that, despite the existence of several literature reviewson this subject, none of them specifically examined how sociopsychological constructs were chosen in relation to the adoption of innovations in sustainable agriculture. This knowledge gap supports the need for more study to learn how academics can communicate clearly with policymakers to support the implementation of sustainable agricultural advances. This is due to the fact that the introduction of these agricultural advances has only met with limited success and that the adoption rate is still low, especially in the Global South. As a result, the emphasis of this research is on a critical review of the information that is currently available with regard to the common models and variables used in studies looking at the adoption of sustainable agricultural technologies. The purpose of the article is to provide answers to the research questions and suggestions for further study on the subject by conducting a systematic evaluation of the literature using the bibliometric analysis approach in conjunction with the vote-count method.

Adoption study is required to look at how inconsistent variable definitions have been employed in conceptual models and empirical studies related to the theme of innovations in sustainable agriculture. In this regard, focused on the importance of intrinsic and extrinsic factors for the adoption of agricultural innovations in the decision-making process, contending that intrinsic factors such as the potential adopter's knowledge, perceptions, and attitudes toward innovation play a critical role. In order to comprehend the factors that affect the adoption of a variety of sustainability agriculture innovations, including agroforestry systems, fertilizer tree systems, conservation agriculture, organic farming, green pesticides and other agricultural practices that promote sustainability, several studies using various conceptual models have been conducted.

A mathematical framework to describe how agricultural innovation spread, gave rise to decision-making models and analytical techniques on the subject of adoption. After fifteen years, developed regression modeling and showed how economic analysis could be used to understand how innovation decisions are made and how it is accepted. The diffusion of innovations (DOI) theory was developed by Rogers and proposes that the compatibility and complexity of the new technology, the characteristics of the potential end-user, the individual's perception and knowledge of the technology, as well as the type of communication channels mass, group, and individual will determine the diffusion and adoption of innovative technologies. The theory of reasoned action (TRA) and the theory of planned behavior (TPB) into the agricultural area in addition to the specialized theories of innovation in agriculture in order to better understand the sociopsychological components of farmers' adoption. All of these theories have often been utilized intensely in empirical investigations pertaining to consumer behavior, industrial industries, advertising campaigns, information technologies, advertising campaigns, and software sciences. According to deconstructed TPB appears to be more all-encompassing.

Definitions of sustainability in relation to agriculture a societal idea related to the management of a natural resource for human use is called sustainable development. Consequently, depending on the interests and values that drive that aim, it is subject to many interpretations. The Critical Limits perspective emphasizes the necessity to protect natural resources in order to continue providing the services that the human population depends on for existence as well as worries about the earth's carrying capacity and resource constraints. The Competing Objectives perspective on sustainability focuses on striking a balance between social, economic, or ecological objectives and seeks to satisfy a variety of human needs, including a healthy natural environment, political freedom, literacy, and other purely material need.

Various agricultural methods, from organic systems at one end of the spectrum to conventional intensive systems at the other, coexist in many regions of the globe today. It has been passionately argued that organic and intensive systems are more sustainable than each other, but more often than not, the critical limits perspective is used to support the idea that organic agriculture is the only form of agriculture that is truly sustainable, and that society must accept the restrictions this would place on the number of people in the world and the lifestyle they can lead. It prioritizes the one goal of environmental sustainability, which is supposed to take precedence over the interests of all other stakeholders and to favor taking precautions when it comes to environmental dangers connected to agricultural systems. Accordingly, the theory goes, our lives and consumption habits will need to be drastically altered in order to feed the world's population utilizing organic agricultural practices. The conflicting aims view on agricultural systems, on the other hand, would acknowledge that compromises are necessary between a varieties of purposes in order to serve a diverse range of human demands. It aims to strike a balance between long-term agricultural land use and economic sustainability, environmental protection, meeting public demand for food, and delivering the landscape advantages associated with agriculture. The pertinent question thus becomes: to what extent can we reconcile divergent stakeholder interests in any given agricultural system? This point of view enables the interests of all key stakeholders in any development or activity to be balanced in the context of overarching policy considerations, but it runs the danger of allowing trade-offs that allow eventually unsustainable behaviors to continue unchecked. Which understanding of sustainable development planners, policy makers, and their advisors choose will determine how future agricultural systems are designed and developed, among other things. The decision will be influenced by personalities, values, and self-interest in addition to scientific data, as is the case in the majority of human endeavors. Despite seeming to be based on science and economics on the surface, discussions on the relative benefits of various agricultural methods are unavoidably emotive. Given the variety of farming practices described in Box 1, intensive or traditional high yielding farming systems on rich soils are often robust to disruption and, with a few noteworthy exceptions, they have seemed to be sustainable in strictly agricultural terms for at least 50 years.

These are the farming systems, or competing objectives, that must continue to be viable from an agricultural and economic standpoint if we are to be able to feed the world's population. Some would also argue that they are necessary if we are to keep some farmland where we can give biodiversity and landscape objectives a higher priority. Although intensive farming practices could seem viable from the viewpoint of the farm alone, they might have effects on the larger environment that are seen as inappropriate or unsustainable at the very least. Extensive farming systems predominantly based on organic or comparable technologies may have lasted for millennia at low levels of production in more unstable agricultural settings, such as on marginal land, steep slopes, poor soils, or regions with little rainfall. When techniques are altered in an effort to increase yields, such as via incorrect cultivation or irrigation, the use of chemical inputs, or overgrazing, they often become manifestly unsustainable. Although the sustainability of such extensive farming systems is frequently crucial to the subsistence farming communities that depend on them, they are unlikely to significantly contribute to the world's food supply, and technological innovation's role in the sustainable improvement of yields in such areas is likely to be localized and context-specific.

The degree to which agricultural systems can maintain a significant level of wildlife biodiversity on farms is a major point of contention in the argument concerning their sustainability. There is a significant difference between the presence of wildlife on the cropped area of the farm and alternatively in field margins and non-cropped regions. Diverse kinds of farming systems will unavoidably have a variety of different consequences on wildlife biodiversity. The increased biodiversity on the farmed lands is sometimes cited as evidence for the improved sustainability of organic farming methods, however it is seldom feasible to promote solely species that have no bearing on crop output. The majority of commercial farmers (organic or conventional) believe that having wildlife around their crops is bad since it lowers production. It is more reasonable for policymakers to understand that farmers who want to be competitive (and hence economically viable) are unlikely to have the promotion of biodiversity as one of their top priorities for the farm's cultivated areas. By effectively using "clean technology," it should be feasible to reduce the influence of the agricultural system on wildlife biodiversity on field margins and other non-cropped areas. So long as the biodiversity of the cultivated area is taken into account, traditional farming techniques need not have a detrimental influence on the environment from the standpoint of "competing purposes." To fulfill conflicting productivity, environmental, biodiversity, and aesthetic objectives, a mosaic of crop production systems using a combination of integrated, organic, and conventional cropping systems would likely be necessary to attain maximum biodiversity at a regional level.

Important caveats include the need to prevent unwarranted agricultural system expansion in more vulnerable places and excessive use of technical inputs like pesticides or fertilizers everywhere. The balance of agronomic, landscape, and biodiversity-related demands, as well as the varying ability of the land area to meet those needs, will determine the appropriate proportions of various cropping systems in a region. The Organic Food and Farming Targets Bill, supported by the WorldWide Fund for Nature, UK, for instance, sets a target of 30% of UK farmland being organic or in conversion by 2010. However, even if this target is met, it is unlikely that organic farming systems will be evenly distributed across the country's farmed land areas.

Technologies to increase the sustainability of agricultural systems

Most agricultural policy makers neglect the requirements of conventional farming systems on the most fertile agricultural land in favor of focusing on organic and related integrated farming systems as the path to sustainability. Scottish Natural Heritage took on this problem a few years ago and launched the TIBRE project to look at the many technical possibilities that may help such systems to become more ecologically sustainable without hurting their ability to compete economically (Annex 1 to this section). The effects of national and international policy environments on the innovation strategies of companies (large and small) developing products in the areas of pesticides, biotechnology, and seeds that could potentially reduce the environmental impact of all farming systems, including conventional/intensive farming, have been studied more recently as part of an EC-funded project (PITA).

LITERATURE REVIEW

Kimberly Schirmer et al. [1] studied about measures in agriculture should look at the wellness and health of farm managers. Given that the farmer is so important to farm-based management and decision-making, excellent farmer welfare may signify a level of operation throughout all parts of the farm system - a key component of sustainability. Despite this, few few frameworks for agricultural sustainability indicators assess farmer well-being. Lack of research on the relationships between farming systems and wellbeing and the discovery of interventions that might illuminate the wellbeing advantages of ecological and financially viable agricultural systems are major challenges.

El Chami, and Daniel [2] To make this agricultural system more sustainable for coping with climate change and meeting the Sustainable Development Goals, the European Union Green Deal has recommended the "organic farming action plan" (UN-SDGs). Although this policy tool is crucial for achieving sustainable agriculture, there is still no consensus on what it is and how to quantify it. In order to enhance decision-making, this opinion paper suggests an ecosystem-based framework on the life cycle of crops to assess the harmony between the economic, social, & environmental pillars of sustainability.

Giorgia Bentivoglio et al. [3] In terms of employment, revenue, and added value, the food and beverage sector was reaffirmed as the largest manufacturing sector in the European Union. The majority of the businesses, however, are small and medium-sized firms (SMEs), which exhibit a sluggish pace of innovation and precision agricultural technology adoption. New possibilities are opening up for agri-food SMEs with the arrival of the digital era to improve their competitiveness via the implementation of technical advancements throughout the supply chain, from farm to fork. The paper's analysis of the state-of-the-art demonstrates that technical advancements in food production are important for assuring sustainable management of agricultural systems.

Marsh, and John S [4] studied about In addition to describing the policy options available to the agricultural industry and the government to create sustainable farming systems in the context of the European Union, the paper discusses the significance of sustainability for farming systems from a natural, economic, and social perspective. The current state of agricultural systems is reviewed, particularly the increased demands agriculture places on certain natural resources at a time when farming populations are deteriorating. Several policy approaches, including pricing, structural, and R&D policies, are looked at in search of a framework to support sustainable agricultural systems. The Common Agricultural Policy and its prospective ability to transition from a price- and cost-setting function to a more complex and multifaceted one are taken into consideration when evaluating the viability of these policy reforms.

Altieri and Miguel A. [5] studied A few fungal species produce mycotoxins, which are tiny (MW about 700), hazardous chemical compounds that rapidly colonize crops and poison them with toxins in the field or after harvest. Since ochratoxin and aflatoxin are important mycotoxins, much research has been done on a variety of analytical and detection approaches that may be practical and beneficial. It is not feasible to analyze or identify these poisons using a single conventional approach because of the diversity of their structural makeup. Routine analysis has difficulties due to practical needs for high sensitivity analysis and the necessity for a specialized laboratory environment. This book has reviewed a number of current analytical techniques that provide adaptable and broadly based methods of analysis and, in some circumstances, detection. There are many different techniques that are utilized, many of which are lab-based, but to our knowledge there does not seem to be one approach that excels above the others, but analytical liquid chromatography, which is often associated with mass spectroscopy, is likely to be well-liked.

Senanayake et al. [6] studied Soil erosion is a severe threat to food production systems globally. Food production in farming systems decreases with increasing soil erosion hazards. This review article focuses on geo-informatics applications for identifying, assessing and predicting erosion hazards for sustainable farming system development. Several researchers have used a variety of quantitative and qualitative methods with erosion models, integrating geo-informatics techniques for spatial interpretations to address soil erosion and land degradation issues. The review identified different geo-informatics methods of erosion hazard assessment and highlighted some research gaps that can provide a basis to develop appropriate novel methodologies for future studies. It was found that rainfall variation and land-use changes significantly contribute to soil erosion hazards.

Birthe K. Groot et al. [7] Studied Smallholder farmers in East Africa have access to significant potential economic benefits from dairy growth, but productivity is limited by a lack of both sufficient and high-quality feed. The key to sustainable intensification, enhancing food security, and reducing environmental trade-offs like GHG emission intensity has been identified as improved cattle nutrition and forages. In this essay from a viewpoint, we make the case that agricultural systems methods are crucial to comprehending the many functions and effects of forages in smallholder livelihoods. We begin by outlining the special place that forages have in crop-livestock systems and the structural barriers to adoption that need interdisciplinary thinking. In the second section, we go through how crucial it is to link forage technology with certain agroecological, socioeconomic, and market niches. Third, they show how agricultural systems modeling is helpful for estimating the multidimensional effects of forages and for minimizing agro-environmental trade-offs.

V. Mutyasira et al. [8] studied At least two contentious innovation pathways have been used in agricultural mechanization in developing nations: the incumbent trajectory that supports industrial agriculture and the alternative pathway that encourages small-scale mechanization for the long-term sustainability of hillside farming systems. Although both pathways have the potential to lessen laborious tasks for both people and animals, there is little or no literature that evaluates the sustainability effects of these mechanization pathways in the particular ecological, socioeconomic, cultural, as well as historical contexts of hillside farms.

DISCUSSION

Organic farming methods are on the right side of this spectrum, whereas conventional or intensive farming systems are on the left. The term "integrated farming systems" is used by both sides of the argument to describe a middle ground that uses natural controls, crop rotation, and a variety of agronomic practices to encourage pest predators, reduce the incidence of diseases, and reduce the need for chemical or biotechnological inputs. On the one hand, the agrochemical industry uses the term to refer to the use of technological options to reduce dependence on pesticides and fertilizers. Typically, organic farming methods are presented as comprehensive and sustainable, whereas conventional farming methods are seen as the reverse. According to the thesis of this essay, there is no reason why either cannot be equally sustainable, and both are unquestionably equally holistic in that they behave as structured systems of interconnected parts, and that the behavior of the system will change if components are added or removed, possibly dramatically. The challenges farmers have when crossing the main split between conventionally based and organically based systems and the relative ease with which they may migrate in either direction to or from that border are evidence of this systemic structure in both situations. 64 Based on this experience, this study takes a conflicting aims approach on sustainability by looking at how governments affect innovation and the adoption of technology for sustainable agricultural systems.

In the context of: globalization and World Trade Organization (WTO) negotiations, potential perturbations like short-term climate fluctuations or global climate change, competing uses for agricultural land, and potential perturbations like these, this appears to be the most likely to deliver the plural set of policies needed to deal with the complex and interconnected nature of modern farming systems (to produce fuel, fibre, commodity chemicals for industrial processes, high value-added pharmaceutical products and also wildlife and biodiversity benefits). Through a variety of innovations in engineering, information technology, pesticides, and biotechnology, reducing the load of known toxins, substituting safer alternatives, protecting ground or surface waters, protecting natural habitats, reducing nutrient loads in soils, reducing gaseous nitrogen loss, or reducing the amount of non-renewable energy used, technological innovation has a potentially significant role to play in improving the sustainability of these farming systems. In this volatile physical and legislative climate, we will be dependent on European intensive/conventional agricultural methods on the most productive soils to feed a rising global population.

It is possible that farmers will become more risk averse as a result of the increased commercial pressure brought on by the globalization of food production systems and market liberalization. In years when crop prices are high, farmers who provide commodities to markets will be under pressure to ensure they have a good crop in terms of quality and quantity. However, they will have to make decisions about the use of fertilisers and pest control inputs before they have information on pertinent market prices. As a result, companies will be more inclined than ever to employ inputs as insurance, but they will also want to keep the cost of this insurance as low as possible, which can drive them to utilize older, non-patent, and perhaps more ecologically harmful technologies. The use of new technology is more likely than any other presently available alternative to be more acceptable to these farmers and to have a greater and faster effect on the sustainability of European agricultural systems. Based on public and unpublished data, as well as interviews with government representatives and business executives, the article offers some of the findings from the PITA project, addressing advancements in pesticides, biotechnology, and seeds. The information from each report that was chosen for this article was that which was most pertinent to the subject at hand. The opinions presented in the analysis are those of the author and may not necessarily represent those of the other project participants. This section covers the following topics: the regulatory environment in which companies creating new agricultural technology must operate; the influence of this regulatory environment on the strategic choices made by the companies involved; and the difficulties that may arise for regulators looking to promote innovation and the adoption of cleaner technology on farmed land.

Policy cues for business and agriculture

Governments may affect the creation and use of technology for sustainable agricultural systems, as suggested by the section's title. Technology development by companies will be influenced by a number of factors, such as: regulatory and approval systems for new products entering the market, such as pesticides and GM crops; the clarity and certainty of these systems; the ease with which companies can meet them; restrictions on the use of some products deemed to be harmful to the environment or to health; and policies to encourage technological innovation and, consequently, international competitiveness. Farmers' adoption of new technology will depend on a variety of factors, such as: the availability of subsidies and other production-related supports; the support for organic farming and allied agricultural systems; and the farmer's capacity to turn a profit at global market pricing. Our research has shown that the policy environment is sending conflicting or confusing signals to the businesses developing the technology and the farmers who might use it, even though there are opportunities to improve the sustainability of conventional farming systems through the adoption of new technology. Reforms to the CAP made in accordance with WTO regulations have changed the justification for agricultural support from the promotion of food production and technological innovation to rural development in underdeveloped areas and specific environmental goals like the preservation of species and habitats.

The overall policy trend moves farmers away from technology-based, conventional agricultural systems and toward organic and related integrated systems, which are shown on the right side of Box 1. It is more challenging to concentrate on encouraging sustainability via the development and application of new technologies when arguments about the need to maintain or enhance food production do not now hold much weight in policy circles. Most agricultural policy measures seem to be based on the idea that food surpluses would remain a burden rather than an advantage for the foreseeable future. However, more dramatic short-term temperature changes or longer-term climate change that hampered food production in crucial growing regions, resulting in shortages in certain years and pressure to boost output, might reverse this perspective. In addition to the need to produce food for a growing global population for the foreseeable future, we could also see increased pressure on agricultural land for non-agricultural uses such as the production of fiber, commodity chemicals for feedstock for industry, high value-added chemicals and vaccines for the pharmaceutical industry, or renewable fuels to provide "carbon credits" under the Kyoto Protocol. In the case of any of these conceivable situations, a legislative strategy that provides for the choice to boost food production without increasing environmental impact would be more resilient and preventative.

This suggests the need for a legislative climate that promotes technical innovation while also fostering the global competitiveness of our increasingly productive agricultural systems. The PITA project's first phase looked at the policy landscape concerning the development of pesticides and GM crops in a number of European nations as well as at the EU level. In order to increase the sustainability of agricultural systems, it concentrated on policies that might have a variety of direct and indirect effects on innovation at the corporate level and the adoption of new technologies at the farm level: Policies promoting environmental protection and biodiversity, regulating the environmental effects of farming systems, directly promoting sustainability and biodiversity, regulating pesticides and GM crops, and policies supporting farm support and CAP reform are just a few examples of the policies that could directly affect research and development (R&D) and industrial decision-making. Policies relating to science, technology, and innovation. The majority of European nations see biotechnology as a rapidly developing field of technology that requires government assistance to promote a quicker transfer of knowledge from the lab to the marketplace and maintain Europe's competitiveness in the global economy. Contrary to the agricultural biotechnology business, which is seen as publicly divisive and generally depressed, the considerably larger investment in pharmaceutical biotechnology reflects the greater profit potential of that market. The agrochemical sector as a whole is not seen to need subsidies to foster innovation, while being crucial to the overall competitiveness of European industry in global markets.

The UK is emphasized as having significant opportunities in the field of biotechnology to establish a leading international profile, in part due to the UK's robust pharmaceutical and agrochemical industries and in part due to the strength of the biological sciences in UK universities and public sector research institutions (PSREs). Government programs, including Foresight and the LINK Programme, stimulate innovation in the agricultural biotechnology and seeds businesses. To detect trends and opportunities and to direct research supporting the future development of UK business, foresight brings together individuals from industry, public organizations, academia, and government. Maintaining a robust publically financed research basis is seen to guarantee the UK's continuing appeal as a site for multinational corporations and to support homegrown small businesses. In order to compete in the global market, the first round of foresight advised that EU agriculture should concentrate on high value goods rather than bulk commodities and should create innovative techniques to boost production in ways that are politically and socially acceptable.

Along with the prior focus on competition, the new round also contains socially interconnected issues like sustainable development. According to the Office of Science and Technology, trade liberalization will further drive down EU food prices while biotechnology (among other technologies) will increase the efficiency of grain production. Additionally, as Asian countries import grain to produce meat, the EU countries may find an export opportunity. These predictions were made in response to the Office of Science and Technology's analysis of the effects of global political and technological changes. A subsequent assessment raised concerns about the viability of such rivalry among EU nations, and technical advancements were regarded as being secondary to EU policies that can win over the public. High value goods, not bulk commodities, are seen to have the potential for global competitiveness, with agricultural futures being driven by socio-environmental objectives. Technology is seen as being crucial for the development of both better farming practices and the exploitation of new markets. Agriculture will need to make the resources it purchases more productive using ways that have the support of both the political and social arenas.

This chapter has provided an overview of one area of the present legislative and policy landscape where innovative methods for the creation of agricultural technology are developing. It only covers a small portion of a very broad region, but some key elements are already starting to become apparent. There are governmental and regulatory measures that may have a significant and quick impact on the innovation processes pertinent to sustainable agricultural systems, but they are rare, and it's possible that their worth and importance are not acknowledged. 79 It is increasingly common to discover that laws and rules passed in one policy area have unanticipated consequences in other areas or are offset by previously unrecognized restrictions. The best way for public arena decision-makers to achieve their goals is to concentrate on creating a policy and regulatory climate that is facilitating rather than constrictive and restrictive. Policy makers need to be more educated and more integrated in order to deal with multinational enterprises, internationally coordinated environmental and other public pressure organizations, and quick information flows utilizing the internet. This will include creating new transboundary national and international regulatory frameworks and cultivating a group of policy experts with cutting-edge, multidisciplinary knowledge.

Adoption behavior theory

On the economic theory of technology adoption, there is a wealth of literature. The development of pollution-reducing technologies requires an awareness of the factors that influence acceptance since the location and timing of a technology's deployment will determine how successful it is (Stoneman and David, 1986). In addition to the use of conventional inputs like agricultural fertilizers and chemicals, the adoption of technology for natural resource management and conservation is taken into consideration. Examples include soil conservation, integrated pest management, soil nutrient testing, and irrigation management. The choice to accept new technology marks a substantial change in a farmer's production plan, while choices about how much traditional input to use are made on a seasonal or yearly basis. Adopting new technology is similar to making an investment choice. While the option may have significant upfront fixed costs, the advantages will be seen over time. The initial expenditures can include the cost of investing in new equipment and learning the best methods for using technology on the farm. The non-financial costs of change could seem quite large to a producer. A person's opinion of a new technology is subjective, and it may evolve when a farmer learns more about it via the media, the extension agency, or neighbors who have already embraced it. When a new technology first becomes available, there is sometimes a lot of ambiguity about how well it will work in a given environment.

Before the technology works successfully in the local manufacturing context, significant customization may be required. The risk and expense associated with adoption decrease over time when certain local farmers use the new technology and acquire expertise. If they find that the technology simply does not perform well given their resource constraints, or if the scale or nature of their farm operation is incompatible with the technology in issue, some farmers may decide not to implement it at all. A new innovation or technology will alter the marginal rate of input substitution in a manufacturing process. Some modifications could seem significant to a prospective adopter. Early adoption studies were predicated on the idea that people were reluctant to change and that this resistance needed to be overcome. However, the distinction between a producer who is unable to adopt and one who is reluctant to adopt is clear. To put it another way, nonadopters can be divided into two categories: (1) those for whom adopting a new technology would not be more profitable than continuing with their current practices, and (2) those for whom adopting a new technology would be more profitable but who decide against doing so due to other obstacles. For these two populations, distinct adoption-promoting policies would need to be developed. The current economic theory of adoption is predicated on the idea that a prospective adopter would choose based on how to maximize predicted utility while taking into account pricing, regulations, individual traits, and natural resource assets.

A certain technological decision is taken, which results in a degree of input utilization and profit. Producers would not be required to take into account advantages that flow mostly outside of the farm when deciding whether or not to implement a conservation technique.

Instead than boosting production on-site, many of the advised methods aim to lessen externalities, or environmental problems that occur off-site. Though the profits are not seen by the farmer who suffers the expenses, the voluntary adoption of preferred technologies may not take place even if the overall benefits of switching to these technologies considerably exceed the costs. Since no two farms or farmers are the same, there will be variations in whether or when a certain technology is implemented. The quality of the land that farmers own and their capacity to comprehend and adopt new ideas will vary. The farmer is aware of these elements and makes an assessment of the anticipated benefits of adoption using this information. The pattern of practice adoption will be determined by the distribution of the underlying diverse elements. The adoption trend might be localized when one of the heterogeneous elements is connected to features of natural resources. Understanding how farmers choose their production methods can help policymakers enhance water quality or other environmental assets by encouraging the use of conservation technology and sustainable management techniques. The Area Studies Project was created with the purpose of characterizing the level of adoption of techniques for managing nutrients, pests, soil, and water as well as evaluating the variables that influence adoption for a variety of management methods across various natural resource areas.

CONCLUSION

From the perspective of the industry, European biotechnology legislation was considered as possibly having a significant influence on the R&D strategy of businesses, especially those with their primary R&D facilities in Europe. Although the regulatory uncertainty may force businesses to go elsewhere, it is unlikely to have an impact on business decisions in international markets where GM crops are still seen as having huge promise for improving the sustainability of agricultural systems. Just a few instances would be: "Low phytate" animal feeds and feeds adapted to the nutritional requirements of various species would lessen the environmental impact of animal husbandry systems; GM insect and disease resistant crops would lessen, but not completely eliminate, the need for pesticide applications; and if fewer pesticides are used, the number of chemical factories (with associated point source pollution issues and worker health risks) can be decreased, as well as the wastage of fossil fuels. Industry experts believe that GM crops might have a far bigger and faster effect on pesticide consumption rates in agriculture than any legislative or regulatory action that could ever be considered. However, there is a growing agreement among policymakers that the introduction of GM crops was done too quickly and possibly didn't pay enough attention to the need for public choice as well as public confidence (based on readily accessible proof of safety) (based on clear labelling). To provide governments a state-of-the-art evaluation of scientific knowledge and to place it in the perspective of society's larger concern, a worldwide forum modeled after the Intergovernmental Panel on Climate Change has been suggested.

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CHAPTER 9

MODERN AGRICULTURAL METHODS: A PROGRAM TO BOOST FOOD PRODUCTION

Dr. Pankaj Kumar Tiwari, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- pankaj.ag@sanskriti.edu.in

ABSTRACT:

In India, agriculture provides a livelihood for more than two thirds of the population. Moreover, India's agricultural system was less advanced than it is today prior to 1950, and as a consequence, there was not enough food production to fulfill the demands of the nation's expanding population. The Indian agriculture sector's largest success story as of the end of 1960 was the Green Revolution, which used some modern farming practices. This was the primary reason for the nation's recurrent famines and other food shortages before to the green revolution, but it's the same reason humans are now dealing with the surplus problem. The development of numerous agricultural technologies and techniques, such as organic farming, vertical farming, genetically modified crop plants, precision agriculture (PA), etc., has led to a rise in crop output today. India has been able to fulfill both the current and future demands for food in the world because to this.

KEYWORDS:

Agriculture, Climate Change, Environmental, Genetic, Vertical Farming.

INTRODUCTION

Contrary to industrialized nations, agriculture remains the foundation of our nation and is believed to have contributed to the Indian economy. Since the atmosphere in India varies throughout the year, a wide variety of crops are grown there, with rice and wheat serving as the country's two main staple foods. Additionally, grains, pulses, tubers, oilseeds, sugarcane, and non-edible products including cotton, tea, rubber, coffee, and jute are grown by Indian farmers. Nevertheless, it was noted that diverse abiotic and biotic stress, water scarcity, and the growing world population all pose challenges to the development of these crops. The key to alleviating or resolving the discrepancy between consumer demand and the global food supply, which is anticipated to grow by at least 25% by 2030, is to raise grain output per unit area.

In India, contemporary systems and technology have a wide range of applications. Indian agriculture is gradually changing as a result of the adoption of green revolution technology. The current policy of liberalization and globalization has created new opportunities for farm modernisation. This has an emphasis on increasing agricultural inputs and infrastructure in rural regions as well as producing excess agricultural products for domestic and international markets. By reducing the likelihood of pest, disease, and crop failure, mixed cropping also diversifies the food supply. The amount of food produced by conventional multiple cropping systems is estimated to be between 15% and 20% of the total. Popular traditional agricultural techniques include agroforestry, intercropping, crop rotation, cover crops, traditional organic composting, and integrated crop-animal husbandry. As shown in Figure 1, these conventional methods are recommended as the benchmarks for a climate-smart approach to agriculture.

The idea of using modern agriculture in the latter part of the 20th century was highly effective in supplying the increased need for food caused by the growth in global population. The pressure and incidence of new diseases and pest infestations on agricultural plants, which have an impact on crop productivity, grew as a result of the continuously changing environmental circumstances. Due to the enormous rise in global population and the consequent decrease in the amount of land available for agriculture, it is now imperative to boost agricultural output. The yields of important crops like rice and wheat grew quickly, food prices fell, and the number of people who continuously go without food was modestly decreased by the adoption of modern agricultural technology and systems. The development of new crop varieties utilizing molecular breeding technologies, organic farming practices, the use of genetically modified crops, and the creation of extensive irrigation systems are just a few examples of how new technologies and scientific advancements have contributed to this increase in food production.

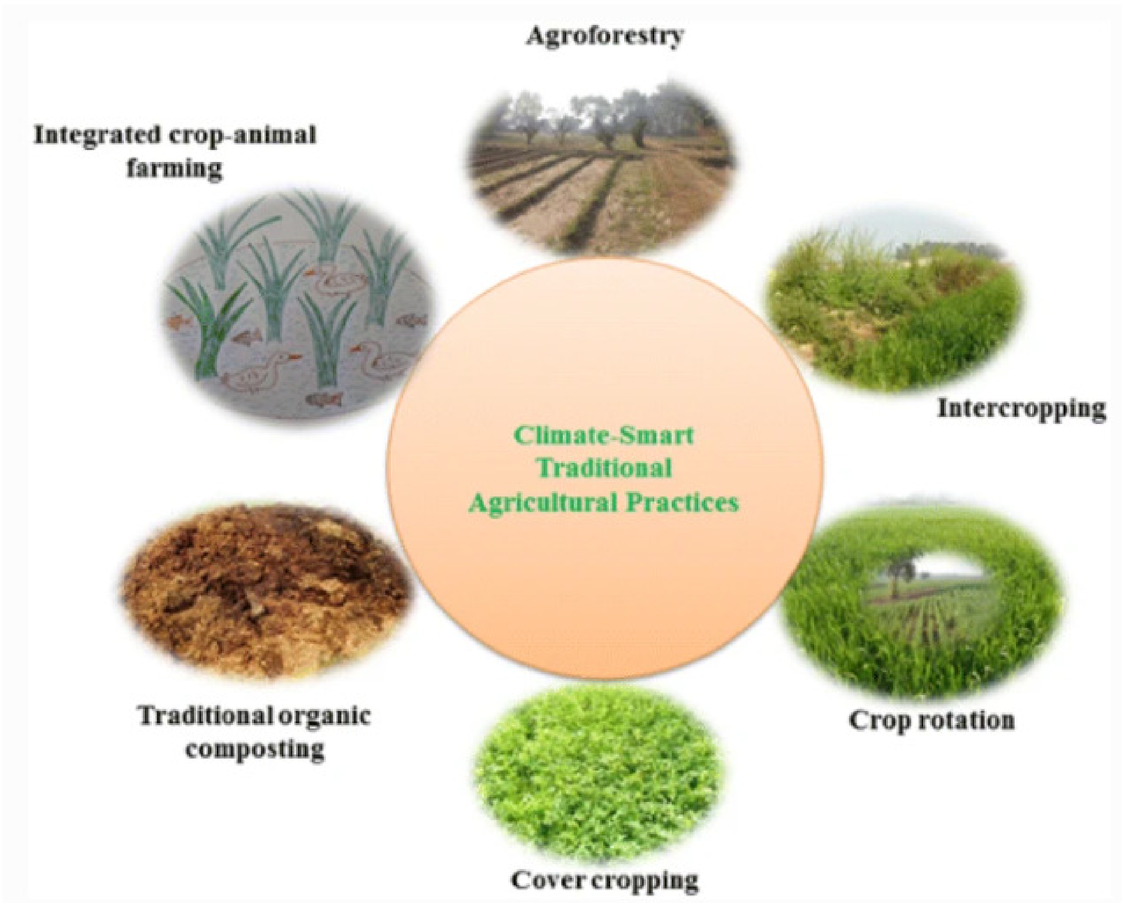

Figure 1: Illustrate the traditional agriculture methods that are climate-smart.

Modern agricultural technologies

When we employed the conventional farming techniques, the crop yield was lost due to a number of issues such climatic variance, biotic and abiotic stress conditions during the peak of the crop, and natural disasters. Although farmers use new methods and systems, their adoption of new technology is sluggish in certain rural regions owing to a lack of farmer understanding. Organic farming, polytonal farming, genetically modified crops, vertical farming, greenhouse farming, developing new applications for satellite-assisted precision agriculture (PA), and multi-crop farming are major emerging approaches that aid in reducing the current and future food demand.

Organic agriculture

Ecological agriculture or biodynamic agriculture are the two terms used to describe organic farming since it coexists with nature, meaning that whatever agricultural techniques are utilized in organic farming do not affect the environment's living creatures. Organic farming is a practical, environmentally beneficial alternative to conventional fertilizer and pesticide-based farming when it comes to increasing crop output. In the contemporary situation, where chemical-based fertilizers and pesticides have been used excessively, there is worry about the environmental toxicity and health risks to the population of people, animals, and soil microflora. This approach is based on methods including the use of resistant varieties, crop rotation, green manure, compost, and the use of biological pest control and fertilizers like Trichoderma and Pseudomonas.

Vertical agriculture

The area under agriculture has shrunk in recent years due to global population growth and urbanization. The conundrum of producing food for an expanding population while maintaining cultivated land is urgently in need of solution. So, the revolutionary idea of vertical farming was introduced to maximize agricultural output while utilizing less area. By understanding the crop's nutritional needs and temperature requirements, the farm employs soilless farming techniques like hydroponics and aeroponics to generate larger yields quicker throughout the growing season. These methods not only use less water, herbicides, and fertilizers to produce the food while increasing the yield by three to five times.

Advances in PA technology

It is anticipated that new technology would be introduced and used by Indian agriculture in order to handle the difficulties of the current competition. By 2050, there will be a tremendous need for 480 million tonnes (Mt) of food grains, which will be met thanks to advancements in IT and space technology (thanks to ISRO, the Indian Space Research Organization). The several satellite constellations that make up the positioning system are what make it operate. The technologies used were crop sensors, GPS, GIS, and variable rate input application.

Crop plant genetic engineering

As a result of modern agriculture's use of a variety of molecular breeding techniques and biotechnological tools, crop yield has recently grown. Using marker aided selection (MAS), QTL mapping, and gene pyramiding technologies, the hybrid varieties tolerance to various biotic and abiotic challenges was generated in a number of significant crops. Compared to traditional breeding procedures, these strategies aid in the early introduction of varieties and provide more precise ways.

In vitro settings are used to create genetically modified (GM) crops by changing the genetic structure of a host organism. This is often accomplished by the transfer of one or more genes or the change of a chosen plant's genome utilizing different gene-manipulation techniques. Bt (Bacillus thuringiensis) cotton with the genes Cry1Ac and Cry2Ab is the most well-known and popular example of a GM crop in India. There are now several GM crops that are resistant to both biotic and abiotic stress, reducing the need for chemical pesticides and fertilizers and reducing environmental pollution. Additionally, GM plants have been created and used to the bioremediation of contaminated soils. Heavy metals including mercury, selenium, and organic pollutants have been removed using GM plants that include genes of interest that create bacterial hydrolytic enzymes used in bioremediation.

Many of the pressing concerns of today are not new, but they have become more significant, have changed how they are portrayed, or have gained new recognition. Therefore, although some of the already employed conventional indicators are still useful, others need revision or new development. Major users and partners were contacted as part of the independent evaluation of the FAO statistics program to get their opinions on any new data requirements. The report's main finding was that the challenges identified by stakeholders, including national statistics centers, nonprofit and donor organizations, academic institutions, and a range of other users, overlapped significantly. Indicators on prices, energy and biofuels, agricultural environments, climate change, trade, water, land, and soils, household consumption, food security, socioeconomic data, economic accounts, management of natural disasters, and financials were all in need of new and improved measures, according to a number of users. Users emphasized the need for enhanced integration, more open and searchable databases, and high expectations for geospatial and remote sensing data. The most important problems are interconnected, and many of the data are required for many indicators. The Strategy aims to define relevant indicators and offer supporting data while also capturing the interrelationships of these emergent concerns. This highlights a serious issue with the agricultural and rural statistics as they stand now. Since many of the topics have only been studied in isolation, it is impossible to do the crucial cross-cutting analysis.

Agriculture is basically an economic activity since it produces food and other commodities, but there is growing awareness about how it relates to environmental and social concerns. The links between agriculture, the environment, and social concerns must be taken into account in a wider framework where they are no longer viewed as separate fields of study. Through laws, rules, taxes, and infrastructure like roads, schools, marketplaces, and processing facilities, institutions and businesses have an impact on all three. The institutional framework's significance is applicable at the local, national, or international levels. Due to the globalization of markets and the fact that some of the most significant concerns, such as global warming and other aspects of poverty reduction, transcend national or regional borders, the international level merits discussion. Many of the businesses participating in this larger picture don't really produce any food, but they do provide services that link production with markets and customers. The land, labor, or capital used in production as well as the products that come as a consequence make up agriculture's economic component. Many different products are produced throughout the manufacturing process. Others are utilized for home consumption, some are saved for use as feed or seed on the farm, and yet others join supply lines that lead to markets. Some of the goods need to be processed.

The agricultural industry's use of natural resources, primarily land and water, as well as its function as a supplier of environmental services, make up the environmental component of the industry. Its effects include those related to manufacturing waste and emission byproducts, in addition to the direct use of natural resources in production. The state of the resources that agriculture consumes may have a significant impact on climate change and biodiversity. Informed examination of the relationships between agriculture's functions in the economy and the environment is necessary because of the recognition of the detrimental and possibly good effects that agriculture has on local, regional, and global ecosystems.

The sector-specific data collection methods and surveys used by the present statistics systems, both in industrialized and developing nations, have several drawbacks. There is no way to gauge the effects of a decision made in one area on another due to the data's sectoral separation.

Ad-hoc surveys are often carried out without reference to a master sample frame or the use of georeferenced units for data collecting. As a result, it is challenging to cross-tabulate variables and analyze data from numerous surveys in-depth. Data on agricultural and livestock production are derived from independent surveys with distinct samples. There is no foundation in the separate data to analyze the characteristics of farms that raise both crops and animals or to contrast them with farms that only raise one kind of livestock. There is often no coordination between household and production surveys, or the sample sizes are too small to allow for the division of the data into the farm and rural sectors. Additionally, these polls' findings are not connected into a single database that data users may access. The gathering and analysis of agricultural, fisheries, and forestry data is often done by many governmental organizations without cooperation.

The annual production data could come from the ministry of agriculture, while the National Statistical Office might produce the agricultural census. The contribution of the fisheries and aquaculture sectors could come from another authority and might be disregarded or overlooked by the National Statistical Office. In certain circumstances, many organizations provide statistics for the same things with disparate outcomes, confusing data users and making it difficult to combine findings across national boundaries. This implies that if such organizations employ various sources to fill their data bases, the outcomes will likewise vary on a global scale. By minimizing duplication of effort, limiting the publication of contradictory information, and guaranteeing the optimum use of resources, integrated statistical systems may alleviate many of these issues. Standardized concepts, definitions, and classifications make it possible to gather data from many sources more methodically. The necessity for integrated national statistics systems is shown by these practical benefits of integrated data systems as well as the growing need for trustworthy and comparable data in the context of globalization and worldwide concern over environmental concerns. Strong arguments are made in favor of the creation of such integrated systems by the World Program for the Census of Agriculture.

LITERATURE REVIEW

Diana Duff Burke et al. [1] studied the effects of a rural agricultural value chain initiative on smallholder farmers, their families, and kids in Liberia in order to better comprehend the relationship between family economic welfare and kid wellbeing. They evaluate the causal influence of the project on the usage of modern agricultural methods and productivity, family assets and food security, and child education, health, and nutrition using longitudinal field-based quasi-experimental survey data. Multiple rounds of farmer focus groups, key informant interviews with local leaders, and project monitoring farmer diaries are examples of mixed-methods. While no significant changes were found for children, treatment children's outcomes for the outcomes of interest showed a positive trend. Treatment farmers demonstrated increased use of modern farming techniques and improved production, households had greater access to food, and despite no significant changes being found for children. Although the study reveals that involvement in agricultural value chain interventions helps to enhance farm results and social assets, improving children's lives alone via economically oriented activities is not enough.

Chaudhari et al. [2] studied Nowadays, everyone is used to using mobile gadgets. Comprising farmers and residents of rural areas. Mobile technology is essential to both farmers' and other people's everyday lives. Farmers who formerly relied on clouds for rain are now turning to cloud computing for ways to cultivate better crops in the contemporary agricultural sector. It's unusual that farmers in India utilize sluggish but comprehensible conventional ways. The tools given for farming as well as other information technologies have not yet made their way into the mainstream of agricultural management, despite the fact that most people can see the advantages of adopting more sophisticated approaches to manage crops with more information.

Ontiri et al. [3] studied Using current technology in advanced farming, particularly on a broad scale, may help a nation achieve food security. In this research, the potential for automation, mechatronics, and contemporary agricultural technologies are examined for Kenya's sustainable agriculture. The application of mechatronics and automation in different smart agricultural technology systems is proposed as a means of technological diversification. With the aid of these contemporary agricultural methods and other related technology, food security in Kenya may advance in terms of development. The benefits of these developments include improved monitoring, surveillance, and tracking on the farm as well as a notable improvement in productivity, effectiveness, and revenues. The influence of these technologies on agriculture is then examined in connection to sustainable food security, and it is shown that mechatronic farm automation linked with mobile apps may improve farm monitoring, enhance yields, and help to better use land.

Faye, Jean B. [4] studied about The Serer people of Senegambia's traditional agricultural and cultural systems, which have been in place for many generations, have produced one of the greatest population densities in the pre-colonial Sahel by ensuring soil fertility, tree preservation, crop rotation, mixed farming, or herding. In the 20th century, serer agricultural methods evolved to creatively incorporate numerous traditional traditions with some contemporary approaches as population swelled, soil fertility decreased, and climate change brought frequent droughts. It is evident that the serer hybrid agricultural method, was first developed in the late 1960s, is more productive than contemporary or indigenous practices used in their purest form.

Beckmann et al. [5] studied about It used factor analysis as a technique to isolate the variables and tier micro-regions in accordance with the degree of modernization. For the majority of micro-regions, the factor related to modern cultivation techniques was the least effective. The country's new agricultural frontier justifies the low degree of modernity that was shown in most areas by the recent establishment of agriculture there. This level of modernization may still be increased, with technical distribution concentrated on certain locations. The findings of this research help in taking activities that are appropriate for each micro region's present context by allowing verification of the advantages and disadvantages of agricultural modernization.

E. Karamagi and M. Nakirya, [6] studied using current technology in advanced farming, particularly on a broad scale, may help a nation achieve food security. In this research, the potential for automation, mechatronics, and contemporary agricultural technologies are examined for Kenya's sustainable agriculture. The application of mechatronics or automation in different smart agricultural technology systems is proposed as a means of technological diversification. With the help of these contemporary agricultural methods and other related technology, food security in Kenya may advance in terms of development.

Amadi et al. [7] studied this research makes an effort to assess how new rural roads affect agricultural growth. Data for this research were gathered across two time periods: one before the roads were built and the other three years thereafter. The quick growth in market prices for agricultural products, the expansion of farm sizes, and the growing use of modern farming practices are all effects of the road development. Additional effects were discovered on the growth of various infrastructure components, including agroindustries, piped water, and electricity. These facilities generate job possibilities in the communities and additional forward and backward connections for agricultural growth there.

Tenagyei et al. [8] studied Indigenous agricultural land management techniques have the capacity to maintain soil fertility and balance the nutritional needs of crops. However, the research has not completely addressed the significance of indigenous agricultural management techniques and their resulting consequences on food production. In semi-arid regions of Ghana, this research examines how rural farmers view the efficacy of traditional agricultural management techniques. To gather primary data for the research, the agriculture sector's stakeholders and farming families were scheduled for interviews utilizing quantitative approaches. Three stakeholders an agricultural extension officer, a representative of a farmer-based organization, and an official of a non-governmental organization.

Messmer, M. [9] Studied the dossier, historic, modern, and nearly-ready-for-use plant breeding techniques are discussed, along with assessments of how well-suited they are to organic farming. The review of the techniques is concluded by a position paper from a professional workshop on ecological plant breeding in compliance with organic farming standards. The dossier provides decision-makers and experts in organic farming with the facts and benchmarks required for a fair and transparent assessment of plant breeding methods.

Pudumalar et al. [10] studied Data mining is the process of looking through data and extracting useful information from it. Data mining is used in a variety of industries, including banking, retail, medical, and agriculture. In order to analyze the many biotic and abiotic components, data mining is employed in agriculture. India's economy and jobs are heavily reliant on agriculture. The primary issue facing Indian farmers is that they often fail to choose the appropriate crop for their land. They thus see a significant decline in production. Precision agriculture has been used to solve this issue for farmers. Precision agriculture is a cutting-edge farming method that makes use of research data on soil types, features, and crop yields to recommend the best crop to farmers based on site-specific factors. This increases production and decreases crop selection errors.

DISCUSSION

The Cambodian economy's most significant sector is agriculture. Nearly 80% of the population is employed by it, which contributed 36% of the nation's GDP in 2012. However, more than 34% of Cambodian children are underweight, while 70% of farmers practice subsistence farming. Despite winning the World's Best Rice title for the second year in a row for Cambodian jasmine rice at the 2013 World Rice Traders Conference in Hong Kong, much of the industry's potential is yet unrealized.

The restricted application of contemporary agricultural technology, equipment, and inputs is one of the main obstacles to increasing production and profitability. For instance, despite the availability of efficient irrigation technology, paddy rice production in Cambodia still relies primarily on vulnerable rain-fed systems. The employment of contemporary equipment may also increase the effectiveness of harvests and contribute to the quicker and better-quality delivery of products to markets. And last, modern agricultural inputs like fertilizers, agrochemicals, and seeds may significantly lower losses. I just learned that weeds, pests, and diseases cause up to 40% of the world's potential agricultural yield to be lost each year.

These options are reachable via Cambodia. By utilizing satellite mapping and computers to tailor seed, fertilizer, and crop protection sprays to local soil conditions, "precision farming," a revolutionary method that increases crop yields and decreases waste, may pay for itself. This is farming in the twenty-first century, and all farmers, not just those in the US, may use this technology. As we've seen in the United States, where one-third of farm acres are grown for export, resulting in over $140 billion in U.S. agricultural exports in 2013, precision farming likewise provides more export potential. Furthermore, not all contemporary farming is corporate farming; in fact, 97% of farms in the United States are still run by individuals, family partnerships, or family organizations.

So how it is that Cambodia can ride the buffalo through the muck? Farmers in Cambodia may boost production, efficiency, and profitability as well as decrease malnutrition and improve food security by employing proven modern agricultural methods and science-based solutions, which are easily accessible there. Additionally, these methods pay for themselves. Because of the increasing production, even small landowners can now afford many of the necessary inputs. Farmers have the choice to combine their resources to share ownership of more costly equipment.

Additionally, the United States offers scientific advice and support to Cambodian manufacturers. As part of the Feed the Future initiative of the US government, USAID is helping Cambodian farmers diversify their incomes through the use of various crops and seasonal rotations as well as by enlisting the help of the private sector to provide services and agricultural inputs like fertilizer and farming equipment. Numerous small-scale rice farmers have seen an improvement in production and revenue as a result of USAID projects during the last three years.

Additionally, USAID funds the International Rice Research Institute's global research, which contributes to the creation of novel rice cultivars and crop management strategies that will increase global production and sustainability. The agriculture industry is developing into a sustainable business model based on contemporary technology thanks to all of these initiatives.

Agriculture in India: Techniques of the Farmer

Agriculture is the oldest industry in India, and it has historically provided the majority of farmers' income. India's agricultural practices have altered throughout time as a result of technological advancements that have made farmers' life easier. Climate, sociocultural norms, and other factors have also influenced the innovation in Indian agriculture. In India nowadays, both conventional agricultural practices and contemporary farming are used. Check out some of India's traditional and contemporary agricultural methods. One of India's oldest practices, primitive farming is carried out on tiny farms with the use of conventional implements like a hoe and digging sticks. For the harvest, farmers rely on the fertility of the land, the environment, and other elements like heat. Those that utilize the output for personal use are more likely to choose this strategy.

When using this kind of farming, which is also known as "Slash and Burn," farmers burn the area after the crops have been collected. Wet and dry crops are grown as part of subsistence farming on broad, more expansive land regions. Paddy is a kind of wet crop, whilst wheat, maize, and pulses are dry crops. This approach necessitates the substantial use of chemical fertilizers and various irrigation techniques. Commercial farming is a contemporary agricultural strategy in which farmers employ a range of cutting-edge instruments to generate extra income.

Due of the crops' extensive area coverage, fertilizers and insecticides are also employed. It significantly raises the GDP of the nation. Orissan farmers continue to choose subsistence farming for high yields whereas farmers in Haryana, Punjab, and West Bengal use commercial agricultural methods. Another division of commercial farming is plantation farming. As plantations cover vast areas of land, it uses both manpower and technology to guarantee that the process is sustainable. Because of the kind of crops farmed, it comprises both agricultural and industrial.

India's Modern Farming Techniques

There are more agricultural practices used in various parts of India than those that were previously listed. Many of these are not produced using Indian conventional agricultural techniques. This comprises:

Airborne System

Without using soil, plants are grown in an atmosphere of mist or air using a technique called aeroponics. It is a branch of hydroponics that relies on suspending the plant root in the air to function. This technology will give farmers more control over how much water they consume.

Aquaponics

A closed-loop system called aquaponics heavily depends on the mutually beneficial link between aquaculture or agriculture for fertilization. This agricultural technique combines hydroponics with traditional aquaculture.

Hydroponics

A less-dirt-intensive way of farming, hydroponics doesn't need any kind of soil. The procedure entails employing nutrients, such as mineral-rich water solution, to produce healthy plants without the need of solid media. A subset of hydroculture is hydroponic farming, and the nutrients utilized in hydroponic farming systems come from several sources.

Monoculture

This technique involves cultivating a single crop in a particular agricultural region. However, the monoculture farming method is not often used in a nation like India. Monoculture includes activities like cultivating therapeutic herbs inside. Monoculture, simply said, is a kind of contemporary agriculture where just one type of plant or product is produced.

CONCLUSION

India's economy is built on agriculture, which contributed more to GDP. Since many years ago and until now, farmers in India use contemporary agricultural methods and practices to increase crop productivity. The ever-increasing need for food today, however, makes conventional farming methods less effective economically. This is because these methods of farming have a number of problems, such as managing diseases and pests. It is essential to switch from conventional to contemporary farming methods. Utilizing innovative, cutting-edge methods increases agricultural output while using less land, all while maintaining environmental health. The biotechnology and information technology revolutions are taking place in this century. Therefore, a crucial strategy to battle the future food supply is to employ GM and molecular breeding technologies to increase the types of important crops, as well as organic farming, PA, or vertical farming.

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CHAPTER 10

VARIOUS STRATEGY FOR IMPROVING AGRICULTURAL PRODUCTS

Dr. Kaushal Kishor, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- kaushal.ag@sanskriti.edu.in

ABSTRACT:

The development of agricultural institutions via both organizations that support agriculture and others that do not. Additionally, financial support was given via banks, cooperatives, and unofficial credit organizations to carry out institutional changes. In order to maintain agricultural productivity, agricultural systems are continually improved by pushing for the change of land uses. To help farmers produce swiftly and effectively, the government also promotes the use of agricultural technology. The government has pursued marketing of agricultural goods in a variety of methods, including controlling product quality, establishing marketing networks, and creating technology-based agribusiness marketing systems to expedite the selling of agricultural goods.

KEYWORDS:

Agriculture, Agribusiness, Climate change, Innovation, Management, Vertical Crop Growing.

INTRODUCTION

Agricultural production is a broad notion with implications for the whole world, but effective on-farm management is where it all begins. The productivity and efficiency of the world's food production systems will have a big influence on how well we'll be off in the future. High agricultural productivity promotes economic development, food security, and the preservation of finite natural resources like land and water. It also assures that food is both plentiful and inexpensive. This is particularly important given that our present food production methods will be put to the test by rising population levels and the extremes of climate change. But although increasing agricultural production has global, far-reaching effects, increasing agricultural efficiency has always been and always will be done at the farm level by leveraging technical innovation to support effective farm management.

There are several ways to assess productivity. A single farm, a cooperative of many farms, a region, a nation, or even the whole planet's production systems may all be evaluated based on their agricultural output. A national indicator of agricultural productivity growth is the ratio of agricultural exports to imports. A government that can maintain a greater level of agricultural exports supports a stronger pace of economic expansion, improves its worldwide competitiveness, and keeps its population's food costs more stable.

History of Agriculture Productivity and Innovation

Throughout history, significant occurrences have increased agricultural output and efficiency, with far-reaching effects. Early communities were able to plan and control their crops because to the early technical breakthrough of artificial irrigation in ancient Mesopotamia. John Deere's 1837 development of the steel plow revolutionized farming by enabling farmers to swiftly convert lush grassland sod into crops.

The most recent period of significant growth in agricultural productivity was the "Green Revolution" of the 1960s and 1970s. During this time, farmers were able to increase their production rates significantly, supplying the world's expanding population with food while using fewer resources such as land, labor, and other resources thanks to the use of chemical fertilizers, pesticides, and plant breeding.

Due to their already high levels of agricultural production, farmers in industrialized nations have seen a slower growth rate in their productivity in recent years. Simply expressed, it is challenging to increase the existing high agricultural production rates in nations like the United States and the United Kingdom since farmers there already farm using extremely efficient methods. However, at the same time, farmers in developing nations like Asia, where agricultural productivity rates are already relatively low due to a slower adoption of new technologies, are experiencing slowdowns in growth of their productivity rates, primarily as a result of the negative effects of greenhouse gases causing climate change and weather extremes. According to a Cornell University research published in 2021, the slowdown in agricultural production caused by climate change has destroyed nearly seven years' worth of agricultural output increase during the previous 60 years. Additionally, according to the United States Department of Agriculture (USDA), agricultural productivity growth slowed between 2011 and 2019 compared to prior years. This means that the world is considering the possibility of a decline in agricultural output at a time when there is a greater demand for food.

Various farming supplies are gathered, stored, prepared, shipped, and delivered throughout the nation as part of the agricultural marketing process. In agriculture marketing, the sale of an agricultural product is dependent on a number of factors, including the current product demand, storage capacity, etc. Before India gained independence, farmers who sold their goods to dealers encountered widespread inaccurate weighing and account manipulation. The farmers were obliged to sell at cheap prices because they lacked the necessary knowledge regarding pricing and storage facilities. The produce may sometimes be offered for sale at a weekly village market in the farmer's hamlet or a nearby community. If none of these stores are open, the goods is then sold in the mandi or in impromptu marketplaces in a nearby hamlet or town. Therefore, the government implemented a number of steps to regulate the merchants' activity.

Agriculture Productivity Measurement

It is more difficult to determine genuine productivity and agricultural growth in food production at the business level than to track yield gains or choose the crops that are best suited for a certain area. Most farms and agricultural enterprises use several inputs to create a variety of goods. These crop production systems frequently complement one another in a whole-farm ecosystem, for example, by planting corn after soybeans to break up disease cycles and reduce the demand for nutrients on the health of the soil or by grazing animals through harvested crops to add manure and lower harvest residue.

Measuring farm efficiency is made more challenging by the fact that most agricultural operations, whether smallholder farms or huge agribusinesses, experience these kinds of operational complexity. Based on climate, soil types, and other factors, various locations and individual farms may achieve differing levels of agricultural output. Additionally, farmers and cooperative farm enterprises must constantly be aware of the economics of the market for their level of output. Without major inputs, a product that grows well but sells for a low price due to limited demand or fierce competition could not be profitable. On the other hand, if the farm can raise its efficiency measures thanks to modern technology, it may actually see a boost in its financial situation.

Measurement Instruments for the Agricultural Sector

Factor Productivity as a Whole (TFP)

A comparison between agricultural inputs and a measure of outputs. TFP compares the entire agricultural production to the sum of the resources used to produce that output, including the land, labor, capital, and material resources like fertilizer, chemicals, and seeds. The total factor productivity (TFP) of a farm or farm company is expanding if the total output is growing more quickly than the total inputs required to create it.

Productivity in Yield

A crop or variety's maximum yield performance per hectare or other measure of land area. Increasing agricultural productivity requires an understanding of the various crop yield productivity potentials per crop or variety. When a farm is technically efficient, it is producing as much as is possible given the technology it has access to. Inputs including soil quality, labor availability, variable costs, capital expenditures, even the farmer's age and education may be taken into account as possible technical efficiency considerations when discussing technology. TE is essentially an assessment of how well a farm manages its operations given the inputs at hand.

Frontier Production

The farm's highest practicable output potential, depending on its particular conditions and inputs, is represented by the production frontier. It represents the pinnacle of optimal management techniques that a particular farm might aspire to. For instance, rice yields in sub-Saharan Africa are unlikely to match those seen in Asia due to the region's more conducive environment, which is typically dry and arid.

Increasing Agricultural Productivity: Farmers may increase their agricultural production in a variety of ways. Strategies consist of:

Methods for precision farming

Based on soil types and other data inputs, technology such as variable-rate seeding and fertilization enables farmers to automatically seed and apply nutrients at the exact quantity needed at the precise area to achieve the greatest yields for necessary inputs.

Healthy Soil Practices

Adopting soil-building techniques, such as cover cropping, to enhance the natural fertility and water-holding capacity of the soil in order to promote high yields and crop quality

Superior Seed Stock: Strong seeds, seeds adapted to a particular environment, or animals with the right genetics for a farm's particular needs may all assist enhance yields.

Automation and mechanization

Automation and mechanization increase productivity while lowering expenses and the demand for manpower. Using the appropriate source, rate, timing, and location to facilitate effective nutrition control.

Agricultural Systems

By putting up a low-energy, labor-intensive, and water-efficient irrigation system, expenditures may be reduced and yields can improve. Implementing integrated pest management (IPM) strategies to prevent, detect, and contain pest and disease outbreaks as they develop.

Analytics of Data: Using farm software management to gather data and analyze it to guide in-season, real-time production choices.

LITERATURE REVIEW

Kerimova et al. studied [1] the primary economic metrics used to gauge Kazakhstan's degree of food security during the course of its independence. The results of the investigation showed that the nation is heavily reliant on food imports for the majority of its needs. Although the Republic of Kazakhstan has made considerable advancements in the development of its agro-industrial complex since gaining independence, the degree of agricultural goods' competitiveness is still low. The fragmentation of economic units, the industry's technical and technological backwardness, the inadequate level of agricultural goods' conformity with contemporary quality requirements, and the poor profitability of agricultural output are the author's key limiting factors.

Wei, Wang [2] studied One of the most important elements to improve the industrial value chain is the technology agglomeration effect, which is the economic impact caused by the geographical concentration of industry and economic activity. China's agricultural market has been rapidly opening up in recent years, accelerating the marketization and commercialization of agricultural goods. The value chain of the agricultural product business is, nevertheless, experiencing several difficulties as a result of the escalating rivalry in the Chinese agricultural market. Upstream and downstream issues are both confronted by the value chain of the agricultural products sector. The need to increase output and resource scarcity are in the upstream, whereas food chain loss, consumption shifting toward pulses and fruits and vegetables, and a lack of transparency but traceability are in the downstream.

Xu Shu et al. [3] studied Agricultural product quality issues can arise during both manufacturing and distribution. As a result, the Internet of Things-based agricultural product supply chain is becoming ever more populous. The study on the perception data fusion of the supply chain for agricultural products in the context of the Internet of things is primarily presented in this article. This is a straightforward study finding based on the Internet of Things technological platform, which assesses the product's present condition in light of customer desire. An information technology system based on the Internet of things is used to convert and optimize the Internet of Things in the circulation of agricultural goods after analysis and comparison to generate a sensory data fusion model suited for the supply chain of agricultural products. According to this article's experimental findings, data fusion technology based on the Internet of Things can track and solve 69.45% of the issue of unidentified agricultural product sources, improve 43% of the supply efficiency of those products, reduce 31.24% of their health issues, and lower prices for those products by 13–20%. 5 million tons of agricultural goods may be saved by increasing logistical efficiency.

Baladina et al. [4] studied The achievement of Indonesia in becoming food self-sufficient was largely unsupported by how simple it was to get food. As a result, national food security has to be strengthened with an eye on accessibility. Increasing the effectiveness of agricultural product marketing is one tactic that may be used. With the help of this method, we will be able to lower marketing margins, raise producer selling prices, and lower consumer buying costs. Additionally, increased marketing effectiveness will enhance the societal availability and accessibility of food. Therefore, the purpose of this research is to evaluate the significance of improving agricultural commodity marketing strategies for enhancing national food security. In this study, the Computable General Equilibrium (CGE) model was utilized to examine NSSE data and the 2008 Annual Input and Output table.

Pawlak et al. [5] studied Increasing food availability and ensuring food security have become critical issues for nations with varying levels of economic development. The agricultural sector plays a critical role in these developments. The purpose of this study is to find connections between the undernourishment index and certain traits that characterize the agriculture sector in designated groups of developing nations. Using Ward's technique, nations were divided into typological categories. The data show that emerging nations with a large agricultural GDP share, unfavorable weather conditions that hamper agricultural productivity, and inadequate infrastructure have the greatest difficulties in sustaining food security. On the basis of study findings, desired and customised solutions for enhancing food security in certain clusters were devised.

Zijiang Bai et al. [6] studied In addition to affecting inhabitants' consumption and health, agricultural product quality and safety also affects agriculture's ability to grow sustainably. It is a popular location with both the populace and the government. In addition to the quick growth of e-commerce and the ongoing rise in consumption among urban and rural populations, agricultural goods' high standards for quality and safety come with new hazards and undiscovered threats. This paper's goal is to investigate the reliability and security of agricultural goods sold online using 5G Internet of Things technology. In order to achieve real-time location, information sharing, and secure circulation in the supply chain of agricultural goods, this article primarily investigates and applies the major technologies of the 5G Internet of Things to create an information system for agricultural product circulation. Studies demonstrate that the 5G Internet of Things can not only provide agricultural producers, sellers, and common consumers with more effective, convenient, as well as accurate product quality and safety information, but it can also increase the efficiency of agricultural products circulation and significantly lower the cost of agricultural products circulation. The 5G Internet of Things' RFID technology is used in this article. The experimental finding indicates that the e-commerce company's sales growth rate is 30%.

Shaoling Zhan et al. [7] For sustainable agricultural development to be possible, agricultural product quality must be improved. Contract farming is one generally accepted strategy that provides guarantees essential for maintaining the continuing operations of vulnerable farmers while allowing manufacturers to control the overall risks and costs of the supply chain. Although power and performance difficulties across organizations have been studied by management experts, few have looked at how they affect contract farming. By investigating the connections between power, supply chain integration, and the qualitative performance of agricultural goods from the viewpoints of farm families and agribusiness enterprises engaged in contract farming, this research adds to the body of knowledge. This research makes a model suggestion and experimentally tests it using survey data from 321 peasant households in China and 78 agricultural firms. The findings demonstrate that various forms of power have various impacts on contract farming. Supply chain integration is particularly strongly and favorably impacted by non-economic power. It has a bigger effect on process coordination than on information exchange. From a binary standpoint, the impact of economic power on supply chain integration is different. Theoretically and practically, these results are helpful for agribusiness and will assist farmers in raising the standard of their main agricultural output and achieving sustainable agricultural growth.

Olanrewaju et al. [8] More efforts are being made to enhance agricultural output and the environment due to the projected rise in global population by 2050. Because of the negative consequences that these chemicals have on the environment and human health, there is an urgent need for chemical-free farming techniques. A significant portion of the soil microbial population consists of actinomycetes. The most prevalent and perhaps most significant species of actinomycetes, Streptomyces, is an excellent source of bioactive substances, antibiotics, or extracellular enzymes. Over time, several genera have shown considerable promise for advancing agriculture. Through its biocontrol and plant growth-promoting capabilities, Streptomyces is highlighted and supported in this study for its relevance in agriculture.

Harpreet Sharma et al. [9] studied Farming contamination is a result of modern agricultural methods. Due to the current agricultural byproducts, this process may result in the destruction of eco-systems, land, and the environment. Agriculture is further harmed by the extensive use of pesticides, chemical fertilizers, and polluted irrigation water. As a result, the agricultural and food sector's present situation is no longer viable. By adding useful applications to traditional agricultural techniques and practices, nanotechnology has opened up new, creative vistas for the agriculture industry. There is a good chance that agri-nanotechnology will significantly affect crop growth and sustainable agriculture. Recent studies have shown how nanotechnology has the ability to improve the efficiency of agricultural inputs and provide answers to agricultural issues to increase food output and security. The potential use of nanoscale agrochemicals in agriculture, such as nanosensors, nanopesticides, and nanoformulations, has changed conventional agro-practices and made them more effective and sustainable.

Jay Shankar Pandey et al. [10] studied in the modern world, sustainable agriculture is essential because it has the ability to satisfy our requirements for food in a way that traditional agriculture cannot. This sort of agriculture employs a unique farming method that allows for the maximum use of natural resources while also assuring that no damage is done to them. Thus, the method provides safe and wholesome agricultural goods while being environmentally benign. Fundamental mechanisms that drive the stability or productivity of agro-ecosystems depend on microbial populations. A number of studies aimed to increase knowledge of the variety, dynamics, and significance of soil microbial communities as well as their advantageous and cooperative roles in agricultural production.

DISCUSSION

Simply put, these many initiatives haven't been performing at their best. To solve these issues, a thorough investigation is required. There is a need for more discussion in this article to help the government's policies and initiatives enhance agricultural productivity in the future. The government's strategies for infrastructure development have been focused on boosting agricultural productivity. On the island of Sumatra, the building of new roads and irrigation systems has increased agricultural output and given farmers more mobility to transport their produce more quickly. The government has invested much in infrastructure, but it also has to pay attention to the quality of the infrastructure that is being constructed. So far, it has been commonplace to expand agricultural infrastructure without considering quality, which drives up the price of agricultural goods due to high production expenses. The common issues that farmers encounter in their everyday activities the high cost of production, their inability to predict the output of their agricultural sales, and the fact that they have little negotiating power for their goods seem to have become insurmountable. To boost agricultural production, the government also engaged in finance sector institutional reform. It has been shown that the agricultural finance schemes available may raise agricultural production.

The well-being of farmers has been able to improve because to the creation of a Village Financial Institution (LKD) that offers financial help. It has also been shown that the village unit cooperative finance scheme (KUD) enhances farmer and company welfare. Farmers have benefited greatly from the funding package that the government has so far put in place. However, there is still room for improvement in the farmers' understanding of and participation in the funding scheme. Intensification, extensification, diversification, agricultural mechanization, land rehabilitation, and subsidies for agricultural production are other components of the plan to boost agricultural output. All of the implemented solutions have so far been successful in raising agricultural yields, but not to their full potential. The government has established fewer effective agricultural projects as a consequence of its inability to manage agriculture using technology. India has reached a point in its growth when it need a "evergreen revolution," or the ability to produce more with less water and less space. Crop diversification should be one of the key tactics in this revolution, which should be primarily driven by agribusiness and agriprocessing.

Improving soil health:

Agricultural colleges, research centers, krishi vigyan kendras, fertilizer manufacturers, state departments of agriculture, and farmers' organizations should work to boost soil productivity by paying close attention to its physics, chemistry (macro and micronutrients), and microbiology at the same time. Dry agricultural regions need special consideration.

Management and Augmentation of Irrigation Water Supplies

Water is not a private asset but a shared benefit and a resource. Its delivery being privatized is risky and can cause water battles in the neighborhood. It should be required to increase supplies via rainwater collection and aquifer recharge. Additionally, a plan for irrigating 10 million hectares of additional land under the Bharat Nirman Program should be designed and adopted on a national level. All current ponds and wells should be updated. Priority should be given to demand control via enhanced watering techniques, such as sprinkler and drip irrigation.

Regulations should be created for the sustainable use of ground water as well as for the prevention of contamination, and a campaign to promote water literacy should be started. Mangrove, salicomia, casuarina, and other suitable halophytic plant cultivation should be encouraged in coastal locations to support seawater farming. It should become standard practice to utilize treated sewage water in conjunction with rain, river, ground, and seawater.

Credit and Insurance

Improving credit is the main approach to increase the productivity of small farms. In India, the difference in interest rates between loans and deposits is substantial by worldwide standards. By managing transaction and risk costs, the financial delivery system must become more efficient. Crop insurance, as well as the speed and efficiency with which the debt collection and settlement procedure runs, would need to be significantly enhanced on the part of the government. The government should think about aiding the banking sector in lowering the interest rate on agricultural loans in light of the declining profitability of agriculture and the farmers' suffering. Restructuring and rescheduling farmer loans are insufficient in the case of further natural disasters. The Central and State Governments must intervene to establish an Agriculture-Risk Fund to aid farmers in the event of repeated droughts, as well as in regions affected by floods and severe insect infestation.

Instead of focusing just on yield per hectare, agricultural experts should report the success of new varieties and technologies in terms of net revenue per hectare. For this reason, a farming system orientation that incorporates crop-livestock integrated production systems is necessary for both resource use and research. The technologies used for production and post-harvest should be compatible. Every krishi vigyan Kendra should have a post-harvest technology wing. Additionally, post-harvest technologies should be included in lab-to-land demonstrations. In arid agricultural regions where millets, pulses, oilseeds, and cotton are cultivated, many of them should be organized. Adding value to biomass will aid in creating skilled occupations outside of agriculture. The greatest crop in the nation is rice, and the creation of rice bio-parks has the potential to increase employment and revenue. Similar to how eco-boards manufactured from cotton stalks may take the place of plywood created from wood.

Market: In the end, the economic feasibility of farming as a way of life and a source of income will depend entirely on prospects for reliable and lucrative selling. Production planning should be the first step in market reform to ensure that each link in the cultivation-consumption-commerce cycle gets sufficient and timely attention.

Regionally Differentiated Plan: There cannot be a uniform strategy for agricultural expansion across the nation due to the considerable variances in agro-climatic and economic circumstances.

High Productivity Region in the North West

The goal of the plan is to encourage agricultural diversification, the cultivation of high-value crops, the strengthening of connections with the agro-processing sector and exports, as well as the development of the necessary infrastructure.

Eastern Region

The goal for this region's approach should be to maximize its productivity potential in order to raise yields to those of high-productive states like Punjab and Haryana. The primary focus should be on flood control, drainage management, input delivery systems backed by appropriate financing and extension facilities, upgrading of irrigation infrastructure—especially minor irrigation.

The irrigation network is one piece of agricultural infrastructure that is now causing a lot of worry. Agriculture's ability to use irrigation has been significantly reduced as a consequence of damage to existing irrigation networks, a lack of new reservoir building, and both. This harm is mostly the result of floods, erosion, river basin degradation, and poor irrigation system maintenance at the farm level. Farming roads, production roads, and ports with warehouses are additional farming infrastructure that the community needs to support the production and selling of agricultural commodities, but their availability is still restricted. The difficulty that will need to be overcome in the future is how to sufficiently provide all the infrastructure required by these farmers in order to be able to lower the high costs brought on by the lack of adequate transportation and logistics infrastructure in the centers of production of agricultural commodities for food crops.

By creating more land, infrastructure development might encourage individuals to increase their capacity for production. Of course, not all infrastructure can have an impact on the rise in agricultural productivity. Agriculture productivity is not entirely increased by road building. The building of irrigation canals, however, has a considerable impact on raising agricultural output. This occurs as a result of farmers directly using irrigation construction to aid in the production process. In addition to building roads and irrigation systems, market growth is crucial for boosting agricultural production. Farmers will find it simpler to sell their produce if there is a market nearby. Farmers' output will rise as a result of this predicament. The time it takes for agricultural goods to reach the market will be shortened by the producing facility's closeness to it. So that farmers won't have to keep their produce in storage for an excessive amount of time. Infrastructure development in agriculture has been carried out in significant quantities. However, it is important to consider the infrastructure's overall quality. The marketing system and pricing for agricultural goods improve with infrastructural quality. In fact, the agricultural institutions already in place may operate as a link for agricultural projects.

like Subak, a facility for agriculture in the Bali area. Subak may sometimes act as a middleman, guiding an improved agricultural system to ensure continued high yields.

Farm production is crucial for a variety of reasons. By producing more food, increasing productivity has an impact on income, labor migration, and market expansion in agriculture. The allocation of limited resources is made more effective by increased agricultural output. Farming may be fruitful if you learn how to increase output. Farmers now have the option to boost output while preserving the long-term viability of their farms thanks to new approaches and procedures. We are here to provide knowledge on the subject to raise agricultural output. have a look below.

Land reforms must be put into effect

Land reforms are the first and most important step towards increasing productivity. Land reform is accomplished using tractors, machinery, and tools. These devices have the characteristics that make difficult agricultural terrain easy to operate in the field successfully. Working in the field is simple, therefore increasing production is simple as well. The most effective way to boost productivity is via land reform. Different crops are grown side by side at the same time as interplanting. It is the greatest method for maximizing your growing area's production. Some combinations of crops work better than others.

Increase plant density

Planting crops close together is the easiest approach to increase agricultural output. Many farmers store their veggies too far away, which causes them to forgo sizable, productive producing regions.

High beds

Raised bedsTraditional farming practices include planting many rows of crops in beds that are the same width, separated by tractor pathways. Fewer walkways, more active growing zones, and thick plantings are the results. Raised beds are a visual representation of increasing agricultural output.

Ingenious water management

Crops must have access to water in order to be planted, and water management may increase yield. The greatest approach to increase productivity is via water management. You are able to boost production by up to 50% by using the sprinkler watering system. Tube wells get a superior irrigation system by the manufacturing canals for the security of the crops.

Heat Resistant Types

The plant can retain its production in hot climates thanks to heat-tolerant cultivars. The heat-tolerant types must be improved since they boost crop production by up to 23%.

Utilize nitrogen

Without nitrogen, most crops would not exist since it is a crucial essential for optimum plant development. Plus 100 million tonnes of nitrogen are added to crops each year as fertilizer to aid in their growth and development. Nitrogen usage may increase output by up to 22%. In farms, seeds are crucial, and better seeds are excellent for raising agricultural output. Improved seeds are appropriate for increasing output.

Plant defense

About 5% of crops are reportedly damaged by insects, pests, and illnesses, according to agricultural specialists. The majority of farmers are unaware of the usage of modern medications and pesticides. Utilizing these medications will increase agricultural yields and productivity. Farmers should take action or use their technical personnel to apply pesticides and insecticides if they are aware of these governments' policies.

CONCLUSION

The discussion's findings are that, while it hasn't always been successful, the construction of infrastructure, such as roads, irrigation canals, and marketplaces, has been focused on boosting agricultural productivity.

The government has promoted the development of farmer organizations and agricultural financial institutions in order to assist enhance agricultural production. To enable the continued expansion of agricultural goods, the government will enhance the agricultural system by adopting varied cropping patterns as well as promoting innovation and technology adoption. The government has pursued marketing of agricultural products in a variety of methods, including controlling product quality, establishing marketing networks, and using technology-based agribusiness marketing systems to speed up the selling of agricultural goods.

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CHAPTER 11

FUTURE OF MODERN AGRICULTURE

Dr. Umesh Kumar Mishra, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- umeshm.ag@sanskriti.edu.in

ABSTRACT:

Future agricultural practices will make use of robots, GPS technology, moisture and temperature sensors, and aerial photography. These state-of-the-art tools, robotic systems, as well as precision farming methods will enable farms to operate more productively, efficiently, safely, and sustainably. A vital human activity that has both positive and negative repercussions is agriculture. To perform better, agriculture must include a variety of production techniques, modern and traditional technology, distribution and marketing strategies, and the efficient application of sensible legislative and regulatory frameworks (such as sustainability, competitiveness, and climate adaptively, efficiency, profitability, biodiversity, or food security). These collective efforts must focus on achieving environmental sustainable development and economic improvement within the framework of the Sustainable Development Goals (SDGs) of the United Nations.

KEYWORDS:

Biodiversity, Economic, Fertilizer, Management, Modern Agriculture.

INTRODUCTION

The environment in which agriculture develops is marked by a rising population with rising demands and diverse consumption patterns, (ii) extreme climatic variability (droughts, floods, and frosts), (iii) the appearance of new weeds, pests, and diseases (WP&D), (iv) frequent and intense political, economic, and social changes, and (v) a great deal of uncertainty because of the ongoing disease pandemic. Furthermore, the global agriculture industry is marked or governed by regional variability and susceptibility in each of these regions. Farmers in many nations have not been able to use technological tools in the face of these challenges because of a variety of issues, such as scientific unfamiliarity or incomprehension, high technology costs, excessive regulation or a lack of regulatory clarity, and a global debate over production methods (e.g., organic, conventional, biotechnological). These facts undermine sustainability and lessen the desire of young people to engage in agricultural activities. But when science and technology (S&T) advances are applied to sustainable agriculture, spectacular developments also encourage the next generation to build their lives on farms.

A revolution in farming management has resulted from computer sciences (such as hardware, software, and the internet), which helps to apply sustainable agricultural methods. Digital technologies, such as satellite and aerial photos and artificial intelligence, make it possible to manage soil and water resources better, plant crops precisely, utilize fertilizers most effectively, and monitor crop health quickly and affordably. Additionally, the usage of smartphones is enhancing crop management, profitability, and agricultural education. Although a number of national initiatives for better connection and computer literacy have been partly implemented, significant efforts are still needed to enhance many nations' inadequate computer and information management capabilities. Additionally, biotechnology is offering extraordinary chances for sustainable agriculture. Various bio-inputs (such as biofertilizers, plant growth regulators, and biological N-fixers), bioinformatics, marker assisted selection, genome sequencing, precision bio-techniques (such as gene editing), novel food products, crop health diagnostics and management, and in vitro cell and tissue culture techniques for various purposes are some significant developments (e.g. cloning, cryo-conservation, embryo rescue, disinfection of planting material). A number of nations, including Argentina, Australia, Brazil, Canada, Chile, Colombia, Japan, Honduras, Paraguay, and the United States, have made significant regulatory changes in response to these advancements in order to address the expansion of bioinputs, the safe application of contemporary biotechnology, the development of gene editing, and the sustainable use of biodiversity. Thus, food and nutritional security are improved via biotechnological innovation to increase food safety and quality within a framework of sustainability. Through management techniques aimed at lowering greenhouse gas emissions, safeguarding biodiversity, utilizing leftovers (circularization), and wisely managing resources, all kinds of agriculture attempt to optimize their operations to increase production and lower environmental impact from water, soil, seed and fertilizer to time, labor and money. At both the national and sectoral levels, several instruments (environmental policies, standards, and protocols) have been developed and are being used to include sustainable practices. Despite these shared objectives, there is a well-known, ideological disagreement over the use of genetically modified (GM) crops in organic farming. The performance of sustainable practices and the advancement of biotechnology have been badly impacted by the discussion on this subject. Additionally, it has confused both consumers and producers, and it often leads to overregulation, interruptions in trade, and higher prices. Given the difficulties in agricultural sustainability that are now and in the future, as well as the evidence.

Farmers must be given the chance to pick the best technical solutions depending on their unique circumstances in order to ensure the safety of biotechnologies. scientifically sound strategies and problems Even though the agricultural industry is inherently heterogeneous, modern agriculture pursues a path of environmental, financial, and social sustainability that is centered on "producing more and better" and provides the opportunity to integrate and permit the coexistence of a variety of technologies, from the empirical (traditional) to the scientific (advanced). Similar to this, institutional context and social norms play a key role in the development or stagnation of the agricultural industry. In order to achieve agricultural sustainability, optimal crop management in various ecosystems necessitates the gradual use of biology- and computer-based approaches, independent of the size of production. Information and communication technology (ICT) help to digitalize national extension systems, establish early warning systems (WP&D, for pricing and weather prediction, etc.), and lower intermediary costs by enhancing stakeholder contact. Inputs for agriculture, such as seeds, varieties, and bioproducts, are produced more quickly thanks to biotechnology's technologies, processes, and goods, which also help to utilize natural resources more efficiently and enhance energy efficiency.

With the development of suitable principles and standards as well as practical and understandable approval procedures, regulations must react quickly. Modern biotechnology goods and sustainable agricultural methods may coexist while yet being compatible. For instance, increasing organic matter through minimum tillage which is made more effective by the prudent use of herbicides; using cover crops (primarily legumes); and incorporating bio-inputs can all help to lessen the effects of water scarcity in small cropping areas and during moderate-to-severe drought conditions. However, it is vital to alter agri-management and employ drought-tolerant seeds in cases of extreme/exceptional drought or in large farmed regions. Both traditional and GM crops that are resilient to drought are produced using various methods. These adapted cultivars often provide equal yields while using less water (up to 70%

less for GM crops and 30% less for conventional crops). Since the different methods for control from biological to chemical rely on several biotic, abiotic, and regulatory elements, there are no practical techniques for broad application in WP&D. In this context, traditional, contemporary, and precision biotechnologies must collaborate with science-based sustainable practices to either produce or verify short- and long-term practical solutions. In order to address the existing and future difficulties, modern agriculture needs research and extension institutions, sectoral and social groups, and effective regulatory frameworks. Therefore, even in the midst of the present crisis, governments must immediately mobilize financial and human resources. Institutional and technological innovation are also required. Both good and negative impacts of communication and social influence on agricultural growth have been shown. For instance, modern social networks have shown they may promote consumers, expand markets, and increase trade but they can also be used to oppose particular technology (like GM) without any supporting data. Similar to the effects of the COVID-19 epidemic, agricultural challenges have an emotional and financial toll on farmers. Regrettably, communities cannot easily organize in a timely or efficient way to solve crucial agricultural concerns, particularly how societal attitudes limit farmers' capacities. Despite some government support, farmers are typically by themselves. Figure 1 shown the future of modern Agriculture an integrated Approach on Science and Technology.

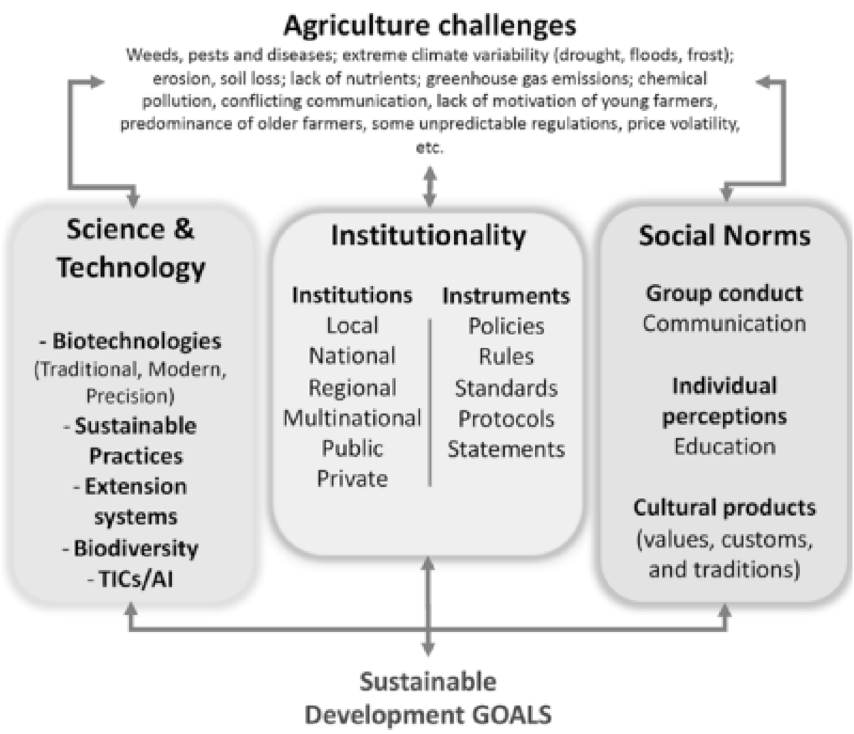

Figure 1: Illustrate the future of modern Agriculture an integrated Approach on Science and Technology.

There are a number of obstacles that must be overcome in order to adopt new technology and sustainable farm management techniques. Numerous of these difficulties were related to the complexity of economic systems. It was often raised that the existence of market externalities may have an impact on the creation and use of certain strategies for enhanced agricultural systems. The obligation for, and prioritization of, financing resources for sustainable agriculture activities was seen as a crucial hurdle, in addition to worries about the absorption of externalities and other possible non-agricultural liabilities. In light of the realization that they have a direct impact on the priority given by the private sector to the development and use of any new technology, intellectual property concerns have been addressed as a crucial component in any practical study. As a practical strategy for success within these complex systems, several stakeholders stressed the need of comprehending diverse agricultural systems and the necessity of developing multilateral collaboration among stakeholders, notably governments. The idea that all parties can work successfully together in multilateral meetings, however, has been called into doubt. It was strongly urged that the growth of multilateral discussion need certain modifications and/or amendments. Farmers are routinely and unjustly excluded from the design of multinational efforts, according to a number of stakeholders.

The utilization of underused, undeveloped, and "orphan crops" in contemporary plant breeding and cultivar development was seen as a high priority to address biodiversity. Concerns were raised about the ten-year development times needed to produce non-domesticated crops that are marketable. It was also pointed out that many of these alternative crops have been grown and eaten for a long time, thus their absence from scientific research and development does not necessarily indicate a lack of promise or the necessity for domestication-focused research and development programs. Numerous "orphan" and undeveloped crops have a significant potential to grow quickly and provide agricultural goods when contemporary scientific approaches for crop enhancement are used. Additionally, it was shown that biodiversity significantly affected agricultural resilience, particularly in African regions experiencing severe effects of climate change (e.g., decreased rainfall, more frequent drought, increasing number of extreme weather events).

While it was acknowledged that industrial animal production posed challenges for the development of African agricultural systems, it was also emphasized that while designing regenerative African systems, alternative livestock-raising practices needed to be carefully examined. Negative environmental effects might result from improper management of livestock production (e.g., land degradation). Some stakeholders raised concerns regarding the need and effectiveness of asking smallholder farmers to prioritize soil testing in the management of soil health in response to issues linked to soil health management. Establishing immediate business incentives for soil management was deemed to be more difficult and difficult, despite the fact that it was cited as an important and effective strategy for promoting soil health. This is because it is more difficult to engage farmers directly through demonstration plots and extension services. It was suggested that certifying carbon neutrality for use in carbon markets by linking soil health and carbon sequestration might possibly provide farmers a sizable, tangible reward directly related to promoting environmental sustainability.

It was hypothesized that providing mature financial systems, technical assistance, and emerging technology to these larger landholdings might be more cost-effective than similar efforts targeted at millions of geographically dispersed smallholder farms with a variety of interests because developed countries frequently promote larger, commercial landholdings. Furthermore, because employees would depend on pay rather than volatile crop yields, it was believed that the employment of smallholders who were displaced within the new food systems created by commercial agricultural expansion may be more stable. To prevent major negative effects, both predicted and unplanned, the study and promotion of paths encouraging the shift from rural livelihoods in farming to waged or urban livelihoods would need to be methodically handled (e.g., displacing subsistence farmers without providing alternative options for a living income). The contrast between growing urban populations and declining rural populations has a substantial impact on how various food systems such as food sovereignty, balanced exports and imports, and the use of natural resources are formed and how they rely on the abilities of farmers. As a result, successful policies continue to be reliant on the actual experiences and adaptability of farmers. It is sometimes challenging to pinpoint markers for "successful" national or local agricultural systems when studying agriculture at the systems level. Although it was noted that these indications would differ depending on the context (e.g., by location, product, and market), some hypothetical examples of situational "successes" in agriculture were given: food security (i.e., caloric production), diverse crop production (i.e., various crops, genetic diversity within species, and a variety of nutrients), mass participation (i.e., involving a large number of people in various social roles), and the capacity to improve upon or circumvent difficult situations are all important factors (e.g., famine). It was suggested that in order to combat the unfavorable perceptions of agricultural lives in emerging nations, smallholder farmers must be assisted in creating profitable businesses that benefit the whole community. In order to successfully engage the next generation and promote a variety of agricultural options in various localities, it was also hypothesized that establishing a "pipeline of skills" related to farming as well as broader agricultural systems (e.g., agricultural processing skills, expanded educational opportunities, real-world scientific and technological training) was necessary.

It was firmly asserted that farmers' participation in decision-making processes was crucial. Regarding the significance of the technical options accessible to farmers, several stakeholders noticed that young farmers are more interested in current agricultural technology than farmers in earlier generations. Despite their curiosity, young farmers often do not have access to many current technology. This is either because these technologies are expensive or there are laws that prevent them from using them. While it is acknowledged that not all technological options can be used to achieve effective results on farms without major improvements, making technological options more accessible to young farmers may facilitate the learning and practice that leads to an increased familiarity with which improvements are required to support better agricultural outcomes. Market access for farmers was seen as a constraint on their ability to choose their business operations. In a related vein, it was claimed that the balance between consumer demands for inexpensive food and their demand for sustainable practices may heavily dictate the conflicting options available to farmers in selecting the crops they grow. This is because many countries are experiencing growing urban areas and middle-class populations. Given shifting cultural values regarding environmental responsibility, it was argued that cost concerns, which may distribute the majority of the financial costs of sustainability to farmers in particular locations, may move towards consumers.

LITERATURE REVIEW

Syed Volova et al. [1] studied The development of technological knowledge has significantly improved logical reasoning within scientific societies, shaping theoretical conceptions into research that is almost entirely focused on producing a product. Nanotechnology has engulfed practically all kinds of life and has its uses in a wide range of industries. Agriculture still has viable competitors despite the fast development of nanotechnology. Agriculture today is an expression of the need to feed the world's population, which is constantly expanding. Nearly one-third of the world's yearly agricultural yield is thought to be lost to crop destruction. The loss is attributable to a number of pressures, including insect infestation, microbial diseases, weeds, natural disasters, a lack of fertile soil, and more. Different technical approaches are used to get beyond these restrictions, but most of them have drawbacks of their own. As a result, there has been a sluggish advancement in the assessment of nanoparticles for use in agriculture, which has the potential to alter the current agricultural system. Applications of these nanomaterials have the potential to significantly improve the present situation of a worldwide food shortage. The negative impacts of the widespread use of chemical agrochemicals, which are thought to lead to biomagnification in an ecosystem, may be addressed through nanotechnology.

Lopez-valdez et al. [2] studied This book's goal is to provide the most current findings in the field of agronano biotechnology modern agriculture for a sustainable future in research on nanoparticles, or Nano products like Nano fertilizers. The main topics covered in this study on nanoparticles and nanotechnologies (including herbicides, sensors, pesticides, and nanomaterials) include agriculture, modern agronomy, as well as technological advancements to increase crop yields. A particular focus is placed on sustainable management as well as the environmental effects of nanofertilizers.

Harlander et al. [3] studied People have been modifying crops to improve their quality and production since since the invention of agriculture. The contemporary corn hybrids and wheat varieties that are now widely farmed were created via conventional breeding, according to seed companies. Radiation breeding is one of the more recent strategies that has improved seed companies' capacity to introduce novel features into crops. Later, in the 1980s and 1990s, researchers started using genetic engineering methods to improve crop quality and productivity. These procedures generated concerns about their safety for customers and the environment, in contrast to older breeding methods. The types of genetically modified crops that have been created and sold to date are discussed in this essay along with the benefits they provide both farmers and consumers. Contrast the official procedure necessary for these crops' safety assessments with the absence of one for conventionally bred crops.

Patharkar et al. [4] studied Plants may lose undesired parts like leaves, flowers, fruits, or floral organs via a process called abscission. The most overt manifestation of abscission in nature may be seen in the shedding of leaves in the autumn. The processes of growth and abscission determine the very form that plants assume. In contemporary agriculture, abscission is manipulated to achieve goals such preventing pre-harvest fruit drop before automated harvesting in orchards. Abscission only takes place in abscission zones, which are established when the organ that will eventually abscise develops. Abscission is started by a complex signaling network when it is time to get rid of the undesired organ. In this article, we discuss recent developments in our knowledge of the signaling pathways that initiate abscission. Additionally included are physiological developments and the functions of hormones in abscission. Our discussion of fundamental abscission research's present prospects and its possibly profitable future paths for use in contemporary agriculture concludes.

Junling Zhang et al. [5] studied Soil health is the foundation of agricultural green development (AGD), which is the future of contemporary agriculture. This article provided a concise summary of the significance, scientific developments, and global trends in soil health. This study presents fresh concepts and ways for increasing soil health, explores the difficulties and potential for soil health engineering, and summarizes the primary management strategies for healthy soil agriculture. The key components for encouraging healthy soils include removing soil limitations, improving soil organic carbon content and nutrient use efficiency, using biological potentials, and fostering synergistic interactions between above- and below-ground organisms. The goal of soil health engineering is to maximize internal regulatory mechanisms while reducing external inputs in order to synergize the production as well as other ecosystem services provided by soils. Holistic engineering is necessary for the development of healthy soil, which necessitates thorough industrial chain integration at the intersection of external input, product processing, crop production, and waste recycling.

Seleiman et al. [6] studied There is a need for a more creative approach to fertilizer that may boost agricultural systems' production and be more ecologically responsible than synthetic fertilizers. In this post, we looked at the most recent advancements and possible advantages of using nanofertilizers (NFs) in contemporary agriculture. By improving the nitrogen usage efficiency (NUE) of field or greenhouse crops, NFs have the potential to advance sustainable agriculture and boost overall crop output. NFs have the ability to slowly and steadily release their nutrients, whether they are used alone or in conjunction with synthetic or organic fertilizers.

Abdelmadjid Benyamina et al. [7] studied In the agricultural sector, water is essential for growing food and producing cattle. Given the present patterns in population expansion, our capacity to effectively harness the remaining water resources will be crucial in meeting the urgent food demand that agriculture must meet. Water management is one of the most important problems. Innovative technology recently enhanced agricultural water management and monitoring. Agricultural applications for the Internet of Things, wireless sensor networks, and cloud computing are many. Existing strategies attempt to optimize water use, enhance the quality and quantity of agricultural products, and reduce the need for direct human intervention by concentrating on the water management problem as a whole. This is accomplished by streamlining the water monitoring process, using the appropriate amount of automation, and enabling farmers to access their fields from anywhere at any time. Monitoring water pollution, reusing water, monitoring water pipeline distribution networks for irrigation, providing drinking water for animals, and other issues are only a few of the water-related concerns in agriculture. These issues have been the subject of many research during the last ten years. As a result, this article provides a summary of current studies supporting sophisticated technology for water management and monitoring in agriculture.

DISCUSSION

Scientifically sound techniques and difficulties

Despite these dismal facts, there is yet a chance to rethink contemporary agriculture in Africa in a way that is environmentally sound, climate-sensitive, and socially uplifting. Five issues may be emphasized as future priorities.

Efficient use of natural resources

Agriculture's future relies on how well natural resources are used (e.g., water, renewable energy,soil, biodiversity). Despite having abundant, underutilized water resources and rich terrain, Africa may not be able to fulfill the potential it offers for the rest of the globe due to soil degradation and a lack of water-saving practices. While the majority of farmers in Africa rely on rainfall for their row crops, increasing productivity would need the adoption of effective irrigation technologies (e.g., micro-irrigation). Africa's agricultural soils have been mapped and categorised by scientific investigations, providing a foundation for better soil health management. Farmers, particularly smallholders, need additional tools to maintain and monitor soil health if we want sustainable development. According to the UN Food and Agricultural Organization (FAO), just 200 of the world's 6,000 cultivated food crops are available for consumption. Only nine of these 200 are in charge of 66% of the overall crop output. In a normal growing season, maize, for example, requires 500–800mm of water, while less often cultivated crops like sorghum/millet, use 450–650mm. By encouraging these alternative grain crops, the world may be able to achieve its nutritional needs.

There are over 100 orphan crops that have the potential to help African farmers with their diets and earnings. A move away from fossil fuels might benefit African agriculture. The industrialized, externally-driven agri-food production paradigm is not the way of the future. This method places excessive strain on ecosystems and small farmers. Improved sustainability requires environmentally conscious strategies that concentrate on soil regeneration and the use of agricultural waste as a source of energy.

Integrated livestock systems

Crop production systems are the subject of much of the attention in agricultural development. However, viable crop-livestock mixed systems that collaborate are required to obtain ecologically balanced results. Cattle and other small animal assist Africa fight exotic species and rangeland degradation. Shows that use of animal manure, in addition to crop/livestock diversity and crop rotation, supports integrated soil management, an important idea in agroecology.

Making use of technology

The biological, digital, and physical sciences have seen significant technological advancements throughout the last century. Opportunities to promote genetic improvement, faster information transmission, and precise nutrition delivery have been made possible by advancements in genetic editing, mobile telephony, nanotechnology, and other fields. To develop alternate technological routes, a balance must be established in the financial and infrastructure sectors. The effective distribution of insurance services, access to finances through digital platforms, and credit profiles for smallholder farmers have all been transformed by secure and traceable fintech advancements. Business models like Uber show that access to high-value assets takes precedence over ownership (e.g., homes, cars). With this strategy, infrastructure such as silos, processing facilities, and production facilities like high-tech greenhouses may be accessible on a pay-per-use basis, providing capital holders with a business case to develop new business models. Efficiency gains are critical as margin pressure throughout agricultural supply chains rises. By enhancing traceability and altering cost structures across the supply chain, technologies like blockchain are required to increase transparency in supply chain relationships. 4. Human Resources: Agri-food systems will struggle if there is no talent pipeline in the human population. Ageing farmer populations, poverty, and prejudice based on gender, race, and ethnicity are some of the obstacles preventing the adoption of modern agricultural methods across Africa. For instance, women often provide work but do not share in revenue. Therefore, women's full participation in the industry as value producers and sharers must be permitted and encouraged if African agriculture is to have a bright future.

Glocality

The sustainability tenet faces an existential danger, according to Solidaridad. Despite all the rhetoric about sustainability from CSOs, businesses, and governments, nothing appears to be really changing locally. The agriculture industry must reduce inequality on a global scale by enhancing producer profitability via improved access to international markets and forward integrations. Locally, it must encourage the production of healthful foods, efficient rural services, and laws that support rural-urban food networks. Furthermore, competition from new and alternative food sources will spur efforts to develop sustainable, field-grown food systems. It is necessary to forge a whole new course that acknowledges global imperatives while guaranteeing local sustainability. Finding a balance between what is beneficial for the local and global agriculture sectors will be made easier with an understanding of glocality. Only if agriculture finds a sustainable way to achieve this balance will it be spared.

By increasing the effectiveness of chemical or mechanical inputs used in agricultural crop production, the Area Studies investigation focused on technologies that help preserve natural resources. Many of these environmentally friendly systems combine information technology and chemical inputs with more intensive management techniques. It could be able to lessen or minimize the negative environmental effects of agricultural production while simultaneously increasing farm productivity and profitability by using traditional inputs more wisely. All locations were merged to study each of the four key management categories, and just a few places were chosen to determine if combining all areas would overlook significant site-specific aspects.

When focusing on prospective adopters, organizations or technology suppliers should take into account the growing complexity of developing technologies. To encourage the adoption of certain recommended practices, technical support, demonstrations, or consulting services may be required. Experienced farmers are less likely to adopt information-intensive strategies, which might indicate that they already possess the knowledge necessary to farm effectively or that they are less eager to modify their practices than younger, less experienced farmers. The premise that landowners would be more willing to invest in novel practices than renters led us to first predict that ownership of the surveyed field would have a greater influence on practice adoption. However, the majority of the activities examined in this research weren't structural. Renters were less likely to invest in irrigation systems than owners, despite the fact that these technologies had large upfront costs. A livestock-related firm was more likely to employ manure instead of information-intensive nutrient management techniques like soil testing, split nitrogen application, or micronutrient utilization. If livestock enterprises are compelled to follow nutrient-management plans that include limitations on applying manure to land, this anticipated outcome may alter in the future. All of the pest and nutrient management measures that we took into consideration were used much more often after irrigation investment. The main means of transportation for chemicals that leave a root zone and go to ground or surface water is water. Consequently, it is anticipated that water and chemical control would work well together. The adoption of chemical management tactics by such farms may be less successful than for farms that are irrigated since water management is less predictable for agricultural output that is rain-fed. Participation in government programs and the use of professional guidance both had significant beneficial effects on the uptake of almost all recommended soil, pest, and nutrient management methods.

When a number of USDA programs required conservation compliance before recipients could get benefits, the Area Studies Survey was carried out. To be eligible for the programs, farms had to implement conservation techniques if their erosion potential was higher than a certain level. The choice to employ the collection of practices examined in this research seems to be significantly influenced by the availability and utilization of technical support. It is probable that farmers who were required to comply with Conservation 103 utilized certain resource-conserving techniques, but the relevance of a farmer's use of guidance raises the possibility that technical help may have had an impact on the decision to apply those specific techniques. The outcome confirms that efforts in extension and education are crucial for bringing about technical transformation in agriculture. These actions have an effect on procedures intended to deliver remote advantages and the adoption of information-intensive technology in particular. A regional dummy performed as well as the more exact resource characteristics in the combined-area model for the majority of activities. The fact that dummies often absorb numerous indistinguishable effects should be anticipated to explain why their larger relevance in the combined-area model. However, the resource factors were often major adoption drivers in the single-area models, supporting the notion that site-specific data is essential for modeling and explaining resource-conserving initiatives. The significant resource features anticipated to impact the adoption of all technologies in all watersheds may not have been represented by the resource measurements we used.

Humans didn't anticipate that the general resource attributes we employed would have a significant impact on the pest-management technique a farmer chooses. In this scenario, a crucial resource attribute is an estimate of insect infestation. However, humans had anticipated that creating site-specific indices would enhance the overall modeling of adoption for techniques related to managing soil, nutrients, and water. We come to the conclusion that the modeling efforts at the single-area or watershed level benefit from the use of field-level resource data. In addition, rather than being a universal index, the selected index should take into account the local environmental conditions as well as technology. For instance, slope, a single variable, has more explanatory power than the index of soil productivity when modeling the choice to irrigate. Site-specific resource information was included in the Area Studies Survey for a number of reasons, one of which was to evaluate the effect of resource features on adoption (i.e., the production-impact). These facts were collected in order to establish a connection between the economic, physical, and transport destiny models. It is still unclear if the micro data are helpful to evaluate aggregate models since that study has not been finished.

The watershed level site-specific resource data is crucial for both production-impact and environmental-impact assessments. The aggregation across several watersheds is represented by the combined-area models. These findings can be deceptive from a policy standpoint. In the Susquehanna River Basin, for instance, a farmer's experience and whether he or she works off-farm have large positive impacts on the adoption of soil-conserving methods, while the findings of the aggregate model reveal no significant benefits of these characteristics. Based on site-specific data, a policy choice to promote the use of conservation technology in Susquehanna would be more effective. On the other hand, sometimes a single region predominates in the combined area model findings. The information enables reasonably accurate environmental policy modeling to be used for targeting. The unified modeling technique we utilized demonstrates that crucial information might be lost during the aggregation phase. It's possible that incentives created to address elements in the aggregate model are only useful in one area and harmful in another. We acknowledge that all policies have this averaging difficulty to some degree. However, the significance of the disparities across the Area Studies areas was shown by our comparison of the combined-area and single-area models.

CONCLUSION

Smart development is fundamentally reliant on agriculture. Any state's independence depends on its capacity to feed its own people. The province of Ontario is endowed with resources that have aided in the growth of a top-notch agriculture sector that offers dependable, healthy, and safe food. It is important to recognize the potential of using local resources to feed the community. Agriculture is often taken for granted, maybe as a result of its long history in the studied region. Many assume it will last forever and that it will move to another place that is less affected by growing pressure when it is forced out of one area by urban expansion. This presumption is incorrect. The agricultural sector is varied and has strong regional ties. Some crops can only be cultivated in particular areas where the correct mix of conditions exists for soil, moisture, temperature, and terrain. The capacity to grow the crops that need that specific set of conditions is likewise lost when such places are lost to agriculture.

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CHAPTER 12

FUTURE OF AGRICULTURE: VERTICAL FARMING

Dr. Dinesh Singh, Assistant Professor,
Department of Agriculture, Sanskriti University, Mathura, Uttar Pradesh, India,
Email id- dinesh.ag@sanskriti.edu.in

ABSTRACT:

Vertical farming is increasingly being used in urban areas. Vegetables are grown vertically using modern agricultural techniques called "vertical farming," which integrates farms inside high-rise buildings in urban areas. This technology must be implemented. But little has been written on the technology of vertical farming, both in agricultural method and architectural technology combined. In this research, a qualitative method is used to examine and evaluate technology as one of the key factors in vertical farming. The technologies provided may serve as a roadmap for the creation and design of novel vertical agricultural enterprises in cities. In fact, it may be used as a benchmark for assessing potential agricultural and building together. Urban areas' integration of food production has been seen as a link to the city and its inhabitants. It concurrently contributes to food safety, context sustainability, human wellbeing, and poverty reduction.

KEYWORDS:

Aeroponic, Agriculture, Hydroponic, Food Production, Vertical Farming.

INTRODUCTION

The soil's fertility has been negatively impacted by rapid urbanization, natural catastrophes, global warming, as well as the indiscriminate use of herbicides and pesticides. In addition, each individual now has access to less land, and soil fertility and production have both deteriorated dramatically. The threats to the water resources in the watershed include a changing climate, rising temperatures, frequent dry periods, and the unpredictability of the weather. A few threats to the water resources of the watershed include excessive agricultural water use, unregulated water pollution, and a downward trend in groundwater levels. The globe will need to produce 50% more food by 2050 due to the predicted increase in population to 8.9 billion people, which would need more arable land that will simply not exist.

The quantity of arable land per person is predicted to be less than 0.20 hectares by 2050, which is less than a third of what it was in 1970. Food production is now a major concern due to the substantial dangers these issues pose to traditional soil-based agricultural production methods. Modern agricultural methods that are more effective and ecologically benign must be used in addition to soil-based farming techniques. When putting these new agricultural practices into practice, it is important to take into account problems like climate change, decreased soil productivity, depleted soil nutrient stocks, and restricted irrigation water availability. Systems of soilless farming could provide a solution to these contemporary problems. Vertical farming methods may be used in place of soil-based farming systems as a supplementary approach to assist address the present scarcity of fertile arable lands and water.

Vertical farming is an effective method for growing a variety of field crops, including rice, wheat, tubers, fodder maize, and several vegetable crops including spinach, okra, cucumber, onion, carrot, and tomato. This method exhibits greater production and better nutritional status. For highly cultivated maize fodder production, the hydroponic vertical farming technology is optimum. Animals enjoy the whole crop of feed, which is ready in 7-8 days. Additionally, crops grown vertically provide a yield that is around ten times greater than that of field crops and use between 70 and 95 percent less water. Using an artificial growing media and a nutrient solution created to deliver the exact quantities of nutrients required for their development and growth, plants are grown hydroponically. This might be seen as the art of regulating water, infusing it with nutrients essential to plants, and timely delivering it to their dried-out roots in order to produce the best yields while using far less water and labor than would otherwise be necessary. Hydroponically grown plants are healthier because their diets are more balanced than those of soil-grown plants.

The ability to completely regulate the crop's nutrition, which leads to enhanced nutrient regulation and water management, is one of hydroponics' main advantages over traditional farming. For the reasons outlined above, hydroponics is recognized as a better way of farming in almost every nation in the world. Hydroponic research is being conducted by an increasing number of affluent countries, especially the United States and China, in an attempt to increase food yields and get around existing problems. Many plants have been considered for hydroponic production in industrialized nations, including lettuce, cucumbers, and tomatoes. Although it is still a new method, additional research is required before it can be applied to agricultural production in impoverished nations. India has an increasing need for hydroponically grown food due to the nation's rapid population expansion. It hasn't become a reality due to a majority of the evidence and study on the technology's many components.

To put it mildly, the region's farming has been negatively impacted by subpar irrigation techniques, inadequate drainage, excessive fertilizer use, other environmental factors including soil erosion and waterlogging, as well as an increase in salt. The cumulative rise in the risk of cancer in the valley has grown as a result of farmers in Kashmir Valley using pesticides and other agrochemicals quickly. Hydroponic systems may be extensively employed in the valley during the harsh winters, when the valley is mostly shut off from the rest of the world, to produce food with limited growing space and water supply. In Jammu and Kashmir, where the majority of farmers own barely under an acre of land, land acquisition plans must take into consideration the fragile hilly terrain as well as meteorological circumstances. Vertical farming is a great answer for Kashmir's depleting acreage and severe winters. Vertical farming, which utilizes no chemicals, enables them to produce organic and pesticide-free foods in a carefully regulated indoor environment. By adopting vertical indoor farming techniques rather than conventional indoor farming methods within a structure, occupational dangers associated with traditional farming may be significantly decreased. Our only chance is for our agricultural researchers, universities, and research institutions to focus more on vertical farming. Hydroponic production may result in a range of products depending on the crops used and the climate.

The vertical farm idea

By growing crops inside of buildings as opposed to on the ground, vertical farming may save water and do away with the need for soil. A vertical farm's ability to produce food is unaffected by the weather or other environmental circumstances. When cultivated in controlled conditions with ongoing monitoring and control of environmental parameters including light, humidity, and temperature, a broad range of plant species may attain ideal growth rates year-round. The goal of the vertical farming approach is to increase productivity. To allow indoor food and pharmaceutical manufacturing, it is possible to artificially regulate the temperature, light, humidity, and gases. As a result of the usage of closed growth systems, chemicals are kept out of the environment. Because of his innovative work in this field, he is known as the "father of vertical farming." Growing vegetables vertically is comparable to using fluorescent lights and metal reflectors in greenhouses. Farmers now deal with a number of challenges. With the highest susceptibility, 220 million people are at danger of drought each year. Pesticide poisoning claims the lives of 20,000 individuals annually in poor nations. Rapid urbanization and industrialization are lowering the amount of land that may be used for agriculture, but they are also diminishing the efficiency of conventional agricultural techniques, which have a variety of negative environmental repercussions. In order to sustainably feed the world's rising population, methods for producing adequate food must be developed. Modified growth medium may be used to produce food sustainably while protecting water and land resources. In the present situation, soless agriculture might be effectively established as a different option for producing wholesome food plants, crops, or vegetables. Security of food is becoming more and more important as the world's urban population rises. Vertical farming is useful in this situation. The concept is straightforward: cultivate your own food instead of depending on imports. The research on the issue has recognized three different forms of vertical farming. These buildings are often tall with numerous levels of growth beds that are frequently illuminated artificially.

Urban farms in all forms and sizes are emerging everywhere. This approach has been used to both new and ancient structures, as well as warehouses that have been transformed for agricultural purposes. This kind of vertical farming takes place on the roofs of both old and new structures, including office buildings, homes, and retail establishments like supermarkets and restaurants. The third kind of vertical farm is the futuristic, multi-story structure. These kinds of serious imaginative initiatives have been more prevalent during the last ten years. But no such building has been built. The success of small vertical farms and the development of their technologies are likely to pave the way for skyscraper farming, therefore it's crucial to keep these three kinds of vertical farms in mind. This mini-revolution has been joined by public health experts, urban farmers, architects, agronomists, and environmental activists who are all trying to find out how to live in a world that is becoming more urbanized and food insecure. Aeroponics, hydroponics, aquaponics, and robotics specialists have all converged on the idea of vertical farming. Non-profit groups have backed the vertical farm idea in an attempt to enhance the local economy and ecology. Similar initiatives that seek to address the need for local goods have also backed this concept. Governments who are searching for methods to improve domestic food security have also financed these initiatives. International nations have gathered to talk about vertical farming.

Vertical farming is required

Food Safety

Food security has grown to be a serious worry in today's society. Demographers predict that during the next few decades, a major increase in the population of cities. Agronomists, and geologists that specialize in land usage claim that there is an increasing shortage of farmland. There is a chance that worldwide famine may result if food demand exceeds supply. According to UN estimates, there will be more than 9 billion people on the planet by the year 2050, an increase of 40%. Additionally, the UN estimates that by this time, 80% of the world's population will exist. According to these projections, in order to feed an extra 3 billion people on the earth by 2050, we will need to produce 70% more food. Farmers anticipate that when oil prices rise and future water, energy, and agricultural resource shortages occur, food prices will increase even more. The encroaching peripheries of suburban expansion are consuming an increasing amount of farmland. On the other hand, the lack of available land and high expenses have already made urban farming challenging. We really need game-changing answers to this massive global issue. Vertical farming relies on a straightforward idea to produce more food on a smaller plot of land. The idea of vertical farming is to create small, self-sufficient ecosystems that can handle a variety of functions, from food production to waste management.

Vertical farming has a number of advantages, including the capacity to produce food in an eco-friendly and sustainable manner, the ability to save energy and water, the ability to reduce pollution and pollution, the ability to increase the economy, and the ability to provide access to wholesome food.

Crops produced in a controlled environment will be less impacted by the weather, pests, fertilizers, runoff, polluted water, and dust. On the other side, producing food indoors could provide a better atmosphere. Indoor farming has the potential to give larger yields and provide a stable source of income since it can be done all year long and regardless of the weather. Through indoor farming, it is also feasible to significantly cut transportation expenses and greenhouse gas emissions by shortening the journey times to and from nearby markets and distant farms. Additionally, the development of much-needed "green collar" employment as a consequence of vertical farming might be advantageous for metropolitan areas. Additionally, vertical farms could ease the agriculture industry's land problem. Every person on Earth had an estimated 0.42 hectares of arable land in 1961, according to estimates. By 2002, urbanization and population expansion had decreased the area to 0.23 hectares, a decline of over 50%. One-quarter of all arable land has been badly degraded, according to a 2011 UN assessment of the world's land resources. There will soon be a lack of agricultural goods. To put that in perspective, the typical person needs 1500 calories each day, therefore by 2050, the amount of agricultural land now used will need to be increased by an area the size of Brazil.

LITERATURE REVIEW

Kalantari et al.[1] Studied in the next 50 years, 80% of the world's population will reside in urban areas as a result of the population's continued fast rise and the enormous increase in food consumption that will accompany it. There is a need for sustainable urban food to feed this expanding population. Urban food production must take into account all sustainability-related issues at once, including social, economic, and environmental progress. In metropolitan settings with a shortage of land and space, vertical farming is a concept that entails raising plants and animals on vertically inclined surfaces like those seen in skyscrapers. However, there is a dearth of knowledge and a dearth of critical assessments on vertical farming in cities that have been published. This research utilizes the concept of sustainability to explore the role of vertical farming in future food supply in cities in an effort to assess the primary potential and problems of the practice. Increasing food production while maintaining high standards of quality and safety and promoting sustainable urban farming are all possible benefits of vertical farming. The well-known benefits of producing food in urban areas may be advantageous for the environment, society, and economy. Additionally, vertical farms may provide ways to improve global food security.

Santini et al. [2] studied In the next 50 years, 80% of the world's population will reside in urban areas as a result of the population's continued fast rise and the enormous increase in food consumption that will accompany it. There is a need for sustainable urban food to feed this expanding population. Urban food production must take into account all sustainability-related issues at once, including social, economic, and environmental progress. Designing and putting into practice vertical farms is a novel approach that has been suggested to solve the problem of sustainability and to satisfy the rising food demand. In metropolitan settings with a shortage of land and space, vertical farming is a concept that entails raising plants and animals on vertically inclined surfaces like those seen in skyscrapers. Nevertheless, there is a dearth of knowledge and a dearth of critical assessments on vertical farming in cities that have been published. This research utilizes the concept of sustainability to explore the role of vertical farming in future food supply in cities in an effort to assess the primary potential and problems of the practice. In this research, 60 documents from linked published articles from pertinent publications and scholarly internet sources are critically reviewed. Increasing food production while maintaining high standards of quality and safety and promoting sustainable urban farming are all possible benefits of vertical farming. The well-known benefits of producing food in urban areas may be advantageous for the environment, society, and economy. Additionally, vertical farms may provide ways to improve global food security.

Beacham et al. [3] studied increased population pressure on agricultural land makes it necessary to maximize food output per cultivable area. In an effort to increase agricultural output per square meter of land, attention is shifting more and more toward Vertical Farming (VF) techniques. However, this phrase has been used to a wide range of strategies, from small-scale vegetable and herb gardening on a personal or communal level to massive skyscrapers used for the commercial cultivation of a variety of crops. The main categories of VF are summarized in this article to help decipher this new but occasionally perplexing area of agriculture. It is also discussed how further scientific research into VF's potential is currently lacking and will be necessary to help determine its viability as a way to contribute significantly to the world's food production.

Roberts et al. [4] studied an innovative method of food production known as vertical farming seeks to maximize the yield that may be obtained per unit of land area in order to provide agriculture with sustainable intensification. This strategy often makes use of glasshouse or controlled environment (CE) facilities with stacked horizontal stages of crop development. However, there hasn't been much research done in the scientific community on vertical farming. As a result, critical elements including economic viability, system design, and manufacturing technique optimization are still being assessed. In comparison to traditional protected horticulture, vertical farming systems need extra considerations for the efficient control of pests and diseases, such as the movement of both harmful and helpful insects between development stages. This article tries to present both the advantages and disadvantages of pest and disease management in vertical farming systems.

Helberg et al. [5] studied in addition to the more apparent usage for nourishment, the mycelium of the edible Pleurotus ostreatus fungus may be utilized for a variety of technological purposes, such as packaging materials or wastewater treatment. Although P. ostreatus often grows on wood, sawdust, or related materials, a previous research looked at mycelium development on various nanofiber mats. Here, they describe how to cultivate P. ostreatus on textiles made of various materials to employ this fungus for textile-based vertical farming. Our findings demonstrate that P. ostreatus develops similarly on synthetic and natural fibers. It has been discovered that the agar medium used to provide nutrients supports mycelium development best when applied by dip-coating, indicating that P. ostreatus may also be produced in this manner on vertically aligned textile textiles for vertical farming.

Benke et al. [6] studied declining supplies of arable land per person are a result of ongoing trends in population growth, urbanization, water supply reduction, and climate change. Urban vertical farming, which makes far better use of technology and automation for land-use optimization, is an example of a solution for enhancing future food production. Within a context of urban, indoor, climate-controlled high-rise structures, the vertical farm concept seeks to greatly boost production and decrease the environmental imprint. Such facilities are said to provide a number of possible benefits, including a clean and environmentally friendly supply of food, biosecurity, freedom from pests and droughts, and a decrease in the usage of fossil fuels and transportation. In this article, the relevant concerns are assessed together with any possible benefits and drawbacks. Policymakers should take into account any potential ramifications, which are also indicated to help with future economic research.

DISCUSSION

Changing Climate The quantity of arable land is decreasing as a result of climate change. Large expanses of valuable agriculture have been devastated by flash floods, hurricanes, storms, and drought, which has had a severe effect on the world economy. For instance, a prolonged drought in 2011 caused the United States to lose a $110 billion grain harvest. As a consequence of man-made global warming, weather-related catastrophes are predicted to increase in frequency and severity. Large tracts of cultivable land will become unfit for cultivation as a result of these catastrophes. Governments have a number of systems in place to provide conventional farming significant subsidies, such as crop insurance for loss from natural catastrophes. As a consequence, the United States uses more than 20% of its total gasoline and diesel for its varied agricultural operations in conventional farming (e.g. ploughing; applying fertilizers; seeding; weeding; harvesting). It is important to understand that "food miles" refers to the distance that crops must travel to reach dense urban populations. 1500 miles is the typical distance that food travels from the farm to the dinner plate. Food miles may rise under certain conditions, such as cold weather, when retailers, restaurants, and hospitals import food from other nations to meet demand. Over 90% of the food eaten in major American cities is regularly imported. According to a research, each household's yearly carbon dioxide emissions from food delivery amount to 0.4 tons. This is crucial since urbanization and population expansion have increased the distance between rural regions and metropolitan centers. Transporting food and agricultural practices have increased greenhouse gas emissions, which has accelerated climate change.

Health Traditional agricultural methods usually hurt both the natural and human surroundings because they do not pay them enough attention. Soil erodes, becomes polluted, and a lot of water is lost as a consequence. According to studies by the WHO, more than half of all farms in the world still use raw animal excrement as fertilizer, which may attract flies and serve as a breeding ground for weed seeds or diseases that can infect plants. Consuming such food is harmful to people's health. Additionally, if crops were produced in a controlled indoor environment, the usage of pesticides and herbicides, which cause damaging agricultural runoff, may be decreased. Eutrophication, for instance, may cause algae growth to be sped up. When algae die as a result of bacteria eating them and removing all the oxygen from the water, a dead zone develops in the body of the water. Indoor vertical farming consumes less water than conventional farming, which requires around ten times as much water, thanks to precise watering and effective scheduling. The demand for water rises as urban populations rise, which may have a significant effect on the amount of water available for agricultural use. Agriculture uses more than two-thirds of the freshwater on Earth, but farmers are losing ground to urban areas, which are growing and using up more water. As temperatures rise and more droughts develop due to climate change, water shortages are predicted to become worse. It's Ecosystem Humans have been intruding on natural ecosystems via agriculture for millennia. Because of human activities, these historic ecosystems are being invaded, which hastens climate change. Through indoor vertical farming, it is possible to restore biodiversity and lessen the consequences of climate change. Vertical farms could produce food using just 10% of the land that cities presently use, which would cut CO_2 emissions sufficiently to encourage the creation of new technologies that would eventually benefit the biosphere. If fertilizer runoff were removed, coastal and river water quality would improve, and wild fish populations would increase.

The greatest justification for shifting most food production to vertical farming seems to be the possibility of restoring ecological services and functions. Economics The food produced by the vertical farm, according to its supporters, will also be offered at reasonable pricing. Due to increased input prices, the cost gap in traditional farming is fast decreasing. Vertical farms, for instance, might be advantageously located in metropolitan areas so that product can be sold to the customer directly, decreasing costs by 60%. Vertical farms may increase productivity by an order of magnitude in addition to the utilization of cutting-edge technology and intensive agricultural techniques. Numerous factors of indoor farming, including light intensity and color, temperature, CO2 concentrations in the air, soil and water, and humidity levels, have been subject to years of research by scientists. Vertical farming may also help the local economy. Wasted urban buildings may be converted into vertical farms to provide needy populations with fresh food. Furthermore, the sophistication of indoor farming may enhance the pleasure of growing food. As a result, the practice has drawn a younger, more tech-savvy population, giving rise to a new generation of farmers.

The development of new agricultural technology is only one of the many advantages of vertical farming. By participating in agricultural activities, it may finally enable urbanites to restore touch with nature. Modern techniques for vertical farming Research on vertical and urban farming aims to improve the sustainability of the food supply. When compared to conventional farming methods, advanced farming techniques may provide larger yields while using much less water. These high-tech farms' layout and design will ensure that all plants get an ideal amount of light as well as accurately calibrated nutrients. In these farms, crops would be cultivated in a closed-loop system, enhancing nutrition and food value, eliminating the need for herbicides and pesticides. In order to satisfy customer desires, indoor farmers may also be able to "design" the taste of their produce. According to academics, these technologies will eventually be able to be used all over the globe and will be able to provide great production while having a little effect on the environment. They represent a paradigm shift in agriculture and food production and are perfect for urban farming because to the scarcity of available land.

Hydroponics

Hydroponics employs mineral fertilizer solutions to produce food without soil. The growing of plants in water that has been enhanced with nutrients, either with or without the mechanical support of an inert medium like sand or gravel, is known as hydroponics, according to the Encyclopedia Britannica. The phrase is derived from the Greek terms hydro and ponos, which indicate "water laboring" or "water performing labor." Although the concept of cultivating plants in water is not new, hydroponics' commercialisation is just relatively recent. NASA researchers have determined that hydroponics is a practical method for producing food in space. They have had success cultivating a variety of crops, including radishes, lettuce, and onions. Overall, scientists have enhanced the hydroponic method by working to make it more efficient, dependable, and fruitful. Without soil, crop cultivation offers great environmental, growth, and development control.

The use of hydroponic farming has dramatically increased in a number of forward-thinking nations. The top commercial hydroponics operation was "Eurofresh" Farms in Wilcox, Arizona, which sold 125 million pounds of tomatoes in 2005. operator of the biggest commercial hydroponic greenhouse. Due to its numerous benefits over soil-based farming, hydroponics is now extensively employed in industrial agriculture. This approach may lessen or do away with soil-borne agriculture problems (such as insects, fungi, and bacteria that thrive in soil). The hydroponic approach, which is also low-maintenance, eliminates the need for weeding, tillage, kneeling, and soil removal. In addition, controlling big production areas using hydroponics requires less labor. Because no animal waste is utilized, it can also be a more ecologically friendly procedure. Because this approach employs hydroponics, it is also simpler to regulate the pH and nutrients levels. It is important to remember that soil-fixed nutrients are dissolved in water through evaporation as well as mineralization, and that a variety of elements, including temperature, oxygen content, and moisture, affect how readily accessible these nutrients are to plants. In comparison to other techniques, hydroponics may provide more consistent and greater yields when nutrients are supplied equally to all plants.

Commercial hydroponic production and the Hydroponics Market According to estimations from the industry, the hydroponics market is predicted to reach USD 21203.5 million in 2016. A few of the food crops cultivated with hydroponics include tomato, cucumber, lettuce, and pepper. With a worldwide market share of 30.4% in 2018, tobacco is the biggest market sector. Growing hydroponic crops for tomatoes, lettuce, and other leafy green vegetables is anticipated to rise. The demand for hydroponics culture is rising in Europe and Asia-Pacific as customers become more conscious of the importance of dependable crops cultivated in greenhouses. The majority of hydroponics has historically been practiced in Europe.

Aeroponics

A key advancement in hydroponics technology is aeroponics. An enclosed air, water, and nutrient environment that promotes quick plant development may be described as an aeroponic system since it lacks soil or medium and requires little water and sunshine. The main difference between hydroponics and aeroponics is that the former uses water as a growth medium while the later does not. Because it employs mist or nutrient solutions instead of water, aeroponics does not need containers or trays to hold water. Hydroponic farming uses 95% less water than conventional growing techniques, yet it takes up much less land. Plant boxes may be stacked anywhere, even in a basement or warehouse. The plants at the top and bottom of a stack of plant boxes are supported, allowing their crowns to grow upward and their roots to develop downward. The plants are misted with a nutrient-rich water-mix solution, which provides nourishment. Since the system is totally enclosed, the nutrition mix is entirely recirculated to save water. It is perfect for locations with a shortage of water as a result. In growth chambers, nutritional solution is sprayed or misted onto roots dangling in the air. Due of its superior aeration, aeroponics has a significant benefit. In an aquaponics system, plants have full access to a range of CO_2 concentrations between 450 parts per million (ppm) and 780 parts per million during photosynthesis (ppm). Crops grow quickly, and 70% less water is used than with hydroponics. In comparison to the most efficient hydroponic systems, aeroponics is the most water-efficient soilless growth method and requires no replenishment of the growing media. Additionally, because the aeroponic process doesn't utilize water, neither fertilizers nor pesticides are needed. Additionally, studies have shown that using this high-density planting technique results in simpler harvesting and larger yields.

Aquaponics

Fish and plants may develop mutualistic interactions when hydroponic food, flower, and herb production is mixed with fish husbandry. Aquaponics is a method of growing food that combines hydroponics with aquaculture. Aquaponic systems utilize around 10% less water than traditional soil-based horticulture does. These methods may be useful in severe rural or urban contexts with limited or poor-quality land. This advantage is also accessible with a hydroponics or re-circulating aquaculture system. Aquaponics may be a big improvement over conventional agricultural techniques in nations where nutrient enrichment is a problem. In the majority of aquaponic systems, fish and plants absorb 70% of the nutrients, and the remaining solid waste may be utilized to produce fruit trees or traditional horticulture crops.

Vertical eco-sustainability farming's challenges

A vertical eco-development farm's is fraught with a number of practical and financial difficulties. Vertical eco-farms would be sustained by plant science and engineering techniques, including agriculture, agronomy, civil planning, architecture, engineering, economics, and public health. For a plant to flourish, it needs nutrients, water, light, and air.

Monitoring of Air Quality, Temperature, and Relative Humidity for Optimal Performance

To guarantee that crops are cultivated in an ideal environment, air quality, temperature, and humidity levels are regularly monitored. A different option for warehouse installations that improves agricultural productivity is the injection of CO2. Warm-season plants do best when the daytime temperature is between 70 and 80o F and the nighttime temperature is between 60 and 70o F. Typically, cool-season plants need temperatures that are 10°F lower than those of warm-season plants. If the plant's growth is outside of this range, it will develop very slowly. It's essential to maintain a pleasant temperature as a consequence.

Stream Quality

Water that includes particle, fluoride, and heavy metal contaminants must be removed and sanitized before it may enter the vertical eco-farm system. Rainwater is collected and utilized when there is an excess. With the help of algae, aquaponics may transform waste water into a drinkable irrigation medium. Vertical eco-farming is considered by Scientific American to be a workable solution to the world food dilemma.

Monitoring of Light Quality

It has often been used to boost crop growth, guarantee long-term viability, and lower operational expenses. In order to enhance plant development, computer systems should be configured to only utilise the portions of the light spectrum that are now required. A varied degree of light intensity is required depending on the species. Most fruiting plants (including maize, tomatoes, and peppers) need eight to ten hours of direct sunshine each day. If such crops are cultivated inside, artificial lighting must be employed to keep the temperature within reasonable ranges.

Management of Nutrients

To maintain optimal levels for each crop's development stage, plant nutrition must be continuously assessed and modified. The secret to a successful eco-farming strategy is the nutrient solution. Vertical eco-farming techniques do away with the requirement for soil by feeding the roots with easily accessible, water-soluble nutrients. For plants to grow, they need sixteen nutrients. Oxygen, carbon, and hydrogen are extracted by plants using water and air. The remaining elements are provided by the nutrient solution. The nutritional components required for vertical eco-farming crop development are sold by chemical businesses, pre-mixed fertilizer, hydroponic material, greenhouse material, and other sources. These goods are regularly offered for sale. Instead of experimenting with their own original formulas, the majority of hydroponics beginners utilize pre-made commercial mixtures. You may, however, be able to get more precise nutrient combinations for certain plants as well as the chance to experiment with novel combinations if you're prepared to put in the time and effort. There is no one recipe that works better with all plants than another, even while some recipes are intended for general usage and others are specialized to particular species.

Checking the pH of a Nutrient Solution

The pH level affects how readily available nutrients are for plants. Nutrients may be given to vertical eco-farming systems based on the demands of the plants. A key factor is keeping track of the pH balance of the nutrients. Within a specified pH range, which varies for each species of plant, all minerals are absorbed by plants. A chemical analysis must be performed on the nutrient solution used to produce vine crops in vertical eco-farms. It is possible to determine the kinds and concentrations of ions by separating the ions that are necessary for the nutritional solution and can, thus, be left in the original formulation from those that are not. pH adjustments must be done every day in soilless systems because of their decreased buffering capability. The ideal pH range for the majority of vine crops is 5.5-7.5, beyond which certain nutrients are inaccessible to plants. The pH of the majority of municipal supply is between 7 and 8. Acid additions are often employed to decrease the pH of nutritional solutions. It's usual practice to add nitric, sulfuric, or phosphoric acid individually or in combination to modify pH.

Design of a Watering System

Many different watering methods are used in vertical eco-farming. Some of the most popular watering techniques include wick systems, water cultures, flood and drain cultures, drip systems, nutrient film approaches, and aeroponic cultures. The first stage in beginning or growing a farm is selecting the appropriate crops and cultivars. A vertical eco-farming operation must start with crop selection, which incorporates a number of factors. Regardless of the region and site of the farm, the crops are generally selected based on their marketability and profitability. A great deal of nations, especially those whose economies are centered on agriculture, utilize farmland that has been acquired or handed down down the centuries.

Crop Selection for Vertical Eco-Farming

Making the appropriate decisions when it comes to the crops that will be cultivated is the key to a successful farming endeavor. Among the most crucial aspects to take into account when choosing a crop are crop or varietal adaptability, commercial viability and profitability, resistance to pests and diseases, technological feasibility, and farming system.

Risks Associated with Vertical Eco-Farming

The most frustrating aspect is the massive amount of energy required to power the extra lights as well as run the other environmental measures. How to create plants with the best chance of growing is a topic of much discussion in the scientific literature. The plants will perish soon if the vertical environmental system malfunctions. Hydroponic systems can have drawbacks, such as pathogen assaults like damp-off caused by verticillium wilt due to high humidity levels associated with them and overwatering of plants grown in soil.

CONCLUSION

The utilization of vertical farms might significantly enhance food sustainability in urban settings. This is crucial when we plan for the long term and anytime it is anticipated that the urban population will increase significantly. Vertical farming offers several advantages over rural farming in terms of sustainability on the social, economic, and environmental fronts. New high-tech production methods like aeroponics, hydroponics, and aquaponics are essentially posing a threat to the requirement for soil-based farming. Vertical farming is getting more and more common when it comes to enhancing crop productivity. Vertical farming, which enables crops such as short-lived vegetables and preferred feed crops like maize, potatoes, to be produced year-round in very tiny spaces with minimal labor, may be particularly beneficial for the poorest and landless places as well as those with limited access to land and water. India's vertical farm businesses are expected to develop significantly in the future. In order to improve commercial vertical farming and lower startup and running costs, low-cost hydroponics as well as other low-cost vertical farming technologies must be developed. The affordability of a vertical farm for low-income households is a significant issue. These individuals are poor due to a number of contemporary dislocations, including slums and food deserts. The success of vertical farming depends on a variety of factors, including the availability and quantity of food, the size of the population, technical development, cultural and nutritional preferences, and the availability of electricity and water.

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CHAPTER 13

A NOVEL PERSPECTIVE ON VERTICAL FARMING METHODS

Praveen Kumar Singh, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- dr.pksnd@gmail.com

ABSTRACT:

The Vertical Farming is the new way or approach in the advanced level and this paper deals with the methodology, harvesting technique, water management, and crop cultivation & yielding process. The Vertical Farming is the advanced level of agriculture technology where this has to be practiced when there is a lack of land and other requirements for the perfect structure of farming mode. And certain naturally occurring renewable resources are employed, such as wind turbines and solar panels, among others. However, since these processes differ from those used in conventional agriculture, extra techniques must be followed for high producing results.

KEYWORDS:

Agriculture, Hydroponic, Greenhouse, Management, Vertical Farming.

INTRODUCTION

The procedure known as vertical farming combines the greenhouse or skyscraper effects to create the most sophisticated kind of agricultural operations. This vertical farming technology is utilized to develop crops using either artificial sunlight or maybe direct sunlight. The greenhouse effect is bad to the environment, thus this method partly reduces it and is constructed naturally. However, most vertical farms are not constructed in an environmentally favorable way. However, this vertical farming contains a glass-less portion that allows oxygen to reach the agricultural regions' outermost layer. In the vertical farming method, many types of water management are used. The windmills in this vertical farming system are used to generate electricity for the water pumping system, and they are also kept at the top of skyscrapers to collect air. Other energy sources, like solar energy, are also added in order to generate artificial light sources for the crops in order to increase crop yields. Water harvesting, hydroponics, fade-type windows, and a proper architectural framework are all need for vertical farming in order to be designed well.

The overall land area of the planet Earth makes up just around 27% of its surface, with the remaining 73% being water. Only a third of this geographical mass is productive; the remainder is made up of high mountains, chilly and arid deserts, etc. Nearly 57% of fertile land has been converted by humans throughout time for the growth of diverse food crops, often at the cost of forests and grasslands (43%). It has been predicted that by 2030, the majority of the world's population (>60%) would move to cities for urban habitation as a result of expanding urbanization, which is a global phenomenon. The few land resources that are now accessible are under stress from growing urbanization, which is contributing to the global cultivated land's slow but persistent decrease. Numerous small and big concrete buildings have been produced as a consequence of urbanization, mostly to accommodate the constantly growing population at the cost of farmland. Today, high rise buildings dot the skylines of major metropolises, but peri-urban agriculture, which grows vegetables and other food, is rarely noticeable. It is apparent that as cities continue to grow, food production, which has already peaked in certain crops, will be under pressure. There is virtually no more arable land left in many areas, and there is little chance of adding more land for agricultural production. The cultivable area has been essentially stable over the last several years in India as well. Any land that is recovered is nearly entirely used for infrastructure development and construction. The amount of arable land available has decreased, and land prices have recently increased dramatically. The issue will be exacerbated by the transportation of perishable and semi-perishable food, particularly from horticultural crops with shorter shelf lives, from rural production areas to urban consumption centers. One idea that has the potential to partially address the aforementioned issue is the production of food inside cities themselves, whether on rooftops, in public areas, or in residential structures. With declining returns on land, water, energy, and other limited resources, the current enhanced agricultural techniques place enormous strain on those resources. However, the new technology of vertical farming is anticipated to significantly alleviate that burden. In light of the aforementioned, it looks to be a breakthrough method to produce vast amounts of healthy food year-round from vertical farming within a little space or region.

Vertical farming is the practice of growing crops, mostly vegetables, ornamentals, and herbs, inside on racks of shelves while using artificial light, nutritional solutions, and little to no sunlight and soil. Such farms are able to increase output year-round with low chance of crop failure since they are not reliant on seasons or a regulated climate. They also provide high-quality fresh fruit without relying on a favorable climate, fertile soil, or heavy water use, and they save labor, which is now a precious resource. With nutritious supplements, vertical farming has the ability to feed the growing global population, particularly in urban settings. Vertical production of mushrooms, green fodder grown in hydroponic systems, certain fruits and vegetables, and even chicken birds is either already popular or well established. Green walls, living walls, bio walls, and vertical gardens are other names for vertical gardens, which are a kind of vertical farming in decorative horticulture. It is an area that is either freestanding or a portion of a structure that is totally or mostly covered with lovely flora that is luxuriantly growing in either an organic or inorganic medium, and in certain circumstances, soil as well.

Throughout history, people have had an effect on practically every aspect of the planet. For instance, industrial farming was a breakthrough that significantly altered the socioeconomic landscape of the globe by generating high-yielding farms for the world's quickly expanding population. These agricultural methods were developed with little to no consideration for the environment, and many of them are still in use today. But as time goes on, society will only be forced to deal with the worsening effects of not taking steps to make these behaviors more sustainable for future generations. Typical farms use a lot of energy, water, and land, and also affect the environment by destroying habitats and runoffing chemicals. By the year 2050, the world's population is expected to reach ten billion, and close to 80% of human settlements would be located in and adjacent to metropolitan areas, according to the Vertical Farming Association. If conventional agricultural methods are used, it won't be able to feed and hydrate so many people in an adequate manner. An example of how unsustainable it is is given by the fact that "over 70% of the world's fresh water supplies are utilized for agriculture and, about 40% of the Earth's total landmass is now being used to support soil-based agriculture, with over 80% of the world's accessible land currently in use.

The proportion of arable land utilized for agricultural production has more than quadrupled during the last 18 years. If society doesn't modify the way things are done, these numbers increase along with the population. We cannot address our issues with the same mentality we used to create them, as Albert Einstein famously stated. Since nature cannot provide the resources we need to thrive at the rate at which humans can, society must put greater effort into creating innovative models of sustainable agriculture. Sustainable agriculture preserves land, water, plant and animal genetic resources, and is ecologically non-degrading, technically suitable, commercially viable, and socially acceptable, according to the Food and Agriculture Organization of the United Nations (FAO). Vertical farming has the potential to become the major source of food for civilization and the future of sustainable agriculture. Vertical farms would take the place of conventional farms, benefiting society socially and economically while also conserving the environment. The major goal of vertical farms is to cut down on total resource use and the carbon impact of agriculture. A kind of indoor farming known as "vertical farming" aims to improve productivity and efficiency per square foot by cultivating crops on numerous levels along a vertical axis. Advocates of vertical farming want to replace conventional farms with vertical farms situated inside of metropolitan areas in order to utilize less land, water, and energy and produce food that is more sustainably.

The vertical farming architecture is divided into a number of categories, including cropping technique, harvesting method, and energy and water management (also known as hydroponics). The vertical farming design also relies on the construction-oriented process, where it might be challenging to ensure that all crops get adequate sunshine radiation to support their healthy development. Renewable Resources, first the vertical farming technique is intended to be used in situations where limited resources, like as energy and water, may or may not be present in the future. Therefore, the system involving the renewable resource process, where the wind mill can be used to generate electricity for the water pump process to supply water to the crops, and solar energy are also added as well to generate power for the producing of artificial sunlight to the crops, is involved in handling those situations. The reaping process is also known as the water management process, therefore the vertical farming structure will specifically manage the water. Some of the methods will be discussed, such as rain water harvesting, which states that water collected from rain is also passed through pipes to crops, resulting in healthy and natural yields by using rain water in an indirect manner. These activities are carried out using a hydroponic system, where it is stated that nutrients will be passed on the crops through the pipes while the water is being passed to the crop.

Working of Hydroponics: The hydroponics technique is a crucial step in the vertical farming system. It must be built to the highest standards since crops are planted in soil and connected to pipelines, which need injectors to draw strong currents of water and enough power sources. The hydroponic system also has a filter to remove water waste, and it is constructed with a mixture of minerals that are kept in a separate storage for use as needed. Bug-killing minerals can also be added to the water to protect the crop from insects that completely destroy crops, showing the versatility of hydroponic farming.

Vertical Farming Assets

One of the main advantages of vertical farming technology is reliable cropping. This method does not require seasonal cropping because all system operations are carried out internally, allowing crops to be harvested at any time of year. By using this method, crop loss will not occur, and other advantages of interior framing include the fact that crops cannot be infected by bugs and that climatic changes will not affect the crops. In the vertical farming technique, led lights are employed in place of sunlight to grow crops more effectively than they would in direct sunlight. Additionally, our approach lowers labor costs since, in contrast to agriculture, where more labor is needed, our system just needs a smaller workforce. As the vertical farming system requires just a little quantity of water. A separate faucet is connected separately to each crop in the system in vertical farming, while land-based agriculture uses more water to cover all of its crops.

Ecofriendly Approaches

Since the vertical farming system uses a variety of methodologies, it is an environmentally friendly process. We can grow any type of crop for any length of time, multiple crops can be grown in this process, and if a heavy rainstorm came, it could harm all the crops in the system, but in this system, the crops are protected by buildings, so they are not harmed by rain. As water is carried through the hydroponics system and any extra water is collected and utilized in the recycling process, it is said that the water used in this system may be reused. It's a completely eco-friendly method where it's simple to grow new kinds of crops in the vertical farming system. In addition, as compared to conventional land farming, vertical farming produces pesticide-free plants or crops that provide nutritious food. This type of method is very effective in bringing the outdoors into urban places.

The current vertical farming technique in India is expensive, and as a result, so is the yield. As a result, it is challenging to compete with the market price attained by contemporary geoponic agriculture today. However, there is only a sizable market for vertical farming products in Indian metropolises, mostly in upscale hotels and among the well-off (those with high incomes). The fact is that soilless vertical farms for greens leafy vegetables, strawberries, and herbs are mostly controlled by the hotel business, which also provides other industrial houses and wealthy individuals with high-quality, fresh food. Unfortunately, this technology is still in its infancy in India in terms of research and development (R&D) and human resources, the two cornerstones of every successful enterprise. Its classification as "organic" or "inorganic" is likewise debatable. Major food crops are currently not compatible with vertical farming. Despite several restrictions, the technology has the capacity to produce ten times more per unit area than conventional agriculture and has the potential to be integrated into both the present and the food production and consumption habits of the future. Additionally, this method is sustainable and has a number of advantages, including a need for less water, land, fertilizer, pesticides, and other inputs. In addition to being viable in all environments where people may live and work, vertical farming is also feasible in lakes, beneath or above the water, in space, even in kitchens (micro greens).

LITERATURE REVIEW

Gaston Ha et al. [1] studied the author need to make significant changes to what they consume as well as how food is produced. The latter is the subject of the current study, namely the development of agriculture in controlled environments. In this context, empirical study employing online surveys on consumer perceptions about vertical farming (VF) an indoor plant factory with artificial lighting is provided. The research was carried out in the UK, Singapore, USA, and China. A multi-method study strategy was applied, including a unique text-highlighting technique that asks participants to read a description of VF with comments of advantages and negatives and use highlighter features to choose text elements they "like" and "dislike." According to the text's facts, the four nations' sentiments regarding VF were generally favorable.

Van Delden et al. [2] studied In comparison to traditional agriculture, vertical farming may produce food while using less land and water and perhaps generating zero pesticides and fertilizers. In order to build resilient food systems, especially in and around highly populated places, vertical farming systems (VFS) may help consumers satisfy their daily needs for wholesome, fresh goods. Fruits, vegetables, and herbs are among the products already produced by VFS, but for vertical farming to be successfully integrated into conventional agriculture, energy efficiency, and improvements in profitability, public policy, and consumer acceptability are necessary. We explore cutting-edge vertical farming, multi-layer indoor crop cultivation systems, future challenges in the areas of plant growth, automation, robotics, product quality, system control, and environmental sustainability, as well as how institutions involved in research and development, socioeconomics, and policy-related institutions must collaborate to successfully scale up VFS to future food systems.

Khandaker et al. [3] studied In an aquaculture system with a recirculating water supply, fish and vegetables are grown using the aquaponics technique. Like hydroponics, aquaponics utilizes fish waste to feed plants naturally, and like hydroponics, it is thought to be more sustainable since more plants can be produced per square meter than in conventional agriculture. However, with aquaponics plants are grown inside horizontally, just as in conventional agriculture. This study examines features of merging living wall and vertical farming technologies in aquaponics in order to decrease the space demand for plants, which would make production even more sustainable. It is believed that growing plants vertically will need less room. Although a living wall system is studied in this study, the possibility for employing different inert substrates in vertical aquaponic living wall systems is the major point of interest.

Garg, Anirudh et al. [4] studied the main forces influencing the development of agricultural research include advances in science and technology as well as global urbanization. Food preferences have evolved as a result of changes in profession, rising per capita wealth in emerging countries, and international connections. The production of more and better food is made more difficult by these developments and the growing population. Utilizing methods from traditional agriculture from the 20th century to increase productivity of agriculture has its limitations. The dependency on chemical fertilizers and pesticides for productivity enhancement and pest control, respectively, poses a hazard to the environment and is a significant restraint on world food supply. These developments imply that new agricultural innovations are unavoidably required, and that these technologies should be included into mainstream agriculture.

Bhowmick et al. [5] studied Since current agricultural lands cannot support the requirements of the expanding population, vertical farming, an unusual farming method, has gained popularity. In vertical farming, careful monitoring of environmental factors may improve crop output and quality. It has been suggested to use the Intel Edison wireless module to create sensor arrays that can measure the environmental factors and upload the information to the Thing Speak Cloud. The web-based program may be used to examine and keep track of the vertical farming stacks' lighting, temperature, humidity, and soil moisture levels. A SMS may be delivered through the Virtuino app if the parameters are below a certain level.

Den Besten, et al. [6] studied Although there is a thriving high-tech greenhouse business in the Netherlands, vertical farming is still relatively young there compared to Asia. The current oldest vertical farm is ten years old. From vocational to university-level courses, horticulture education is offered. There are several venues for scientific and practical vertical farming research in the Netherlands. Applied research produces useful information for the sector. The utilization of plasma-activated water, biocontent, plant life cycle duration, hypocotyl length, growing without substrate, and the light-yield relationship are examples of applied research that is presented. The open innovation mindset and fusion of technology and green thumbs in vertical farming are perhaps unique.

Cicekli et al. [7] studied By 2050, there will be almost 9 billion people on the planet. Brazil's size in more land is needed to feed this people with current technology. Due to the shrinking amount of arable land that can feed people, crop losses brought on by newly emerging pests and diseases, climate change, and environmental pollution, it is now necessary to develop alternative agricultural systems in order to produce the amount of food that is required to feed people. Thus, Vertical Farming Systems, one of the agricultural systems where the yield to be gained from the unit area is high, is developing and will eventually become a fast expanding agricultural system. However, the utilization of engineering, technology, architecture, and experiences must be combined for sustainable production or energy in this system.

Michael et al. [8] studied an automated monitoring method for vertical hydroponic gardening is suggested. The goal of this project is to create an automated system for monitoring and maintaining the nutrient level for vertical farming. Electrical Conductivity (EC), pH, liquid level, and water temperature of the nutritional solution held in the rectangular PVC are among the conditions being monitored. The experiment grew the leafy vegetable Bok Choy utilizing the hydroponics technology rather than soil as the growth medium. The technology has control capabilities as well to manage the level of nutrients and the flow of solution into each layer of veggies. The technology that has been put in place is anticipated to minimize water and electricity use and enable periodic plant growth supervision without the need for a caretaker.

Kurt Tomkins et al. [9] Supplies of arable land per person are a result of ongoing trends in population growth, urbanization, water supply reduction, and climate change. Policymakers are confronted with the dilemma of sustainability and feeding the fast expanding global population, which is estimated to reach around 9.7 billion in 2050, while land resources for agriculture are depleted. Within a context of urban, indoor, climate-controlled high-rise structures, the vertical farm concept seeks to greatly boost production and decrease the environmental imprint. Such facilities are said to provide a number of possible benefits, including a clean and environmentally friendly supply of food, biosecurity, freedom from pests and droughts, and a decrease in the usage of fossil fuels and transportation. In this article, the relevant concerns are assessed together with any possible benefits and drawbacks. Policymakers should take into account potential ramifications, which are outlined in order to encourage more economic research.

Francis J. Ferson [10] studied about three major obstacles must be overcome by the developing vertical farming (VF) sector: profitability, environmental sustainability, and standardization. High failure rates are expensive and may be caused by hasty business choices on system design, pricing strategy, site selection, as well as other crucial factors. For lucrative business models to satisfy investors or policy makers, it is essential to improve information transmission and provide adaptive economic analyses for VF. A decision support system (DSS) that enables risk-empowered business planning for vertical farms is needed, according to an analysis of the state of the art in horticulture software. The proposed DSS centralizes data from the literature and lessons acquired from industry practitioners while employing imprecise data approaches to account for incomplete information. For complex/new industries with little data, like VF, this is essential.

Gustavsen et al. [11] studied urban agriculture is becoming more widely acknowledged as a significant sustainable avenue for mitigating and adapting to climate change, creating more resilient cities, and improving citizen health. There are many different types of urban agricultural systems, both for profit and nonprofit purposes. It may be challenging to quantify the value of the services provided by urban agriculture, such as improved food security, improved air quality, water control, and high levels of biodiversity, in order to assist policymakers and the general public in making decisions. Four forms of urban agriculture are the subject of a contingent value study that we conduct. When the people of Oslo are questioned about their opinions and readiness to pay for commercial and non-commercial such as urban community gardens and urban gardens for job training, education, or kindergartens types of urban agriculture.

DISCUSSION

Waste Reduction

One advantage of the vertical farming technique is the reduction of waste, as opposed to conventional farming where crops or plants are damaged by pesticides and heavy rains. Energy for vertical farming is typically managed with solar and wind power so that the energy used is derived from renewable sources, and vehicular transportation is also a crucial aspect of vertical farming. Today, there is an increase in vertical farming and greenhouses, which are constructed entirely using hydroponics and renewable resources. Because greenhouses are not suitable for the earth's environment, vertical farming and greenhouses are combined, and carbon dioxide is passed over the building's exterior. There will be a maximum crop output and temperature control with the use of vertical farming.

Advanced Technology

One of the most cutting-edge vertical farming techniques is integrated technology, which in our system must analyze water, air, and mineral maintenance instead of having to be fully controlled by computers and other embedded systems like sensors etc. While it is true that in order to maintain good air quality, crops and plants require carbon dioxide, which is provided by an integrated system for managing air quality. However, in order for plants to grow in a healthy way, a separate system must be developed in addition to one for managing water and air quality.

In places where the environment and animals do not favor excellent harvests, humans utilize fertilizers and insecticides to increase the productivity of their crops. The health of these ecosystems and the people who depend on them is negatively impacted by the chemical pesticides and nutrient-rich fertilizers that runoff or seep into several habitats where they either don't belong or where, in large enough quantities, they become harmful. Agricultural runoff carries nutrients and pollutants into ecosystems, but it also picks up vast amounts of silt that is distributed abnormally. This section will look at how runoff from agriculture fields may occasionally tilt ecological balances to the point of collapse. Pesticides are the primary agricultural chemicals that pose a threat to the environment. In order to prevent "pest" from eating and disrupting the crops in the fields, farmers employ chemicals known as pesticides. Preservationists see the idea of "pests" as a harmful human-environment connection; a "pest" is any animal or bug that could obstruct human activity. According to preservationists, people are the true threats to the viability of the ecosystem. Farmers accuse a rabbit of devouring their crop, although the rabbit has every right to do so since they are the ones who transported the crops into the rabbit's natural habitat. The majority of animals that come into contact with pesticides, including people, are poisoned by them. Animals who are not considered pests or animals that are harmed unintentionally by pesticide application are often affected. Pesticides may harm an ecosystem as a whole when rainwater, in the form of agricultural runoff, sweeps them into water sources like tiny streams and groundwater. There are several ways in which chemical pesticides used in agriculture get up in water ecosystems and supplies. In a current research on pesticides and the byproducts of their breakdown, the National Water Quality Assessment Program discovered that "more than 95% of river and stream samples and over 50% of groundwater samples they studied included at least one pesticide." Five or more pesticides were found in more than 50% of all stream samples, while ten or more pesticides were found in around 10% of all streams. The use of fertilizers in crop fields is the next source of pollution from agricultural runoff.

Farmers apply minerals called fertilizers to the soil to help their crops flourish. For plants to develop effectively and produce, they need a variety of nutrients. A plant can only develop naturally when it receives all of its nutrients from the soil; however, when farmers plant crops in areas with nutrient-deficient soil or where years of soil erosion have prevented the replenishment of natural nutrient sources, they must provide those nutrients themselves. The surplus fertilizer does not seem to be a problem until rain produces runoff into streams, lakes, and other bodies of water. Enrichment happens when more nutrients enter a body of water. When new nutrients enter a body of water, an algal bloom results, this is referred to as enrichment. An algal bloom is made up of millions of microscopic algae that multiply and expand rapidly all at once. It may take over a body of water and deplete other plants' nutrients. In addition to suffocating marine life and even totally preventing sunlight from reaching aquatic plants and animals that need on it for survival. Some algae are poisonous to the aquatic life they grow on. Toxins from the algae may go up the food chain and endanger vital species, such as keystone species, or even people when they consume tainted fish. Agricultural runoff sediment from soil erosion contributes to environmental issues like algal blooms. Fish may choke when sediment becomes stuck in their gills when there are many soil particles floating in a body of water that otherwise wouldn't have been there. The sun's ability to reach organisms at the bottom of ordinarily clear waters is also hampered by the suspended material. Sediment normally enters streams and lakes after a heavy rain, but when a large portion of a land's natural ground cover vegetation growth is removed to make a farm, this impact is accentuated. In addition to loosening the soil and allowing more sediment to be washed away by rain, this also causes the soil to deteriorate over time as a result of repeated planting and harvesting of crops. As a result, the soil has less natural moisture content and is less able to withstand erosion, frequently because it contains less clay. Agriculture affects the makeup of the soil, increasing soil erosion and the demand for fertilizers. It also releases hazardous chemicals and excessive nutrients into the environment. To save the environment from several risks brought on by humans and stop the loss of naturally rich soils crucial to many ecosystems, this cycle must be broken.

Effects of Agriculture on Society

Social Problems Harvest loss has a significant effect on farmers' livelihoods as well as the communities they serve. Farmers might lose a season's worth of output when crops are ruined by natural conditions like droughts and pests, which results in financial failures and often destitution. Hunger is a source of both poverty and poverty is one of the main causes of hunger. There is a cycle in which poverty causes malnutrition, and malnutrition causes poverty. The effects of malnutrition on a person's growth and cognitive development have a detrimental impact on economic development and productivity, which makes it difficult for them to work effectively and pushes them farther into poverty. One in nine individuals throughout the world experience food insecurity. Malnutrition affects almost 800 million people daily. Food security, according to the FAO, is "a state in which everyone, at all times, has physical, social, and economic access to adequate, safe, and nutritious food that fits their dietary requirements and food choices for an active and healthy life.

There are many aspects of food security

Food availability, affordability, accessibility, consumption, and stability across time. Social Responses Vertical farms have the potential to end the cycle of poverty and have a profound effect on both food insecurity and poverty. Crop production is possible year-round because to indoor farming in a regulated atmosphere. Crop environmental hazards are no longer a concern, and disease damage is now readily detected. The cost of food would drop and the economy might flourish by putting vertical farms into areas that are struggling with poverty. By situating the farms close to the neighborhoods, transportation expenses are drastically reduced, which lowers food costs. The development of crops with better yields results in lower food costs. The farms themselves would boost employment and the chances for education. People would be able to achieve economic stability and dietary stability with a dependable technique to grow crops all year long, ending the cycle of hunger and poverty.

CONCLUSION

As a result, the article goes into great detail regarding the vertical farming structure, which must be composed entirely of cutting-edge technology, including a hydroponic system, artificial lighting system, and effective farming management in urban locations. The development of vertical farming may be well-organized and result in high agricultural yields by assembling all these traits. According to all available studies, vertical farms are a strong option to address problems caused by the unsustainable nature of agriculture. According to the co-founder of AeroFarms, their production per square foot is "75 times more yearly than we would have in the field and 10 times more in a greenhouse." The business Plant Lab has "created a novel high-tech growth concept for culture of plants in conditioned production units in the lack of sunshine," according to a report on the 2015 International Conference on Vertical Farming. In addition to conserving 90% of the water typically used in horticulture, Plant Lab has increased photosynthetic efficiency by 15-18% as opposed to the 9% typically attained under outside settings. The environment and the towns they reside in are being significantly impacted by these facilities, among others. Engineers and farmers alike have the capacity to protect the environment from the harmful consequences of climate change and overpopulation by using this technology worldwide.

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CHAPTER 14

HYDROPONICS AGRICULTURE

Sunil Kumar, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- sunilagro.chaudhary@gmail.com

ABSTRACT:

For the agricultural production industry, soilless agriculture represents a viable possibility, particularly in regions with significant soil degradation and few water supplies. Additionally, this agronomic technique represents a positive reaction to environmentally friendly agriculture and a useful tool in the context of a broader problem with regard to food security. Therefore, the goal of this study is to identify the drawbacks and potential of hydroponic systems employed in soilless cropping systems with a focus on the process of plant mineral feeding.

KEYWORDS:

Agriculture, Aeroponics, Hydroponics, Nutriculture, Soil-Less Culture.

INTRODUCTION

The most readily accessible growth medium for plants is often soil. For effective plant development, it offers anchoring, nutrients, air, water, air, etc. However, soils may sometimes impose significant restrictions on plant development. Some of these include the presence of nematodes and disease-causing organisms, inappropriate soil reactivity, unfavorable soil compaction, poor drainage, deterioration brought on by erosion, etc. Additionally, typical crop growth in soil is rather challenging since it requires a lot of land, laborious work, and water. In addition, certain locations, such as urban areas, lack any soil suitable for agricultural growth, or we discover a shortage of rich cultivable arable lands there because of poor topographical or geographical characteristics. The inability to get labor for traditional open field agriculture has recently become a severe issue. Soilless culture may be effectively introduced under these conditions.

The terms "soil-less culture" mostly relate to the hydroponic and aeroponic growing methods. The Greek terms hydro, which means water, and ponos, which means labor, were combined to form the phrase hydroponics. It is a technique for growing plants without soil by employing mineral nutrition solutions. With their roots just in the mineral nutrient solution or in an inert media like perlite, gravel, or mineral wool, terrestrial plants may be cultivated. The method of growing plants without soil while keeping their roots submerged in nutritional solution is known as hydroponics. This method aids in managing the production system for effective use of natural resources and reducing hunger in addition to assisting in addressing the difficulties posed by climate change. Another method, known as aeroponics, is somewhat similar to hydroponics in that plants are grown using tiny droplets (a mist or aerosol) of nutritional solution.

Open field/soil-based agriculture has faced significant difficulties since the dawn of civilization, chief among which is the decline in the amount of land available per person. Per capita land was 0.5 ha in 1960 when there were 3 billion people on the planet. Today, there are 6 billion people, but that number will drop to 0.25 ha by 2050. Arable area under agriculture will continue to shrink as a result of increased urbanization, industrialisation, and iceberg melting a clear result of global warming. Once again, soil fertility has reached a saturation point, and more fertilizer application does not result in an improvement in production. The production of food using traditional soil-based agriculture is also threatened by factors such as low soil fertility in some cultivable areas, reduced chances of natural soil fertility build-up by microbes due to continuous cultivation, frequent drought conditions, unpredictable climate and weather patterns, rise in temperature, river pollution, poor water management and waste of enormous amounts of water, decline in ground water level, etc. Under these conditions, it will soon be difficult to feed the whole population only via open-field agricultural output. In order to meet these issues, soil-less cultivation is unavoidably becoming more significant in the current environment. Plants are grown in soilless culture without the need of soil. Improved soilless culture techniques for food production have shown some encouraging outcomes globally in terms of saving space and water.

A new paradigm known as Industry 4.0, also known as Smart Production, which is built on cyber-physical manufacturing systems and the Internet of Things, is developing in the industrial sector. It is noteworthy to highlight that the most significant discrepancies between agricultural and industrial processes will be diminished by the hydroponic cultivation of vegetables carried out in constrained and well-controlled conditions, which will ultimately enhance quality control. But in order to do so, a special set of monitoring tools for the hydroponic-based production strategy is required. In this context, sensors for real-time analysis of the composition of hydroponic solutions (i.e., the availability of nutrients/elements) and interpretation algorithms based on machine learning logics are crucial. In reality, it may only be able to maintain/adapt in real-time the composition of a hydroponic solution in order to produce goods of the appropriate quality owing to these instruments, which might be adapted from the industrial environment.

This study aims to analyze the unanswered concerns surrounding hydroponic systems and to highlight prospects for their practical usage on a field size, while also taking into account current scientific breakthroughs and applications in the workplace. They want to identify the issues and themes that have received sufficient scientific attention as well as those that still need to be thoroughly investigated. All of this knowledge is crucial for improving the control of crop nutrient uptake in soilless systems. Additionally, from a practical standpoint, the possible application of novel nutrients and/or bioeffectors, as well as novel technology for data collection and analysis, might be a useful tool for farmers in the context of smart agriculture at the field scale. Unresolved Problems with Hydroponics in Soilless Agriculture Techniques. It is commonly known that the productivity and quality of crops produced in hydroponic systems are strongly reliant on the amount of the plant nutrients acquisition from the growth media.

Chemical Control of the Hydroponic Solution's Nutrient Availability

Solution chemistry is essential when working with hydroponic cultures to maintain proper nutrient concentrations for plant uptake. When making nutritional solutions with salts or concentrated liquid stocks, it's very important to consider certain chemical equilibria, notably the solubilization/precipitation equilibria. In reality, a variety of physical-chemical events, the most significant of which are (1) precipitation, (2) co-precipitation, and (3) complexation, may change the availability of nutrients for plants. In this regard, it should be noted that these processes may be significantly influenced by the temperature of the nutrient solution, which affects the chemical equilibria in solution. This is especially important for regions where the overheating of the nutrient solution often happens and affects crops physiologically.

When cations and anions in an aqueous solution combine to produce an insoluble ionic solid, precipitation processes may take place (the precipitate). When the concentrations of certain cations and anions in solution approach their maximum allowable value, such circumstances, known as saturation, occur (solubility). It is possible to determine the concentrations of ions that are in equilibrium with the precipitate (i.e., solubility) by utilizing the solubility product, a particular equilibrium constant that is listed for a variety of chemical compounds and is temperature-dependent. Along with temperature, other factors like pH and ionic strength may also affect the equilibrium of precipitation (a parameter that considers the sum of the concentrations of all the ionic compounds in solution and their charge). Cations must be carefully balanced and adjusted to prevent losses from solution since they may combine with other anionic nutrients to generate additional insoluble precipitates or insoluble hydroxides at alkaline pH (by interacting with OH anions). In such circumstances, it is necessary to continually monitor or regulate the pH and redox potential (Eh) levels.

In this respect, nutrients including iron (Fe), nickel (Ni), copper (Cu), zinc (Zn) and manganese (MnII) may precipitate as insoluble (hydr)oxides at pH levels above 7 and positive Eh values. FeIII precipitation is possible even at pH levels that are well below neutral. The same components may also precipitate as insoluble sulfides when sulfate is converted to sulfide at negative Eh values and acidic pH, for example, in unmanaged hydroponic systems under anoxic circumstances. Macronutrients like calcium (Ca) and magnesium (Mg) may precipitate as carbonates at high pH values and high dissolved CO2 concentrations. Another process to prevent in hydroponic solutions is the precipitation of phosphates, namely hydrogen phosphates. Along with removing phosphorus (P) from the nutrition solution, this procedure may also make other nutrients including calcium, magnesium, iron, and manganese dioxide less soluble. It is well known that precipitation with calcium may restrict phosphate availability at pH levels higher than.

The availability of sulfur (S) may also be constrained by the precipitation of Ca-sulfate minerals. At acidic pH, silicon solubility typically decreases and SiO2 precipitates may form. Since pH variations often encourage precipitation/dissolution processes, pH must be continually managed or buffered. When nutrients are added to hydroponic solutions in the form of salts, hydrolysis processes may occur that cause the medium to become acidic or alkaline. If nitrogen (N) is simply provided as NO3 (for alkalinization) or NH4 (for acidification), the pH of the solution may also be affected. However, hydroponic solutions often include both N types. In general, saturation conditions for a particular nutrient might be met if its concentration rises as a result of the hydroponic system's water evaporating (owing to high temperatures or plant evapotranspiration). However, it has subsequently been shown that water losses of 20% (or perhaps more) have no impact on the equilibrium of precipitation.

Co-precipitation phenomena are closely related to precipitation. These later ones describe the trapping of an element (often trace metals) within the structure of an insoluble compound (typically not containing that element) during its precipitation from solution. When insoluble species like Fe Ca-carbonates, (hydr)oxides, or Ca-phosphates develop during co-precipitation, such as Cu, Zn, MnII, and Ni, the solubility of the nutrients may be significantly reduced. According to Martnez and McBride (2000), co-precipitation has the power to significantly reduce an element's solubility to levels substantially below those of the element's least soluble pure crystalline phases that are expected to occur in an environmental setting.

Complexation, or the production of a chemical compound where a metal nutrient is bonded by one or more neutral molecules or anions (ligands), either of organic or inorganic origin, is a crucial process to take into account in hydroponic solutions. Depending on whether positive or negative charges are more prevalent, the resultant complex may either be a neutral molecule, a cation, or an anion. Elemental bioavailability changes as a result of complexation processes that reduce the concentration of free ions in the nutrient solution. Although they are often less accessible for plant absorption than their free ions for particular nutrients, complexes generally boost metal solubility. Certain elements, particularly Fe, Cu, and Zn, may have their stability in solutions increased by the addition of organic ligands like EDTA, DTPA, EDDHA, citrate, etc. However, as will be covered later in this analysis, various complexes may have varying effects on how plants absorb and distribute nutrients (e.g., the case of Fe acquisition). Additionally, several types of soluble hydrogen carbonates, phosphates, and chlorides may bind with free metal cations to lower their concentration in solution. Another factor to consider when creating a nutrient solution is the stability of the complexes. While effective complexing agents may make it easier for nutrients to dissolve in water, strong complexes are often more difficult for plants to use.

Since an altered nutrient availability in the growing medium is a known risk for the quality of the vegetables, it seems likely that the composition of a real hydroponic solution could reasonably differ from the one planned. Given this, the availability of tools for a real-time analysis of the nutrient solution composition is undoubtedly of particular value and interest. Ion activity should be taken into account rather than concentration for a more accurate estimation of chemical equilibria in solution. Ion concentrations are really only useful in calculations involving perfect solutions, or diluted solutions without solute interactions. Ion activity should be utilized in calculations rather than concentrations since interactions among solutes cannot be ignored in actual solutions, such as hydroponic solutions. The concentration of an ion in solution is multiplied by an activity coefficient that also relies on the concentration and charge of all other ions in the solution, or the ionic strength of the solution, to calculate the ion activity.

As the amount of electrolytes in the solution rises, the ion active concentration decreases. Since the activity coefficient of the chemical species in highly diluted (ideal) solutions may be roughly calculated to be 1, ion concentrations are not affected by events like ion-pair formation or ion conductivity decrease. However, these phenomena become significant and may lower the ion active concentration when working with stronger electrolyte solutions that are more concentrated, such as in hydroponic solutions. For instance, the activity coefficient for KNO3 is around 0.92, meaning that its active concentration is 8% lower than the concentration that was actually added to the solution for a single KNO3 solution at 6 mM concentration (as is often the case in Hoagland nutritional solution). The activity coefficient of a single electrolyte, on the other hand, is influenced by the whole solution's ion strength and decreases with increasing concentrations of all dissolved electrolytes and charges. In nutrient solutions for soilless cultivation, electrolyte concentrations are typically quite high, ranging from 6.4 to 37.8 meq L-1, and as a result, the ion activity can be greatly diminished (for example, the activity coefficient for KNO3 is about 0.85, with an overall reduction of 15% active concentration).

By managing chemical equilibrium calculations using specialized software, all of the aforementioned processes may be simulated and predicted. Some of the most popular ones for both water and soil chemistry include Visual MINTEQ, MINEQL+. These software tools use a variety of mathematical models, all of which are based on thermodynamic data and often ignore kinetic characteristics. Kinetic restrictions, however, are recognized to be able to either prohibit a process from happening or reduce its representativeness. For instance, oversaturation or under-saturation occurrences in the context of precipitation processes may alter the solubility of nutrients beyond or below the concentration permitted by thermodynamics, respectively.

An explanation of the depleted hydroponic solutions at the conclusion of a productive cycle is necessary in the context of more sustainable agriculture. In this regard, it is evident that they represent an intriguing resource in terms of water and fertilizer savings, which is becoming increasingly relevant, especially in those countries where there is a lack of rain or good-quality water and farmers are unable to afford the costs associated with buying large quantities of fertilizer. Reusing used solutions might also be a successful way to stop groundwater and environmental contamination, particularly as a result of intensive agricultural practices. The lack of some essential macro- and micronutrients, as well as their increased salinity, are the main issues with the reuse of exhausted nutrient solutions, even though the severity of these issues varies from one plant species to another. The development of management techniques or instruments that lessen the physiological effects of salt on plants and/or lower the salinity in recycled solutions is thus unquestionably a scientific problem in this area. Additionally, according to thermodynamic data at pH 5.5 and chemical equilibrium models, few other nutrients could easily reach oversaturating conditions if certain ions accumulate in exhaust Hoagland solutions, primarily phosphates, and molybdate. These ions are most commonly found in typical Hoagland solutions and are made up of calcium, magnesium, and iron (as Ca molybdate). When it is intended to reuse the hydroponic solution for another cycle, this element also requires careful monitoring.

By treating the recycled water with the proper osmotic systems, such as forward and reverse osmosis, salinity growth might be countered. Forward osmosis (FO) technology has received a lot of interest recently, especially with regard to reusing wastewater for fertigation suggested using concentrated fertilizer solutions as draw solutions in FO systems in this regard. For hydroponic cultures, in particular when the feed water is of poor quality, such as wastewater or an exhausted fertilizer solution, this use may be of interest. To obtain clean water from this source, concentrated fertilizer solution is utilized. In this approach, nutrients lost to plant uptake or other chemical processes are replenished while simultaneously adding nutrients back into recycled water (e.g., complexation, precipitation, and sorption). Recently, a commercial nutrient solution was used to produce hydroponic lettuce using a technique known as fertilizer drawn forward osmosis (FDFO). These authors showed in a pilot study that the FDFO process can produce the necessary nutrient concentration and final water quality (i.e., pH and conductivity) appropriate for hydroponic applications, and the hydroponic lettuce displayed similar growth patterns to the control without any indication of nutrient deficiency.

LITERATURE REVIEW

Gosavi, and Jyoti Vilas [1] studied a technique for growing plants in water without soil using only mineral fertilizer solutions, hydroponics is a component of hydroculture. Fish waste, regular fertilizers, or duck dung are all acceptable sources of nutrients in hydroponic systems. Requiring a process called hydroponics, plants may thrive without using soil. This method ensures that the plant receives all the nutrients it needs from the water solution. The hydroponics techniques come in so many different forms. The method of water culture is one of them (WC). Using the water culture method, nutrients are delivered straight to the plant's roots up until harvest time. In this method, the plant root is continuously immersed in water that contains nutrients and oxygen. The pH level in the water solution, water conductivity, and water luminosity that have a negative impact on plant growth will be automatically monitored by the microcontroller ARM7 and sensors in this study. The suggested method automatically measures the crucial plant development factors conductivity, brightness, and pH. Light intensity is a crucial aspect in every plant's development.

Herman [2] studied a possible answer to the shortage of arable land, which may reduce the capacity of agriculture, is hydroponic farming. Precision farming is a problem in hydroponics farming, particularly for certain delicate plants like bok choy and lettuce. To develop optimally, these plants need a certain quantity of nutrients and water each time. Every element of a person's life may be regularly monitored thanks to the Internet of Things (IoT). Periodically assessing the plants' need for nourishment and water may be a solution. In this research, we present an IoT-based, fuzzy logic-based monitoring and control system for hydroponic precision agriculture. Fuzzy logic is employed to regulate the delivery of food and water to the plants, and IoT is used to provide frequent monitoring of the nutrition and water requirements of plants. The experiment's findings demonstrate that the suggested approach may result in lettuce and bok choy plants growing more quickly and with larger leaves.

Sarathkumar et al. [3] studied the method uses solar energy to grow a plant without utilizing soil. 90% of the water is effectively used. When compared to the soil cultivation method, the production rate of the suggested system is increased by 3 to 10 times. In order to grow plants without using soil, hydroponics uses water-soluble solvents to dissolve mineral nutrients into a substrate that is typically inorganic, with rock wool being the most popular choice globally. A reliable technique, hydroponics is becoming more popular in agriculture, particularly in urban and suburban farming. Current years have seen the rapid development and widespread application of hydroponic growing technologies. The tracking and recording of many factors throughout the hydroponics growing process aids in the development of the best plant growth solutions.

Aggarwal et al. [4] studied more than 50% of people still work in agriculture and related industries in the land of farmers, where farming has traditionally been the main employment of the populace. However, the contribution of the agricultural sector to India's GDP rate has been shown to significantly and rapidly diminish over time. By illustrating the multiple flaws in conventional Indian agricultural practices and how hydroponic agriculture is urgently needed for the expansion of Indian agriculture, we want to highlight the discrepancy between the ratio of expensive inputs to poor yields.

Srivani et al. [5] studied a Controlled Environment Agriculture System may be used effectively to perform soilless agriculture and hydroponics (CEA). Smart agricultural advancements and technical advancements have given CEA a foundation for effective implementation. The CEA now has a flexible design and control plan to execute a higher degree of automation thanks to improvements in artificial intelligence, adaptive data analysis, and the usage of complicated mathematical models through hardware and software interfaces. In the review, many hydroponic methods are discussed together with their benefits and drawbacks for creating an economic system. This research examines a number of physical and environmental factors that affect plant development for an effective and sustainable agricultural system. The approaches employed to automate, monitor, and regulate the variables for optimum plant development are also highlighted in this study. In the end, the study suggests prediction models for understanding the correlation analysis with plant development dynamics utilizing machine learning approaches.

DISCUSSION

Application of pesticides is generally avoided under hydroponics system. With reduced pest problems and constant feeding of nutrients to the roots, productivity in hydroponics is high, despite limited plant growth by the low levels of carbondi-oxide in the atmosphere, or limited light. To increase yield further, some sealed greenhouses inject carbon-di-oxide into their environment to help growth (CO2 enrichment), or add lights to lengthen the day, control vegetative growth etc.

Fueling the Plants with Nutrients

Due to the system's limited ability to buffer nutrients and its flexibility to adapt quickly, hydroponics requires regular system monitoring. The supply of nutrients from the nutrient delivery system and the plant's reaction to nutrients are two elements of nutrition that must be taken into account. Critical nutrient levels for the majority of agricultural plants have been established. The kind of substrate being utilized (volume and physical-chemical properties), the crop (species and stage of growth), the size of the container, the crop and irrigation systems being used, and the local climatic conditions all affect how often and how much nutrient solution is administered. Plants need to be fed every day. Although water needs vary greatly during the day and from day to day, the optimal time to deliver the nutritional solution is between 6 and 8 am. In order to avoid damaging the leaves and the development of illnesses, the solution should only be administered to the roots. The ultimate yield of plants should never be compromised by allowing them to experience water stress. In order to flush out any leftover excess salts, it is often advised that you water the plants just once a week. Use twice as much water as is typically used, but without fertilizer additions. To avoid the buildup of harmful ions and an excessive rise in electrical conductivity in the root region, between 20 and 50% of the solution should be drained off. During daily watering, extra nutrient solution is emptied from containers and may be re-used for the next watering. You may get rid of this liquid at the conclusion of the week.

A Preferred PH Range Of Nutrient Solutions

As a plant develops in hydroponic systems, the pH is continually changing. Less than 0.1 unit changes in pH are not considered significant. Therefore, pH regulation in hydroponic solutions is essential. Although species vary substantially and some may thrive outside of this range, the pH range of 5.5 to 6.5 is ideal for the availability of nutrients from most nutrition solutions for most species.

Contaminant Management

In a soilless culture, maintaining a sterile root-zone environment is crucial for healthy plant growth. It is crucial to reduce the number of plant pathogens in the root zone, but it is also highly difficult to do. Wilt is a disease that often affects hydroponic systems and is brought on by the fungi Fusarium and Verticillum. Pythium and Phytophthora species obliterate everything save the primary roots. There are no safe hydroponic fungicides that are effective. For the management of Pythium on vegetable crops, only Metalaxyl has been proven to be very effective, however it is not approved for usage. It has also been shown that heating nutrient solutions helps to keep pathogens out of the root zone. Nutrient solution heating at 20–22°C proved successful in preventing Pythium root mortality in tomato plants. The roots of ginger plants developed more quickly and generated marginally more fresh rhizome yields in an aeroponic system with heated nutrient solution than they did in the same medium without bottom heat.

Benefits of Solvent-Free Culture

Growing plants without soil has a number of benefits over soil-based culture. These gardens regularly give the healthiest crops with large yields; gardening is clean and very simple, requiring very little effort. Since nutrients are given directly to the roots in this situation, plants develop smaller roots more quickly, may be grown closer together, and need less room and water overall to grow in soil-less culture than in soil-based culture. There is no possibility of a disease assault, weed infestation, or soil-borne insect pest. Overall, soilless culture offers effective fertilizer control, greater planting densities, and enhanced yield per acre along with superior product quality. It works well in areas of the world where there is a lack of arable or fertile land for farming.

Soil-Less Culture Limitations

Despite having numerous benefits, soil-free cultivation has certain drawbacks. Although there are large rewards, commercial application demands technical expertise and a sizable upfront investment. The soil-less culture is only used for high-value crops because to the high expense. The regulation of plant health must be done with great care. Finally, the system needs energy inputs to function

Impact of This Technology In The Future

Agriculture's fastest-growing industry, hydroponics, may eventually control how food is produced. People will resort to innovative technologies like hydroponics and aeroponics to provide extra channels of agricultural production when population rises and arable land shrinks as a result of bad land management. Humans simply need to look at some of the early adopters of this technique to gain a peek of hydroponics' future. Due of the rapidly growing population, land is particularly expensive in Tokyo. The nation has shifted to hydroponic rice farming to feed the populace while protecting important land mass. Without using any soil, the rice is harvested in subterranean vaults. Four harvest cycles rather than the usual one may be carried out yearly since the environment is precisely regulated.

Israel, which has a dry and arid environment, has also successfully employed hydroponics. Crops have been grown hydroponically in 40-foot (12.19-meter) long shipping containers by a business by the name of Organitech. Bananas, citrus fruits, and berries in considerable numbers are also cultivated there, which is unusual given Israel's climate. The yield from hydroponics is 1,000 times larger than what a yearly crop of the same size could be grown on land. The procedure is entirely automated and is run by robots utilizing an assembly line-style system similar to those seen in factories, which is the best part. Then, the cargo containers are moved throughout the nation. The possibility of using hydroponics in third-world nations with limited water supply has already generated a lot of noise in the scientific community. Although the initial capital expenses of installing hydroponics systems are now a barrier, prices will eventually fall as with other technologies, making this alternative far more practical. In regions of Africa and Asia where both water and crops are limited, hydroponics has the potential to feed millions of people. Future space exploration will also depend on hydroponics. NASA has ambitious goals for hydroponics research that will advance both the long-term settlement of Mars or the Moon and the agency's ongoing space exploration. Hydroponics may hold the key to the future of space travel since we haven't yet discovered soil that can sustain life in space and because it would be logistically difficult to deliver soil through space shuttles. Hydroponics in space has two advantages: It provides a biological component known as a bio-regenerative life support system as well as the possibility for a wider range of food. This only means that the plants' natural growth process will allow them to absorb carbon dioxide, stale air, and deliver fresh oxygen as they expand. Long-term settlement of both space stations and other planets depend on this.

The previously discussed difficulties amply demonstrate how unexpected physicochemical events occurring in the hydroponic solution may quickly change its composition as well as how a number of nutrient interactions can significantly affect the efficiency of the process by which crops acquire nutrients. Unfortunately, when these phenomena are taken into account as a whole, they have the potential to significantly impact the output of the hydroponic soilless system, both quantitatively and qualitatively. The availability of new nutrient forms, such as nanoparticles (see "Nanoparticles"), as well as bioeffectors that can improve the functionality of the root nutrient acquisition mechanisms, such as PGPRs (see "Use of Plant Growth-Promoting Rhizobacteria in Hydroponic Solutions," may therefore be of particular importance. Similar to this, it may be possible to use tools to analyze the data (interpretation algorithms, section "Interpretation Algorithms and Smart Agriculture") for a prompt correction and to monitor the composition of a nutrient solution in real-time (sensors, section "Realtime Monitoring of Hydroponic Solutions via Sensors").

Utilization of Rhizobacteria that Promote Plant Growth in Hydroponic Solutions

The extraordinary flexibility of the molecular machinery utilized by plants to acquire minerals, which is frequently discussed in literature, ensures that it can respond to changes in nutrient levels in the growing medium. Numerous variables, including the quantity and type of nutrition supply, the pH, and the redox potential, may be blamed for such fluctuations, especially in the bioavailable nutrient portion. Additionally, a growing amount of research has highlighted the contribution that plant growth-promoting rhizobacteria (PGPRs) provide to the mineral nutrition of plants. Numerous studies and reviews have been done on the various methods that PGPRs use to increase the bioavailability of mineral nutrients in the rhizosphere, including atmospheric N2 fixation, phosphorus solubilization, and the synthesis of siderophores for Fe3+ chelation. However, recent studies have shown that the PGPRs may modify how the molecular machinery responsible for nutrition absorption functions on its own (Pii et al., 2015). This way, the notion that PGPRs may directly affect plasma membrane (PM) H+-ATPases was supported by the discovery that they altered the release of protons from wheat roots and other model plants.

Given that certain mineral nutrients, including H2PO4, SO4 2, and NO3, need the H+ electrochemical gradient at level of the PM for absorption an increase in PGPR-induced H+ release might actually result in a greater capacity of plants to absorb nutrients. Similar to this, it has been shown that the bacterium Achromobacter may raise the content of NO3- in plant tissues. This is most likely due to the bacteria's impact on the constitutive high-affinity transport system. The impact of PGPRs on the molecular processes underlying the uptake of Fe (Fe3+ reduction - FRO, Fe2+ transport - IRT1, and rhizosphere acidification - PM H+-ATPase) in dicot plants was also observed. By increasing the activity of the root Fe-chelate reductase, the fungus Trichoderma asperellum can promote Fe uptake in Fe-sufficient plants like Lupinus albus and cucumbers. Most of these research have been conducted in soil contexts, and little is known about how effectively PGPRs operate in hydroponic systems, where their activities also rely on their capacity for flourishing and reproducing in certain situations as well as on colonizing the plant roots. However, some bacterial strains have previously been successfully tested in fruits and vegetables produced hydroponically, yielding favorable results and improving the quality of the agricultural goods.

The effects of the Bacillus spp. PGPRs on the hydroponically grown tomato and pepper plants' development and production have been studied B. licheniformis, in example, has been shown to considerably increase plant height and leaf area in both tomato and pepper plants, the impact being species-dependent. Nevertheless, the inoculation led to an increase in tomato fruit production and diameter. The fruit output of tomato plants increased by roughly 8–9% after being inoculated with the commercially available PGPR B. amyloliquefaciens. Additional research has shown that the use of particular PGPRs, like B. sphaericus UPMB10 and A. brasilense Sp7, which are capable of carrying out biological nitrogen (N2) fixation, may help reduce the external input of nitrogen sources in the hydroponic solution used for the soilless cultivation of banana plants while still ensuring adequate plant production. It's interesting to note that A. brasilense has also been shown to increase the size of strawberries provided by infected plants and to improve the nutraceutical properties of fruits, such as the content of flavonoids, flavonols, and micronutrients, as well as their sweetness index.

However, hydroponically grown plants in indoor systems could be in danger from pathogen attack, necessitating the use of disinfection techniques that could be either physical (using ultraviolet light or gamma radiation, for example) or chemical (using carbendazim, hymexazol, imidazole, or prochloraz triazole). In fact, the use of beneficial microbes in hydroponic farming systems is constrained since these management approaches may also lead to a decline in the

PGPR population in the systems. However, using PGPRs that also possess biocontrol properties might be a beneficial alternative to the aforementioned disinfection techniques. Overall, our findings hint to an intriguing situation in which the possible use of beneficial microorganisms (PGPRs) in the hydroponic growth of plants might enhance crop yield and nutraceutical characteristics. In fact, by allowing for a more rational use of water resources and external agrochemical inputs, this technique would also have an influence on the long-term viability of agricultural systems (e.g., fertilizers and pesticides).

CONCLUSION

The primary study areas in which the research world is engaged in the field are clearly highlighted in this review of certain challenges influencing nutritional solutions in soilless farming systems. Unquestionably, this farming method has a vast amount of potential, ranging from increased productivity and quality to environmental advantages due to more effective use of water and nutrients. Currently, there are well-researched and tried areas whose findings are often used in soilless farming, such as the management of NO3 or the improvement of crop quality by controlling the electric conductivity of the solution. On the flip side, there are additional, more challenging to control factors connected to the interactions between nutrients in their acquisition processes and the dynamics of the nutrients (bio-geochemical cycles) in the hydroponic solution. Since producers need to have specialized knowledge and skill sets to deal with and precisely with each crop species, these factors serve as a crucial differentiator for soilless management and, in certain situations, may restrict its spread.

It is interesting to note that there are other recently emerging, technologically advanced, but little researched research areas that are parallel to those that deal with these aspects, even though they appear to offer promising tools (nanoparticles, PGPRs) for a more effective use of this hydroponic-based cultivation approach. However, it is crucial to have a deeper understanding of the mechanisms behind nutrient uptake and distribution in the various tissues, even in the presence of these promising technologies. Additionally, a consistent and appropriate design of the information system's characteristics with the associated hardware (sensors) and software (algorithms) components is essential in the context of the use of smart agricultural techniques. It could be wise to take these tools from the industrial setting where the new Industry 4.0 paradigm is currently in use.

In addition, from a practical standpoint, the implementation of this clever strategy in the hydroponic production system will unavoidably necessitate a decoupling of the management of all the software components (maintenance of database structures/persistency, controlling data consistency, interpretation algorithms, reporting updates) from that of all the hardware components (sensors and data loggers, connections, actuators - in charge to the farmer). In reality, the intricacy of this latter job necessitates the establishment of a service center with expertise in smart agriculture, at least until widespread adoption of native digitals in the context of agriculture is accomplished. Future industry growth is anticipated to be exponential as soil conditions for growing become more challenging. There is no other choice but to embrace soil-less culture to assist enhance the yield and quality of the product in order to secure food security for our nation, particularly in a country like India where urban concrete conglomerate is rising every day. The deployment of this technology may, however, be accelerated by government action and research institute interest.

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CHAPTER 15

TECHNOLOGIES ASSOCIATED WITH HYDROPONICS FOR MEDIUM- AND SMALL-SCALE OPERATIONS

Divya Prakash Singh, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- d.p.singhg@gmail.com

ABSTRACT:

The Food and Agriculture Organization of the United Nations projects that by 2050, there will be nine billion people on the planet, 78% of whom would reside in urban areas. Meeting the need for food will be one of the major problems, since farmland is being lost due to causes including soil contamination, water shortages, and climate change, among others. In this situation, a practical solution to solve this issue is provided by hydroponics, an agricultural technique that does not need soil. Although hydroponics has been shown to be successful on a broad scale, there are still difficulties when trying to use this method in urban and suburban areas. Additionally, in remote areas where access to acceptable technology is limited. Precision agriculture is promoted on a small scale by paradigms like the Internet of Things and Industry 4.0, which enable the management of factors like pH, electrical conductivity, and temperature, among others, leading to increased productivity and resource savings.

KEYWORDS:

Agriculture, Climate Change, Hydroponics, Small-Scale Production, Sustainability.

INTRODUCTION

According to projections from the United Nations Food and Agriculture Organization (FAO), the human population will reach roughly 9 billion people by the year 2050, marking a significant turning point in human history. The world's output will need to increase by almost 70% from 2007 levels in order to meet the demand for food. In addition, 75% of the world's population is anticipated to reside in metropolitan areas since the globe is getting more urbanized.

Currently, cities account for 60-80% of global energy consumption, 75% of carbon emissions, and 56% of the world's population, although only taking up 3% of the planet's surface area. According to the forecasts, urban regions would see the majority of the world's population growth by 2050, growing by 2.5 billion people, compared to the world's overall population, which is predicted to increase by 2.1 billion. Natural population growth, rural-to-urban migration, and reclassification the territorial expansion of urban settlements at the cost of rural areas via annexation and transformation are among the key drivers of urban population growth.

Migration and reclassification put agriculture in a competitive position for soil, water, and human resources with thriving urban centers, forcing it to not only produce more food with fewer workers and less land but also to fight climate change on all fronts: preserving habitats, protecting endangered species, and maintaining biodiversity. The strain on agriculture, which serves as the foundation of the supply chain for food, seems to be fairly severe. Despite the thousands of acres that have been made unusable for farming owing to climate change, water shortages, and soil contamination by chemical pesticides and fertilizers, open-field agriculture is still widely practiced around the world. As a result, agriculture must take decisive and radical steps toward efficiency and sustainability, driven by a rising demand for food that is rising along with the population. Agriculture must also use technology to improve and better serve the needs of consumers rather than just for its own sake.

It seems logical to include urban and peri-urban regions in the 2050 endeavor to feed the globe with nutritious, reasonably priced, and sustainably produced food since urbanization appears to remain unabated. Urban agriculture (UA), as it is known, integrates into the urban economic and ecological system, producing crop and livestock goods to supply products to the local population, including peri-urban agricultural areas around cities and towns, where space is constrained and vegetative land uses are difficult to maintain. The potential of UA systems for cities includes social and environmental advantages including improved food security and perhaps reduced environmental impact.

In order to fulfill the need for wholesome, reasonably priced, and sustainably produced food, productive places where arable land and water are becoming limited are resorting to intense high-yielding agricultural techniques and technologies, such hydroponics. By 2028, hydroponic tomato cultivation is anticipated to be most prevalent in Europe and the Asia-Pacific region. By utilizing not only the horizontal surface area but also the vertical space above it, hydroponics can increase yield compared to traditional farming by effectively increasing the number of plants per unit area and leaning toward vertical farming to meet daily consumer demands for wholesome fresh products in and around densely populated areas. Additionally, hydroponics allows for the year-round harvesting of several crops while utilizing less water and land than conventional open-field agriculture and without haphazard chemical or fertilizer discharges into the environment. In fact, hydroponics optimizes the use of water and chemicals to reduce potentially harmful waste and residuals by employing smart greenhouses outfitted with a variety of technologies to regulate key factors for good plant physiology.

Nutrient Solutions Sterilization

Hydroponic systems need an aseptic environment to effectively generate high-quality goods, but it is challenging to maintain sterility in the area surrounding the plant's roots. The most noticeable sign of a damaged plant is leaf withering, which is brought on by the fungus Fusarium and Verticillium. The roots of the plant are also threatened by other parasite species including Pythium and Phytophthora. Sadly, there isn't a fungicide safe enough to use in hydroponics without endangering consumer health. Recirculating the nutrient solution reduces the amount of water used and waste to be disposed of from a sustainability standpoint, but it is not always feasible to create systems that balance resource use, energy use, and cost. A mix of strategies might be a better way to deal with the sepsis issue of the nutrient solution, even if each strategy has its own pros and downsides when it comes to preventing infections in hydroponic solutions.

On the other hand, constructing closed systems that recover the water at the conclusion of the cycle via treatment and sterilization, as schematized in Figure 1, might be a sustainable method of managing residual-nutrient solutions in hydroponics. To increase the effectiveness of water use, they have suggested using dielectric moisture sensors in soilless agriculture. Their findings suggest that to maximize water use in such crops, a network of wireless sensors for real-time substrate humidity monitoring and detailed knowledge of the impact of water availability levels on basil are needed.

Large-scale hydroponics facilities run under regulated lighting, irrigation, and climatic conditions, which are provided by the many sensors, online platforms, software, and mobile apps that are now available. A compound annual growth rate (CAGR) of 20.7% is predicted for the hydroponics industry from 2021 to 2028 as a result of these technical improvements.

Hydroponics may offer partial solutions to the drawbacks of conventional open-field agriculture, including significant contributions to CO2 emissions and the loss of cultivable land due to outdated, unecological practices.

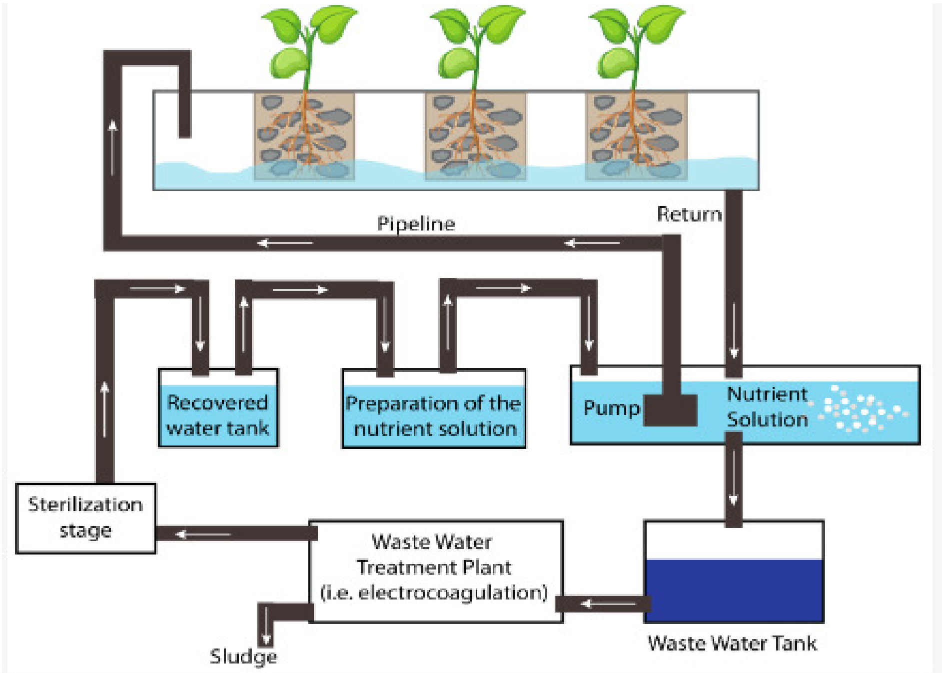

Figure 1: Putting in Place a Treatment System to Allow Hydroponic Systems to Reuse Water.

However, feeding the human population by the milestone year of 2050 is not the only issue of concern; current global warming and generalized Earth pollution are pressing environmental and socioeconomic concerns. The first step in meeting the world's food demands in 2050 is to embrace sustainability in all vital human endeavors, including agriculture. Hydroponics stands out as a suitable, sustainable alternative for urban and peri-urban settlements, contributing to the Sustainable Development Goal (SDG) number: sustainable cities and communities, of the United Nations' 2030 Agenda for Sustainable Development. This is in contrast to the intrinsically unecological ways of modern open-field agriculture. The expanded use of hydroponics is crucial for UA and transformative for the food supply chain, social welfare, and environmental improvement; nevertheless, in order to realize its full potential, it must be applied to small- and medium-scale production. It requires producers to comprehend the advantages of applying new technologies to maximize cost-benefit at small- and medium-scale levels, to attend to either local consumers' needs or self-consumption needs. Technologists must have a basic understanding of hydroponics to develop appropriate technologies.

On the other hand, agriculture has changed human communities and contributed to the rise of the human population from its incipient stage approximately 10,000 years ago to the present. Although plant physiology has advanced, agricultural practices have essentially stayed the same, embracing small-scale technical advancements in machinery and equipment, fertilizers, pesticides, and other chemicals to increase output. Because of the catastrophic degradation of soil quality and low output, new, sustainable food systems are urgently needed. Through increased cooperation amongst pertinent sciences, academia and industry have worked together to identify the primary demands of the agroindustry and develop ad hoc solutions to support agriculture's transition to efficiency and sustainability.

By examining the fundamentals of hydroponics, which is a required step for the technologist to comprehend the demands of medium- and small-size enterprises, which are crucial to achieving SDG, the current study seeks to bridge the gap between the two sectors. The project is structured as follow. They go through the best crops for hydroponic growth. The reader is given ideas in pertaining to the usage of nutrient solutions in hydroponics and maintaining their pathogen-free status. With a small- to medium-scale production method, we provide the reader with an overview of the key technological factors that contribute to the adoption of hydroponics in urban settings.

In they provide an outline of how Industry transformed the agricultural industry and gave rise to the idea of Agriculture many technology strategies that may be used in small- and medium-scale agriculture are reviewed. In addition to reviewing instances of autonomous systems used in small-scale hydroponic agriculture, also demonstrates a process for choosing the amount of technology suited to farmers' requirements.

Plant physiology's history and contributions are described

A kind of gardening known as hydroponics substitutes fertilizer mineral solutions for tillage. The murals on the walls of the more than 4,000-year-old Egyptian temple Deir El Bahari are the earliest known instances of hydroponics. Hydroponics was utilized in Babylon around the sixth century BCE to cultivate mostly decorative plants. Around the ninth and tenth century CE, the Mexican Aztec civilization created the chinampa, which is thought to have been used across Mesoamerica, to cultivate crops on the shallow lake bottoms in the Valley of Mexico. A marsh was transformed into a viable environment by the Aztecs, as shown by the 1000-year-old network of canals and man-made islands at Xochimilco, a suburb of south Mexico City.

Additionally, it exemplifies how useful UA may be as a source of sustainable food and as a driving force for both social and environmental wellbeing. As a result, this hydro-system was designated a World Heritage Site by UNESCO. With the advancement of our knowledge of plant physiology, hydroponics has followed suit. A series of tests were carried out in 1600 by Belgian scientist Jean Baptiste Van Helmont to show that plants could get certain nutrients from water.

Later, in 1800, French researchers De Saussure and Boussingault demonstrated that for plants to develop healthily, they need carbon, hydrogen, oxygen, and nitrogen. Then, in 1860, German scientists Sachs and Knop expanded on De Saussure and Boussingault's list by adding phosphor, sulfur, potassium, calcium, and magnesium, and they produced plants in aqueous solutions containing these elements' salts.

Since then, research in the area of plant physiology has led to the understanding that additional elements, commonly referred to as micronutrients, like manganese, molybdenum, chlorine, iron, zinc, copper, and boron, are required for the healthy growth of plants and that the nutrient solution's composition is highly correlated with the physiological response of plants in terms of size, color, and other crop features.

Hydroponic Planting Methods

Contrary to conventional farming, hydroponics does not use soil to produce food. This method involves growing plants on artificial or natural substrates so that the roots may readily draw nutrients from a prepared nutrition solution. The implementation of various hydroponic farming techniques varies depending on the kind of plant, regional climate, and financial constraints, among other things. The majority of systems include an aerator and a tank for the nutritional solution.

Agriculture

Modern farms and agricultural operations are undergoing fast change as a result of technical advancements in electronics, which have resulted in the adoption of equipment, temperature and moisture sensors, aerial imagery, and GPS. In 2017, concepts like artificial intelligence (AI), the Internet of Things (IoT), and big data (BD) were integrated to autonomous food production systems for precision irrigation, pest control, plant disease identification, and production management. This was the beginning of the concept of industry 4.0 in agriculture. This revolution, branded as "Agriculture 4.0," aims to seamlessly integrate agricultural techniques with cutting-edge technology, such as sensors, gadgets, machinery, and information technology. Robots, temperature and moisture sensors, aerial and satellite imagery, and GPS technology are just a few of the complex technologies that are being employed more and more to improve the whole food value chain and make enterprises safer, more effective, and more environmentally friendly.

As huge corporations increasingly leverage advancements in indoor vertical farming, artificial intelligence, and plant biology to cultivate a wide range of goods, hydroponics fits well into the framework of Agriculture 4.0. Human can declare with sure that hydroponics has won a central position in future food production systems thanks to the backing of cutting-edge and innovative technology and solid scientific understanding to guarantee high output. To accomplish SDG 11: sustainability and resilience of urban populations, hydroponics may considerably help. The task at hand is to bring these technical advancements down to the medium- and small-scale operations common in urban and peri-urban settlements.

Agriculture 4.0 is not universally adopted, and there are still many barriers to be overcome before concepts like ecoagriculture, agrophotovoltaics, and precision agriculture are integrated into global farming methods and culture. Agriculture and technology will need to find common ground for both farmers and technologists in order to accomplish it. In order to meet producers' expectations for highly improved products, services, and processes to support sustainable and effective food production in urban and peri-urban settlements, the first step is to understand the best uses of technology and demand innovations that address the real needs of the food supply and value chains. The second step is to meet producers' expectations. Appropriate Technology for Small- and Medium-Scale Food Production Employing Hydroponics.

Small firms have sprung up as a result of indoor manufacturing, boosting regional economies. The profitability of an indoor urban vertical farming (IUVF)-based company to that of a greenhouse in Denmark. Due to the greenhouse's high maintenance costs, the findings demonstrate that IUVF is more profitable on a small- to medium-sized scale than it is the greenhouse. The authors come to the conclusion that in order to generate an economic profit without the need for government subsidies, product prices must be increased to 10 euros per kilogram.

In order to set up a hydroponics farm, it is important to take into account the cost of various pieces of equipment, such as heating, ventilation, and air conditioning (HVAC), fans, irrigation systems, control systems, railways, and lighting. The adoption of hydroponics as a farming technique is significantly hampered by the enormous initial cost of the system, which is estimated at USD$ 110,000 for a 46.5 m2 farm that is not completely automated [48]. Thus, it is crucial to create new, better goods and services to aid UA based on hydroponics. Such technologies must be scaleable to meet farmers' demands, not only for large-scale operations but also for medium- and small-scale ones, taking into account the limited amount of area that may be used for farming. In Europe, Asia, and North America, where there is a dedicated surface area of more than 150,000 m2, the practice of producing food in urban contexts has risen dramatically since 1988. Hydroponics is essential for the establishment of UA and might make a substantial contribution to achieving SDG 11. However, it needs the creation and uptake of the right technology.

Offer a framework that combines heterogeneous devices on several computer levels to monitor and improve the production process, describe some technologies suitable for indoor farming. In addition, they created the AgroRobot, an aeroponics-based robot for growing microgreens. The AgroRobot includes a touch-screen visual interface created using Nexion, and an Arduino Nano8 is used to manage watering and lighting. Additionally, various accessories for this project like culture trays are produced using 3D printing technology. Applications of Agriculture 4.0 to the hydroponics industry are already well underway. An open-source project called Mycodo Environmental Regulation System, for instance, produced a graphical user interface that can be customized for indoor hydroponic cultivation of leafy species. In the kernel of a Raspberry Pi, especially, Mycodo operates in a Linux environment. The technical contribution of this system is its scalability, or the ability to add calibration procedures for sensors and control algorithms for variables like pH, EC, and humidity, among others, to the interface created by the authors. They also used additive manufacturing for a few of the physical system's accessories.

Similar to this, the CNC robot Farmbot can cultivate a variety of leaf and fruit crop species using a hydroponic drip watering system. Users that lack the technical know-how may purchase their Farmbots pre-assembled from their developers if they lack the knowledge and abilities to obtain the CAD models and programming instructions. An intriguing idea for the development of technologies specifically geared at small-scale farming via the S3 production model, which consists of three components:

- Sensing: the capability of a system to detect events, collect data, and precisely measure changes in environmental physical characteristics.
- Smart: A system's ability to include control and actuation features that, after interpreting input data, help the decision-making process using predictive or adaptive logics. Additionally, the capacity of several linked systems to function at once is further enhanced by the word "smart."
- Sustainable: When considering technological development from a social, economic, and environmental standpoint, this idea is relevant.

LITERATURE REVIEW

Rui Wang et al. [1] studied Hydroponically grown lettuce may preserve its freshness by being harvested with roots. Additionally, the impact of varying root lengths on freshness may vary. A root cutting and storage experiment was conducted to examine several influencing aspects of freshness, such as changes in weight loss rate, color, and chlorophyll levels, in order to establish the ideal root length of hydroponic lettuce for keeping freshness. Root lengths of samples were divided into five groups, including full root length, 0 cm, 3 cm, 6 cm, or 9 cm. Every other day for 15 days, we measured the influenced indicators of various root lengths using the balance, chroma meter, and chlorophyll meter. Results indicated that there was no clear correlation between the hydroponic lettuce roots' length and the rate of chlorophyll content depletion.

Ruizhe Wu et al. [2] The fundamental technology for robotic sorting is the accurate and quick identification of aberrant hydroponic lettuce leaves. The two most common aberrant leaf kinds in hydroponically grown lettuce are yellow and rotting. This work intends to show that machine learning models, such as Multiple K-Nearest Neighbor (KNN), Linear Regression (MLR), and Support Vector Machine, are capable of identifying yellow and rotting lettuce leaves (SVM). To decrease the amount of RGB, HSV, and L*a*b* characteristics in photos of hydroponically grown lettuce, one-way analysis of variance was used. For the purpose of testing models, a picture of hydroponic lettuce was segmented using image binarization, image masking, and image filling techniques.

Amina Touil, et al. [3] studied If the waste nutrient solution is not properly managed, the rapidly expanding hydroponic farming industry, which is a soilless cultivation technique of growing plants using mineral nutrient solution dissolved in water, offers serious environmental and human health risks. This review's goal is to provide information on hydroponic systems, such as: the many classes and operating procedures; benefits and downsides; current techniques and developments in hydroponic wastewater treatment. Removal of root exudates from recycled waste nutrient solution in closed systems has received particular attention. The technologies for nutrient removal or recovery that have been evaluated include denitrification, the growing of microalgae, the creation of wetlands, and activated carbon techniques.

Magwaza et al. [4] studied with an increase in population, especially in metropolitan areas, problems with pollution, nutrient-depleted soils, or water shortages are anticipated to become worse. As a consequence, inadequate sanitation or wastewater disposal systems may lead to issues with the public's health and the environment. This calls for a paradigm change in the way waste is managed in order to safeguard the environment while also allowing for the recovery and reuse of nutrients for food production, which benefits society. Therefore, there is increased possibility for using urban wastewater for agricultural irrigation, particularly when reusing minerals like nitrogen and phosphorus, which are crucial for crop productivity.

Arcas-Pilz et al.[5] studied due to its low weight burden, inert substrate conditions, or overall superior management of plant nutrition and development, hydroponic systems are a desirable kind of urban agriculture. Nevertheless, growing environmental effects from phosphorus fertilizer usage, such as eutrophication and the loss of nonrenewable resources, cannot be the price of achieving urban food sovereignty. A possible slow-releasing P source that might replace mineral P fertilizer is stauvite, a wastewater byproduct. In this work, we investigated the suitability of struvite in hydroponic systems, evaluating various dosages (5 g, 10 g, and 20 g per plant) in comparison with monopotassium phosphate for the hydroponic production of pepper and lettuce.

Lukito et al. [6] studied One agricultural method that uses water media to supply the nutritional demands of plants is hydroponics. When compared to soil-based production techniques, hydroponic systems utilize less water. The roots of the plants were regularly irrigated with water that had been diluted with the mineral nutrients required by plants. This method's usage of the existing space in the house makes it ideal for use in constrained settings like urban dwelling surroundings. Urban dwellers spend more time outside the house on daily activities such as work, shopping, school, and other activities. Therefore, it is crucial to be able to remotely observe hydroponic systems from any location. In hydroponic systems, it's necessary to monitor a number of variables on a regular basis in order to choose the best course of action, including school, temperature, school, and water pH.

Ramasamy Rajesh Cho et al. [7] studied in many regions of the globe, achieving sustainable agriculture is a top priority. The use of hydroponic farming is encouraged by growing environmental consciousness and continued efforts to implement agricultural systems that are both commercially viable and ecologically safe. A method for growing plants in nutrient solutions that uses artificial media to provide mechanical support is known as hydroponics.

Higher operating costs and pollution caused by the discharge of waste nutrient solution are the two main issues with hydroponic farming. The nitrogen effluent discharged into the environment has the potential to negatively affect nearby ecosystems as well as pollute groundwater used by people for drinking.

Robert Newman et al. [8] This study examines how hydroponic systems could help the fodder industry mitigate climate change. The research compares the greenhouse gas (GHG) emissions but also carbon sequestration potential of hydroponically produced sprouted barley fodder to traditional barley grain fodder using British Columbia (BC) and Alberta as case studies. In scenarios where Alberta was expected to be the primary producer of barley, several scenarios for BC or Alberta as consumers, centralized/distributed hydroponic systems, and renewable/nonrenewable energy sources were explored. Through scenarios that assessed the possibility of switching from conventional to hydroponic barley and from tillage to no-tillage techniques, carbon sequestration options were studied.

Jung Eek Kim et al. [9] Plant factories need hydroponic systems, such as the deep flow method, nutrient film technique, or aeroponic systems. Electrical conductivity (EC), pH, dissolved oxygen, or temperature should all be assessed to ensure proper management of water and nutrients in the hydroponic system. Real-time measurements of all nutrients are necessary owing to the fact that ion concentrations in the nutrient solutions fluctuate over time, leading to a nutritional imbalance in closed hydroponic systems, however such measurements are not possible due to technological issues. Instead, commercial farms use hydroponic systems based on EC. Nutrient balance may be improved by routinely analyzing nutrient solutions and adjusting nutrient ratios. Ion-selective electrodes or artificial neural networks may be effective instruments for determining the concentration of each ion as an advanced technique.

Amina Fizir et al. [10] A viable substitute that could solve the world's food and environmental problems is hydroponic farming. Farmers may use less water and fertilizer when using hydroponically grown crops. Additionally, effective nutrient monitoring enables crop development to be optimized. Ion-selective electrodes have been developed as sensors for this purpose, and the internet of things has been developed for accurate monitoring. Here, they examine how ion-selective electrodes are used to monitor hydroponic solutions, with particular emphasis on parameters, accuracy, sensitivity, and the internet of things.

DISCUSSION

Root System in the Water or Deep Water Culture (DWC)

In this arrangement, the plant's root is submerged in the nutritional solution while the remainder of it is held above water using, among other things, polystyrene, cork bark, or wood.

Drip irrigation

For crops that resemble tomatoes and peppers, this technique works well. In this instance, a controlled flow of fertilizer solution is injected straight to the plant roots. At specified intervals, the solution is supplied, and for closed systems, the remaining solution is added back to the storage tank.

Aeroponics

Aeroponics is the best method for growing tubers and roots. In this setup, a sprinkler system periodically sprays nutrients onto the plants, which have roots that dangle down in the air. The key benefit of this method is that it does not need an airing system since oxygen is carried in the fertilizer solution that is sprayed. The plant roots in this technique, also known as NFT, are similar to those in a floating root system, but instead of being entirely immersed in the nutrient solution, they are instead suspended in a liquid stream that is passing via a pipe system. NFT needs more energy and components to function, even though it uses less nutritional solution than the floating root system. The flow of nutritional solution may be continuous or intermittent, and the surplus solution returns to the storage tank via gravity. A tray with plants in it receives regular fills of nutrient-rich water blasted up from a reservoir below. The technology employs gravity to recycle the water by returning it to the reservoir.

Aquaponics

This method takes use of the symbiotic relationship between plants and animals to create a productive system where fish waste meets the nutritional needs of the plants. A healthy microecosystem is created when fish tank water is recycled via the plants' uptake of nutrients and the microbial nitrification and denitrification processes.

Benefits

Hydroponics provides numerous options for growing food, it is not a cure-all. Like any other farming method, it has advantages and disadvantages that should be considered in order to pinpoint potential areas for the development of useful technology. Like any other farming method, hydroponics has advantages and disadvantages. Reviewing them can help you find places where technology may have a positive influence. Efficiency in space and ubiquity. Food may be grown wherever a regulated atmosphere can be used thanks to hydroponics. In fact, hydroponics is regarded as the primary method of providing food for spacecraft crews even during deep space travel. It is also feasible to design vertical arrangements for greater product yield, depending on the kind of plant. Guarantee of quantity and quality. Crop rotation is essential in conventional agriculture to maintain soil fertility, but hydroponic crops may be cycled as often as necessary, boosting the output per cycle per crop. Additionally, as nutrition is given in accordance with the plant's physiological needs, the quality of the product is guaranteed. One must keep in mind, nevertheless, that in fully automated greenhouses, even modest adjustments to the operating environment might prompt immediate crop reactions.

- **Sustainability:** Water evaporation, seepage, and pollution are avoided and rinse water is not required since the produce is not in touch with the soil and the nourishing solution is recycled. Furthermore, a regulated environment ensures the best circumstances for development and protection against pests and diseases that affect plants, obviating the need for chemicals and pesticides and conserving vital natural resources like soil and water.
- **Economics:** Operations in hydroponics are sometimes less complicated than those needed in conventional agriculture. In this regard, traditional methods call for labor-intensive preparations prior to planting, including the expense of large machinery and specialized equipment, which finally may be rented. Hydroponics may demand greater effort in other areas, often requiring a collection of sensors and tools for an accurate follow-up of the crop state.

CONCLUSION

This manuscript provides instructions for those who wish to contribute to addressing the global demand for food that is coming sustainably and efficiently for the year 2050 by describing the theoretical and technological aspects of hydroponic-based food production for its implementation on a small and medium scale. However, a decentralized production method is required, where small producers in densely populated regions minimize the ecological imprint produced from this activity. The market for food production utilizing hydroponics is expected to develop over the next 20 years. The adoption of technology in small- and medium-scale decentralized food production systems can have a positive impact on local economies by encouraging self-employment or lucrative business activities and favoring a cooperative atmosphere in the communities, despite the typically high initial investment. Small- and medium-scale precision agriculture will be revolutionized by platforms like Raspberry Pi and Arduino, together with a new variety of sensors and actuators that are already on the market. This will enable the farmer to optimize output in more controlled surroundings at accessible pricing.

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CHAPTER 16

AUTONOMOUS TECHNOLOGY IN AGRICULTURE

Devendra Pal Singh, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- dpsinghevs@gmail.com

ABSTRACT:

The agricultural industry contributes significantly to the economy. The primary worry and a hot topic globally is the automation of agriculture. The population is growing rapidly, and with it, so are the need for food and work. Farmers have been using traditional techniques, but they were insufficient to meet these demands. New automated techniques were therefore introduced. These innovative techniques meet the billions of people with work possibilities while simultaneously meeting their needs for food. A revolution in agriculture has been sparked by artificial intelligence. This method has protected agricultural productivity from a variety of factors, such as population growth, employment challenges, and worries about food security. This study's main objective is to assess the many applications of artificial intelligence in agriculture, such as weeding, irrigation, and spraying utilizing sensors and other instruments integrated into robots and drones. Automation and robotics in agriculture are popular fields that have received substantial investment. There have been significant recent developments in the areas of automated vehicle guidance and steering control, automatic headland sequencing, automatic implement guidance, turn management, and other agricultural automation and robotics. Sensing for variable-rate technologies, perceptual sensing, performance-improving machine coordination, coordination of the machines, and machine-to-machine communication. Regarding these eight areas of development, the scientific literature, publicly held intellectual property, or commercially available technologies are all examined.

KEYWORDS:

Artificial Intelligence, Automation, Irrigation, Herbicide, Pesticide.

INTRODUCTION

Since 2012, investments in cutting-edge agriculture technology have grown by 80% yearly. These investments have mostly been made in automation, and new robotic technologies in particular are receiving a lot of attention. Automation is highly suited for many agricultural activities since vehicles often operate in sizable, well defined open spaces that are mostly devoid of workers and obstacles. Automated robotic systems (ARS) must boost productivity beyond present levels in order to be commercialized. Even semi-automated systems that must react fast in unstructured agricultural contexts must boost productivity and work quality. Defects in detector performance and automated decision-making, as well as the necessity for minimal human intervention in dynamic situations, are technical constraints that restrict ARS. The technology must be able to detect shifting environmental conditions and geographical variations, maybe with the help of intelligent systems.

Farming field equipment has already experienced a substantial amount of automation and is moving from the usual automated guiding of today to the completely autonomous field robots of future. The following are important areas of development: (1) automatic vehicle guidance and steering control; (2) automatic implement guidance; (3) automatic headland sequence and turn management; (4) sensing for variable-rate technologies (5) sensing for perception ;(6) machine operation optimization; (7) machinery coordination; and (8) machinery communication. On these subjects, the writers wrote and delivered a variety of conference presentations during the 2018 ASABE Annual International Meeting in Detroit, Michigan. Only three of those papers are presented in this collection for the purpose of coherence and conciseness. The fourth focused on nitrogen management solutions based on sensors.

As a result, although attempting to address automation as it relates to major agricultural equipment, this article falls short of providing a truly comprehensive picture of automation in agricultural output, which would go beyond the four articles indicated. In addition to discussing research and untapped intellectual property, each of the highlighted areas of progress offers a summary of already accessible commercial technology. The authors conducted interviews (with varied degrees of success) with corporate staff from six major equipment manufacturers: John Deere, CLAAS, AGCO, SDF, CNH, and Kubota in order to learn more about commercially accessible technology.

Robots with autonomy might aid in overcoming these urgent issues. While their physical form consists of hardware, such as a vehicle and manipulators, their autonomy is generated from very complex artificial intelligence-based algorithms. These algorithms combine sensor data to provide for real-time decision support and control. Co-bots, or autonomous robots, may work alongside people to complete tasks, or they can work independently. Aside from a few isolated instances on farms, autonomous platforms with robotic mobility that combine several technologies into a single fleet (such as crop forecasting, planting, harvesting, and packaging) are not yet completely implementable and face significant obstacles. However, static robotic milking technology is already being used in the dairy industry, and robotic manipulators installed to tractors are being used in the field to pull weeds and guard crops against pests and disease.

However, we are aware that the history of agricultural innovation is rife with failure and delayed uptake, and that autonomous agriculture has legal, ethical, and societal challenges. Depending on how technologies are developed and put into use, autonomous agriculture may provide difficulties, possibilities, and repercussions. The emerging literature on the social and ethical effects of digitization in agriculture. There is still little empirical study on autonomous agricultural robots; possible problems have mostly been inferred from empirical studies on the deployment of autonomous robots in other professions or on smart farming technology in general. Here, we highlight instances of responsible innovation concepts in action and point out areas in which more work needs to be done.

Ethical innovation in agriculture and other fields

The most popular framework for responsible innovation was put forth by Stilgoe and colleagues8 and consists of four essential elements: anticipating the effects of innovation; reflecting on one's work and adapting accordingly (reflexivity); involving a wide range of stakeholders in the design process; and responding to stakeholders' concerns, ideas, and knowledge by developing suitable institutional structures. By 2050, the world's population is projected to reach close to 10 billion, increasing agricultural order in a context of modest financial growth by around 50% compared to 2013. Currently, 37.7% of the earth's surface is dedicated to growing crops. Agriculture has a significant role in the nation's economy and in creating jobs. It makes a substantial contribution to the economic success of industrialized countries and actively influences the economies of emerging nations as well. The rural community's per capita income has significantly increased as a consequence of the expansion of agriculture. Therefore, it will be sensible and appropriate to give the agriculture sector more attention. In nations like India, the agricultural industry contributes 18% of the country's GDP and employs 50% of the workforce. Agricultural sector growth will spur rural development, which will then accelerate rural transformation and ultimately lead to structural change.

Many global sectors have seen a drastic transition as a result of the development of technology. Surprisingly, despite being the least digitalized sector, the research and commercialization of agricultural technology have gained traction. Artificial intelligence (AI) has started to play a significant part in everyday life, expanding our senses and enabling us to change the surroundings. On the basis of combining crop assignment with vehicle route, a system for harvest planning is provided. The workforce, which was formerly limited to a small number of industrial sectors, is now contributing too many industries thanks to these rising technologies. Artificial intelligence is built on a wide range of disciplines, including biology, computer science, linguistics, mathematics, psychology, and engineering. A succinct rundown of how agricultural automation is now being used. The report also discusses a suggested IOT-based system for watering and identifying flowers and leaves at the botanical farm. The fundamental idea behind AI is to create technology that works similarly to the human brain. The development of intelligent software and systems is based on research into how the human brain functions, how people learn, make choices, and work together to solve problems. Similar to the human brain, these clever machines give us the appropriate response for every legitimate input after being supplied with training data. AI encompasses a wide range of fields, including machine learning and deep learning. While DL is the learning of deep neural networks, ML is the capacity to learn anything without being explicitly taught, and AI is the study of creating intelligent computers and programs. The primary objective of AI is to simplify problem solving, which may include using ANN.

The Engineering and Physical Sciences Research Council9, InnovateUK10, and the European Commission, among others, provide guidance on responsible innovation that encourages businesses to be aware of their responsibilities and committed to responsible research and innovation principles by exploring the challenges that could arise from innovation and acting on their findings in a transparent, inclusive, and timely manner. There is a lack of commitment to, or reporting of, the steps made in technological development in the agricultural sector despite repeated demands for businesses to engage in a transparent and iterative process of responsible innovation. The four fundamental elements discussed above may be operationalized to direct technological development in agriculture, and we outline the most pressing areas for future study in the sections that follow. The examples provided here, coupled with the advice from provide a clear picture of the methods that may be utilized to put responsible innovation ideas into practice.

Anticipation

Anticipation entails recognizing, forecasting, and examining the possible short- and long-term effects of future innovation throughout society with the aim of limiting undesirable, unexpected outcomes8, and is thus crucial for the responsible development of autonomous robots. Although a recent publication by Legun and Burch starts to outline a method of co-design in the context of robotic apple orchards in New Zealand, very little empirical anticipatory work for autonomous robots in farming has engaged a range of stakeholders in the process. Otherwise, empirical investigations have been restricted to the limited use of foresight exercises in the form of farmer or public opinion surveys employing online questionnaires and brief interviews, as well as technology usage and acceptance surveys. Future advantages and difficulties of merging a technology with other approaches, such as the Delphi process (which depends on anonymous rounds of voting), are also clarified via the application of foresight. Other anticipatory tactics include "horizon scanning" (searching data sources for early developments) and "socio-literary techniques. The where autonomy is "faked," and robots are often remote-controlled, anticipate the capabilities they would have if fully deployed. This paradigm is common in robotics and human-robot interaction. In video studies, people are shown recordings of robot behavior and asked to evaluate it from a third-person standpoint. Back casting, which entails creating a (ideal) future situation and working backward to determine the actions required to get there, is another strategy to take into account. This is carried out, for instance, in anticipatory governance techniques.

User-centered design has largely contributed to the flexibility of autonomous robots in agriculture. Work iterative development approach, fusing combined subjective user experience with real system logs, has been acknowledged as being necessary for robotic systems interacting with people up to this point. Designers have changed prototypes and design routes to guarantee that the robots are user-friendly after involving stakeholders and obtaining their preferences and information needs for autonomous robots via surveys, workshops, and field experiments.

However, this is limited reflexivity; it consists of designers making design adjustments based on user feedback rather than performing a fundamental analysis of the presumptions and values supporting the suggested solution or debating whether agricultural robotics is really the direction we want to go as a society. They don't often engage in deeper forms of reflection, which might lead us to overlook potential answers.

Another form of reflexivity that can direct industry to conduct innovation in a responsible manner is the creation and engagement with best practice guidelines, codes of conduct, and international standards. It is not always clear, however, whether they will still serve this purpose after being adopted. Australia is actively developing a code of practice for agricultural mobile field equipment with autonomous features to assist direct safe working practices in the field; this code of practice is intended to have some legal weight. Norms for worker safety while cooperating with robots in a structured, industrial context are provided by international standards for the use of autonomous robots, such as ISO 10218.

AI's effects on agriculture

The AI-based solutions assist to increase productivity across all industries and also manage the difficulties that many sectors of the economy, especially the agricultural sector, must overcome, such as crop yield, irrigation, soil content sensing, crop monitoring, weeding, and crop establishment. In order to supply high-value AI applications in the aforementioned industry, agricultural robots are constructed. The agriculture industry is in danger due to the rising global population, but AI has the ability to provide a much-needed answer.

AI-based technical solutions have helped farmers increase production while using less input, enhance output quality, and ensure a quicker time to market for the harvested crops. Farmers will use 75 million linked devices by 2020. The typical farm is anticipated to produce an average of 4.1 million data points per day by 2050. The following list outlines the different ways that AI has benefited the agriculture industry:

Perception and image recognition

According to autonomous UAVs and their applications, such as identification and surveillance, human body detection and delocalization, search and rescue, and forest fire detection, have experienced an increase in attention in recent years. Drones or unmanned aerial vehicles (UAVs) are becoming more and more popular because of their adaptability, incredible imaging technology that ranges from delivery to photography, ability to be piloted with a remote controller, and the devices' dexterity in the air, which allows us to do a lot with these devices.

Workforce and skills

Artificial intelligence enables farmers to compile vast amounts of data from official and open websites, evaluate it all, and provide answers to many perplexing problems. It also gives us a more intelligent irrigation method, which increases the farmers' produce. A combination of technology and biological talents will be used in farming in the near future as a result of artificial intelligence, which will not only improve quality for all farmers but also reduce their losses and workloads. According to the UN, by 2050, two-thirds of the world's population will reside in cities, necessitating a reduction in the load placed on farmers. AI may be used in agriculture to automate various procedures, lower risks, and provide farmers relatively simple and effective farming.

Maximize production

The best possible performance level for all plants is determined by variety selection and seed quality. Emerging technologies have aided in the best crop selection and even enhanced the selection of hybrid seed options that are best suited for farmers' requirements. It has been put into practice by gaining an understanding of how seeds respond to various climatic and soil conditions. By gathering this data, the likelihood of plant illnesses is decreased. We can now effectively fulfill customer demands, market trends, and annual results, enabling farmers to optimize crop returns.

LITERATURE REVIEW

Relf-Eckstein et al. [1] studied A new frontier of innovation is developing as agricultural and digital technology converge, opening up several routes to a future of smart farming. This research examines a smart farming innovation developed by a small- to medium-sized firm (SME) that creates and sells equipment for conservation tillage farming on broadacre farms. An entrepreneur created the DOTTM concept as a solution to issues in the agricultural sector. This research used the innovation opportunity space (IOS) conceptual framework to identify the tacit knowledge (experience-based knowledge of farming and agribusiness) and codified knowledge as the foundation of the innovation process (drawing on computer programming). Other businesses are integrating the autonomous capabilities into their short-line manufacturing processes via licensing agreements, and early farmer uptake is good. The invention provides a solution to agricultural challenges. The public policy for the safe deployment of autonomous agricultural vehicles is lagging behind invention and commercialization. However, this smart farming IOS is currently an Unstable IOS, and there remain some gaps.

Abbasi et al. [2] studied one of the key industries that strategically contributes to maintaining food security is agriculture. But as the world's population grows, so do agri-food needs, necessitating a shift from conventional agricultural operations to smart agriculture practices, often known as agriculture 4.0. Agriculture 4.0 has a lot of promise, but to fully realize that potential, it is important to recognize and handle the issues and difficulties that come with it. By examining the new digital technology trends in the agricultural sector, this research hopes to further the development of agriculture 4.0. An analysis of the scientific literature on crop farming published in the last ten years is done for this purpose using a systematic literature review based on the Protocol of Recommended Reporting Items for Systematic Reviews and Meta-Analyses. The amount of digital technology adoption in agriculture was analyzed in the context of service type, technological readiness level, and farm type after the protocol was applied to 148 publications. The findings indicate that digital technologies such autonomous robotic systems, the internet of things, and machine learning are heavily investigated. In contrast to indoor farms, which are more usually evaluated in research projects (31%), open-air farms are regularly taken into account (69%). Additionally, it has been noted that the majority of use cases are still at the prototype stage.

Alatise et al.[3] studied recent years have seen an increase in the popularity of autonomous mobile robots due to their usefulness and applicability in the modern world. It has become more promising and practical because of its capacity to travel in an environment without the use of physical or electro-mechanical guiding systems. Autonomous mobile robots are being used in a variety of settings, including businesses, industries, hospitals, educational institutions, agriculture, and households, to enhance services and everyday activities. The need for mobile robots has grown as a result of technological improvement owing to the tasks and services they carry out, such as moving large things, monitoring, search and rescue operations, etc. Researchers have conducted several studies on the value of mobile robots, their uses, and their difficulties. This literature review explores the problems that mobile robots are now facing. A thorough examination of tools/sensors and well-established sensor fusion methods created to address problems with localization, estimation, and navigation in mobile robots is also offered, and they are arranged according to relevance, strengths, and shortcomings.

Iqra Hassan Alam et al. [4] studied in addition to monitoring and identifying the technologies that may be utilized to convert conventional agricultural systems into contemporary agriculture systems, the goal of this study is to present an overview of smart agriculture systems. It also gives the reader a wide range of areas to focus on in order to enhance agriculture, and it explains how to apply cutting-edge technology like spectral imaging, robots, and artificial intelligence (AI) in agriculture. Design/methodology/approach: We looked at several clever use of contemporary technology in agriculture that assist to monitor plant stress levels and carry out tasks as needed. Operations include things like crop monitoring, pest control, irrigation, yield output monitoring, and more. The literature assessment has led to the recommendation of a smart agricultural system. The variables investigated were artificial intelligence (AI), rotatory and fixed unmanned aerial vehicles (UAVs), water or soil moisture, nutrients, and insecticides.

Raviteja et al. [5] studied an autonomous vehicle is a self-driving vehicle, driverless vehicle, or robotic vehicle. Whatever the moniker, the technology's goal remains the same. Only in 1920 did tests in autonomous car technology begin, and these were radio-controlled. In the future, trails started in 1950. Since a few years ago, automation technology has been improving every day and being used in various facets of daily life. In the modern world, businesses including agriculture, medicine, manufacturing, transportation, and the IT sector all heavily rely on robotics and automation technology.

Diego Mazzia et al. [6] studied with the emergence of agriculture 3.0 and 4.0, researchers are increasingly focusing on the development of novel smart farming and precision agriculture technologies by integrating automation and robotics into the agricultural processes in order to ensure the efficient and sustainable use of resources. Farmers and industry have been paying close attention to autonomous agricultural field devices as a way to save prices, labor for humans, and resource requirements. Localization, mapping, as well as path planning are just a few of the steps that aim to give the machine the right set of skills to operate in semi-structured as well as unstructured environments; however, achieving sufficient autonomous navigation capabilities necessitates the simultaneous cooperation of various processes.

Anand, et al.[7] studied pesticides must be used in agriculture if high standards of output are to be maintained. By employing an airplane to spray these materials, the process is sped up and soil compaction is avoided. However, unfavorable weather conditions, such as wind speed and direction, might reduce the efficacy of pesticide spraying in a target agricultural area. As a result, there's a chance that the pesticide may drift to nearby agricultural fields. Only a tiny portion of the pesticides used worldwide are thought to be useful in preventing pest infestations since a substantial portion of them are thought to drift away from the intended agricultural area. However, with greater spraying accuracy, it is feasible to cut down on the quantity of pesticides used, raise the caliber of agricultural output, and lessen the chance of environmental harm. Agriculture has made substantial use of UAV in recent years. However, the effectiveness is still below what is ideal, and pesticide contamination is still a problem. The first and second issues below are the major causes of this. The majority of UAV systems currently in use have relatively little autonomy. Actually, the majority of them are still controlled remotely. The UAV's operational precision is insufficient as a result of the proximity of the plants' poor accuracy flying control. The study combines innovative methods and technology used in contemporary agriculture.

Sireesha et al. [8] studied an autonomous vehicle is to be constructed and used for crop transplanting and yielding, crop protection, temperature monitoring, soil moisture properties, weed detection, water status, fertilization and pesticides with their resource usage, as well as with a focus on control and data monitoring with the embedded system, in order to avoid the various issues that have an impact on crop production. This study also discusses some of the difficulties and factors to be taken into account when using these sensors and their technology for crop production. To collect the data needed to improve target placement precision, fiber optic gyroscopes and numerous resolvers are used. A technique that defines how agricultural automation vehicles behave while going along curvy roads is also available for evaluation.

Ju, Wenshuai [9] studied the robot industry has advanced greatly, and it is now extensively employed in a variety of fields including agriculture, food production, machining, transportation, and medicine. An important technique in the advancement of robot intelligence is autonomous navigation. The applications of autonomous navigation technology in the transfer robot, the medical robot, and the agricultural robot are thus thoroughly examined in this work. Additionally, we review and discuss the advancements and applications of fundamental technologies connected to autonomous navigation, such as 5G connectivity, autonomous location, and sports planning. Finally, the potential for robot and autonomous navigation technology development is shown.

Moysiadis et al. [10] studied With the introduction of mobile robots in agriculture, a number of labor-intensive, resource-intensive, and time-consuming agri-field tasks have been optimized by new automation technology. As a result, there is a lack of a widely acknowledged technical vocabulary for mobile robots since relevant terminology are often used interchangeably. Stakeholders in research and practice are confused as a result of this. Furthermore, due to a lack of relevant research, a uniform definition of planning qualities in automated agricultural operations is currently lacking. In this respect, a "narrative" study was used to evaluate the fundamental planning features of mobile robots in agricultural contexts as well as to offer the basic language over technical aspects of mobile robots employed in autonomous operations.

DISCUSSION

Chatbots for agriculture

The conversational virtual assistants that automate conversations with users are known as chatbots. With the use of machine learning and artificial intelligence-powered chatbots, we can now interpret natural language and communicate with people more individually. Agriculture has made use of this facility by supporting the farmers in receiving answers to their unanswered queries, for offering them guidance, and for giving them other suggestions as well. They are mostly prepared for retail, travel, and media.

In agriculture, robots

Large economic sectors with poor productivity, including agri-food, are introducing robotics and autonomous systems (RAS). UK-RAS White Papers (2018) state that the UK's whole agri-food supply chain, from primary farming to retail, produces around £108 billion annually, employs 3.7 million people, and produced £20 billion in exports in 2016. In the administration and production of agriculture, robotics has had a significant impact. The inefficiency of traditional farming machinery has led academics to focus more on developing technology for autonomous agricultural implements. This technology's primary goal is to replace human labor and provide tangible advantages to both small- and large-scale industries. The availability of robotic technology in this industry has greatly increased production.

The robots carry out a variety of agricultural tasks on their own, including weeding, irrigation, guarding the farms to deliver accurate reports, making sure that unfavorable environmental conditions do not affect the production, increasing precision, and managing specific plants in various unfamiliar ways. Eli Whitney's cotton gin, which was invented, gave rise to the concept for developing such a technology. Eli Whitney, a native of the United States who was born in 1765 and died in 1825, created a machine in 1794 that revolutionized cotton manufacturing by greatly expediting the process of separating cotton seed from fiber. In a single day, it produced 50 pounds of cotton. Thus, the autonomous agricultural robots were born as a result. Ultra-high precision seed placement was also developed, and a simple automated model was presented to determine the real location of seeds.

Mechanisms to guarantee that seeds are placed with no ground velocity. This is crucial because it prevents the seed from bouncing from its real place after the hit with the soil. Automated machinery kept track of the state or progress of the factory. To track plant development and identify plant diseases, many biosensors have been developed. The human weeding procedure was replaced with laser weeding technology, which uses a computer-controlled beam of mobile focused infrared light to damage the weeds' cells. Automated irrigation systems were also developed for efficient water utilization.

Watering

Around the globe, 85% of the freshwater resources are used by the agricultural sector. And this fraction is rising quickly in tandem with both population growth and rising food consumption. As a result, we must develop more effective solutions to guarantee the optimal use of water resources for irrigation. Automatic irrigation scheduling methods have taken the role of manual watering that was dependent on soil water monitoring. While implementing autonomous irrigation equipment, it was taken into account that plant evapotranspiration was reliant on a number of meteorological variables, including humidity, wind speed, sun radiation, and even crop aspects, such as crop stage, plant density, soil characteristics, and pest.

The various irrigation techniques with the main goal of creating a system that uses less resources and is more effective. On the field, instruments like fertility meters and PH meters are put up to measure the proportion of the soil's main constituents, such as potassium, phosphorous, and nitrogen. Drip irrigation is used to automatically plant plant irrigators on the field using wireless technology. This technique guarantees the soil's fertility and the efficient use of water resources. The development of smart irrigation technology enables farmers to boost productivity without using a lot of labor by monitoring soil temperature, fertilizer content, water level, and weather forecasts. Turning the irrigator pump ON/OFF causes the microcontroller to conduct the actuation. The M2M, or machine-to-machine, technology was created to make it easier for agricultural field nodes to communicate with one another and to share data with a server or the cloud via the main network. For the sensing of temperature and moisture content, they created an automated robotic model.

The Arduino microcontroller, which is coupled to edge level hardware, receives the data at regular intervals and sends it on to further transform the input analog to digital. To activate the water supply for irrigation, the signal is transferred to the Raspberry Pi 3 (which has the KNN algorithm built in). The resource will provide water in accordance with the demand, and it will update and store sensor readings. Additionally, an automated irrigation system was created using Arduino technology to save time and labor during the irrigation process. The concept of a productive and automated irrigation system that uses remote sensors and Arduino technology to boost output by up to 40%. Kandasamy and provided a different automatic watering system. In this method, many sensors were created for various functions, such as the soil moisture sensor for measuring soil moisture, the temperature sensor for measuring temperature, the pressure regulator sensor for maintaining pressure, and the molecular sensor for improving crop development. Installing cameras with a digital sensor. All of these devices' output is transformed to a digital signal before being sent to a multiplexer through a wireless network like Zigbee or a hotspot.

The first method was subsurface drip irrigation, which reduced water loss from evaporation and runoff since the water was buried under the crop. Later researchers developed other sensors, such as soil moisture sensors and rain drop sensors, which were controlled by wireless broadband networks and powered by solar panels and used to identify the demand for water delivery to the fields. The soil moisture sensor and rain drop sensor use GSM technology to send the farmer an SMS letting them know how much moisture is in the soil. As a result, the farmer is able to turn on and off the water supply using SMS messages. Thus, we may assume that this system will identify any areas or parts of the fields that need more water and may prevent the farmer from watering during periods of rain. One of the many methods used to monitor soil moisture content is employed by soil moisture sensors. It is buried close to the plant roots. The sensors assist in precisely measuring the moisture level and relay this signal to the irrigation controller. Significant water conservation is also made possible via soil moisture sensors. When the appointed time comes, the sensor analyzes the zone's moisture content or level, and watering will only be permitted there if the moisture content is below a threshold. The other was suspended cycle irrigation, which, in contrast to water on demand irrigation, required irrigation time. It needs the beginning and ending times for each zone.

Dielectric approach

The sensors use the soil's dielectric constant also known as the bulk permittivity of the soil to determine how much moisture is present in the soil. The dielectric constant may also be used to calculate the required quantity of irrigation, and it even suggests an automated system that employs dielectric soil moisture sensors for real-time irrigation management. The measuring technique based on the dielectric characteristics is seen to be the most promising one since it provided data on how the different kinds of soil impact the precision of dielectric moisture sensors. The only ability of soil to transmit power or electricity is its dielectric constant.

CONCLUSION

Perhaps more challenging to handle than the technological implications of the development of technology are the social, legal, and ethical implications of autonomous robots. Further research is necessary to ensure that initiatives in foresight, reflexivity, and inclusivity are converted into realistic responsive action on the ground. The bulk of empirical research for the development of autonomous agriculture has, as this article has shown, focused on the technical aspects of robot operation with a degree of inclusivity and reflexivity to ensure technical performance improvement. There isn't a lot of published work that uses methods that enable substantial inclusion and deeper subject reflection beyond this. Nevertheless, if society finally decides that autonomous agricultural robots are the way to go, then using responsible innovation techniques in their development is essential to avoiding upcoming debate, implementation delays, and adverse repercussions. In the end, the success or failure of autonomous robots in agriculture will rely less on our technical prowess and more on our ability to interact with society, absorb its lessons, and make necessary adjustments.

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CHAPTER 17

DRONE TECHNOLOGY USED IN AGRICULTURE

Upasana, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- upasana35954@gmail.com

ABSTRACT:

India's agriculture has difficulties on many fronts, including declining production, climate change, and sustainability. In terms of social, economic, and environmental elements, using drones in agriculture promotes sustainable agriculture. The benefits of drone technology adoption in India are covered in this paper. This study also discusses the government of India's attempts to advance drone technology. The utilization of drone technology presents several difficulties. The research discovered that the use of drone technology reduces expenditure on chemicals while also saving time, labor, and water. Additionally, it reduces chemical usage and prevents human exposure to chemicals. The study's findings suggest that the government should properly employ drone technology in order to revolutionize India's agricultural industry and the lives of millions of farmers.

KEYWORDS:

Climate Change, Crop protection, Drone technology, Sustainable Agriculture.

INTRODUCTION

India is an agrarian nation with a sizable quantity of cultivable land (nearly 155 million hectares). Agriculture continues to be a significant source of income, employment, and subsistence for rural families even after seven decades of independence. Even though the agriculture industry accounts for 20.2% of India's GDP, its employment proportion is just 45.6%2. (GDP). Although the Indian economy is expanding, the GDP share of the agricultural sector has not changed throughout the years. Comparing the agricultural sector to the industrial and service sectors, the agriculture sector still generates minimal income and is technologically behind.

Agrarian Crisis

The agriculture industry faces a number of age-old problems, including low productivity, shrinking landholding sizes, unplanned resource allocation, inefficient input use, frequent crop failures, farmer suicides, low income generation, high biotic losses, low levels of mechanization, increased chemical use, inefficient resource management, increased reliance on labor, and minimal links to the market and extension system. The current difficulties are prohibiting farmers from increasing their income levels and the agricultural industry from reaching its full potential. 6 40% of Indian farmers, according to the 59th National Sample Survey Organization (NSSO) evaluation from 2003, are not interested in continuing their occupation. If they are offered other jobs, they will stop farming. The country's agricultural misery was made evident by the farmers' periodic protests. As has already been said, agriculture predominates in India's rural areas, which are also home to the vast majority of the country's impoverished. The deteriorating living standards and low wages of those working in the agricultural sector highlight the need for change in this industry.

Agriculture transformation with digital technology

The first option in front of policymakers to promote sustainability and change in Indian agriculture may be the use of existing modern technology. For the agricultural industry to reach its full potential, productivity and efficiency must grow. With the aid of cutting-edge technology, it is necessary to identify the problems with current methods and their potential long-term solutions. Numerous unsustainable techniques linked to irrigation, chemical spraying, crop monitoring, pest control, etc. are used in modern agricultural operations. The FAO recommended using the potential of many new technologies to address the current issues facing the agricultural industry. In order to address long-standing issues and advance the agricultural industry, new technologies like artificial intelligence (AI), big data, satellite, drone, Internet of Things (IoT), digital dashboards and portals, climate smart advisories, information technology (IT), geographic information system (GIS), global positioning system (GPS), remote sensing (RS), and cloud computing are now being used. These new digital technologies help to increase the predictability, sustainability, and efficiency of the food production and supply chain.

Unmanned aerial vehicles, or drones, are multifunctional flying robotic aircraft that may be controlled by a person on the ground or that can operate on their own in accordance with a predefined algorithm. Drone technology may be used for a wide variety of reasons, including military operations, disaster management and relief, remote monitoring, building projects, mineral prospecting, and numerous agricultural endeavors. Drone usage for agricultural purposes is encouraged by prevailing societal norms as well as the fact that maintaining agriculture is crucial for preserving populations' access to food security. The prospects for drone usage in agriculture during the lockdown and the labor shortage were underlined by the different studies.

In practically every industry, including agriculture, the use of digital technology has increased since COVID-19. Farming communities must become more robust to feed the population constantly amid unpredictable times as a result of the epidemic and climate change. In addition to offering chances for tackling agriculture's conventional problems, digital technologies are also helping the world's Sustainable Development Goals be achieved (SDGs). 8 The Indian agricultural industry must employ cutting-edge digital and precision agriculture technology in order to meet the goal of doubling farmers' income. By enhancing agricultural production and expanding all sorts of farmers' access to market information, digital technology may move Indian agriculture toward sustainable agriculture. The usage of drones in agriculture helps to fulfill the expanding population's need for food. This technology has the potential to help farmers overcome the difficulties presented by their line of work. Drone technology has the potential to revolutionize agriculture by offering a substitute for labor-intensive manual labor. This is the digital technology that is most often utilized to modernize the agricultural industry on a worldwide scale. Due to the lack of labor and the growing significance of precision farming, the agricultural community is taking a favorable stance toward the employment of drone technology in agriculture.

LITERATURE REVIEW

Ayamga et al. [1] studied Drone technology is one of several ICT breakthroughs that have quickly entered the agricultural industry as a result of the increased need for food on a global scale. In precision agriculture, drones are utilized for airborne observation, sensing, or pesticide application. Drone usage must be regulated since they have the potential to break public order, data protection laws, and privacy laws. But obtaining a license for drone operation is difficult in many African nations since there are either extremely severe rules or no laws at all.

Talaviya et al. [2] studied the agricultural industry contributes significantly to the economy. The primary worry and a hot topic globally is the automation of agriculture. The population is growing rapidly, and with it, so are the need for food and work. Farmers have been using traditional techniques, but they were insufficient to meet these demands. New automated techniques were therefore introduced. These innovative techniques supplied the world's food needs while simultaneously giving billions of people access to jobs. A revolution in agriculture has been sparked by artificial intelligence. The agricultural output has been shielded by this technique from a number of circumstances, including population expansion, job issues, and food security concerns. The primary goal of this study is to evaluate the numerous ways artificial intelligence is being used in agriculture, including irrigation, weeding, and spraying with the use of sensors and other tools built into drones and robots. These technologies reduce the overuse of water, pesticides, and herbicides, preserve soil fertility, assist in making effective use of human resources, increase output, and enhance product quality.

Ayamga et al. [3] studied drone technology is one of several that is contributing to globalization and is being used more and more in a wide variety of fields, including agriculture, health care, and the military. Drones can provide real-time data on farms, allowing farmers to make knowledgeable choices about the use of agricultural supplies. Additionally, during medical situations, they may be used to fly medical supplies like blood, vaccinations, medications, and laboratory test samples to isolated places in underdeveloped nations. Military drones are also useful for security and tracking the movements of the enemy, which aids in choosing targets for assassination. Despite its advantages, drones have the potential to harm persons and property if the operator is inexperienced or if a component fails while the drone is in flight. Extremists might even take control of drones and change the payload to suit their own purposes.

Kangunde et al. [4] studied this paper provides an overview of relevant literature on remotely piloted, or unmanned, aircraft. Systems under real-time control provide more predictable responses, ensuring that activities will be finished within a certain time frame. For drones that are increasingly needed to execute more complex jobs, this system feature is much desired. The studied papers were selected to illustrate real-time operated drones and to cover technology applied to various drone applications. The creation of highly agile drones for use in surveillance, aerial mapping, military conflict, agriculture, etc. has advanced. Such highly agile vehicles need complicated control, real-time reaction, and task management, which are all difficult to handle.

Maanak Abdelsalam et al. [5] studied smart computing and the Internet of Things (IoT) have completely changed how people live in the twenty-first century. Just ten years ago, IoT technology and the data-driven services they provide were unimaginable. They now surround us and have an impact on many industries, including the vehicle, healthcare, smart home, etc. The agriculture and farming sectors, in particular, have welcomed this technological involvement. From farmers to business owners, a variety of individuals utilize smart gadgets often. These technologies are employed in many different ways, from monitoring the condition of crops and the moisture level of the soil in real-time to using drones to help with chores like spraying pesticides.

Kitonsa et al. [6] studied Commercial, industrial, professional, and private uses of drone technology have spread since its inception in military applications. Unmanned aerial vehicles (UAVs), sometimes referred to as "drones," have a variety of uses in the economy, such as in transportation, entertainment, infrastructure, and telecommunications. Drones are time- and money-saving devices that help cut carbon dioxide emissions in addition to being environmentally benign. As a result, drones have the potential to be a powerful force for good in achieving the sustainable development goals (SDGs) that the United Nations Organization established in 2015.

Jakob et al. [7] studied a novel and promising method for quick and accurate data collection and transmission of high-resolution hyperspectral data to a wide range of end users is drone-borne hyperspectral imaging. Drones are able to bridge the scale gap between field and airborne remote sensing, producing data that is highly detailed and multi-temporal. They offer data with a resolution of cm and are simple to use. Too far, however, photogrammetry and precision agriculture have mostly and effectively utilized drone-borne images. A few hyperspectral drone sensors have recently become accessible, however their application for geology-related investigations is complicated by complicated geometric and radiometric consequences.

Kurkute et al.[8] studied agriculture is one of India's key industries. A number of factors, including temperature, humidity, rain, and other factors, affect the pace at which crops are produced in agriculture. Those are external variables beyond the control of farmers. In order to regulate issues like disease, pests, fertilizers, etc. in the realm of agriculture, crops must be treated properly. Pesticides may boost agricultural yield, but they also have an impact on people's health. Therefore, the primary goal of this work is to build an agricultural drone for pesticide application. This essay will discuss several unmanned aerial vehicle-based architectural designs (UAVs). The usage of pesticides in agriculture is crucial, and if we employ intelligent devices like robots utilizing modern technology, it will be very simple.

Doddamani et al. [9] studied precision farming has benefited from advances in technology, which are represented by unmanned aerial vehicles (UAVs). It offers sharp crop photos, and when exact indices are used, useful results are produced for farm management decision-making. The present study reviews and discusses the many ways that UAVs are used in agriculture. In this study, a quick review of current drone technology for farming, including crop health monitoring and farm operations, is presented. The consequences of the new regulatory regime for usage in agriculture are also being thought through. Several examples are offered that are made feasible by the use of UAVs in agriculture, as well as prospective future paths for agricultural technology.

Gallego-Madrid et al. [10] Studied in smart spaces including situations like agriculture, forestry, coast preservation, and connection survival against calamities, the spread of Internet of Things (IoT) devices in distant places and the necessity for network resilience in such deployments are becoming more and more crucial. Large areas are still challenging to cover with wired gateways due to the lack of network or power infrastructure, even though Low-Power Wide Area Network (LPWAN) technologies, like LoRa, support high connectivity ranges. The idea put forward here suggests mounting LPWAN gateways on drones to create airborne network segments that would provide improved connection to sensor nodes wherever it is required.

DISCUSSION

Agriculture's use of drone technology

Researchers are currently investigating a variety of uses for drone technology, including locating rhino poachers in dense forests, searching for people in need during disasters and natural calamities, and delivering medicine to far-flung locations during medical emergencies. These organizations include both public research institutes and private businesses. Drones may be utilized in agriculture for a wide range of tasks, from agricultural production to agro-forestry, which includes planting expansive and challenging terrain, monitoring crop development, and managing soil and water. Various drone uses for agriculture are described in Figure 1.

Figure 1: Illustrate the Implementation of Drone Technology in Agriculture

Analysis of the for field planning

Before choosing a suitable crop for planting, it is important to assess the soil's condition, type, and availability of micro and macronutrients in order to enhance crop yield. Decision-making about the use of various inputs and their quantities requires field and soil evaluation both before crop cultivation and after planting. Drones can analyze soil and fields to determine nitrogen levels, schedule irrigation, and plan crops. The use of drones for soil research for field planning was emphasized in the FAO's case studies on drone technology in agriculture. Drones may gather data and assist in making precise decisions about crop cultivation that are appropriate for the soil's conditions and the quantity of nutrition and water that must be used periodically.

Establishment of Plants

It has been noted that there used to be a labor shortage during agricultural planting operations. This problem can be solved by using drone technology to quickly and accurately plant crops over a broad expanse. A certain pattern is followed while using drone planting devices to plant seeds and apply nutritional sprays to an agricultural area. It has been noted that the deployment of drone technology improves crop management's uniformity and effectiveness while also lowering costs. For drone systems, several inventors have created additional attachments that may fire pods containing seeds and plant nutrients into previously prepared soil. This results in cheaper planting costs. In addition to eliminating labor-intensive tasks, such a way of crop seeding has cut plantation costs by about 85%.

Spraying of crops precisely

15–25% of the food produced in India is lost to crop loss due to pests, weeds, and plant diseases. The Food and Agriculture Organization (FAO) estimates that farmers would lose 40% of their production to pests and plant diseases if they cease employing crop protection methods. The typical method of spraying pesticides in agriculture requires a lot of labor and puts the workers' health at danger since they are exposed to hazardous chemicals via their skin, eyes, and lungs. Due to pesticide spraying, about 0.3 million farmers have respiratory illnesses. Several investigations showed that between 2013–13 and 2017–18, 442 farmers nationwide and 183 in Maharashtra died as a result of pesticide usage. In India, snakebites are a significant factor in the mortality of farmers. A total of 58000 farmers are killed each year. These problems in agriculture might be solved by drone technology.

In dangerous geographic areas such mountainous areas with slopes, it is challenging to guarantee the administration of chemicals in a recommended amount. By merging drone technology with AI, machine learning, and the Normalised Difference Vegetation Index (NDVI) for accurate insight into soil conditions, plant health, and yield estimates, these obstacles may be overcome. The drone's high-quality camera and sensors allow for site-specific spraying. The drone can scan the agricultural area before spraying, and it also makes sure that the scanned crops get an exact or set dosage of liquid nutrients and pesticides. According to several research on drone agricultural spraying, drones can spray five times quicker than the conventional approach, saving time and cutting input costs. According to the experiments, map-based optimized nitrogen application reduces nitrogen input by 20%.

Crop monitoring

Crop monitoring is a significant cause of worry for many stakeholders engaged in agricultural operations, not only farmers. The emergence of unpredictable weather patterns has made this problem worse by raising the danger of crop loss and raising maintenance costs. Crop damage and insect attacks must be assessed often in order to take appropriate action. By gathering multispectral geographical and temporal statistics at preset scales pertaining to crop growth and health, drones may be utilized to design monitoring routes. When compared to human field scouting, data analytics may provide crop health information. Farmers are able to monitor their fields at their leisure with the use of drones. Farmers can quickly take preventative measures thanks to regular crop monitoring. The real state of the cultivated crop may be obtained by accurate and regular crop monitoring, which aids in the early identification of any issues. Crop monitoring using a multi-spectral camera placed on a drone is more efficient, claim. This camera takes crop photos in a single trip, making it simple to locate the pest-infested region after image analysis. With the use of GPS coordinates, the drone can accurately spray the necessary chemicals.

Management of irrigation

It might be difficult to provide enough water to produce crops in the majority of drought-prone locations. A field now receives water in a consistent way thanks to the existing irrigation systems. To make the best and most efficient use of the water resources that are now available, water must be provided where it is truly needed. Water is a crucial component for crop development; little or excessive water causes issues with the plant's ability to grow properly. In a big agricultural area, farmers must regulate irrigation effectively depending on the planted crop. With the use of infrared digital cameras, the drone can help farmers make correct judgments for precision irrigation management. The soil moisture stress state and surplus water at a specific location in the agricultural field may be captured by the drone. Drone-assisted fieldwork assists in improving water usage efficiency and identifying irrigation leaks via regular irrigation monitoring.

Drones using sensors, multispectral imaging cameras, and thermal cameras can record the effects of heat and water stress on crops in specific agricultural areas. It allows irrigation to be used on crops according to their requirements. This will guarantee that irrigation water is utilized efficiently and prevent water from being wasted. The International Water Management Institute (IWMI) utilized drones in Colombo to monitor rice growing in the water-scarce Anuradhapura area. The institution used red, green, and blue sensors together with near-infrared technology to capture images of the paddy fields. Water is a deciding element in the rain-fed agricultural system in Africa. The design and implementation of a workable irrigation system is being aided by UAV technology.

Crop health evaluation

For the early detection of any disease, frequent crop monitoring is necessary. Early disease detection and prompt preventative action may significantly lower crop failure and output loss. The spread of infection may be stopped by the early diagnosis of bacterial, fungal, and pest-related illnesses. By scanning cultivated crops using green visible light and near-infrared light, the drone may assist in crop health monitoring. Drone-based agricultural health assessments may increase crop productivity and decrease the cost of chemicals like insecticides. "UAVs fitted with specific sensors may gather multispectral photos that are stitched to produce spectral reflectance bands," according to FAO.

Livestock surveillance

Farmers used to work in industries other than farming, such animal husbandry, to make extra money. It may be difficult to manage cattle since they often travel from one location to another and need more labor, which drives up costs. Keeping an eye on sheep and cattle when they are grazing in a big open area might take a lot of time. Animal monitoring technologies include wearable Radio Frequency Identification (RFID) tags and distant sensors that may record physiological or behavioral data and provide alarms when anything is out of the usual. Automatic technology, which also could provide more information than human monitoring, allows for continuous monitoring. The drone can simply keep an eye on the animals that have RFID tags. The precise position of each animal can be determined by the drone using RFID tags, making it simpler for farmers to monitor their animals and save costs associated with specialized staff. Drones equipped with thermal sensors may assist veterinarians discover injured and ill animals as well as locate misplaced pets. High-quality cameras and sensors enable drones to identify and cure animals with any ailment quickly and to identify predators before an attack. Drones are helpful if the animals are located in areas where a herder may find it dangerous to go, such as on sloped water reservoirs or in challenging terrain.

Disaster preparedness

A favorable climate may encourage agricultural development, yet harsh weather can be harmful for farmed crops. It is exceedingly challenging to deal with the abrupt shift in weather since it cannot be forecast with any degree of accuracy. Real-time meteorological conditions may be detected by drones, and farmers can analyse the data they gather to create a strategy for risk reduction in preparation. Planning various agricultural operations and judicious resource allocation might be aided by advance knowledge. In disaster management, the risk is reduced by forecasting potential catastrophic occurrences using real-time data collected from the ground by drones. Drone-based data gathering is more flexible, timely, accurate, and less costly than satellite-based Remote Sensing (RS). Through accurate prediction and necessary adjustments, this drone-enabled data helps to increase agricultural output and supply chain management.

Geo-fencing

In several parts of the nation, wild animals are deployed to damage the crops that have been planted. Farmers may pay attention to animal or human entrance during the day, but it is highly challenging to monitor the field at night and avoid crop loss from wild animals. Animals may be found using drones equipped with infrared cameras both during the day and at night, alerting farmers. Therefore, farmers can prevent agricultural damage caused by outside animals with the use of drones. Birds may also be a big problem when many crops have been planted. For the field to be protected, further work is needed. The birds may flee the field after a few drone flights.

Estimating crop biomass and damage

Ultra-compact LIDAR sensors placed on drones can measure the crop/tree canopy density and the distance from the ground surface. This enables the evaluation of the tree/crop biomass change derived from differential height measurements, which forms the basis for estimating crop production in crops like sugarcane and calculating wood output in forests. A drone can quickly and easily detect weeds, diseases, and pests with the use of multispectral and Red-Blue-Green (RBG) color sensors.

Farmers can more efficiently and precisely schedule the pesticide spraying on the basis of the information they have collected. When compared to a human survey, the high-quality aerial photos of crops taken by drones may give information on post-disaster agricultural damage with more accuracy. This use of drone technology may improve the accuracy and speed of operations related to assessing crop damage, assisting the agricultural community in effectively resolving crop insurance claims. The basis for employing drones to enhance agricultural insurance instruments for cross-verifying farmers' insurance claims is also this feature of crop monitoring and crop health assessment.

Control of roaches

Farmers are facing a new difficulty as a result of locust attacks on crops in addition to their inherent vulnerability. The devastation and financial loss for the agricultural community were caused by the farmed crop being decimated by an army of locusts. Many Indian states are deploying drones to spray pesticides to eradicate locusts in order to solve this problem, since doing it manually would be incredibly difficult.

Shifting products in agriculture

According to the needs of the farmer, the drones may also move agricultural products from one location to another. The drones are able to do service-type operations; they may park in a field and be used for various tasks including spraying, monitoring, and moving cargo.

Agriculture sustainability and drone technology

Drones may assist farmers collect continuous real-time information, crop production metrics, and other insights on the management of agricultural fields, which can help farmers practice sustainable agriculture. By preventing environmental deterioration, effectively monitoring crop health, learning about the health of the soil, organizing irrigation, and making the most use of available resources, drones may assist farmers in increasing productivity. Drone technology is a cutting-edge innovation that has the potential to revolutionize the farming industry by enhancing the three pillars of agricultural sustainability.

Environmental Perspective

Drone usage facilitates resource optimization by improving input utilization effectiveness. Utilizing water wisely and using chemicals sparingly will stop pollution and environmental deterioration. Drone-assisted crop sowing or planting may lessen the need for tractors and contribute to sustainable farming by saving labor, money, and fuel. Low petroleum fuel use will assist in attaining sustainability's environmental component.

Financial Dimension

The most effective and exact use of input resources will lower the demand and boost crop yield, which will eventually enhance farmers' revenue. The economic aspect of sustainability is supported by decreased labor demand and manufacturing costs. Drones made it possible to do agricultural tasks faster, with fewer labor-intensive methods, and with more safety for the farmers. The social aspect of agricultural sustainability may be attained via time savings, increased safety, decreased labor requirements in the profession, and respect in society.

CONCLUSION

Drone technology is developing swiftly since it has so many applications. Drones increase agricultural output overall, encourage farmers to employ precision farming methods, and provide them the opportunity to transition from farming being a labor-intensive to a technology-intensive profession. It will help to reduce human error or inefficiencies in present agricultural procedures by giving accurate and reliable information on the condition of agricultural areas. Software, cameras, sensors, and other analytical tools can automatically gather data and images and interpret them into knowledge and insights, considerably reducing the possibility of human error. Drone technology might be advantageous to farmers in two ways: first, by assisting in decision-making; or second, by replacing human labor by doing different tasks in the field more precisely and rapidly. Several difficulties prevent the deployment of drone technology in agriculture. These challenges must be solved in order to employ drone technology successfully and take advantage of its potential to change India's agriculture sector and the lives of millions of farmers.

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CHAPTER 18

ROLE OF DRONE TECHNOLOGY FOR INCREASING THE PRODUCTIVITY OF AGRICULTURE

Ashutosh Awasthi, Associate Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- ashuaw@yahoo.in

ABSTRACT:

Small flying platforms weighing up to 20 kg are known as unmanned aerial vehicles (UAV), sometimes known as drones (50 lbs). Because of their size, a human body cannot board them (yet). Drones may be controlled in one of two ways: directly, in which case a person uses a wireless remote to take full control of the machine; or autonomously, in which case the machine is capable of controlling itself and following a course based on information from GPS or other sensors. Using precision technology, farmers may maximize agricultural output or profitability based on current field data, safeguarding the environment and perhaps converting failure into success.

KEYWORDS:

Agriculture, Aerial Vehicle, Drone Technology, Environment, Fertilizer.

INTRODUCTION

Legality

The Federal Aviation Administration (FAA) urged farmers to adopt this cutting-edge technology to keep an eye on their crops as drones began to be used in agriculture. However, the FAA soon withdrew such encouragement in the wake of the unanticipated rise in agricultural drone use, awaiting new rules and restrictions. The beneficial use of such drones in a safe and effective way in response to events like drones colliding with crop dusters. The FAA released regulations for commercial drone operations in 2016. Commercial drone operators must adhere to the established regulations, pass a knowledge test, and register their aircraft in order to operate legally. The American Farm Bureau Federation is pleased with the regulations as a whole but requests minor modifications to some of the limitations that have been put in place. Many nations, like Malaysia, Singapore, and Australia, have put drone use restrictions into place. While 15 nations have banned all drone activities, such rules are still lacking in many other nations. For all of its members, the EU intends to enact a single set of drone laws.

Safety and Morality

Drone usage in agriculture has moral and societal repercussions. They can effectively monitor and manage the usage of pesticides, which is one advantage. This enables reducing the negative effects of pesticides on the environment. However, drones flying under 400 feet above ground level do not need authorization to do so (120 m). Drones may be equipped with microphones and cameras, which has led to some criticism due to worries about possible privacy violations. The accuracy with which drones are operated is another advancement. This opens up a wide range of research opportunities with regard to developing agricultural drone technology. Other businesses may start using drones to inspect their rivals, the health of their crops, and agricultural output in unrestricted regions.

The market for agricultural drones has a lot of room to develop. Crop imagery will need to advance along with the rapidly advancing technology. Farmers may assess their crops and make informed choices about how to continue with the help of the data that drones collect from the fields. The market for software tools that analyze and improve agricultural productivity has room to expand. Farmers will use a drone to correctly scan their crops for problems, then take the appropriate steps to address those problems. As a result, the farmer has more time to concentrate on the production process as a whole rather than spending time inspecting their crops. Keeping tabs on animals, inspecting fences, and keeping an eye out for plant infections are further applications. Modern drones are too costly for small farms in underdeveloped countries due to the expense of both the initial purchase and ongoing maintenance. Pilot projects in Tanzania are aimed at reducing such expenses by building agricultural drones that are simple and robust enough to be maintained locally. A Washington State University research team has created an autonomous drone system that keeps pests like European starlings and crows away from grapes and other crops. The drone's loudness could drive the birds away, but researchers might also use predatory bird sounds and distress cries.

You will have a very tough time looking at any economic area without seeing drone usage. Drones are employed in the agricultural industry for a wide range of duties, such as spraying fertilizer, aerial surveillance, crop monitoring, land inspection, mapping, looking for damaged or rotting crops, and many more. Different drone kinds are being investigated to see which has the most promise for farming, agriculture, and gardening. Quadcopters and other multirotor drones are the finest option for fertilizing crops. Fixed-wing drones are perfect for fertilizing crops, but they are difficult to use because of their large construction and need for a large landing space. In many places, using drones has become an essential component of massive precision agricultural operations. Farmers may improve their planting and treatment plans using the information acquired from the drones' recordings to provide the finest potential crop. The application of precision farming equipment, according to some sources, has the potential to boost yields by up to 5%, which is a considerable gain in a sector with narrow profit margins.

Fertilizer is sprayed

One of the most popular applications of drones in agriculture is their swift movement to their desired locations. Drones with this skill may apply fertilizer and pesticides to crops to hydrate and provide them with the nutrients they need. Such additives may help crops grow and stay healthy. To prevent worms, pests, and insects and prolong crop life, drone commanders have total control over the drone spraying nutrients.

Assessing the state of the soil

Powerful drone capabilities help with the time-consuming procedure of evaluating the soil's health. The character and health of the soil may be monitored, modified, and maintained using UAVs, which collect and analyze data from monitoring systems. The soil may benefit from drone technology by receiving the nutrients it needs to become healthier. Through data processing and 3D mapping, drones carry out the role of monitoring the condition of the soil.

Seeding Technique

Agriculture is by definition a labor-intensive and time-consuming sector since it requires a high degree of skill to do its tasks. Particularly seeding requires human labor since it is a lengthy procedure. To make this strenuous operation simpler, drone technology is employed to spread the seeds of several crop species. They can quickly and efficiently sow seeds thanks to the drones' built-in lasers, sensors, tanks, and other functions. Drones' great capacity to evaluate, diagnose, and survey crops for any deficiencies is another wonderful benefit of employing them to fertilize crops. Their laser-equipped sensors and high-resolution cameras help with the quick completion of a variety of activities. These defects are also mapped in real-time by unmanned aerial vehicles, and crop management choices may be made using the data that is acquired and analyzed.

Drones for agricultural fertilization

In general, the time-consuming procedure of agricultural fertilization has been made easier thanks to drones and their applications. Farmers benefit immensely from their entrepreneurism and strong personalities for a range of tasks and operations. An aerial aircraft that receives remote pilot orders or depends on software for autonomous flying is referred to as a drone, also known as an unmanned aerial vehicle (UAV). A lot of drones are equipped with cameras for gathering visual data and propellers for adjusting flying patterns.

- Drones have a variety of applications, such as the following:
- Pesticide and fertilizer application
- Mapping water spread area
- Water sampling
- Mapping macrophyte infestation
- Aquaculture management techniques

Application costs

- According to the WEF, drone use may cut application costs by 20% while reducing the health risks associated with human labor.
- This helps to encourage precision agriculture and maximize input utilization.
- Data-driven agricultural advice services and precision agriculture know-how may boost productivity by 15%.
- Data gathering and resource-efficient fertilizer application made possible by drones make it easier to anticipate crop yield and make informed decisions.

New technologies

- Drones have the potential to help mainstream emerging technologies like insurance or yield estimate.
- Support for government programs: Drones will make programs like Per Drop More Crop more effective and reduce irrigation's inefficient use of water.
- By assisting with crop cutting experiments, crop loss calculation, insurance assessment, and dispute settlement, data from drones coupled with GIS and Google Earth satellite pictures would expedite programs like PMFBY.
- Agri-research: Agri-research will become much more tailored and localized with the use of drones.
- Because drones can record links going back and forth, food processing firms will be able to purchase from farmers at a lower cost.

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LITERATURE REVIEW

Qiang Zhang et al. [1] studied the study on drones has grown more in-depth, and the sectors of practical application have widened as a result of technological advancements. Its unrivaled benefits are also a key factor. The development of drone technology is currently progressing. A new agricultural revolution is being sparked by drones. In the next years, it is predicted that the market for drones in agriculture would grow to billions of dollars. Information specialist Gerard Sylvester, editor of the research report by the UN Food and Agriculture Organization as well as the International Telecommunication Union on "UAVs and agriculture," stated that as farmers attempt to adapt to climate change and face other challenges, drones are expected to aid the entire agricultural enterprises in improving efficiency.

Tanha Shah et al. [2] studied the agricultural industry contributes significantly to the economy. The primary worry and a hot topic globally is the automation of agriculture. The population is growing rapidly, and with it, so are the need for food and work. Farmers have been using conventional techniques, but they were insufficient to meet these demands. New automated techniques were therefore introduced. These innovative techniques supplied the world's food needs while simultaneously giving billions of people access to jobs. A revolution in agriculture has been sparked by artificial intelligence. The agricultural output has been shielded by this technique from a number of circumstances, including population expansion, job challenges, and food security concerns. The primary goal of this study is to evaluate the numerous ways artificial intelligence is being used in agriculture, including irrigation, weeding, and spraying with the use of sensors and other tools built into drones and robots. These technologies reduce the overuse of water, pesticides, and herbicides, preserve soil fertility, assist in the effective use of labor, increase output, and enhance product quality. In order to provide a quick overview of how automation is now being used in agriculture, including weeding systems using robots and drones, this study analyzes the work of several academics. Two automated weeding approaches are covered together with the different soil water sensing techniques.

Tolga SERT et al. [3] studied "Autonomous drones are being considered the largest item in military technology since the nuclear weapon," as many researchers have noted. According to MAD ideology, if both sides engaged in a full-scale nuclear war, neither side would prevail and would instead be wiped out by the other. This deadlock has mostly prevented the globe from igniting into yet another all-consuming conflict. Regarding drones, their technological advancements, which were first demonstrated in 1917 with the pilotless winged aircraft, have continued to proliferate. In the US, the FAA issued the first commercial drone permits in 2006 after realizing the potential of non-military, non-consumer drone applications. Academic literature has been mostly devoted to the idea that employing drones, especially ones that are armed, may lead to long-term security and stability.

Yan Liu et al. [4] studied drones with multiple rotors are regarded as cutting-edge new technology. As a result, numerous industries are becoming more interested in using multirotor drones, such as mining for mapping and transportation for monitoring. New technologies have been sluggish to catch on in the building sector. Multirotor drones, however, have the potential to simplify construction in many ways. Therefore, a thorough investigation of their applications and an examination of their functions in construction engineering and management are necessary. The purpose of this article is to thoroughly examine the advantages of multirotor drones, assess their existing uses, and consider how they could be used in the construction sector in the future. The evaluation and discussion of a number of key elements includes land surveys, logistics, on-site building, upkeep, and destruction. The findings show that the key contributions are reduced carbon emissions, cost-effectiveness, and workplace safety, while there may be unfavorable effects due to multirotor drones' existing technical limits. However, it is possible to forecast that drones will become more beneficial in the building business in the future.

Balasingam, Manohari [5] studied this is a critical time in medicine. Drones are unmanned aircraft that are utilized for a variety of scientific research endeavors, public safety, and commercial businesses. Drones were originally employed only by the military. Their technological prowess and usability are particularly advantageous to the healthcare sector. Common uses for drones in medicine include providing disaster assessments when other access options are severely constrained, delivering aid packages, medications, vaccines, blood, as well as other medical supplies to remote locations, providing safe transportation of disease test samples or test kits in areas with high contagiousness, and possibly enabling patients in cardiac arrest to receive rapid access to automated external defibrillators. Drones are also shown early promise for use in geriatric medicine by assisting senior people with movement utilizing robot-like technologies. In the future, telemedicine may be used by drones with diagnostic imaging capabilities to evaluate the health of isolated populations. These organizations keep an eye on all drone-related technological, security, and administrative concerns.

Siddappaji [6] studied Unmanned aerial vehicles (UAVs), sometimes known as drones, are examples of cyber-physical systems (CPS), which combine physical, networking, and computational processes. Drones' physical structural structure, propulsion system, embedded computer systems (ECS) such ground control stations (GCS), autopilot system, virtual radio connection, numerous payloads, launch and recovery system, and embedded computing systems (ECS) are their primary technological components. Virtual cyber networks and embedded computing systems are necessary for the functioning of drone systems. The purpose of cyber security is to safeguard systems and procedures. An attacker could abuse or manipulate the sensor input or functionality, or he might just turn them off to create unintended failsafe mechanisms and denial-of-service assaults. The drone has been classified as being susceptible to cyber-attacks because to its distinctive network, scattered physical systems, and distant locations, as well as cyber-attacks that might cause the control loop to malfunction, a denial of service, data corruption, and destruction and exfiltration.

Falorca et al. [7] studied The usefulness of deploying drones as a viable substitute for bulkier, more costly, and traditional techniques of technical building facade inspection is discussed in this study. Several field experiments are given and analyzed in attempt to qualitatively validate this premise. Design/methodology/approach: A literature review was the initial step. The study started off looking at drone technologies. Then, a summary of certain common civil engineering applications was put together, paying special attention to the Construction Industry (CI) and the range of building envelope inspections. In the second step, drone field tests were conducted, and the collected data was evaluated to provide the most precise diagnosis of facade diseases.

Madeleine Ansari et al. [8] studied Technologies are recognized to disrupt status hierarchies, change jobs and connections, and change social structures in the workplace. Less consideration has, however, been paid to how evolving technologies affect the moral principles and meaning that bind individuals to their job and give it significance. They conducted an inductive, qualitative research of military personnel engaged in drone operations for the U.S. Air Force to better understand how employees react to such a novel technology.

Latimer et al. [9] studied about future and coming technology that will be included into the systems of care for these patients will have an impact on how victims of out-of-hospital cardiac arrest are treated. For patients with refractory or recurrent cardiac arrest, recent developments in extracorporeal life support and point-of-care ultrasound imaging, both within and outside of hospitals, may provide a treatment option. Advances in digital and mobile technology to alert and harness bystander intervention, wearable life detection systems, and drones that can carry automated external defibrillators to the site of an out-of-hospital cardiac arrest may enhance survivability.

Quayson et al. [10] studied Smallholder farmers in developing nations' cocoa supply chains have subpar livelihoods due to fraud, exploitation, corruption, dishonesty, child labor, and financial exclusion, which is often committed by powerful individuals. The social sustainability issue this scenario generates requires immediate action. Digital innovations like sensors, satellites, drones, and blockchain have the potential to promote social sustainability all the way up the supply chain. This idea is congruent with the 2030 Sustainable Development Goals of the United Nations, which include shifting global economies toward a more sustainable future by eliminating inequality and poverty.

DISCUSSION

The Use of Drones in Agribusiness

Many farmers, ranchers, and vineyard owners, both big and small, are employing drones in a variety of ways to simplify and improve their agriculture operations. The creation of a technology ecosystem for the agriculture sector is DEP's top priority in order to boost output and efficiency. DEP's technology offers a versatile drone platform to enable adaptation for varied applications via both hardware and software modification, as shown in Figure 1.

Saving time

It might take a lot of time to maintain land, crops, stables, and cattle by hand. Even tiny hobby farmers may invest several hours scouting their property to identify possible problems before they grow into larger ones. One can only see so much on foot, however. Using drone technology, agribusinesses may get more detailed findings instantly. Agribusiness owners may get high-definition photographs, videos, and data within minutes using images obtained from a farming drone. A bird's-eye perspective makes it simpler to perceive the wider picture, identify crop problems or possible safety risks, and take prompt action.

Assist in troubleshooting potential issues

Drones could also aid in problem-solving. Monitoring has always included looking for issues that you may not notice until it's too late to fix them. Instead, owners of small agricultural businesses may utilize Ag drones to keep an eye on crucial areas like irrigation systems for possible leaks or damage before it becomes a serious problem that might affect crops. Drones are now being used by the US Department of Agriculture to test irrigation pond water for E. coli infection. An agricultural drone may assist in locating potentially harmful germs or pesticides. This may lessen the danger to those assets and final customers by preventing farmers and ranchers from utilizing polluted water for crops and cattle.

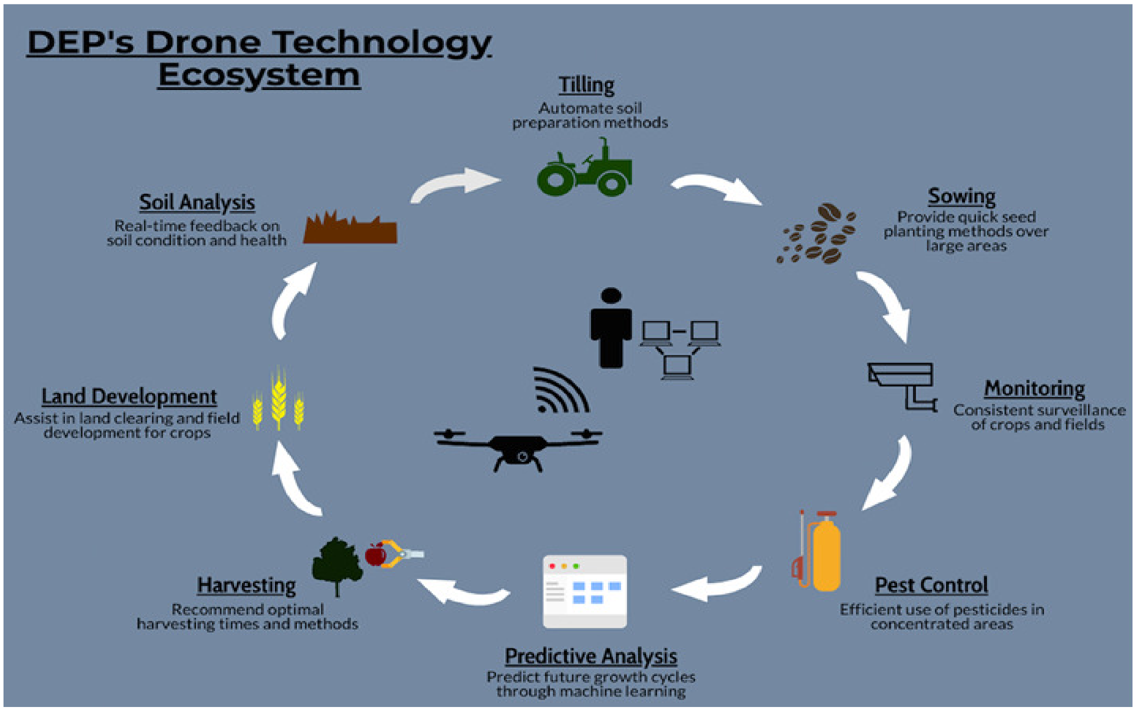

Figure 1: Illustrate drone technology ecosystem.

Offer improved data and price reductions from improved images

Many farmers used satellite images from the U.S. Department of Agriculture to get aerial views of their farms prior to the development of agricultural drone technology. Despite their great resolution, these photographs could often only be zoomed in so far, and it may take weeks for the images to be made accessible for viewing. Modern drones are capable of scanning enormous areas faster than bigger human aircraft, often in a single trip. Additionally, drones may fly more often and affordably throughout the season. High-resolution drone footage delivers more insights than more pixelated satellite photographs, in addition to saving time. In order to better understand crop growth, health, and soil moisture, farmers and ranchers may aggregate data from drones. This will allow them to make more educated choices. Getting better knowledge while saving money might be beneficial to your organization when every dollar matters.

Enhance health and security

Agribusinesses often place a high priority on safety, and Ag drones have the ability to significantly enhance this. Drones may be used to map agricultural land instead of sending personnel or surveyors, for instance, if the location is potentially hazardous or challenging to access. Agribusiness owners may also utilize drones to quickly examine wind, fire, or hail damage after a disaster, preserving worker safety and accelerating the claims process. The same holds true for keeping an eye on cattle. Drones, for instance, may help you follow the movement of your livestock and perhaps identify sluggish animals that may require assistance if you fear that part of your livestock is ill or wounded. Thermal imaging-capable drones may be used to monitor cattle temperatures, which can reveal disease or infection in the herd.

Assist in lowering environmental impact

Agriculture drones for spraying may provide spot applications of pesticides and fertilizers as opposed to spraying a whole area, which may have a detrimental environmental effect.This will benefit the soil and surrounding crops by reducing agricultural runoff and chemical drift. In addition to lowering air pollution emissions, using drones for spot tasks instead of huge full-field sprayers or crop dusters may also help farmers save money on input expenses.

Drones for Farming Reduce the Risk to Your Farming Business

One approach to assist your agribusiness avoid risk is by using farming drones. With data that enables owners to lower operating costs, increase efficiency, and increase yields, drones may help companies enhance their return on investment. Verify local, state, and federal laws surrounding the use and registration of drones. Drone use is expanding quickly across practically all economic sectors, but it is particularly strong in the agriculture sector. The market for agricultural drones is predicted to increase from a $1.2 billion (USD) sector in 2019 to a $4.8 billion industry in 2024, according to certain projections. In a few years, drone usage on big and small farms will be increasingly commonplace, from reconnaissance to security. Drone-based data collection on farms is part of a system known as "precision agriculture" and is often used to better inform agronomic choices.

Drone usage has already become a crucial component of extensive precision agricultural operations in several places. Farmers may better plan their planting and treatments by using the information gathered by drones that record fields. According to some statistics, adopting precision farming equipment may boost yields by as much as 5%, which is a significant improvement in a sector where profit margins are normally low. Drone technology is currently being utilized on farms, some fresh agricultural drone developments, and some of the obstacles that still stand in the way of broad drone usage in agriculture.

Plant health monitoring and scouting

Plant health monitoring is one use for drone imaging that has already been widely used with remarkable effectiveness. The Normalized Difference Vegetation Index (NDVI), a specialized imaging tool used by drones, uses precise color data to assess the health of plants. This enables farmers to keep an eye on crops as they develop so that any issues may be resolved quickly enough to preserve the plants. Simply said, this graphic demonstrates how NDVI works.

Crop health is also monitored by drones equipped with "normal" cameras. To monitor crop growth, density, and coloration, many farmers currently utilize satellite images. However, acquiring satellite data is expensive and often less efficient than closer drone surveillance. Cloud cover and bad lighting conditions are less important with drones than with satellite photography since they fly near to fields. While satellite imaging may provide precision down to the meter, drone imaging may provide millimeter-level accuracy in image placement. This implies that regions with stand gaps may be identified and replaced as necessary after planting, and disease or pest issues can be quickly identified and dealt with.

Drones are continually being developed using artificial intelligence and machine learning. Small farmers in poor countries may benefit from it. Since maize is grown in massive monoculture fields, modern drone technology is more useful for crop monitoring. To teach AI systems to detect uncommon crops and varied planting patterns, further effort is required. Animals used as livestock are plentiful among farmers. Drones, sensors, and cameras may be used in this situation to effectively manage and monitor the animals. In addition, the drones may see predators before an assault and can spot ill animals.

Advantages of Agri-Drones

- There is no danger of abuse since certified pilots fly the drones.
- They may raise ROI (Return on Investment).
- They work twice as quickly as people do.
- Drones employ ULV (ultra-low volume) spraying technology, which reduces the need for excessive chemical usage and water consumption.
- They are inexpensive and need little upkeep.
- They aid in raising agricultural production.

CONCLUSION

The use of drones in agriculture has the potential to change the industry. Future generations will find things easier and more efficient thanks to modern technologies. You must, however, keep in mind to protect your data. As a result, in order to prevent fraud, you must also get familiar with emerging technology. Returning to our subject, the market for agricultural drones is outstanding and expanding every year. Farmers that employ drone technology will be able to operate more efficiently and swiftly come to terms with the fact that drones are here to stay.

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CHAPTER 19

USE OF AUTONOMOUS TRACTOR IN THE AGRICULTURE

Vineet Kumar, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- vineet38121@gmail.com

ABSTRACT:

A tractor that can automatically steer and follow a predetermined course was created as part of continuing research into the specifications for autonomous agricultural machinery. It was decided to convert a small grounds tractor with steering, throttle, and continually a unique automated steering system controls the variable transmission actuators. It was also possible to regulate the three-point linkage and power takeoff. The resultant system demonstrated that it could reliably execute specified commands in a deterministic manner on its own, but it was discovered that it cannot be used as a practical tool unless it can be programmed to respond to unforeseen barriers and circumstances.

KEYWORDS:

Agriculture, Autonomous Tractor, Management, Robotic, Sensor.

INTRODUCTION

Precision crop management may be improved via the development of autonomous and intelligent technology, which also opens up new opportunities for precision agriculture. This implies that the appropriate management approach may be used at the appropriate time and location. Agronomy and cropping system advancements and levering possibilities will be presented by the implementation of these technologies. Even if there is a lot of interest in the creation of new automation and robotic technologies, multinational equipment manufacturers have already created a number of agricultural technologies that are autonomous and have the potential to be sold soon. Australia offers a large potential for the development and commercialization of these technologies and is quite well along in the actual use of precision agricultural technology compared to North America and Europe.

In order to inform future discussions with equipment manufacturers and to hasten the availability and uptake of autonomous tractors for the Australian Grains Industry, an assessment of autonomous tractor advances and supporting technologies was conducted. The six main tractor manufacturers (original equipment manufacturers, or OEMs) were included in the assessment; they were John Deere, Case New Holland, AGCO, CLAAS, Same Deutz-Fahr, and Kubota. Additionally, the present state of intellectual property in this field, aftermarket technological advances, completely autonomous tractor ideas, and new technologies were all studied in this paper. It also looked at the state of research on autonomous tractor technologies.

The potential for efficiency advantages from more accurate tractor control as well as the labor-intensive, methodical nature of agricultural machine operation have both influenced the development of autonomous vehicle enabling technologies, which are reasonably advanced in this industry. The operating environment for agricultural operations is particularly ideally adapted to automation, with vehicles operating in large, well defined open spaces that are generally devoid of obstacles and people. Over the last two decades, many technologies have been created to increase tractors' productivity and operational effectiveness e.g. guidance, drive-by-wire, continuously variable transmissions. Additionally, technologies have been created to enhance crop management utilizing precision agriculture (PA) methods e.g.

precision seeding, variable rate application, yield monitoring. In-field management of tractor operations and performance monitoring are now provided by new telematics solutions that are now available, and machine-to-machine connections are enhancing logistics and coordination across several tractors. These technologies are widely employed today, and a variety of products are either already on the market or are actively being developed. Although these technologies are being developed as products to help tractor operators, they also serve as important technical building blocks towards complete tractor autonomy.

Establishing the operating requirements for an autonomous tractor was the aim of this study. It was deemed crucial to retain the study in an agricultural setting while also examining novel perspectives on how we think about crop production. They made use of as many commercially accessible parts as we could in our apparatus. The Danish Institute of Agricultural Science, Aalborg University, and this project were all partners in the Autonomous Platform and Instrumentation system (API) project. All of the activities and actions performed as part of an agricultural operation may be divided into three categories based on our research so far: deterministic tasks, reactive behaviors, and reflexive reactions. A job is specified before it begins if it is deterministic. It is widely known and can even be optimized to enable for resource-efficient usage. One such assignment would be to do an agricultural activity such as sowing, weeding, fertilizing, spraying, etc. across an entire field. Before the tractor reaches the field, an effective route plan may be created using knowledge about the tractor, the implement, the land, and the crop structure. When the tractor encounters an unexpected circumstance such as an unidentified impediment in its route, it exhibits reactive behaviors. Given the circumstances detected, the tractor ought to respond logically. A logical course of action for the tractor would be to maneuver around the tree and continue with its work if it came across a fallen tree.

Actions that may be performed automatically are referred to as reflexive reactions. Typically, they are error-reducing closed loop feedback systems. A few of examples are adjusting the flow of fertilizer on a VRT spreader or changing the steering angle to go to the next waypoint. In order to implement all of these operations, a hybrid system that can flip between deterministic and reactive replies while simultaneously executing a number of reflexive reactions is required. In this study, two autonomous platforms one fully deterministic automated guided tractor and one wholly reactive research robot are being deployed. This paper describes the first and introduces the second. The used behavioural decomposition technique.

The most significant industry on the planet is agriculture. The need for crops and animals will soon be greater than ever as the world population is on the verge of crossing the eight billion milestone. Innovation must be ongoing if the globe is to continue to be fed. In order to feed more people as effectively as possible, our equipment and technology must constantly advance. The autonomous tractor comes against this background. An updated version of the equipment that has been essential to farming for more than a century are autonomous farm tractors. The tractor has been at the center of increasing agricultural productivity ever since the industrial revolution, when actual horsepower was replaced by the horsepower of internal combustion engines.

Farms all over the world will need to do these crucial duties as effectively as possible in the next years, including cultivating, plowing, fertilizing, harvesting, and planting. The tractor market is anticipated to develop at a compound annual growth rate (CAGR) of 4.59 percent from 2020 to 2025. Alongside this expansion, we anticipate that more and more equipment will be managed remotely by operators rather than by cab-based operators. Read on to learn how autonomous farm tractors work and how they are changing the face of agriculture. The thought of robots in agriculture and farming may seem strange.

Tractor History: From Conventional to Autonomous

Farm machinery has continuously advanced and changed throughout the history of humanity. Prior to having access to cutting-edge technology and agricultural automation, mankind depended on the strength of enormous animals and basic equipment.

- 5500BC: The wooden plow, which creates a trench in order to sow seeds, was created by Sumerian farmers.
- 1500 BC: Traditionally, wooden plows pulled by domestic animals were used to prepare the land for planting.
- 1903: The country's first two-cylinder gasoline tractor was made by Charles W. Hart and Charles H. Parr.
- 1928: We present the General Purpose Tractor. The ability for farmers to plant and grow in three rows dramatically enhanced yield.
- 1939: the Company’s first diesel tractor, John Deere tractors were the first to offer electric starters, lights, rubber tires, and increasing horsepower.
- 1940: By wrapping a cable from the tractor's front steering arm to a field barrel or fixed wheel, Frank W. Andrew created the driverless tractor.
- Ford created "The Sniffer," a tractor without a driver, in the 1950s. But since it was so difficult to operate without burying cable through the field, it was never marketed.
- 1966: The roll bar for operator safety was initially offered by John Deere, a tractor manufacturer.
- 1970: Agricultural tractors started incorporating plusher operator seats and sound shielding to protect against heat, cold, and dust.
- 1994: Engineers at the Silsoe Research Institute created a photo analysis system in 1994 for controlling a tiny autonomous tractor intended for vegetable and root crops.
- 2008: Based on global positioning technology, Deere and Company's ITEC Pro guiding system automates vehicle operations including end turns.

Figure 1: Hako tractor displaying a few of the upgraded electrical parts.

It utilizes Microsoft Windows 2000 and utilizes the ESX receives the directrix data and processes it for interpretation and application. The set points for the three main control loops—steering, engine speed, and CVT are interfaced to the ESX. Both the CVT and the engine speed featured specialized Proportional Integral but also Derivative (PID) electronic positioning controls with linear actuators. As part of the API project, Sauer Danfoss replaced the steering with electro-hydraulic proportional flow valves (PGV32). Inductive proximity switches on the front prop shaft and resistive potentiometers positioned over the kingpins were installed as sensors to provide input on tractor speed and steering angle, as shown in Figure 1. To coordinate the many safety features, interlocks, and operating modes, a third CPU was installed.

The tractor's operation

The tractor may operate in three different ways. After supplying power to the circuits, Standby was the first mode to be selected. This mode enabled the CPUs to start up and function independently. Program verification before enabling the user to start the engine, a sub mode named "start" was utilized to ensure that all systems were functioning properly (Safety circuit reset, throttle set to idle, CVT in neutral). The user may control the engine speed, CVT, and steering angle via a remote hard connected handset in the second mode, which was referred to as "Remote." The tractor would be operated in the third mode, "Automatic," by the appropriate CPUs. All the circuits are operational but the tractors are all in neutral, meaning they are not moving, in the "neutral" submode found in both Remote and Automatic modes. The tractor is started and operated by a single person who is identified as the operator. The second individual is known as the safety operator and is responsible for controlling the "dead man's handle," which, when released, ceases transmitting radio signals to the tractor safety circuit, shutting down the tractor. The safety officer's only responsibility is to watch out for any circumstances that may be considered dangerous. On each corner of the tractor, four hard wired emergency stop switches were also included. The tractor would stop when tested at full speed two meters after the emergency stop switch was released. This short distance was mostly caused by the engine being stopped and the significant braking power of the CVT.

Software

This program was an AutoCAD plug-in that included a variety of tools and scripts to create the final route plan. The GEOTEC software called AgroNAV Drive was used to direct the activities of the tractor on the GT2000. The first step in the procedure is to specify the tractor and other tools that will be utilized, as well as to locate the field's edge and any existing buildings using WGS84 or UTM coordinates. This may be gained by using current digital maps or by using the tractor to drive around the field and record the points. The working direction is then selected, which is often parallel to a long edge of the field.

Based on the working width and intended overlap of the implement, AgroNAV Plan may then provide a set of proposed parameters for the body of the field and the headlands that the tractor might adhere to. The plan may then be completed by selecting each of these points one at a time with the mouse. The program will notify the user if the user attempted to specify a path that the tractor cannot follow (for example, creating a turning circle that is too small). Since AgroNAV Drive also has control over the three point connection, implement on and off, and the PTO, operations or treatments may also be specified in the route plan. A text file that may be sent to the tractor on a USB memory stick holds the final route plan after that.

LITERATURE REVIEW

Chan Woo Kim et al. [1] studied in order to allow the tractor stationed at the entrance to autonomously go to the start point of an agricultural work and return to the entrance after finishing the task, a new route planner for the entry and exit operations of an autonomous tractor was built using the A* algorithm. The A* algorithm was used to generate a route for the tractor to arrive at its destination through the entry-exit path properly in terms of location and heading using an occupancy grid map with virtual impediments.

Liang Zhai et al. [2] studied an improved Stanley controller (IMP-ST) is suggested in this study to increase the route tracking precision of autonomous tractors in use. A model of two-wheel tractor dynamics was used with the controller. In order to improve tracking performance, the settings of the IMP-ST were modified using the multiple-population genetic algorithm (MPGA). Implementing route tracking control on an autonomous tractor is the major goal of this work. Because of clever agricultural progress, it is important to examine this area. Five working routes for tractors were created, including straight, U-shaped, acute-angle, and obtuse-angle routes, in accordance with the turning strategy of tractors used in field activities.

Kayacan et al. studied [3] studied an agricultural vehicle's ability to do certain autonomous tasks would make the operator's work easier, but maintaining precision would be necessary to maintain a high yield. The management of many dynamic subsystems, including the longitudinal speed dynamics and yaw angle dynamics, is necessary for an agricultural vehicle to operate autonomously. In this work, the tractor's longitudinal velocity is managed using a proportional-integral-derivative controller.

Moorehead [4] studied results from an extensive field test of an autonomous multi-tractor system that executes spraying and mowing tasks in a citrus plantation in Southern Florida are presented in this study. Two autonomous tractors are part of the system, as well as a remote human supervisor is used to assign jobs and provide assistance as required. Each autonomous tractor has a sensing system that uses cameras and ladar to find impediments. To identify dangers in the congested orchard environment and direct the tractors through the middle of the tree rows, the perception system employs both a geometric-based detector as well as an appearance-based classifier. An orchard map is used by a mission planner to create efficient pathways that span the territory specified by the supervisor.

Blackmore [5] studied in this study, certain system requirements for a tiny autonomous tractor are proposed. These criteria include both the tractor's physical characteristics and its behavior under specific circumstances. Physically, the tractor should be compact, lightweight, and dependable, have strong real-time communication capabilities, and be simple to operate, particularly when fleet management is involved. There are five internal and thirteen external contexts that may be utilized to set off various behaviors. There are four different ways the tractor may operate.

P. Ribeiro et al. [6] studied in order to effectively manage weeds, diseases, and insects in agricultural crops and forests, new methods are needed. Because this technology enables pest control measures to be applied only if, when, and where they are actually needed, it can be very advantageous to develop and use autonomous tractors equipped with cutting-edge sensor systems, data processing techniques, and actuation tools. This technology reduces costs, environmental damage, and risks to farmers. An EC-funded research project called RHEA is being carried out by a collaboration made up of 15 research partners from eight different European nations. The project's main objective is the design, development, as well as testing of a new generation of robotic and autonomous devices for pest control, both chemical and physical.

Michio Noguch et al. [7] Studied in order to determine an absolute vehicle heading, a sensor-fusion algorithm based on the least squares method for measuring FOG bias in each step was created. Given that the tractor employs different kinds of implements while operating at different PTO, transmission, or engine speeds, an autonomous tractor must include a mission planner that includes a route planner. For each agricultural operation, a GIS program created navigation maps with a desired route and orders for things like PTO status, transmission, as well as other things.

Qiyue Wang et al. [8] studied Trajectory planning is a crucial step in allowing such a system to drive autonomously. Tractor-trailer vehicles, which consist of a car-like tractor pulling a passive trailer, have been extensively used in the transportation business. The development of motion-planning algorithms is greatly hampered by the tractor-trailer system's characteristics of being extremely nonlinear, no holonomic, and having complicated dynamics. In order to address the issue that the traditional planning framework cannot take into account the feasibility as well as quality simultaneously in real-time trajectory generation of the tractor-trailer vehicle, an indirect trajectory planning framework for a tractor-trailer vehicle under on-road driving is presented in this study.

Alonso-Garcia et al. [9] studied the positioning sensor was a low-cost GPS receiver. The autonomous navigation of the tractor with the low-cost receiver was tested using three distinct control laws. The tracking of straight paths and the step response were used in experiments to assess the guiding. The receiver accuracy as well as the direction error were used to calculate the overall guidance error. Positioning data from many inexpensive receivers were captured and evaluated to assess the receiver's accuracy. Tests were conducted with each control law at three different speeds to evaluate the guiding error.

Ming Zhang Kang et al. [10] studied the ability of an autonomous mowing tractor to move and mow requires careful path design. The paper's goals included analyzing a farmer's operational patterns, extracting and optimizing waypoints, and demonstrating the creation of prepared planned paths for autonomous mowing tractors. On grass fields, an experienced farmer ran an 18-kW midmower tractor. An RTK-GPS antenna with a 2-cm RMS inaccuracy, an inertia motion detecting device, a gyro compass, a wheel angle sensor, and a mower on/off sensor were attached on the mower tractor to assess tractor travel and operating parameters. Data were gathered at a 10-Hz rate.

DISCUSSION

Changes in the Agriculture Industry since Automation

Automation is transforming almost every industry. As we go through the so-called "fourth industrial revolution," more intelligent robots are replacing people in roles that have historically only been filled by humans. Agriculture is experiencing a transition due to the possibilities of automation and artificial intelligence, much like healthcare, retail, or any other industrial sector. The positive effects of technology on agriculture cannot be denied, but there are always trade-offs involved with disruption.

Unlocking Greater Efficiency

The severe skills gap that the world is now experiencing is hurting the agricultural business. Thanks to mechanized agricultural equipment, farmers can do more with less. Even if they are short on human labor, farm owners are nevertheless able to carry out their activities at the essential level. Agile teams may also allow skilled workers to focus on important tasks like scheduling the planting season, keeping equipment in good condition, and monitoring production, while AI handles the labor-intensive, repetitive tasks via the use of autonomous farming practices. Additionally, because autonomous farm tractors can function in the dark, year-round longer working hours are feasible.

Enhancing Farm Productivity and Profitability

Agriculture automation makes it possible to produce goods that are more sustainable, faster, and fresher. Since they don't need to eat or sleep, machines can work for longer periods of time than people. They also have a lower error tolerance than humans. Manufacturing advances more fast as a consequence, and profits are produced more steadily. Because of this, agricultural companies are investing in automated irrigation systems, self-driving tractors, planting robots, and robotic harvesters. Furthermore, automation increases productivity, output, and production rate without raising consumer costs since robots need less maintenance than a human worker.

What Is An Autonomous Farm Tractor?

An autonomous farm tractor is a self-driving piece of agricultural equipment that completes its responsibilities without a person within the cab. Autonomous tractors are designed to calculate and assess their own position and speed while avoiding field hazards including humans, animals, and objects. Tractors without drivers may run totally independently or under remote supervision. Frequently, a single operator will oversee a fleet from a remote yet nearby location.

How Does an Autonomous Farm Tractor Work?

Autonomous agricultural tractors are equipped with automated systems, computers, and processors. These connections transform electrical impulses into a controller or CPU, which allows the tractor to operate. Each tractor is equipped with a distinct set of integrated features and failsafe emergency systems. Every autonomous farm tractor features a remote emergency stop feature for everyone's safety. For navigation, tractors may be equipped with GPS-enabled cameras, radars, or lighters. Two lighters, a camera set, and a side robotic camera are all part of the tractor's sensor suite. These are used for navigation and environmental monitoring, and the data they collect is relayed to the central system. It goes without saying that any mistakes in the main guiding device (the RTK GPS) would significantly affect the tractor's location accuracy. At such high latitudes (like Denmark), reliability of access to "visible" satellites seems to be a challenge, particularly when.

The relative position is measured using machine vision sensors. And direction by utilizing the on-board image sensor. The use of machine vision for sensing has several facets. The guiding information may be measured using a variety of sensor modalities. Understanding the geometric connection between the image sensor, the vehicle, and the field of-view that the sensor utilizes for guiding information is necessary for placing the sensor on the vehicle. For detecting a guided directrix on row crops, soil tillage, and the margins of harvested crops, researchers have investigated the use of vision sensors. The extraction of the guiding data has been examined using a variety of image processing approaches. The output signals from the processed photos may be utilized to give the vehicle with steering signals. Segmented binary image-based row detection. For identifying a guided directrix on row crops, soil tillage, and the margins along harvested crops, one of the most popular machine vision techniques is utilized. A guided combine harvester was created by Bensonbased on the lateral location of the crop cut edge. Employed the Hough transform for real-time (10 Hz) row tracking and discovered that their method was only forgiving of outliers (i.e., weeds) when their quantity was very low in comparison to the total number of genuine data points. Marchant used this method to steer a farm vehicle through a transplanted cauliflower field, and he reported an overall RMS error of 20 mm in the lateral position at a travel speed of 0.7 m/s.

The threshold approach has been used in several vision applications to distinguish important items from background images. The main issue with the threshold approach for accurately identifying crop row information from field photos is the complexity of selecting an appropriate effective threshold value under fluctuating ambient light levels or changing crop development phases. Another difficulty in establishing a route utilizing the collected field photographs is the efficacy of differentiating crops from weeds. Sometimes poor precision dilution brought on by satellite geometry while we can't do much about these issues, we can add more sensors to increase accuracy and dependability. An inclinometer may be added to the tractor to measure the tractor's inclination as it pitches and rolls over uneven surfaces, which will increase accuracy, particularly over tough terrain. This is crucial when the antenna is positioned on the top of a compact tractor with a short wheelbase and is somewhat high.

Second, to increase the accuracy of the positional data, the Kalman filter makes use of both the RTK GPS and the steering potentiometers. Potentiometer curves in the route plan might be replaced by an Inertial Measurement Unit (IMU), which would increase accuracy although being more costly.

Although this test demonstrated the tractor's positional precision, the implement that is placed on the tractor often has to have the maximum degree of accuracy. The lateral movement of the implement on the three point connection with respect to the tractor is thus anticipated to be stabilized or dampened using a soil engagement disc coulter. When this was done, there were just a few centimeters between adjacent slots, showing that many of the faults are symmetrical and may be eliminated.

A second RTK GPS may be added to the tool as a further improvement, and a motorized side shift can be used to regulate the tool's lateral position. Due to the tight study guidelines, two persons had to drive the tractor in a fully deterministic manner throughout these testing. Although the tractor performed as expected, it was discovered that it is not yet a useful tool until we can include appropriate reactive behaviors into the control system.

CONCLUSION

These studies have shown the capability of programming an autonomous steering tractor to travel a specified path to within a few centimeters. Based on the size of the implement and the layout of the field, this route plan may be optimized to reduce the distance the tractor drives before it begins. This deterministic strategy aids in efficiency and optimization but is unable to respond to unforeseen circumstances and challenges. As a result, it is an incomplete system that requires reactive capabilities to be combined in a hybrid system in order to be useful in real-world applications.

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CHAPTER 20

DIFFERENT MEDIA USED IN HYDROPONIC AGRICULTURE

Arvind Pratap Singh, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- apsingh8960@gmail.com

ABSTRACT:

Plants may be grown hydroponically without requiring soil. Plants may be cultivated in hydroponics either directly in a nutrient solution (water culture) or in an inert medium (media-culture). The success of plant production in media culture depends on the sort of media being used. The soil gives plants access to certain nutrients as well as support and a location for plant roots to grow under typical field growth circumstances. The medium in hydroponic systems may stabilize, creating room for the roots to expand. The choice of media is crucial for producing hydroponic plants. This guide, which is intended for those new to hydroponics, will go through the fundamental characteristics of media and especially examine media used in hydroponics.

KEYWORDS:

Hydroponic Agriculture, Hydroponic Media, Macroalgal, Rockwool, Solution Culture.

INTRODUCTION

Growing plants, often agricultural or medicinal plants, without soil using water-based mineral fertilizer solutions in aqueous solvents is known as hydroponics, a subclass of hydroculture. Plants that are grown on land or in water may have their roots exposed to the nutrient-rich liquid or they can also have their roots physically supported by an inert material like perlite, gravel, or other substrates. Despite the presence of inert medium, root exudates and pH variations in the rhizosphere may have an impact on the biology and physiological balance of the nutrient solution. Pharmaceutical proteins may be released from transgenic plants growing in hydroponic media as part of the root exudate. Fish dung, duck manure, commercial chemical fertilizers, or synthetic nutrient solutions are just a few examples of the various organic or inorganic sources that may provide the nutrients utilized in hydroponic systems.

In a greenhouse or other enclosed space, plants are often cultivated hydroponically on inert material using the controlled-environment agriculture (CEA) method. Tomatoes, strawberries, lettuces, peppers, cucumbers, and cannabis are among the plants that are often cultivated hydroponically. Arabidopsis thaliana, which is used as a model organism in plant science & genetics, is also a popular hydroponically produced plant. Numerous benefits of hydroponics include less water being used in agriculture. When plants are grown in same environmental conditions and given an equivalent quantity of nutrients, hydroponic cultures result in the maximum biomass and protein output when compared to other growth substrates. In the future, it could be conceivable for individuals who live in harsh regions with limited access to water to grow their own plant-based food since hydroponics need significantly less water and nutrients to grow produce and climate change threatens agricultural output. In addition to being employed on Earth, hydroponics has also shown its worth in space production trials for plants.

Techniques

Sub-irrigation and top irrigation are the two basic variants for each medium. The majority of hydroponic reservoirs are currently made of plastic for all methods, although they have also been made of concrete, glass, metal, vegetable solids, and wood. In order to keep algae and fungus from growing in the hydroponic media, the containers should be light-tight.

Culture of static solutions

At the Crop Diversification Centre (CDC) South Aquaponics greenhouse in Brooks, Alberta, there is a deep water raft tank. In static solution culture, plants are grown in nutrient solution-filled containers like pots, buckets, tubs, or tanks usually used in domestic settings. The solution is often gently aerated, however this is not required. If the solution is not aerated, it is maintained at a level where enough roots are above the solution to provide them with ample oxygen. Each plant has a hole cut or drilled in the reservoir's top; if the reservoir is a jar or tub, the lid may be used; if not, the top may be made of cardboard, foil, paper, wood, or metal. A single reservoir may be used by many plants or just one. As plant size grows, reservoir size may be expanded. A homemade system composed of glass canning jars or food containers may be aerated using an aquarium pump, airline tubing, valves, or even a biofilm of green algae that has grown on the glass via photosynthesis. To counteract the effects of negative phototropism, clear containers may also be covered with aluminum foil, butcher paper, black plastic, or other materials. A timetable, such as once per week, or when the concentration falls below a predetermined level as detected by an electrical conductivity meter are the two options for changing the nutritional solution. Either new nutrition solution or water is supplied whenever the solution drops below a particular point. The solution level may be automatically maintained using a float valve or a Mariotte's bottle. Plants are grown in raft solution culture, which involves floating a sheet of buoyant plastic over the nutrient solution. In this manner, the roots are always above the solution level.

Culture of continuous-flow solutions using the nutrient film method (NFT) to cultivate different salad greens the nutrient solution continuously flows through the roots in a continuous-flow solution culture. Because monitoring and modifications to the temperature, pH, and nutrient concentrations can be done in a large storage tank with the ability to accommodate thousands of plants, it is considerably simpler to automate than the static solution culture. The nutrient film technique, also known as NFT, is a well-liked variation in which a very shallow stream of water containing all the dissolved nutrients necessary for plant growth is recirculated in a thin layer past a bed of bare-root plants with an upper surface exposed to air in a watertight channel. As a result, the roots of the plants get a plentiful supply of oxygen. Using the correct channel slope, flow rate, and length is the foundation of a well-constructed NFT system. The NFT system's key benefit over other hydroponic systems is that the plant roots are exposed to sufficient amounts of water, oxygen, and nutrients. Since too much or too little of one causes an imbalance of one or both of the others, there is a conflict between the supply of these needs in all other kinds of production. The architecture of NFT allows for simultaneous fulfillment of all three conditions for healthy plant development, provided that the straightforward idea of NFT is constantly recalled and used. These benefits lead to increased yields of superior food being acquired over a longer time of cropping. NFT has extremely minimal buffering against flow disruptions, which is a drawback (e.g., power outages). Overall, however, it's definitely one of the most effective methods.

All traditional NFT systems have the same design elements. Although slopes of 1:100 along channels have been advised, it is challenging to provide a foundation for channels that is sufficiently accurate to allow nutrient films to flow without ponding in locally depressed places in reality. It is advised to employ slopes between 1:30 and 1:40 as a result. This allows for slight surface imperfections, although even with modest slopes, ponding and water logging are still possible. The appropriate slope might be created by the floor, benches, or racks that store the channels. Both techniques are used and are dependent on regional needs, which are often established by location and agricultural needs.

Rates during planting might be half of this, and it seems like 2 L/min is the very maximum. Flow rates over these limits are often linked to dietary issues. Numerous crops have shown slower growth rates when canals are longer than 12 meters. Tests on crops that develop quickly have shown that although oxygen levels are still sufficient, nitrogen levels may be decreased over the length of the gully. Channel length should thus not exceed 10-15 meters. If this is not practicable, the growth losses may be removed by adding an additional nutrient supply halfway down the gully and reducing the flow rates via each outlet by half.

Hydroponic inorganic solutions

The creation of hydroponic solutions is a plant nutrition technique, and the signs of nutrient insufficiency are similar to those seen in conventional soil-based agriculture. However, there are a number of fundamental ways in which the underlying chemistry of hydroponic solutions may diverge from that of soil. Contrary to soil, hydroponic fertilizer solutions lack the cation-exchange capacity (CEC) of organic matter and clay particles. The pH, oxygen saturation, and nutrient concentrations may vary significantly more quickly in hydroponic systems than they do in soil due to the lack of CEC and soil pores. The number of counter ions in solution is often unbalanced by plants' selective uptake of nutrients.

The pH of the solution and a plant's capacity to absorb nutrients with a comparable ionic charge may both be quickly impacted by this imbalance (see article membrane potential). For instance, plants often quickly convert nitrate anions into proteins, leaving an excess of cations in solution. Even when the proper amount of those nutrients is dissolved in the solution, this cation imbalance may cause deficiencies in other cation-based nutrients (such as $Mg2+$) to manifest as symptoms. Iron may precipitate out of the solution and become inaccessible to plants depending on the pH or the presence of water pollutants. It is often required to make regular pH changes, buffer the solution, or apply chelating agents. Contrary to soil types, whose chemical makeup may vary widely, hydroponic solutions are often standardized and need for regular upkeep for plant culture.

Hydroponic solutions are regularly pH-adjusted to close to neutral (pH 6.0) and aerated with oxygen under carefully regulated laboratory settings. Additionally, water levels must be replenished to make up for transpiration losses, and nutrient solutions must be re-fortified to address nutritional imbalances that develop when plants expand and exhaust their nutrient stores. In order to reestablish a balanced solution, the regular monitoring of nitrate ions is sometimes utilized as a vital parameter to predict the remaining proportions and concentrations of other crucial nutrient ions.

LITERATURE REVIEW

Bertoldi et al. [1] studied Industrial and agricultural wastewaters have been tested as alternative culture medium for the growth of microalgae. These wastewaters enable residue recycling by bioconverting the waste into a rich, nutritious biomass that can be utilized as a feeding supplement in aquaculture and other applications. The goal of this study is to identify the fatty acid profile, lipid, and carotenoid levels of the microalga Chlorella vulgaris grown in various dilutions of hydroponic effluent. The findings demonstrated that there were no significant variations in lipid contents.

Andre Suteja et al. [2] studied the agriculture sector is one of the potential commodities in trade both domestically and internationally. The inability of local farmers to expand their operations and boost their output due to conventional farming methods' huge acreage requirements, the scarcity of farm workers, and the length of the harvesting season. Hydroponic farming is a concept in the agricultural system that differs from traditional agriculture yet may already be employed by local farmers. Because it doesn't need a lot of space, hydroponic farming, which employs water as a planting medium, may be done everywhere, even in urban areas. The Nutrient Film Technique, which may be used in both highlands and lowlands, is one of the hydroponic systems that is presently being developed. This method is capable of producing good crops. Farmers may operate their farming operations on less extensive land in urban locations thanks to the NFT system, which also increases agricultural commodities produced and increases farmers' expertise of the hydroponic farming system. Because they employ effective fertilizer, water, and non-pesticide components, the products are of great quality and are ecologically benign.

Gaikwad et al. [3] studied in this research, the possibility of cultivating spinach utilizing various hydroponic systems was explored. Two separate hydroponic systems the raised trays hydroponics system and the A-Frame hydroponics system were created for the growing of leafy plants. Sawdust, coco peat, and sterilized absorbent cotton were the three basic kinds of growth medium employed. The results revealed that plants grown in sawdust in the A frame hydroponic structure had the greatest values for all physiological parameter measurements. Most of the time, plants produced in coco peat media were on par with those grown in sawdust media, however the raised tray hydroponics system plants grown in sterilized absorbent cotton had the lowest values.

Haraz et al. [4] studied in a hydroponic setting, BC may improve nutrient availability and lessen natural changes in the nutrient solution by using a similar strategy. Using hydroponic nutrient solution controls, this research tracked the effects of BC addition to peatmoss growth medium with ratios of 0%, 5%, 25%, and 50% on pH, electrical conductivity (EC), and macronutrient retention over 15 days. The closed loop hydroponic system's nutrient discharges were measured using deionized water, and the results showed that biochar raised the pH level throughout both the retention stage and the release stage. Due to the inherent liming properties of BC, the pH rose by a maximum of 1.5 units with the greatest biochar to growth media ratio.

Kennard et al. [5] studied a typical soilless growing medium called perlite can only be disposed of in landfills after a short time of use since it must be extracted from nonrenewable resources. To create a novel, sustainable growth medium that can be recycled or modified for re-use, research is necessary. Used almond shells and recycled plastic drainage boards were two replacements for hydroponic growing material that were investigated in this study. The physiochemical properties of various media were evaluated, and a germination and greenhouse growth research was conducted, in order to ascertain the effect these media have on lettuce production and nutritional quality.

H. S.Shekhar Fleming et al. [6] studied a biostimulant is an organic substance that, when used sparingly, increases plant growth and development in a way that cannot be explained by the use of conventional plant nutrients. The objectives of this study are to summarize the biologically active components of brown macroalgae, highlight improvements in the processing of macroalgae for agricultural biostimulants (AB), and investigate the characteristics that encourage the use of macroalgal AB for crop plant stress management. Also emphasized are the policy factors that favor the use of macroalgal-derived ABs in agriculture. They examined the advantages of seed priming, foliar application, soil drenches, and hydroponic treatments while using macroalgal ABs in crop production.

Haggag et al. [7] studied Higher yields of flowers, herbs, vegetables, and other crops are produced by hydroponic culture, which is a regulated technique that uses a soilless growth medium and provides all of the plant's nourishment in the plant's solutions (water with dissolved nutrients). There are many different kinds and variations of hydroponic systems. The majority of conventional hydroponic systems are highly specialized, climate-controlled production systems. A system that is designed around organic agriculture or culture is known as organic hydroponics. Plant diseases are controlled using a variety of techniques, including physical, organic chemical, biological, biofertilizers, bioremediators, and integrated pest management. All necessary nutrients are provided in precisely measured proportions, even for organic crops.

Fredy Suryani et al. [8] studied the industry has a significant impact when food consumption is a critical factor. Must be in line with the present situation, in which there is less land available for agricultural and food security. Due to the inadequacy of current farming practices to meet the rising demand, hydroponic agriculture has become more crucial as a result of the restricted amount of land available. There are two types of hydroponic farming suggested in this study: agricultural and fisheries. In this research, agriculture is the only topic covered. The hydroponic farming system has evolved, and it is now well suited to the conditions that must be created. Clarifying concerns like pest management and fishing techniques' effects on the ecosystem is of utmost importance.

Marques et al. [9] studied in the agricultural practice of hydroponic gardening, nutrients are effectively supplied as mineral nutrient solutions. Numerous benefits are offered by this area of contemporary agriculture, including effective location and space needs, suitable temperature management, water conservation, and regulated fertilizer consumption. The Internet of things (IoT) idea presupposes that numerous "things," such as communication devices as well as every other physical item on the earth, will be linked or controlled through the Internet. Mobile apps in particular or mobile computing technologies in general may be considered as important approaches to manage data analytics and data visualization.

Sambo et al. [10] studied for the agricultural production industry, soilless agriculture represents a viable possibility, particularly in regions with significant soil degradation and few water supplies. Additionally, this agronomic technique represents a positive reaction to environmentally friendly agriculture and a useful tool in the context of a broader problem with regard to food security. Therefore, the purpose of this study is to clarify the drawbacks and potential of hydroponic systems employed in soilless cropping systems, with a particular emphasis on the process of plant mineral feeding.

DISCUSSION

Properties of Media

The qualities of various media types will vary, much as those of soil. Different physical qualities will provide benefits and difficulties when choosing media. In an ideal world, media-based systems would employ chemically inert or "inert" media materials, enabling the grower to apply fertilizers to provide all nutrients. The selection of media is influenced by a number of variables, such as the plants being grown and the kind of hydroponics system being utilized. Numerous physical characteristics of the medium will impact how well the plants can absorb water and nutrients. Pore space, water-holding capacity, aeration, cation exchange capacity, and pH are a few of these physical traits. A major advantage of employing media over water culture is that there is more room for mistake when it comes to probable power surges or outages. Because the media may store some water for a while, plants without water will swiftly deteriorate in the absence of any media. The expenses of utilizing, maintaining, and replacing media over time, both in terms of money and labor, are some additional important factors to take into account.

The area between a media's particles is known as the pore space. Pore space has a direct impact on aeration and water-holding capacity. The amount of water that a medium can retain is known as its water-holding capacity. The amount of air that a medium can contain is known as aeration. In order for plants to thrive, the roots need both liquid and air, which may both be found in the pore space. Media with more pore space provide more aeration and water-holding ability. Less pore space indicates that less water and air can be held in the medium. Larger-textured medium will have more space between the particles, which may improve drainage but may also lower the amount of water they can store. Water and air must be in the proper proportions for plant roots. The ideal hydroponic medium will strike a balance between aeration, drainage, and water-holding capacity.

Alternative Media and Chemistry

The roots of plants can absorb nutrients in addition to water and oxygen. These nutrients are taken in by roots as ions. Because of this, the cation exchange capacity of soilless medium is a crucial property (CEC). This refers to the capacity of the medium to store and release positively charged ions known as cations. An atom or molecule having an electric charge that results from the acquisition or loss of electrons is referred to as an ion. Most hydroponic systems already have the nutrients in ionic form, diluted with water. If the medium can retain nutrients, it will be determined by the CEC. To ensure that nutrients are supplied directly to the plants in hydroponics without chemically attaching to the growth medium, a media with no or low CEC is preferred. Numerous medium types have low CECs, preventing the storage of nutrients. All nutrients are given via the nutrient solution when using medium without CEC. However, certain media may bind and store nutrients because they have a greater CEC. Programs for fertilization should take into consideration the fact that plants may sometimes access nutrients that have been stored in the medium. In other instances, the media's binding of nutrients might render certain nutrients inaccessible to the plants.

The pH of the medium, which is a measurement of how many hydrogen (H) ions are in a solution, is another significant component that will affect fertilization. The plant's capacity to get nutrients may be impacted by this. You must modify the pH of your fertilizer solution while making it in order to satisfy the demands of the plant. For most plants to be able to absorb nutrients, the pH level has to be between (5.5 to 7). Different pH ranges could be preferred by certain plant species. Even if nutrients are available, plants may not be able to absorb them at pH levels that are greater or lower than the optimal range. The total pH of the nutrient solution might be impacted by the media's pH.

Hydroponics system selection and media selection go hand in hand. Some hydroponics systems need specialized media in order to avoid compromising the system, while other systems are not well suited for the use of media. For instance, recirculating hydroponics systems should avoid using fine or loose particle media and should take pump and irrigation emitter clogging into account.

Media, Organic Vs. Inorganic

If a media's constituents, like coco coir, are carbon-based, then it is regarded as organic. Over time, these materials will begin to degrade or break down. When employing organic material for hydroponic production, the carbon to nitrogen (C:N) ratio is crucial (Arenas et al. 2022). Plants and the microbes that break down the medium will compete for nitrogen at a high C:N ratio, often more than 30:1 C:N. These microbes remove nitrogen from the nutrient solution, and part of it escapes as a gas during the media's breakdown (Grunert et al. 2016). If nitrogen is not given to the fertilizer solution, plants may suffer from a nitrogen deficit. To ensure that plants get adequate nitrogen while utilizing a medium with a high C:N ratio, more nitrogen fertilizer may be necessary.

Vermiculite and perlite are examples of inorganic media that don't contain carbon (though constituents might be found in nature). In operations that are certified organic, certain inorganic media are still authorized. The word "organic" denotes to management techniques like fertilization and pest control for a certified organic enterprise for additional details on organic crop protection.

Media Used Regularly

Hydroponic systems employ a broad range of media, however not all media are appropriate for all plants or hydroponic setups. The availability and pricing of various media, which might alter depending on the market, are additional considerations. Here, we go through a handful of the most often used media, along with their characteristics and use guidelines. Figure 1 provides a summary.

Figure 1: Illustrate the comparison of a few of the typical medium types used in hydroponics systems.

The outer husk of coconuts is used to create the fiber known as coco coir. This substance was formerly seen as a waste product, but it is now employed as a growth medium. It is one of several organic media that include carbon. Because it is renewable and simple to compost, coco coir is regarded as sustainable. Products made from coco coir may have a fine or coarse texture. In recirculating hydroponics systems, neither chunky- nor fine-textured coco coir should be utilized since they might block the machinery. The coco coir with a chunky texture has larger pores but greater drainage and good aeration. A lot of pores may be found in fine-textured coco coir, which also has a lot of water-holding capacity and strong aeration. The pH of coco coir is often close to neutral or slightly acidic (5.5–6.8). It does possess CEC and has the capacity to retain nutrients like phosphorus, potassium, and nitrogen. This can have an effect on the fertilization plan. The high amounts of salt that are typical where coconuts are cultivated also call for washing or rinsing coco coir prior to use. There are several ways that coco coir may be marketed, either as free material or crushed into mats, cells, or other shapes. It is necessary to soak loose coco coir before using it in media, and it may be sold compressed. Cubes may be piled high as plants grow to give the roots more room to spread out.

The bark of pine trees is used to create composited pine bark. It is a byproduct of the business, thus it is easily accessible where there is active pine logging. This material may be used in hydroponics thanks to the composting process, but only in certain hydroponic systems. Pine bark that has been improperly or incompletely composted may have a high C:N ratio, which may increase competition for nitrogen. Composted pine bark might lower the pH of the nutrient solution due to its neutral to low pH of 6-7. Composted pine bark often has excellent pore space, a strong ability to store water, and some CEC. It may be purchased in a broad range of textures, from fine to thick, depending on the level of decomposition. The chunky-textured pine bark offers wider pore space with improved drainage and aeration, similar to coco coir. Like other organic media, compressed pine bark may decompose fast. Other tree bark is also compostable and may be purchased for hydroponic media. They resemble the characteristics of composted pine bark and might vary depending on the kind of wood used. Hardwood sources often have a pH of 7 or higher and typically decompose more quickly than pine bark.

Based on the kind of wood used, sawdust might vary greatly. It is formed of finely pulverized wood. Some wood sources contain poisons that are harmful to plants, making them unsuitable for use in hydroponic systems. For instance, Western Red Cedar sawdust is poisonous to plants. Although sawdust has a fairly high capacity to store water, depending on the texture, it may have poor aeration and drainage. Composted bark shows how various sources and tree species may have varied pH levels. It could have a little CEC. It may decay over time like other organic media, and it often does so more quickly than bark. It is exclusively used in certain hydroponic systems, much as composted pine bark. Since the development of hydroponic media like rockwool, the use of sawdust has decreased in recent years.

Peat is produced from bog-dwelling plants that have partly decomposed, such as mosses, grasses, and sedges. Peat comes in two main varieties: sphagnum peat moss and hypnum peat moss. Depending on the source and even from the same source from year to year, peat quality may vary significantly. Although peat often has a strong ability to retain water, it does not do so as effectively as coco coir. Peat may be more difficult to rewet after drying than other forms of organic medium despite having many pores and adequate drainage. Peat can withstand compaction because of its porous composition. Peat typically has an acidic pH that may need raising with calcium carbonate, depending on the source. Peat may hold onto nutrients and also contains CEC. Peat may deteriorate more with time, but more slowly than other organic materials.

Rocks, more especially aluminosilicates, are used to create rockwool. High temperatures are used to produce the material's fibers, which are subsequently used to create blocks, cubes, and other forms. Rockwool forms may be piled as plant roots mature, similar to how coco coir cubes can. Its pH ranges from neutral to mildly basic (7–8.5). Depending on the source, soaking to reduce the pH may be necessary; the vendor will usually note this in the instructions. Rockwool has a high water-holding capacity and effective aeration. Rockwool lacks the CEC of coco coir. When dry, it is incredibly light; yet, when wet, it may become rather hefty. Rockwool may be susceptible to algal development despite being sterile before use and cannot be recycled. Because rockwool is not biodegradable, disposal is often seen as a significant problem.

Rockwool-like qualities may be found in foam cubes, often known as grow foam. The substance closely resembles the foam used in floral arrangements. Foam cubes have a large pore space and strong aeration, similar to rockwool. Rockwool has somewhat greater drainage than foam cubes, and foam cubes are less likely to get waterlogged. In addition, although foam cubes cannot be reused, they may be biodegradable or mostly biodegradable, depending on the manufacturer, which helps with the disposal problem associated with rockwool. Foam cubes tend to disintegrate over time, making them unsuitable for crops with sluggish growth.

Siliceous volcanic rock is used to make perlite, which is often found in deposits in North America and the Mediterranean. Rock is enlarged and heated. Perlite contains a lot of pore space and a good water-holding capacity. Perlite has strong aeration and simple drainage because to its large pore space. This medium lacks CEC and has a neutral pH. It is very light and sanitary before usage. Perlite may be split into smaller pieces while being handled, but it does not decompose. Additionally, it may release a dust that harms the lungs. Masks are advised, especially when handling big volumes. Perlite is often used in conjunction with other medium to grow plants.

One of the first kind of hydroponic medium is sand. Different quantities of sand may be found in soil. Sand content is greater in Florida soil, although silt and clay are also present. Sand that is completely free of clay and silt may be utilized as a hydroponics medium. Sand is not costly on its own, but because of its weight, transportation costs might be significant. Sand contains a lot of pores but little to no CEC and a limited water-holding capacity. The optimal particle size for hydroponics is between 0.6 and 2.5 mm in diameter, however the size of the particles might vary. Sand is often used with other media to increase weight and enhance drainage. Sand may include clay, depending on how it was obtained, which might interfere with manufacturing.

Like sand, gravel and pebbles were one of the first hydroponic medias employed, for instance during World War II. Gravel and pebbles are larger than sand particles, ranging in size from 5 to 15 mm. They provide excellent aeration and drainage and are quite heavy, like sand. Their CEC and water-holding capacity are poor. Pebbles and gravel are often utilized in aquaponics and ebb-and-flow systems. Gravel made of limestone called calcareous gravel need to be avoided since it might cause the nutrient solution's pH to change and release calcium carbonate. Prior to usage, gravel and pebbles may need to be sterilized.

Despite the name "stone," pumice is comparable to perlite. Crushed volcanic rock is used to make them. Pumice stones lack CEC and are lightweight. This substance retains water well and aerates well. Rockwool, perlite, or coco coir have a lesser water-holding capacity than sand. Pumice stones are inexpensive and simple to buy, but because of their very low weight, they are seldom utilized. The majority of the time, aquaponic systems employ them. To guarantee effective drainage while using pumice stones, a combination of big and tiny particles (0.3 to 5 cm) is required.

Expanded clay, often known as "grow rocks," is created by heating clay to very high temperatures. This item is artificial and is available in several different sizes (1 to 18 mm). The degree of aeration required determines the ideal size. It may need more regular watering because of its very limited water-holding capacity. This medium can store salts and nutrients and has a high CEC. Expanded clay is somewhat sustainable since it can be cleaned, sterilised, and used again. Due to its high cost, one disadvantage is that it is mostly employed by enthusiasts rather than business companies. A naturally stratified silica that has been heated and stretched to create vermiculite. It is available in a number of grades, with particles ranging in size from tiny dusts to large pellets. It has a strong water-holding capacity and is lightweight and porous. Vermiculite is a typical addition to germination medium because of its fine, lightweight properties. Low CEC and close to neutral pH (7–7.5) characterize it. This medium often adsorbs magnesium, which might be troublesome. Vermiculite may also release aluminum into the solution, which is hazardous to plants, if the pH is low. Fine vermiculite, like perlite, may create irritating dust that is inhaled.

Reusing media

In order to stop the development of infections and pests, hydroponic systems significantly depend on cleanliness. When used properly, certain media may be recycled. Like most organic media and foam cubes, other forms of media will deteriorate or lose shape with time. Even if certain media don't break down right away, they shouldn't be used again since they can't be thoroughly cleaned.

Examples of reusable media include expanded clay, sand, gravel, and pebbles. Pathogens from earlier harvests might remain in the media and kill fresh plants in future plantings. To avoid issues in the future, it is crucial to start each planting with a clean system. The main methods of sterilizing media for re-use include steam sterilization and chemical sterilization. In steam sterilization, germs are eliminated from the medium by steaming it for a predetermined amount of time at a high temperature (over 180°F). For effective sterilization, this may need specialized equipment, and the usefulness may vary depending on the hydroponic system type. Steam sterilization is an alternative to chemical sterilization, such bleach. Because many of the chemicals employed during this procedure are poisonous to humans, it might be dangerous.

CONCLUSION

For hydroponic growers, choosing the right media is crucial. In media-culture, the medium affects important characteristics like water-holding capacity or aeration and may provide stability for plants to thrive in. Even though there are many distinct media types, each has unique qualities and factors to take into account while using them to grow various plants in various hydroponic systems.

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CHAPTER 21

CLIMATE CHANGE'S EFFECTS ON SMALLHOLDER AND SUBSISTENCE FARMING

Akanchha Singh, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- singhakanchha3@gmail.com

ABSTRACT:

The populations known as "subsistence" or "smallholder" farmers, who are mostly found in developing nations, will experience some of the most significant effects of global climate change. Both their mostly tropical location and different socioeconomic, demographic, and legislative tendencies impeding their ability to adapt to change make them vulnerable to climate change.

KEYWORDS:

Climate Change, Sustainability, Organic Farming, Vertical Crop Growing, Urban Agriculture

INTRODUCTION

Because it involves the process of generating food, feed, fiber, and many other desired items via the cultivation of plants and the breeding of domesticated animals, agriculture is a significant source of income (livestock). It is the art of controlling plant and animal development for human benefit. Let's investigate the effects of changing agricultural practices on the environment and ecology. Due to I the lack of standardized definitions for these types of farming systems and the consequent lack of standard data above the national level, (ii) the inherent characteristics of these systems, particularly their complexity, location-specificity, as well as integration of agricultural and non-agricultural livelihood strategies, or (iii) their vulnerability to a variety of climate-related and other stressors, these impacts will be challenging to model or predict. A conceptual framework for comprehending the many types of effects in an integrated way is suggested, some recent work that is pertinent to these farming systems is reviewed, and future research requirements are noted.

Modern agriculture

In order to fulfill the world's demands for fuel, food, and fiber, farmers must use less natural resources, such as water, land, and energy, via the use of agricultural advances and modern farming techniques. Other names for contemporary agriculture include agribusiness, intensive farming, organic farming, and sustainable agriculture.

Environmental effects of modern agriculture

As is well known, modern agriculture has made food more accessible and affordable while also increasing food production, sustainability, and the production of biofuels. However, since it is based on a high input-high output technology that uses hybrid seeds of high-yielding varieties together with copious amounts of irrigation water, fertilizer, or pesticides, it also contributes to environmental issues. The following is a discussion of how modern agriculture affects the environment:

Soil Erosion

Due to the overabundance of water, cropland loses its top layer of rich soil. As a result, nutrient-rich soil that hindered production is lost. Additionally, it contributes to global warming because soil carbon is released from particle organic matter in water bodies due to silt. Despite the fact that both phrases are often used, "smallholder agriculture" and "subsistence agriculture" have remarkably few written definitions. According to the definition of subsistence farming, it is "farming and related activities that together comprise a livelihood strategy where the major product is eaten directly, where there are few or no bought inputs, and where only a modest fraction of output is sold." However, the phrase is also also used to refer to the practice of self-provisioning with agricultural goods or a corresponding shift in that direction, as in developments in Eastern Europe after the demise of planned economies. It is widely used to refer to the rural underclass of emerging nations in non-technical contexts. † Such a use obscures the reality that market relations have permeated nearly every aspect of agriculture throughout the globe and that many of these farmers' most pressing issues are related to the conditions of their membership in the market.

The term "smallholder agriculture" is more broadly used to characterize rural farmers, primarily in developing nations, who cultivate using mostly family labor and whose primary source of income is the farm. These farmers are referred to as "smallholder and subsistence farmers" in this chapter because they fall somewhere between the two extremes of concentrating on crop production for the market and subsistence farming. Smallholders in transitional or developed nations may have farms and earnings that are several times bigger than those in developing nations. This group also includes individuals who rely on artisanal fisheries and aquaculture businesses as well as pastoralists, who nearly exclusively purchase essential foods and other requirements from the sale of animals and livestock-related items. All have comparable issues brought on by exclusion and outdated technology, as well as uncertain exposure to global markets, to varied degrees.

They have been described as "complex, diversified, and risk-prone systems." Farms are often tiny, frequently owned under informal or customary tenure, and located in unfavorable or risky locations. Although the variety of soils and farmer soil management techniques are also significant, there are many, severe, and growing soil-related limits on production. The combinations of plant and animal species that are exploited, the ways in which they are integrated, the production goals, and the institutional setups for managing natural resources are all complex and varied in production systems. Risks may affect a single home or a whole community, and they come in many different forms, including drought and flooding, animal and agricultural diseases, and market shocks. To meet their needs for energy, clothes, health care, cash revenue, and direct food as well as other necessities, smallholder and subsistence farmers and pastoralists often engage in hunting and collecting of natural materials as well as crop and animal production. Additionally, they often engage in off-farm and/or non-farm jobs. Beyond these issues, smallholder agriculture is impacted by what has been dubbed "the centrality of the social": its roots in interpersonal interactions within and between households, particularly those involving gender, which have a significant impact on the negotiation of production decisions, knowledge management, and marketing.

There are few accurate estimates of the number of smallholder or subsistence farmers in the globe or in specific regions due to the absence of precise and established criteria for these groups. For instance, the Food and Agriculture Organization (FAO) of the United Nations does not provide statistics broken down into these categories. Even in developing nations, not all smallholders are impoverished, but statistics released by international organizations dealing with rural poverty offer some notion of the scope of these livelihood systems.

LITERATURE REVIEW

Bryceson, and Deborah Fahy [1] studied The 1970s oil crisis altered the gender and generational dynamics of African peasant families, which developed under European colonial practices starting in the late 19th century and generally continued in the early post-independence period. As demonstrated by diminishing smallholder commercial agriculture in the 1980s, sometimes but not always accompanied by rural out-migration, peasant labor displacement was intensifying. On the basis of statistical information and qualitative case studies, the ensuing differential engagement of peasant smallholder family members in developing processes of deagrarianization and depeasantization is investigated. The different effects of deagrarianization on household members can be understood through spatial and temporal analysis of sex/age ratios derived from published data on sectoral labor force participation, quantitative surveys of intra-household labor time allocation, and data from the national census population. The following salient trends are emerging: labor contraction in male commercial peasant family farming; smallholder subsistence-based land cultivation squeezed by medium-scale commercial farmers, in the countryside, who provide an agrarian fallback for migrant family members who have returned and other family members engaged in local non-agricultural occupied.

Amogne Bantider et al. [2] Ethiopia is included among the nations that often experience drought and are very susceptible to the effects of climate change due to its climate-sensitive agricultural system and limited adaptation ability of the subsistence farmers. When developing strategies to deal with the consequences of climate change, a micro level vulnerability assessment is of the utmost importance. By fostering coping mechanisms and facilitating adaptation options targeted at particular contexts, assessing vulnerability to climate is important for defining the risks posed by the change and it serves as a starting point for the determination of effective methods for encouraging remedial actions to minimize impacts.

Chawala et al. [3] studied The Theory of Planned Behaviour is used to further the literature on smallholder farm commercialization in a setting of understudied developing nations. The research looks at how attitudes, subjective norms, and perceived behavioral control affect smallholder village chicken (free-range or indigenous) producers' intentions to scale up in northwestern Zambia. Examined as well are gender disparities in commercialization purpose. Statistical correlation and student's T-test models were used based on a quantitative correlational design using 556 smallholder farmers' primary data from a structured questionnaire. The results show that attitudes, subjective norms, and perceived behavioral control have special, substantial positive impacts on the intention to engage in commercialization practices (CPI), and that CPI in turn favorably promotes the desire to engage in commercialization scaling-up (CSI). Aside from subjective standards, the research discovered substantial gender variations in every component of the model. Despite being cross-sectional and only focusing on one area in Zambia, the study's conclusions have significant ramifications. Before implementing any interventions to help the commercialization of the village chicken, policymakers and entrepreneur support organizations must have a thorough grasp of the socio-psychological aspects of smallholder farmers.

Simon J. Chalabi et al. [4] studied Global health impact models indicate that declines in food quantity and quality brought on by climate change will have a detrimental influence on undernutrition, which contributes significantly to the global burden of illness. However, only a small portion of the mechanisms that may affect future nutrition are represented by these models. They take a different stance by creating an agent-based model in which smallholder producer-consumer farmers engage in various styles of farming within the global food system.

Ogutu et al. [5] studied Although there are still a large number of individuals living in severe poverty, global poverty rates have significantly decreased. Smallholder farmers make up a large portion of the worlds impoverished. Agriculture commercialization, or the transition from subsistence to more commercial farming, may be a key factor in raising the wellbeing of smallholders. Prior research assessed how agricultural commercialization affected income poverty, but little research has been done on whether the cash generated by commercialization is really utilized to meet fundamental requirements. Here, we assess how commercialization affects both economic poverty and the multidimensional poverty index, which examines deprivations in terms of health, nutrition, and other aspects of living standards. They estimate average treatment effects and utilize quantile regressions to examine impact heterogeneity using data from 805 agricultural families in Kenya.

Kuchimanchi [6] Rapid changes in agricultural practices, often requiring greater land and resource usage, are being brought on by rising food demand. While transitioning provides advantages in terms of reducing poverty and increasing food production, it also has long-term negative effects on the environment and society. This research tries to comprehend the changes in agricultural systems that occurred in an area of Telangana between 1997 and 2015 and their impact on smallholder livelihoods & livestock rearing. We also look at how the transformations have affected women and lower caste communities in particular. To provide a complete picture of the shifts in the area, we gathered data using a mix of techniques, including a household survey, focus group talks, or secondary data sources.

Manners et al. [7] Sub-Saharan Africa's food systems are expected to be significantly impacted by climate change. The considerable dependence on rainfed agriculture and the predominance of subsistence farming are predicted to magnify the severity of these effects. Smallholder farming families in the Great Lakes Region of Central Africa rely heavily on root, tuber, and banana crops. The potential effects of different climate change scenarios on these crops, however, are not extensively documented. But for development and research investments in regional climate change adaptation, data-rich insights regarding the future effects of climate change on these crops and the adaptability of food systems in the Great Lakes Region are essential.

Georges F. Diedhiou et al. [8] For sustainable food production and livelihoods in semi-arid West Africa, strategies that promote and utilize biodiversity are essential. This paper sought to examine the role of biodiversity in sustaining various forms of multifunctional farming practices while also providing ecological services to subsistence-oriented farming families in the region under study. Our investigation demonstrates that crop associations, such as those between perennials and annuals or between cereals and legumes, generally enhance soil properties and increase crop yields. Both termites and woody perennials contribute to soil variability. Local management offers chances to year-round harvest a variety of nutrient-dense species and maintain family nutrition.

Coelli et al. [9] In Papua New Guinea, smallholder farming systems are distinguished by an integrated mix of income cropping and food cropping operations. Production of sweet potatoes rules the sub-system of subsistence food crops in the Highlands provinces. A few food crops are also cultivated for cash sale, although coffee dominates the subsystem of cash crops. Particularly in light of the seasonality of demand for domestic labor and managerial inputs within the agricultural system, the dynamics between sub-systems might affect the potential for complementarity between and technical efficiency of their operations. Diversification into commercial agricultural production, which may affect factor productivity as well as the efficiency of crop production when smallholders retain a strong production base in subsistence foods, is an important component of these dynamic processes.

Mutiro et al. [10] studied Sub-Saharan African nations often experience declining food security as a consequence of ever-increasing population, decreased water availability, and degraded soil. About 90% of the sub-Saharan populace depend primarily on rainfed agriculture for their livelihoods, despite the fact that the majority of fresh water resources in wealthy countries are substantially invested in irrigation. Therefore, the vast majority of the people, who are rainfed subsistence farmers, do not immediately profit from established water supplies. So, in sub-Saharan Africa, methods that increase water productivity (WP) may help to mitigate the effects of water shortage, particularly for agricultural production. In the semi-arid Makanya watershed in northern Tanzania, where farmers rely on rainfed subsistence farming for their livelihoods, a research was undertaken.

DISCUSSION

With reference to pastoralists in the Horn of Africa and elsewhere, the intricate interplay of such stresses that results in growing susceptibility may be shown. There are disagreements over whether environmental deterioration in these tropical dryland areas is pervasive, irreversible, or properly referred to as desertification; however, there are at least significant localized environmental degradation processes occurring around small towns that are fueled by the sedentarization of poor pastoralists and further erode their means of subsistence. The lack of government recognition of communal ownership of rangelands as well as traditional natural resource management is at the root of all of these problems, as is the enclosure of land for farming by outsiders and by pastoralists themselves, as well as the demarcation of rangelands as Protected Areas. Sandford argues that the recognition of human population growth, along with other stressors, necessitates a significant change in perspectives on pastoral development, with more emphasis on diversification away from pastoralism and out-migration from the rangelands.

Human population growth has long been neglected in pastoral studies. Pastoralists are also susceptible to market-related stressors: Kenyan pastoralists still regret the government's and parastatals' abrupt exit from direct engagement in the purchase of animals and the processing of meat in the 1980s. As a result, they are particularly vulnerable to sudden import bans on meat and livestock due to veterinary reasons, sometimes with disputed scientific justification. However, this is also seen as a sign of a general trend wherein Arab markets are becoming more concerned with the quality and safety of their meat. The effects of violent conflicts, from international wars to quasi-traditional raiding, on pastoralists across the area are now well documented, despite the fact that there is a major dearth of knowledge on but some worry over the impact of HIV/AIDS on these pastoral communities. All of these stresses and others are thought to make people more susceptible to drought, which in turn causes environmental damage, conflict, and market underdevelopment.

However, all of the populations classified as smallholder and subsistence farmers, including pastoralists as well as artisanal fisherfolk, also have access to a number of crucial resilience factors, such as the effectiveness of using family labor, the diversity of livelihoods that allows risks to be spread, and indigenous knowledge that enables the exploitation of risky environmental niches and crisis management. Complex positive and negative livelihood trends are created by the interactions of stressors and resiliency variables; these trends are envisioned differently by various authors and have a significant impact on policy contexts. Rural-urban migration will continue to be significant since it accounts for between 35% and 60% of reported urban population increase in many big developing nation cities where urban population growth is above 4% annually. As people are drawn or forced into different livelihoods, it is expected that the number of smallholder and subsistence families will decrease, with those who remain experiencing increasing vulnerability and increased poverty. Over the medium- and long-term time scales associated with research and modeling on climate change, global and regional projections made for the category of smallholder and subsistence farmers will become progressively less meaningful due to the decline in numbers and qualitative changes in livelihoods.

Adapting and Coping

Smallholder, subsistence, and pastoral systems are frequently characterized by livelihood strategies that have evolved I to reduce overall vulnerability to climate shocks ("adaptive strategies") and (ii) to manage their impacts ex-post particularly those located in marginal environments, areas of high variability of rainfall, or high risks of natural hazards. However, the line between these two groups is usually blurred: what begin as coping mechanisms during difficult times may develop into adaptations for families or whole communities.

Many distinguishing characteristics of dryland livelihoods in Africa and elsewhere might be seen as climate-adaptive mechanisms. For Northern Nigeria, Mortimore and Adams, for instance, list five key components of adaptation:

- "Negotiating the rain" means allocating agricultural labor according to erratic intraseasonal rainfall changes.
- Making advantage of the variety of wild and domesticated flora.
- Growing incorporation of cattle into agricultural systems (at a cost of increased labor demands).
- Increasing labor input per acre while maintaining or even decreasing external non-labor inputs.
- Diversifying sources of income.

Other writers have cited drought adaptations from rain-fed parts of Morocco, such as on-farm food and feed storage, strategic fallow usage, and late planting of legume crops when cereals fail. In order to survive in severe regions with a high degree of spatial and temporal rainfall unpredictability, African pastoralism has developed. Morton evaluated several recent research on Northern Kenya and Southern Ethiopia that focused on pastoralists' drought coping mechanisms and the longer-term adaptations that underpin them.

Because of distance, land tenure restrictions, animal disease issues, or conflict, mobility continues to be the most significant pastoralist adaptation to spatial and temporal variations in rainfall. In drought years, many communities use fall-back grazing areas that aren't used in "normal" dry seasons. The urge to dwell in order to use human services and food assistance, as well as the encroachment on and individuation of community grazing areas, have significantly reduced pastoral mobility.

Herd accumulation is a practice among pastoralists, and the majority of available research points to it as a sensible drought insurance strategy. There is much discussion surrounding the extent to which pastoralists survive by routinely selling livestock during drought or the onset of drought, as well as the reasons they might not do so. However, there is some evidence to suggest that they would sell more livestock if markets were more effective.

Traditionally, pastoralists have kept mixed-species herds to benefit from various ecological niches and the work of men, women, and children. A small percentage of pastoralists now have some wealth in bank accounts, and others use informal savings and credit mechanisms through shopkeepers. Pastoralists also use supplementary feed for livestock, purchased or lopped from trees, as a coping strategy, and they intensify animal disease management through I

There are a number of intracommunity mechanisms to distribute both livestock products and the use of live animals to the needy, but these appear to be failing due to high levels of covariate risk w. Livelihood diversification away from pastoralism in this region mainly takes the form of shifts into low-income or environmentally unsustainable occupations like charcoal production.

In the face of climatic unpredictability in the developing world, switching to irrigated farming is sometimes considered as a coping mechanism. illustrates this for Mexico, but adds that the mix of market unpredictability and weather risk may actually make families making this switch more vulnerable. In South Asia, agricultural strategies like upping livestock production in comparison to crops and choosing crop varieties are responses to both drought and floods. However, several case studies highlight the significance of diversifying livelihoods in both rural and urban areas, both in advance of disaster and in response to it. These and other research demonstrate the significance of knowledge, networks, and social capital in addressing climatic variability and change.

Climate Change's Effects on Subsistence Agriculture and Smallholder Farming

Despite the fact that the impacts of climate change on rural areas of developing countries have received considerable recent public attention, there has been little discussion that both engages with the science of climate change impact on agriculture and with the particulars of smallholder and subsistence systems. First, quantitative predictions of future impacts from modeling studies, at various geographic scales, concentrating on important smallholder crops or ecosystems used by smallholder farmers, or reviewing data from such studies at a regional level, are some of the trends that can be seen in the literature. An important illustration is the research of Jones and Thornton, who find that the overall yields of maize in smallholder rain-fed systems in Africa and Latin America are likely to decrease by about 10% by 2055, but that these results hide enormous variability and raise serious concerns, particularly in some subsistence agricultural areas. This method has been developed by ILRI, which creates maps of sub-Saharan Africa's vulnerability to climate change based on geographical data sets of the region's current farming practices, socioeconomic vulnerability indicators, and projections of the length of the growing season, further differentiated by SRES scenario. According to this research, semiarid mixed rain-fed crop-livestock systems in the Sahel, arid and semiarid grazing systems in East Africa, and mixed crop-livestock and highland perennial crop systems in the Great Lakes Region are "hotspots" for susceptibility.

Adaptation has been the main focus of a second trend, which often uses qualitative data and views the categorization of effects as a supplementary and generally simple effort. Some of this work has focused on the impacts of extreme events, such as tropical storms, which have an impact on agriculture at a gross or landscape-level as well as affecting livelihoods through the destruction of housing and physical capital. Such work frequently uses recent or current climate variability as a base on which to discuss adaptation, treating it largely as a proxy for future climate change. A conceptual framework is now required to comprehend how climate change will affect smallholder and subsistence agriculture. Utilizing the expanding knowledge of the biological mechanisms affecting how climate change affects crop and animal production, agriculture and allied livelihoods like pastoralism and artisanal fishing may adapt to the unique characteristics of these livelihoods.

Physical and environmental processes.

Although there is some overlap with the discussion of severe occurrences, another class of consequences that affect people, landscapes, and watersheds have received less attention in the literature on climate change and agriculture. One such consequence is how declining snowcaps affect large irrigation systems used by hundreds of millions of small farmers, especially in the Indo-Gangetic plain. The peak water supply will shift from the summer months when irrigation is most necessary to winter and early spring because of warming, less precipitation turning into snow, and earlier spring melting. This will likely have significant implications in locations where storage capacity cannot be increased. Such an effect might be disastrous given the rising water demand, previous susceptibility of many less wealthy irrigated farmers, and growing water demand.

Effects of climate change on soil fertility and water-holding capacity should also be considered. All soil processes are predicted to be affected by global warming and concomitant hydrological changes in a variety of complicated ways, such as via rapid decomposition of organic matter and decreased nitrogen-fixing activity. According to various variables are anticipated to make soils more erodible globally, including the predicted rise in rainfall erosivity. The effects of sea level rise on coastal regions, the intensification of tropical storms that make landfall, and other types of environmental impact that are still being discovered include increased risk of forest fires for the Mount Kilimanjaro ecosystem and remobilization of dunes for semiarid Southern Africa are additional examples of such environmental or larger-scale impacts societal effects of climate change.

The aforementioned effects on agriculture will be paired with effects on human health and labor availability, such as an increase in the risk of malaria, and on crucial secondary nonfarm livelihood choices for many rural residents in developing nations. One such tactic includes tourist-related activities, and climate change is already expected to have some detrimental effects on tourism in underdeveloped nations. The paradigm mentioned above demonstrates how intricate and site-specific the projected effects of climate change on smallholder and subsistence agriculture will be. The challenge of differentiating between impact and adaptability adds another layer of difficulty. There will be significant methodological challenges in monitoring or anticipating consequences that do not also require adaptation since these systems are already defined by ongoing adaptation to climatic variability.

A substantial number of smallholder and subsistence farming families are concentrated in the dryland tropics, which generally raises concerns about temperature-induced declines in crop yields as well as an increase in the frequency and severity of droughts. These result in the following broad conclusions: Crop failure risks rising; livestock mortality and disease rates rising; forced livestock sales occurring at unfavorable prices effects on livelihoods, such as the sale of other assets, debt, out-migration, and reliance on food aid; potential feedbacks from unsustainable adaptation strategies into environmental degradation, such as loss of biodiversity and eventual effects on human development indicators, such as GDP growth.

Consequences for Upcoming Research Needs

Additional study on a range of subjects and using a variety of methodologies will be necessary to comprehend the relationships between the many kinds of climate change effect. One need is for modeling efforts to be based on a profound understanding of the complexity of particular smallholder systems in the real world. One strategy here is the multiagent modeling. Increased empirical study into the conditions that existing tactics for dealing with catastrophic occurrences stimulate or prevent longer-term adaptation will be crucial. More crops, livestock, and wild species that are important to smallholders and subsistence farmers, such as tropical rootcrops, sorghum and millet, beverage crops, backyard poultry and pigs, and browse systems based on acacia, need to have their knowledge of crop responses to climate change expanded. Research is also needed to understand how climate change will affect how smallholder farmers store and market their crops.

This research should look at how losses from insect pests and pathogens will affect crops that are stored on-farm or by small traders, how damage will occur during transport (for example, due to deteriorated rural roads), and how indirect costs will increase as farmers become less able to store their crops on-farm and more susceptible to seasonal price fluctuations. There is a greater demand for study on adaptation than there is for research on effects. Although rigorous multidisciplinary and participatory research is required, many of the possible agronomic adaptations highlighted such as enhanced soil and water conservation, are extremely applicable to smallholder and subsistence systems. Careful investigation is required on how smallholder farmers utilize seasonal climate forecasting, with emphasis on their capacity to obtain, trust, and act on forecasts. Another requirement is to broaden discussion by including more works from languages other than English, which have been conspicuously absent up until now.

CONCLUSION

Impacts of climate change on smallholder and subsistence farmers will be unpredictable and localized. Compared to commercial farms with more constrained crop varieties, a household's production of a diversity of crop and animal species, their interconnections, and the significance of nonmarket linkages in production and selling will make both the effects and the ensuing adjustments more complicated. Social science research on the potential effects of climate change on impoverished rural populations in developing nations has tended to focus on the increasing frequency of catastrophic occurrences with broad-reaching effects. Given the significance of severe occurrences in the short to medium range and the difficulty of anticipating any patterns, whether due to climate change or not, over the longer term, this is comprehensible. To adapt the fast advancing scientific understanding of how climate change affects crops and cattle to the "complex, diversified, and risk-prone" agricultural systems of developing nations, there must now also be a really multidisciplinary effort. This will help create adaptive capacity at all levels, including that of farmers themselves, and will not merely increase understanding of repercussions.

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CHAPTER 22

IOT USED IN SMART AGRICULTURE MANAGEMENT SYSTEM

Anil Kumar, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- anilsingh2929@gmail.com

ABSTRACT:

Agriculture, sometimes known as farming, is the science and practice of growing plants. It is essential to the development of human life. By farming with domestic animals, it produces food and other associated goods, allowing humans to live long and healthy lives. There are two types of agriculture; one is conventional. Agriculture is the first, and modern agriculture is the second. Farmers in traditional agriculture faced numerous challenges, but with modern agriculture, they can observe many improvements in farming thanks to agronomy, the use of agricultural chemicals like pesticides and fertilizers, plant breeding, and technological advancements, all of which will produce good crops.

KEYWORDS:

Climate Change, Sustainability, Organic Farming, Vertical Crop Growing, Urban Agriculture.

INTRODUCTION

The term "Internet of Things, or IoT, refers to a system that may link actual physical objects, embedded software, implanted sensors, and other technologies in order to connect and transmit data across several different devices through the Internet. On the path to too many fields, it is the optimistic expertise or technology that provides precise and most dependable answers. There are several real-time uses for IoT devices, including industrial, consumer, Commercial and infrastructure developments one of the finest technologies for improvements in various fields is the Internet of Things. IoT-based solutions might let farmers work less while yet providing agricultural sound. This presentation will give a brief overview to examine how the Internet of Things and related technologies represent technology. Along with the presentation of modern agricultural advancements, SMART AGRICULTURE would benefit from AI and cloud computing. The network of things, often known as the mechanical net, or the Internet of Things (IoT).

Another way of looking at innovation is as a global network of devices and equipment designed for communication with one another. The IoT is regarded as one of the most promising future innovation sectors and is fostering Brobdingnagian thinking among a wide range of people. The Internet of Things (IoT) offers several applications that incorporate a variety of heterogeneous technology. Real-time IoT devices and physical objects have developed autonomy. The current police inquiry, aided by Wireless Detector Network (WSN) developments, spans several of the most recent existing zones. After complicated etiologies of traditional qualities to urban settings, it may be able to measure, generate, and materialize environmental indicators. The development of these devices into a transfer-efficient organization creates the Internet of Things (IoT), in which sensors and actuators integrate systematically with local weather in the United States and communicate information at various stages to build up a typical operational picture. The IoT has strayed from its earliest organizations and is the accompanying reformist development in unique web the online the net into an extremely consolidated Future web, fueled by the continued change of partner variety of exciting far-off advances, such as RFID marks and embedded locator and component centers. When used for an accurate range of sectors and applications, a sizable number of police investigation tools in the IoT era also provide entirely distinct physical information. In keeping with their nature, these devices may assist users in learning new knowledge and anticipating their future experiences. Making the right management choices might be a crucial cycle that gives firms an admirable IoT perspective and spurs expanding innovation. IoT links disparate devices.

Transportable another technological advancement that refers to a framework where all data preparation and storage take place away from mobile devices is distributed computing. The Internet of Things is another recent breakthrough. Another invention that is swiftly gaining traction in the realm of broadcast communications is the "Net of Things." Additionally, IoT is explicitly linked to distant broadcast communications. To meet the goal provided to them as a consolidated element is the fundamental goal of the affiliation and cooperation between things and things transmitted via distant organizations. Additionally, the two innovations distributed computing and the Internet of Things are improving quickly in terms of the field of distant correspondences. Since the previous decade, a great deal of data has been given due to the reduction of internet of things devices. However, as it lacks a fact-finding force, this knowledge is not useful. IoT devices generate enormous amounts of data, which has been made accessible to people via a number of mammoth information, IoT, and research arrangements. Developing agriculture as effectively as possible is a growing idea. Temperature change affects agriculture development; if the climate is monitored using IoT technology, it may be easier to identify practical outcomes in the ideal framework. Because it is the main source of food grains and other essential raw resources, commerce is regarded as the foundation of existence for the human race.

It takes a crucial role in the growth of the country's economy. Additionally, it offers the people enough opportunities for employment. Geographical expansion is essential for the improvement of the state's monetary situation. Unfortunately, many ranchers still cultivate using the outdated methods, which results in poor yields of organic produce and harvests. However, the output has increased everywhere mechanization had died and humans had been replaced by computerized hardware. Then, in order to increase the yield, current research and innovation in the business world must be put into practice. The majority of the publications refer to the usage of remote sensing element networks, which collect data from various types of sensors and then transmit it through distant communication to the principal employee. The information acquired provides knowledge about a variety of natural factors, which helps with the framework's verification. Checking natural components is not a sufficient and full plan to increase harvest output. There are several different factors that affect profitability**.**

These factors include a creepy crawly invasion and irritations, which may be driven by dousing the crop with pesticides and legal insect spray. As the crop matures, uncontrolled animals and birds may attack the target. Additional edibleness of burglaries at the target after the yield is in the portion where it is being collected. Ranchers have difficulties outside of agricultural harvesting even after reaping. In order to address all of these issues, it is crucial to create a coordinated framework that might adversely affect every component's ability to be profitable at every step, including creation, collecting, and post-collection storage. As a result, this study suggests a framework that can be used to verify industry data as well as the dominating sector actions that provide the ability. The goal of the article is to make farming more intelligent via IoT and motorization. The highlights of this work include a clever GPS-based remote-controlled automaton that can execute tasks like gardening, bathing, moisture detection, seeing flying creatures and other creatures, exercising caution, and so on.

Additionally, it has a smart water system with astute management who is dependent on ongoing field information. Thirdly, the board for careful storage that covers temperature adjustments, humidity support, and criminal activity detection in the storage area Each and every one of these activities will be dominated by a more advanced device or computer connected to the internet; as a result, the activities will be carried out by integrating sensors, Wi-Fi or ZigBee modules, cameras, and actuators with a raspberry pi and a small regulator. Farming plays a crucial role in the development of rural nations. In an Asian nation, 70% of the world's economy is based on agriculture, and 33% of the nation's GDP is generated by it. Issues with industrial farms often impede the state's progress. The most common way to address this problem is through upgrading this age-old agricultural practice. As a result, the company aims to develop agricultural shrewd through advancements in motorization and IoT.

Applications of New Technologies in Smart Agriculture

Many of the applications for "smart agriculture" wind up in many applications; some of these "smart" technologies are included in the table below. The use of technology has made strong impact on agriculture. According to recent research, there will be 9.6 billion more people on the planet by 2050. Additionally, receiving the Internet of Things is confined to the agricultural industry in order to take care of this enormous planet. IoT is eradicating issues like extreme weather, environmental condition changes, and ecological effect while also assisting the United States in meeting its need for a lot more food. Mechanical developments such as farm vehicles and gatherers happened over the world in the late 20th century and were incorporated into husbandry operations. Due to the steadily growing need for food, the agricultural industry also wisely relies on original ideas.

Applications for smart agricultural systems

The major objective of this system is to minimize human participation and to make the system autonomous. Smart agriculture has various application areas. Many researchers often employ emerging technologies like those that were listed above. In every sector, automation would provide better outcomes since it attempts to increase system performance while also producing positive effects, as is mentioned in this research. Technological farming produces productive crops, alerts farmers to unfavorable weather, and alerts them to food and other item theft.

IoT and AI's role in agriculture

- Drones: Drones aid in agricultural monitoring and the execution of essential steps to enhance crop growth.
- Weather forecasting or climate estimation: The majority of farming is dependent on the weather, therefore keeping an eye on weather reports and providing Farmers with the findings may help enhance farming.
- Machines/Robots: Robots are helpful in reducing manual labor and are essential to timely crop production.
- Image Analysis: Researching farming would be helpful.

LITERATURE REVIEW

Boursianis et al. [1] Unmanned aerial vehicles (UAVs) and the Internet of Things (IoT) are two popular technologies used in agricultural sectors that are transforming conventional farming techniques into a new age of precision agriculture. In this work, we conduct a review of recent studies on the use of IoT and UAV technologies in agriculture. In this article, we go over the fundamentals of Internet of Things (IoT) technology, including intelligent sensors, different kinds of IoT sensors, networks, or protocols used in agriculture. They also discuss IoT solutions and applications for smart farming. We also discuss the use of UAV technology in smart agriculture by looking at how UAVs are applied in a number of different contexts, such as irrigation, fertilization, pesticide usage, weed control, plant growth monitoring, crop disease management, and field-level phenotyping.

W. Tao [2] Studied The emergence of the Internet of Things (IoT) inspired a shift in agricultural research, and a number of IoT communication technologies are now being employed to communicate with various devices at various levels. Information became dispersed as a result of the rapidly growing number of research and initiatives regarding IoT-based smart agriculture, and the underlying communication technologies were not previously examined and addressed in prior reviews. This study critically reviews the most current research relevant to smart agriculture using IoT communication technologies with the aim of identifying and reviewing academically certified literature in the field.

Ayaz et al. [3] studied Contrary to popular belief, today's agriculture business is more data-driven, accurate, and intelligent than ever. In practically every business, including "smart agriculture," the fast development of Internet-of-Things (IoT)-based technology has led to a redesign that has switched from statistical to quantitative methods. Such radical developments are upending traditional agricultural practices and opening up new possibilities alongside a number of difficulties. This article discusses the promise of wireless sensors and the Internet of Things (IoT) in agriculture as well as the difficulties that will be encountered when combining this technology with conventional agricultural methods.

Rayner Obit et al. [4] studied In especially for the production of rice, machine learning (ML) and the internet of things (IoT) are anticipated to have a significant influence on smart farming and engage the whole supply chain. The growing volume and diversity of data being collected and acquired by these new IoT technologies provide the smart farming for rice strategy additional tools for anticipating changes and spotting possibilities. The effectiveness of the modelling procedures utilizing ML algorithms is strongly influenced by the quality of the sensor data obtained. These three components for example, BD, ML, and IoT have greatly enhanced all aspects of rice production processes in agriculture, ushering in a new age of rice smart farming or rice precision agriculture.

Kamienski et al. [5] studied For agricultural precision irrigation to increase crop output, lower costs, and promote environmental sustainability, smart freshwater management is crucial. The intensive use of technology provides a way to provide plants the precise quantity of water they need. Despite the fact that there is still work to be done in the integration of many technologies to make the Internet of Things (IoT) function effortlessly in reality, it is the obvious option for smart water management applications. It also includes a performance analysis of the FIWARE components used in the Platform because scalability is a major concern. Results indicate that it is capable of offering the SWAMP pilots an appropriate level of performance, but it necessitates the use of specifically designed configurations and the re-engineering of certain components to provide greater scalability while using less computing resources.

Rehman et al. [6] studied Increasing the efficiency of agricultural and farming operations is essential to increasing yields and cost-effectiveness as new technologies, like the Internet of Things, proliferate. By automating human involvement, IoT, in particular, may increase the effectiveness of agricultural and farming operations. Nearly every aspect of life has transformed as a result of the rapid development of Internet of Things (IoT)-based technologies, including business, agriculture, surveillance, etc. In the face of diverse challenges, these radical breakthroughs are upending conventional farming techniques and offering new possibilities. The Internet of Things (IoT) facilitates the collection of information that is helpful for the farming industry, including changes in climatic conditions, soil fertility, the amount of water needed for crops, irrigation, insect as well as pest detection, bug location disruption of creatures to the sphere, as well as horticulture.

Navarro et al. [7] studied the need for food production is rising as the world's population expands. The decline of the workforce in rural regions and the rise in production expenses are additional difficulties facing the food industry today. Internet of Things (IoT) technology may be used in "smart farming," a farm management concept, to address the present problems with food production. The available literature on smart farming with IoT is systematically reviewed in this article using the recommended reporting items for systematic reviews (PRISMA) approach. The study attempts to identify the key hardware, software platforms, networking standards, data processing technologies, and the viability of IoT-enabled smart farming for the agricultural sector.

Shafi et al. [8] studied Automation of agricultural activities based on the Internet of Things (IoT) has the potential to transform the agriculture industry from static and manual to dynamic and intelligent, resulting in increased productivity with less labor. The two primary factors driving automation in the agricultural sector are precision agriculture (PA) and wireless sensor networks (WSN). To make sure that the crops get precisely what they need to maximize yield and sustainability, PA employs specialized sensors and algorithms. PA involves obtaining accurate information from the sensors placed in the fields on the state of the soil, crops, and weather. Piloted or unmanned airborne vehicles may provide high-resolution photos of crops, which are then analyzed to extract data for use in making future choices.

Hassan et al. [9] studied Currently, automation in agriculture is a key area of growth for many nations. The need for food is rising in line with the world's population growth rate, which will double in the next decades. Automation in agriculture is the greatest approach to addressing this sharp increase in demand. Farmers' traditional methods are ineffective for meeting the escalating demand. When nutrients, water, pesticides, and fertilizers are used improperly, agricultural development is disrupted and the land stays unproductive and desolate. This study examines several automation techniques used in agriculture, including Internet of Things (IoT), aerial photography, multispectral, hyperspectral, NIR, infrared, and RGB cameras, as well as machine learning and artificial intelligence methods. By using the many automation and control approaches stated above, problems in agriculture such plant diseases, irrigation, pesticide control, weed management, or water management may be readily resolved. Automation of agricultural practices using advanced control mechanisms has been shown to boost crop output and strengthen soil fertility.

Wen Jye Huang et al. [10] studied this research employed IoT teaching modules and textbooks while applying the technology acceptance model (TAM) to an Internet of Things (IoT) smart agriculture course. It accomplishes the educational objectives of the IoT smart agriculture course by using the students at a technical high school as the objects and assisting them in the development of IoT ideas. In this work, the structural models were measured using SmartPLS, and the independent sample t test, reliability analysis, or regression analysis were all employed. The implementations of the technology acceptance model to the IoT smart agriculture course are among the outcomes. IoT training modules and textbooks, which have a high level of learning pleasure, were the tools employed. The components of the technological acceptance model are correlated, and all assumptions are true and reach substantial levels.

DISCUSSION

The phrase "Internet of things" (IoT) refers to the use of technology to collaborate, communicate, and deliver real-time sensor data wirelessly for processing, as well as to give more useful information for effective decision-making in the relevant study area. IoT is rapidly expanding. IoT is an emerging technology with many characteristics that may be used to advance civilization and improve quality of life. Examples of these application fields include health care, military, industry, agriculture, and others. To implement IoT, one has to be familiar with the research fields, hardware, and opportunities for connecting to the internet and accessing the devices. IoT is not a new concept, but recent advancements in hardware technology have made it popular for application.

The United States president issued a supportive comment following Auto-ID utilizing IoT in 1998, which led to significant encouragement and growth in the sector. The Internet of Things (IoT) with sensor networks offers a new tool for interacting and seeing real-time data in the physical environment with automation and decision-making processes. Even while gathering raw data is vital, mining and analyzing the data is also seen as a crucial job in developing an intelligent system for agriculture that can monitor the development of crops and their surroundings. Agriculture field goods have a number of IoT-related problems that may be fixed, allowing us to forecast, manage, and track the cycle of agricultural products. With its massive population, agriculture still provides the majority of livelihoods in India, although only half of the people still does. Three levels make up our proposed architecture model: the physical layer, the IoT layer, and the cooperative layer. These layers function as the overall management system and are integrated with consumer monitoring and automation services. The system is capable of handling any form of agricultural problem, including animal control, quality control, supply-chain management, and so on.

As the nation's economic engine, agriculture is still one of the key factors that may improve Indonesia's reputation internationally, particularly given that it is one of the world's most prolific agricultural nations. Indonesia has excellent climatic conditions, natural resources, and human resources, yet many farmers still use traditional practices. One may say that traditional agriculture now is mostly used in underdeveloped nations, like Indonesia, while modern agriculture is primarily used in wealthy nations. The productivity of the outputs is impacted by these variations in agricultural systems. Because the inputs used for agriculture are also different, productivity in conventional and modern agriculture differs. For instance, conventional agriculture still uses very simple tools like hoes, sickles, or plowing with the help of animals and people, as well as planting, tending to the soil, and harvesting. Production resilience in traditional agriculture is solely long-term in nature. Because of this, a nation becomes heavily reliant on imports while ignoring the viability and sustainability of agriculture. Given the massive growth of agriculture, all parties involved must utilize this potential. However, there are obstacles to maximizing agriculture's potential. Since there are many parties involved, both the government and agricultural players need to be better equipped to deal with issues in the age of information technology advancements.

As part of the continuing industrial revolution in the industrial era 4.0 and as we go forward towards the industrial era 5.0, it has brought about some very major changes. More crucial than changes in technology is a shift in how people think about and approach this industrial age. This has a very substantial effect on how the country is developing, which in turn affects the agricultural system. Agriculture is now more than simply farming; it is a component of the industrial system, which is defined by the transformation of raw materials into agricultural products that are usable and have added value from an economic, social, and environmental perspective. The evolution of modern agriculture is characterized by a shift in perspective toward utilising both biological and nonbiological resources in accordance with demands. Precision agriculture is thus the term used to describe the exact usage of resources in agricultural production systems. Low-input, high-efficiency, and sustainable agriculture are the goals of the agricultural concept known as precision agriculture. Alternatively, one may define precision agriculture as an agricultural system that both minimizes its negative environmental effects while optimizing the use of resources to achieve maximum outcomes. A systems approach that considers inputs, processes, outputs, and outcomes is one of the ideas that is taken into consideration.

In the era of precision agriculture, it is difficult for farmers to manage their land, crops, agricultural equipment utilized from pre-harvest to post-harvest or processing, as well as their human resources. The degree of precision agriculture implementation success will be significantly impacted by this. The rapid advancement of precision agriculture in Indonesia is likewise inextricably linked to the usage of contemporary technologies. In order to benefit the many phases of the agricultural production system, the technology used must be able to identify what is on agricultural land, determine what to do about it, and then administer therapy in response to those determinations. Since 1999, the Navigation Satellite System (GNSS) has been created. Many cattle industries employ GNSS technology to complete tasks involving automated control systems and geographic reference data. GNSS enhances the performance of auxiliary work equipment, Traffic Management Systems with regulated automated controls. Variable Rate Technology (VRT), which allows accurate seeding, planting optimization, denser and better application rates, and the efficacy of herbicides, insecticides, and fertilizers, is another crucial element of precision farming in agriculture. Cost effectiveness and a decrease in environmental contamination are therefore possible. In order to give data on vegetation indicators, such as monitoring chlorophyll content, stress levels, and their fluctuations in place and time, VRT can distinguish different wavelengths of multi-spectral and hyperspectral cameras mounted on drones. The employment of inexpensive crewless aerial vehicles (UAVs), sometimes known as drones, is given special consideration.

Processes may be made more efficient by using new and existing technologies, like the Internet of Things and Big Data, which can also result in the development of new goods and services. The farmer's perspective plays a key role in precision farming technologies. Farmers with the greatest orientation and enthusiasm kicked out this procedure in the early 1990s. Desperation ensued owing to a lack of assistance and relatively poor profitability. This strategy is now being used almost completely by the private sector, which provides farmers with equipment, goods, and services. Sadly, there aren't many national advising services for agriculture.

Physical layer

A layer of automation for managing the smart agricultural system is the physical layer. A control monitoring system and sensors are included in the automation process controller. It is intended to control and controls the sensors and also carries out system device monitoring. Soil moisture sensors, temperature sensors, motion detection sensors, water level sensors, and photosynthesis sensors are all employed in the automation process. This sensor is a component of the IoT Layer's IoT Devices category. These sensors are designed to monitor soil moisture levels, crop water requirements, plant temperature, environmental conditions, and animal movements. The automation field was observed using CCTV cameras, infrared cameras, water systems, and weather monitoring systems. In order to enable automation, the underlying communication protocols act as an interface between any two or more devices based on real-time data.

A process controller for automation

The sensors and monitoring tools of the physical layer provide input to the IoT devices. The in-house server makes use of the Internet of Things data manager, which gets real-time data from the system controller. It briefly saves data on a local server. The cloud receives data from the gateway and analyzes it before starting the appropriate service. Through a clearly defined security channel, the Com-Op layer gets real-time data from the IoT layer. Depending on the data received, a specific service is then selected.

Layer IoT

The IoT layer is where data from the physical field is gathered and transferred to the Comp-op layer for further processing. A system controller is present in the IoT layer, and the IoT devices are linked to it. For instance, a physical local system receives data from the devices and uses this system controller to move it from the local server to the main cloud server. The IoT devices feed data to the controller and issue alerts every second, notifying the controller of any changes. Digital cameras, embedded electronics, and wireless sensors are the core components of the automation system. As a local server, the in-house servers are employed. It is a component of the automation process controller whereby locally developed servers house IoT data manager data that gathers data from the devices and saves it in temporary storage. Through the gateway used to move data from local to the main server in the cloud, the data is then sent to the cloud for processing.

System for monitoring and managing energy

The energy management and monitoring system is used to regulate the energy and power resources utilized in the automation process in order to conserve and minimize power and increase the efficiency of automation. The automation process controller in this area of the system may be programmed to regulate the power source that is linked to every device involved in the automation process. When sensors or capturing devices are not being used, the power sources are either lowered or switched off to conserve energy and improve automation.

Layer Com-op

To communicate data securely inside cloud services, the com-op layer security level protocols are utilized. It serves as a storage place for a variety of data kinds, storing both processed and unprocessed data. The analyzer is the primary mechanism for processing data and making decisions and preparations for subsequent processes based on the results. When specific messages, warnings, and alerts are sent by cloud services to the client, the services are the full-power processes that are established for the client to determine what should be done.

CONCLUSION

By improving the quality and production management, which allows the farmers to obtain a significant number of results from the real-time data from the crop field, an IoT system development for agriculture might address various real-time concerns. The cloud connects three levels in the architecture. The devices are all linked, and all data is uploaded, analyzed, and retrieved by API libraries. Crop cultivation techniques are offered as a process flow that is presented from the beginning of planting through crop producing. The testing is done on groundnut and banana crops, and the signals from various sensors are gathered and put in the cloud to combine with IoT for automation and effective decision-making. The system is operating successfully and efficiently. The architecture suggested in this study could serve as a foundation for the creation of an IoT-based smart agricultural system. The layers utilized in this architecture are meant to store, manage, and monitor crop growth information as well as to enable effective decision-making for the usage of fertilizers, water supply, and crop planting based on information gathered from sensors linked to the field's ground. The suggested work has been evaluated on actual agricultural fields, with a 98% accuracy rate based on the data stream.

The rural area is very important to the district. It is moving toward a laissez-faire economy via a cycle of important changes in the social, legal, auxiliary, helping, and graciously setups, just as it is in all other sectors of the economy. A good cultivation is taking hold significance resulting from the interaction of the growing global population, the growing desire for higher harvest yields, the need to effectively use natural resources, the growing use and complexity of knowledge and communication technology, and consequently the growing demand for environment conscious. This chapter reviewed how changes in new technologies have affected agriculture.

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CHAPTER 23

UTILIZATION OF ARTIFICIAL INTELLIGENCE IN MODERN AGRICULTURE

Kusum Farswan, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- kusumfarswan.14feb@gmail.com

ABSTRACT:

The future of AI in farming will be significantly impacted by the adoption of AI technologies. The agriculture industry needs greater help even though some major research are happening and several applications are now on the market. Furthermore, the creation of predictive solutions to a real issue faced by farmers in farming is still in its infancy.

KEYWORDS:

Agriculture, Artificial Intelligence, Climate Change, Machine Learning, Organic Farming, Sustainability, Vertical Crop Growing,

INTRODUCTION

For any nation's economic sector, agriculture is essential. The need for food is rising along with the global population on a daily basis. At this time, the farmers' conventional techniques are unable to meet the demand. In order to meet these needs and provide many individuals in this industry fantastic career prospects, various innovative automation approaches have been devised. In every industry, including education, finance, robotics, agriculture, etc., artificial intelligence has emerged as one of the most significant technological advancements. It is revolutionizing the agriculture industry and playing a very important part in the agricultural sector. AI protects the agricultural industry from a number of concerns, including food safety, population increase, climate change, and job difficulties. AI, modern agriculture has advanced to a new level. Crop production, real-time monitoring, harvesting, processing, and marketing have all been enhanced by artificial intelligence. In order to identify numerous crucial criteria, including weed identification, yield detection, crop quality, and many more, different high-tech computer-based systems are created.

Artificial intelligence is founded on the idea that human intellect can be described in a manner that makes it easy for a computer to imitate it and carry out tasks of any complexity. Artificial intelligence has three main objectives: learning, reasoning, and perception. Some examples include voice and language recognition in the Siri virtual personal assistant on the Apple iPhone, vision-recognition systems in self-driving vehicles, and recommendation engines that make product suggestions based on what you've previously purchased. In many facets of the business, AI is having a significant influence. Every sector is attempting to deploy intelligent equipment to automate certain tasks. And all you need to enter any sector is an excellent artificial intelligence course online. By 2050, the population is predicted to exceed nine billion, necessitating a 70% increase in agricultural output to meet the need. Land, water, and other resources are running out due to the growing global population, making it impossible to maintain the demand-supply cycle. Therefore, we must adopt a wiser strategy, increase our level of efficiency while farming, and strive to maximize our output. In this paper, people will discuss the difficulties farmers experience while utilizing conventional agricultural techniques as well as how artificial intelligence is revolutionizing the industry by replacing inefficient old techniques with more effective ones and making the world a better place. In Figure 1 shown the Process of Agriculture into different parts.

Lifecycle of Agriculture

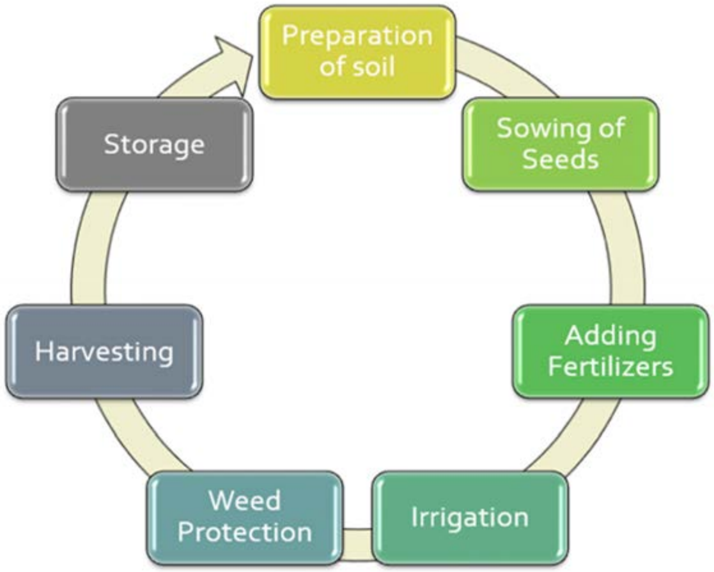

Figure 1: Illustrate the Process of Agriculture into different parts.

Soil preparation

The first step of farming involves farmers preparing the ground for seeding. Large dirt clumps must be broken up and debris, such as sticks, pebbles, and roots, removed during this procedure. Additionally, depending on the kind of crop, add fertilizers and organic materials to the environment to make it appropriate for crops. Planting of seeds At this point, attention must be paid to the spacing and planting depth of seeds. Climate factors including temperature, humidity, and rainfall are significant during this stage.

Fertilizer Addition

Maintaining soil fertility is crucial for the farmer to be able to create nourishing and robust crops. Fertilizers are used by farmers because they provide plant nutrients including nitrogen, phosphorus, and potassium. Fertilizers are just nutrients that are planted and added to agricultural areas to augment the necessary minerals already present in the soil. This stage affects the crop's quality as well.

- *Irrigation:* This step aids in maintaining humidity and soil moisture. Crop development may be hampered by under- or overwatering, and if done improperly, can result in damaged crops.
- *Protecting against weeds:* Weeds are unwelcome plants that sprout up next to crops or along agricultural boundaries. Because weeds reduce yields, raise production costs, interfere with harvest, and degrade crop quality, weed prevention is a crucial consideration.

Gathering mature crops from the fields is the process of harvesting. This activity is labor-intensive since it calls for several workers. Additionally, post-harvest processing tasks including cleaning, sorting, packaging, and refrigeration are included in this step. Storage is the stage of the post-harvest system when items are held in order to ensure food security outside of agricultural seasons. Crop packaging and transportation are also included.

Challenges farmers who use traditional agricultural practices must overcome

- In farming, climatic variables including rainfall, temperature, and humidity are crucial to the cycle of agriculture. Farmers find it challenging to make judgments on how to prepare the soil, plant seeds, and harvest as a result of rising deforestation and pollution.
- The soil must have a certain level of nutrients for each crop. The three primary nutrients that soil needs are nitrogen (N), phosphorus (P), and potassium (K). Poor crop quality may result from nutritional insufficiency.
- Weed control is crucial, as can be seen from the lifespan of agriculture. Unless it is regulated, it may raise production costs and deplete the soil of nutrients by absorbing nutrients from the soil.

Artificial intelligence applications in agriculture

In order to improve a wide range of agriculture-related tasks throughout the entire food supply chain, the industry is turning to Artificial Intelligence technologies. These technologies can help produce healthier crops, control pests, monitor soil and growing conditions, organize data for farmers, lessen workloads, and organize pests. Utilization of weather forecasts: Farmers find it challenging to determine the best time to sow seeds due to climate change and rising pollution. With the aid of artificial intelligence, farmers can analyze weather conditions by using weather forecasting, which helps them plan the type of crop that can be grown and when seeds should be sown.

System for assessing the health of crops and soil: The kind of soil and nutrition of the soil have a significant impact on the crops that are produced and their quality. The quality of the soil is deteriorating as a result of growing deforestation, making it difficult to assess. An IT startup established in Germany PEAT has created an AI-based tool called Plantix that can detect nutrient deficits in soil as well as plant pests and illnesses, giving farmers the knowledge they need to utilize fertilizer to increase the quality of their crop. Utilizing picture recognition-based technologies, this app. Smartphones may be used by the farmer to take pictures of the plants. Through brief movies on this program, we can also view soil restoration methods with advice and other alternatives.

In a similar vein, Trace Genomics is another machine learning-based business that aids farmers in doing a soil study. With the use of these kinds of apps, farmers can monitor the quality of their soil and crops, resulting in healthier, more productive harvests. Drone-based crop health analysis Crop health monitoring systems based on drone-based Ariel imagery have been introduced by SkySqurrel Technologies. This method uses a drone to collect data from fields, which are subsequently sent by USB drive to a computer for expert analysis. This business analyzes the photographs it has collected using algorithms and then provides a thorough report on the state of the farm. It aids in the identification of pests and germs, enabling farmers to utilize pest control measures and other approaches when necessary to take the necessary action.

Predictive analytics and Precision Agriculture the use of AI in agriculture has produced tools and applications that assist farmers in conducting accurate and controlled farming by giving them the necessary instructions regarding water management, crop rotation, timely harvesting, the type of crop to be grown, the best time to plant, pest attacks, and nutrition management. AI-enabled systems provide weather predictions, monitor agricultural sustainability, and assess farms for the presence of diseases or pests and undernourished plants using data like temperature, precipitation, wind speed, and sun radiation in conjunction with photographs taken by satellites and drones.

With equipment as basic as an SMS-enabled phone and the Sowing App, farmers without connection may profit from AI right now. Farmers with Wi-Fi connectivity may utilize AI apps to acquire a constantly AI-tailored plan for their farms, in the meanwhile. Farmers can fulfill the rising demand for food while boosting output and income responsibly and without diminishing priceless natural resources with the help of IoT and AI-driven technologies. AI will assist farmers in the future as they become agricultural scientists, using data to maximize yields down to individual plant rows.

Robotics for Agriculture

AI firms are creating robots that can effortlessly carry out a variety of activities in agricultural settings. When compared to people, these robots are taught to harvest crops more quickly and in greater quantities while controlling weeds. These robots are taught to harvest and pack crops while simultaneously inspecting the crops' quality and looking for weeds. These robots can also overcome the difficulties experienced by agricultural laborers. AI-powered pest detection system: One of the deadliest adversaries of farmers that cause agricultural damage are pests. AI systems employ satellite photos and historical data to determine if any insects have landed and, if so, which species such as locusts, grasshoppers, and others have done so. AI aids farmers in their battle against pests by sending notifications to their cellphones so that farmers may take the necessary measures and use the necessary pest management.

LITERATURE REVIEW

Yubin Wang et al. [1] studied the growth of modern agriculture urgently requires accelerating the use of artificial intelligence (AI) and other contemporary information technologies, which will support the creation of digital villages, smart agriculture, and national rural regeneration strategies. We reviewed the key technologies of agricultural AI and the state of research in agricultural AI for planting, poultry, animal husbandry, and the traceability and classification of agricultural products in order to thoroughly analyze the potential and direction of smart agriculture driven by AI technology. Humans also examined the gap between agricultural AI technologies at domestically and internationally as well as the international situation as well as challenge of agricultural AI technology in China, and we proposed a remedy.

Jinha Maeda et al. [2] studied the availability of land, water, and more lately, a pandemic, are all putting growing strain on modern agricultural and food production systems. The economic and environmental viability of the present and future food supply systems are being threatened by these issues. More than ever, scientific and technical advancements are required to ensure there is enough food for a rapidly expanding worldwide population. From the cellular to the field level, scientific advancements have improved our comprehension of how diverse agricultural system components interact with one another. They have made tremendous strides in genetic tools over the last several decades, but until recently, we were sorely deficient in our capacity to reliably evaluate crop condition at scale in the field. They are now able to correctly quantify field scale phenotypic information and incorporate big data into predictive and prescriptive management systems as a result of recent advancements in remote sensing and Artificial Intelligence (AI).

Ammulu et al. [3] studied although agriculture is essential to human life, our nation will produce less owing to a lack of information and support for our decisions. In order to estimate the best scenario for the production of a certain crop, data are examined and grouped based on the user's requirements. The introduction of artificial intelligence (AI) into Indian agriculture has a significant impact on our whole civilization. Despite the fact that machine learning, a branch of artificial intelligence, has been used for classification and forecasting tasks in, to name a few, food grading and crop yield forecasting, a new set of deep learning and data science algorithms indicates that there is potential to advance the study of and use of AI to much higher levels and with much greater accuracy. Similar to this, other AI approaches are demonstrating benefits across various industries, including agriculture.

Miguel A. Llanes et al.[4] Studied the digital revolution is being driven by the Internet of Things (IoT). Al Thanks to the analysis of data produced by IoT, almost all economic sectors are becoming "Smart" in some way. Advanced artificial intelligence (AI) approaches are used for this investigation to provide insights that had not previously been thought of. An emerging trend known as AIoT is the result of the integration of IoT with AI, and it is opening up new avenues for the advancement of digitalization in the modern day. But there is still a significant difference between AI and IoT, namely in the former's need for processing capacity and the latter's lack of such resources. This is especially true in rural IoT situations, where a lack of connectivity (or low-bandwidth connections) and a lack of power supply require researchers to look for "efficient" options to give computing resources to IoT infrastructures without increasing power consumption.

Aggarwal et al. [5] studied Things grew sentient as a result of technological advancements and gained the ability to self-communicate with one another. The Internet of Things (IoT) made common home items linked to the Internet and gave them decision-making abilities comparable to those of the human mind. Real atmospheric data is collected by sensors, and data analysis is done with the aid of artificial intelligence (AI) algorithms to make devices act more shrewdly. The topic of this essay is how IoT transformed the agriculture industry. In India, it is estimated that 70% of the population depends on agriculture for a living, yet the situation of agriculture is no longer kept secret from society. Technology makes it simple to forecast weather conditions like temperature, precipitation, humidity, the demand for fertilizers, water use, etc. Modern agricultural methods integrating IoT and AI are transforming conventional agricultural practices and turning farming into a lucrative business.

Loukatos et al. [6] studied Numerous low-cost credit card-sized computers that can run educational apps with artificial intelligence characteristics and are aimed for students of different levels have emerged in response to the boom in the mobile phone industry. This essay discusses the educational process and emphasizes the technologies used to enhance the performance of home-built robots. The study also discusses how the pupils viewed the event. Despite their limited programming experience and time constraints, the students taking part in this problem-based learning exercise sought to come up with effective strategies to enhance the DIY robotic car build and interact with it more effectively. Investigational scenario instances mostly used smart phones or tablets and used touch button, gesture, and speech recognition technologies that took advantage of contemporary AI advances.

Sharma, Robin [7] studied In the aforementioned circumstance, it is necessary to develop more cogent agricultural procedures by employing current technical breakthroughs and to remove persistent farming hurdles. A change in the way farming is practiced at the moment might be embodied by an unwavering use of artificial intelligence and its subsets in agriculture. Numerous challenges are faced in the agricultural sector, including illness, incorrect soil analysis, insect infestation, irrigation, poor drainage, and many more. Due to these difficulties, excessive pesticide use causes severe crop loss and hazardous environmental dangers. Artificial intelligence and its thorough learning capabilities have developed into a crucial strategy for addressing a range of farming-related difficulties. The applications of AI techniques in several fields of agricultural research, as well as industry insights and obstacles to AI adoption in agriculture, are highlighted in this study.

Loukatos et al.[8] studied the electronics industry's explosive expansion and the widespread accessibility of specially designed programming tools and assistance are hastening the agriculture sector's digital transition. In order to meet the demands of Earth's continually expanding population, the latter transition seems to create expectations for combating the depletion and degradation of natural resources and boosting productivity. Therefore, anybody engaged in contemporary agriculture, from farmers to students, should learn about, be able to utilize, and enhance the cutting-edge systems that are emerging. Students of agricultural engineering are not an exception.

Srinivas Kumar et al. [9] studied Agriculture, sometimes known as farming, is the science and practice of growing plants. It is essential to the development of human life. By farming with domestic animals, it produces food and other associated goods, allowing humans to live long and healthy lives. Both ancient agriculture and modern agriculture fall under the umbrella of agriculture.

Farmers in traditional agriculture faced numerous challenges, but with modern agriculture, they can observe many improvements in farming thanks to agronomy, the use of agricultural chemicals like pesticides and fertilizers, plant breeding, and technological advancements, all of which will produce good crops. The term "Internet of Things," or "IoT," refers to a system that may link actual physical objects, implanted sensors, embedded software, and other technologies in order to connect and transmit data across numerous different devices through the Internet.

Fedotova et al. [10] studied The goal of the study is to evaluate how the shift to intellectual technologies for controlling production processes in many realms of public life has changed the structure of national economic systems today.

In light of the mounting possibility of a food shortage, the writers focus on certain aspects of contemporary agriculture's growth. It is imperative that agriculture's production of food goods be intensified in order to address the issue of the planet's population expansion. It is vital to seek for new, inventive manufacturing methods that allow for the greatest possible cost reduction and a rise in the quantities of produced goods since the production areas are stable. The goal of the program to digitize all aspects of public life via the use of digital tools and processes is to unlock the potential and resources of currently used conventional methods for solving issues.

DISCUSSION

Challenges in Agriculture using traditional methods

- People must first grasp the issues in agriculture using conventional approaches, which are listed below, before we can appreciate the effect and applications of AI in agriculture.
- In agriculture, several weather variables including rainfall, temperature, and humidity are crucial. Because of pollution, the environment might sometimes change unexpectedly, making it difficult for farmers to decide when to harvest, plant seeds, and prepare soli.
- A productive soil with the proper nutrients, such as nitrogen, phosphorus, and potassium, is essential for a better harvest. Poor quality crops may result if these nutrients are not effectively present in the soil. However, these soil qualities are challenging to determine using conventional methods.
- In the cycle of agriculture, protecting our crops against weeds is essential. If not, it might raise the cost of manufacturing while also absorbing nutrients from the ground. However, agricultural weed detection and prevention using conventional methods are ineffective.

Applications of Artificial Intelligence in Agriculture

Figure 2: Illustrate the Implementation Artificial Intelligence In Agriculture.

Farmers would encounter a plethora of difficulties, just as with conventional agricultural practices. In this industry, AI is often utilized to address these problems. Artificial intelligence is now a ground-breaking technique in agriculture. By producing better crops, controlling pests, monitoring the soil, and in a variety of other ways, it benefits farmers. Several significant uses of artificial intelligence in agriculture are shown in Figure 2:

Price and weather forecasting: As we covered in problems, farmers find it challenging to make the best choices for harvesting, planting seeds, and sole preparation because of climate change. But with the use of artificial intelligence (AI) weather forecasting, farmers may gain knowledge of weather analysis and, in accordance, plan for the sort of crop to grow, the seeds to sow, and crop harvesting. Farmers may have a better sense of the price of crops for the next few weeks with the aid of price forecasting, which can allow them to maximize profit.

Crop health monitoring

The kind of soil and nutrition of the soil have a significant impact on crop quality. However, it is difficult to assess the soil quality because of the daily decline brought on by the pace of deforestation. AI has developed a brand-new program named Plantix to address this problem. PEAT created it in order to detect soil inadequacies, such as plant pests and illnesses. This application may provide farmers ideas on how to apply better fertilizer to increase the quality of their produce. Farmers may use this app to take pictures of their plants and get information about their quality thanks to AI's image recognition capability.

Agriculture Robotics

Robotics is extensively utilized to carry out complicated tasks in a variety of industries, mostly in manufacturing. Currently, several AI firms are creating robots for use in the agriculture industry.

These AI robots are designed so that they can do a variety of agricultural activities. AI robots are also taught to inspect crops for quality, spot and eradicate weeds, and harvest crops more quickly than a person. Cannabis can be quickly and readily recognized using AI sensors, which can also identify weed-affected locations. Herbicides may be accurately applied in these locations after locating them, which reduces the need for herbicides while also saving time and crop. A variety of AI firms are developing robots with computer vision and AI that can accurately spray weeds. The usage of AI sprayers may significantly decrease the amount of pesticides needed to be applied to fields, improving crop quality and reducing costs.

Diagnoses of illnesses

Using AI predictions, farmers may readily learn about illnesses. With this, they can quickly and effectively identify illnesses. It may save both plants' lives and farmers' time. First, computer vision technology is used to pre-process photos of plants. This guarantees that plant photos are appropriately segmented between the healthy and unhealthy sections. The infected area is cut off after discovery and sent to the laboratory for further diagnosis. This method also aids in the identification of pests, vitamin deficiencies, and many other things.

Precision agriculture

"Right location, Right time, and right goods" are the three pillars of precision farming. The labor-intensive aspect of farming that involves performing repeated chores may be replaced by the precision farming technology, which is considerably more precise and regulated. The measurement of plant stress levels is one instance of precision farming. High-resolution photos and other plant sensor data may be used to get this. The machine learning model used for stress identification is then given the sensor data as input.

The advantages of AI in agriculture

Advantages

AI improves decision-making

The agricultural sector greatly benefits from predictive analytics. It aids farmers in overcoming the major difficulties they face in farming, including analyzing market needs, predicting prices, and determining the best window of time to plant and harvest a crop. Additionally, AI-powered equipment can assess the health of the soil and the crops, suggest fertilizer applications, track the weather, and assess crop quality. The farmers can make better judgments and practice effective farming thanks to all these advantages of AI in agriculture.

AI reduces expenses

With fewer labor and resources required, farmers may produce more crops by employing precision farming techniques and AI-enabled machinery. Farmers can make informed decisions at every step of farming thanks to the real-time information that AI offers them. With this wise choice, there will be less product and chemical loss and more effective use of both time and money. Additionally, it enables the farmers to pinpoint the precise locations that need irrigation, fertilization, and pesticide application, preventing the overuse of chemicals on the crop. Together, these factors lead to a decrease in the usage of pesticides, improved crop quality, and more profit while using fewer resources.

AI helps with the labor deficit

The agricultural sector has long struggled with a labor deficit. This problem of agricultural automation can be resolved by AI. Farmers may complete tasks without adding additional workers thanks to AI and automation. Some examples are driverless tractors, intelligent irrigation and fertilization systems, smart spraying, vertical farming software, and AI-based harvesting robots. When compared to human agricultural workers, AI-powered machinery and equipment are significantly quicker and more precise.

CONCLUSION

With the use of artificial intelligence, farmers may automate their operations while also switching to precision cultivation for improved crop quality and production while using less resources. Future technological advancements will enable businesses that use machine learning or artificial intelligence to produce goods and services like training data for drones, automated manufacturing, and agriculture to offer more beneficial applications, assisting the world in addressing issues related to food production for the expanding population.

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CHAPTER 24

AGRICULTURAL PRODUCTION AND PROFITABILITY ARE IMPROVING AS A CONSEQUENCE OF TECHNOLOGICAL ADVANCEMENTS

Kuldeep Mishra, Assistant Professor
College of Agriculture Science, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India
Email Id- mishraypikuldeep@gmail.com

ABSTRACT:

Agriculture has been much more productive because to the application of technology, which also allayed any worries about future food shortages. Technology has advanced thanks to the development of agricultural sensors, irrigation systems, and fertilizers have contributed to maximizing agricultural yields, and variable rate technologies have made sure that fields get the necessary quantity of input, which will ultimately result in significant gains in output. History demonstrates that farmers have generally been adept at embracing new techniques and technology.

KEYWORDS:

Agriculture, Artificial Intelligence, agricultural yields, Disease, sustainability.

INTRODUCTION

Over time, technology has changed how farming is done, and it has had a wide range of effects on the agricultural sector. There will be increasing pressure on the land since only an additional 4% of the planet's surface will be cultivated by 2050, when the population is projected to rise from 7.5 billion to 9.7 billion. Agriculture is the primary employment in many nations across the globe. Farmers will thus need to work harder with fewer resources. The same report estimates that in order to feed an extra two billion people, food output must rise by 60%. Traditional approaches, nevertheless, are unable to meet this enormous demand. This is pushing farmers and agricultural businesses to develop fresh strategies for raising output and cutting waste. As a consequence, Artificial Intelligence (AI) is progressively becoming a part of the technical advancement of the agricultural sector. To feed an extra two billion people, the task is to boost global food output by 50% by the year 20202. AI-powered solutions will help farmers increase productivity while also enhancing crop quality, quantity, and ensuring a quicker time to market.

Farming using Artificial Intelligence

AI-powered chemical spraying reduces costs by being more intelligent

Thousands of data points on temperature, soil, water use, weather, etc. are generated daily by farms. This data is used in real-time by artificial intelligence and machine learning models to get insightful knowledge, such as when to plant seeds, which crops to choose, which hybrid seeds to choose for higher yields, and other things.

Precision agriculture, often known as artificial intelligence systems, is assisting in enhancing the overall quality and accuracy of harvests. AI technology aids in the detection of pests, plant diseases, and undernutrition in farms. Artificial intelligence (AI) sensors can identify and target weeds before deciding which herbicide to use in the area. This lowers the need for herbicides and lowers costs. Many technical firms created robots that accurately monitor weeds with spray guns by using computer vision and artificial intelligence. These robots may reduce the amount of pesticides that are typically sprayed on crops by 80% and the cost of herbicides by 90%. By substantially reducing the amount of pesticides required in the fields, these smart AI sprayers may increase the quality of agricultural output while also bringing about economic efficiency.

Farm harvesting using AI-based robots: Overcoming the manpower shortage

Have you ever wondered who harvests the crops on the farmland? Actually, the majority of the time the food that ends up on your dinner plate is not the result of a regular farm worker, but rather robotic robots that are capable of mass harvesting with greater precision and speed. These devices aid in increasing crop yield size and decreasing agricultural waste that is left in the field.

The efficiency of agriculture is being improved by several businesses. Products like an autonomous strawberry-picking equipment and a vacuum harvester for ripe apples are available. These devices locate the harvestable produce and assist in fruit selection using sensor fusion, machine vision, and artificial intelligence models. The second-largest sector after defense where service robots have been used professionally is agriculture. According to the International Federation of Robotics, up to 25,000 agricultural robots have been marketed, which is the same amount utilized for military applications.

Using AI for predictive analytics - Facilitates making the correct decisions

Estimating the ideal time to plant

A single data point about the timing of seed planting may make the difference between a successful year and a failing one. To tackle this, ICRISAT scientists employed a predictive analytics technique to determine an exact timing for planting the seeds in order to get the most yield. In addition to a 7-day weather prediction, it also provides information on the health of the soil and fertilizer suggestions.

The variation in the crop's price is a major source of concern for many farmers. Farmers are never able to set a certain production pattern because of fluctuating pricing. When it comes to crops with a short shelf life, like tomatoes, this issue is particularly common. Companies examine the land and continuously monitor crop health using satellite images and meteorological data. Big data, AI, and machine learning technologies enable businesses identify pest and disease infestations, calculate tomato production and yield, and anticipate pricing. They may advise farmers and governments on future pricing trends, demand levels, the best crops to plant for optimum profit, the use of pesticides, and other topics.

Artificial intelligence is being used in agriculture by creative businesses. A Berlin-based agricultural technology startup3 created a multilingual plant disease and pest diagnostic app that uses images of the plant to find diseases. A smartphone gathers the image and compares it with a server image, which then provides a diagnosis of that specific disease that is then applied to the crop using intelligent spraying technique. In order to address plant diseases, the program makes use of AI and ML. This software has been downloaded by over 7 million farmers and has assisted in the identification of over 385 agricultural diseases in field crops, fruits, and vegetables.

LITERATURE REVIEW

Gagan Rashide et al. [1] studied Farmers are under tremendous pressure to boost agricultural productivity, so they indiscriminately use synthetic pesticides and fertilizers without considering the negative effects on the environment. Increased use of synthetic fertilizers not only harms the environment and human health, but also reduces profit owing to their expense.

As a consequence, an agricultural production strategy that is economical, ecologically friendly, and capable of boosting output and profitability at the same time is needed. Through a range of intricate techniques including biological nitrogen fixation, antibiotic production, systematic resistance development, siderophores, growth hormones, enzymes, organic acids, and many more, beneficial bacteria benefit both crops and soil.

Sagar Brestic et al. [2] studied For sustaining high food production, agricultural sustainability is crucial. Responsible resource management has a detrimental impact on agroecology as well as the production system's capacity to generate a profit. Soil is one of the most important resources for agriculture, among other resources. The secret to achieving great agricultural output is fertile soil. Conscious management efforts must be made to prevent excessive nutrient loss, maintain organic carbon content, and reduce soil pollution in order to maintain soil fertility and soil health. Even though the use of chemical fertilizers has successfully increased crop production, its integration with organic manures as well as other bio-inoculants aids in increasing the efficiency with which nutrients are used, improves soil health, and to some extent alleviates some of the problems related to excessive fertilizer application.

Xiaoyu Kung et al. [3] studied in many places, pyrolysis and gasification are promising renewable technologies because they may provide renewable energy while also increasing energy sustainability. This research, in contrast to smaller-scale studies, intends to aggregate the economic and environmental implications, such as agricultural benefits, energy sales, and carbon sequestration, to provide decision-makers more thorough knowledge before these initiatives are extensively implemented. The feasibility, economic viability, and emission reduction of four key pyrolysis and gasification technologies utilizing agricultural residuals are first investigated in this research using a lifecycle assessment, followed by a sensitivity analysis to look at the most important variables.

Ramírez-Arpide et al. [4] studied Agriculture biomass may be digested anaerobically to provide renewable energy that is both inexpensive and ecologically beneficial. This research assessed the economic viability of producing biogas on a farm in Mexico by co-digesting manure and nopal. Biogas production, power generation, and methane production were the three use paths examined. The overall advantages also included the opportunity to utilize digestate and reduce greenhouse gas emissions.

Garcia-Ulloa et al. [5] studied the fifth-largest producer of palm oil worldwide is Colombia. By 2020, the government of the nation and the organization of oil palm growers want to have increased output of crude palm oil by a factor of six. Through a spatially explicit scenario analysis, we predict the effects of increasing oil-palm production in Colombia. Given the low environmental value and economic utility of pasture lands as well as their great agricultural potential, we show that by building new plantations on pasture lands, the effects of oil-palm development (such as deforestation and the conversion of natural savannahs) would be mitigated. It may be possible to make up for the effects of oil-palm development on cattle and dairy output by increasing the productivity of other grazing areas.

Ustyna Len et al. [6] studied the development of the quality of life for those who live in rural regions as well as the best use of rural resources are the key aims of the European Union's (EU) common agricultural policy. Land consolidation projects, which aim to improve the territorial organization of farms, forests, and forestland; reasonable land configuration, which aligns the boundaries of real properties with the irrigation system; drainage facilities, roads, and terrain, are the most effective tools for improving management conditions and utilizing the potential of land. Poland's agricultural development and output capability varied greatly in terms of spatial distribution.

Monlau et al. [7] studied the market for the generation of biogas by anaerobic digestion (AD) is expanding very quickly in the agricultural sector of several European nations. The biological conversion of an organic matrix into biogas and digestate, the latter of which corresponds to the anaerobically non-degraded fraction, via AD is a straightforward and reliable process. Digestate has mostly been used up to now for soil improvement on farms. However, because to its high nitrogen concentration and concerns with shipping costs and greenhouse gas emissions during storage, its usage is restricted to only terrestrial application. Therefore, future interest in studies on alternate valorisation pathways to lessen AD plant environmental impact and increase economic viability should grow.

Ostaev et al. [8] studied in recent years, the Russian economy's agrarian sector has seen rapid growth, placing unique demands on agricultural organizations that need swift responses and decision-making based on strategic analytical techniques. Agricultural firms may accomplish the objectives they had established throughout the business planning process by employing trustworthy information, instruments for analytical activities, and wise management choices. Any management choice in agriculture should be based on current information that has been carefully considered, taking cost effectiveness, usefulness, profitability, and efficiency into consideration. For the growth of the agricultural organization, it is vital to analyze this company over the long term while taking management effectiveness into consideration. The issue of a thorough evaluation of an organization's management performance is not addressed in management accounting for agricultural output, and the significance of a business evaluation is also understated. The enhancement of management accounting in terms of a thorough evaluation of the management effectiveness of agricultural organizations, based on readily accessible accounting documentation for both internal and external users, is the focus of the research. The primary aim was established in line with the stated objective: to provide suggestions for enhancing management accounting methods and to evaluate the efficiency of management of agricultural enterprises.

Martin C. Keoleian et al. [9] studied the US food system is in need of transformation. Understanding the connections between food consumption patterns, processing and distribution activities, and agricultural production techniques is essential to enhancing the sustainability of this intricate system. An effective paradigm for examining the connections between societal requirements, the natural and economic processes involved in addressing these needs, and the resulting environmental effects is the product life cycle method. The main objective is to direct the creation of system-based solutions. Indicators for all phases of the food system's life cycle are presented in this research. Aspects of each life cycle stage are covered by indicators, including the origin of (genetic) resources, agricultural production, food processing, packaging, and distribution, as well as end-of-life care. The report then provides a first critical assessment of the state of the US food system by taking developments in the different variables into account. Rates of agricultural land conversion, income and profitability from farming, the degree of food industry consolidation, the percentage of edible food wasted, diet-related health costs, the age distribution of farmers, the legal status of farmworkers, the rate of soil loss and groundwater withdrawal, and the intensity of fossil fuel use are some of the key trends.

Cevdet Manirakiza et al. [10] studied The profitability of a sandy clay loam (SCL) soil is well known to be constrained by poor aggregation as well as rapid infiltration, aggregate stability, and drainage of water, in addition to low capacity to retain water and nutrients, which ultimately leads to decreased water and fertilizer use efficiency, which in turn decreases agricultural production. Thus, it has long been suggested that organic materials provide a viable means of resolving the aforementioned issues in various soil types. In light of this, the purpose of this research was to ascertain the impact of adding Oleaster tree pruning residues (OPR) as an organic material in two distinct forms on enhancing aggregation and water retention properties of a SCL soil.

DISCUSSION

Using AI for predictive analytics - Facilitates making the correct decisions

A single data point about the timing of seed planting may make the difference between a successful year and a failing one. To tackle this, ICRISAT scientists employed a predictive analytics technique to determine an exact timing for planting the seeds in order to get the most yield. In addition to a 7-day weather prediction, it also provides information on the health of the soil and fertilizer suggestions.

Forecasts for Crop Output and Prices

The variation in the crop's price is a major source of concern for many farmers. Farmers are never able to set a certain production pattern because of fluctuating pricing. When it comes to crops with a short shelf life, like tomatoes, this issue is particularly common. Companies examine the land and continuously monitor crop health using satellite images and meteorological data. Big data, AI, and machine learning technologies enable businesses identify pest and disease infestations, calculate tomato production and yield, and anticipate pricing. They may advise farmers and governments on future pricing trends, demand levels, the best crops to plant for optimum profit, the use of pesticides, and other topics. Artificial intelligence is being used in agriculture by creative businesses. A Berlin-based agricultural technology startup3 created a multilingual plant disease and pest diagnostic app that uses images of the plant to find diseases. A smartphone gathers the image and compares it with a server image, which then provides a diagnosis of that specific disease that is then applied to the crop using intelligent spraying technique. In order to address plant diseases, the program makes use of AI and ML. This software has been downloaded by over 7 million farmers and has assisted in the detection of over 385 agricultural diseases in field crops, fruits, and vegetables.

Enhancing crop quality and controlling illness

Identification of pests and illnesses has been an important use of AI. With nothing more than a cell phone, farmers can spot pests and plant diseases thanks to customized databases for certain crops. The expense of consulting an expert is avoided, and most significantly, there is no delay in diagnosis. Additionally, weeds are being located and targeted using sensors. Robots are sometimes employed to remove weeds, and in other cases, they aid in the precise administration of insecticides. One study team that used AI to identify illness in Tanzanian cassava plants discovered that the technique had a 98 percent accuracy rate. ML may help in accurately targeting the inputs in terms of time, location, and affected plants. This saves the farmer money by avoiding the costly practice of evenly spraying pesticides across the whole cropping area. This may lower the amount of chemicals needed, raise the caliber of the product, and save costs.

Forecasting and Advising Services for the Weather

Hyper-local weather forecasting is being advanced by AI and machine learning. More precise hyper localized weather forecasts are now achievable because to the vast amounts of data from weather satellites, together with the constantly growing number of weather stations and IoT devices on the ground. Some models have a resolution of 4 km. An growing number of warnings in a specific cluster of villages are now being targeted using this kind of hyper-local meteorological data. Using AI/ML technology, several agricultural scenarios may be generated using historical weather data, anticipated weather, crop type, and crop stage. These scenarios can then be used to offer targeted and accurate actionable warnings to farmers at the village level.

Management of Crops

The difference between a successful year and an unsuccessful crop may be entirely determined by the timely knowledge on when to plant the seed. In order to pinpoint the ideal period for planting for the highest yield, ICRISAT and Microsoft worked together to employ a predictive analytics technology. The mapping and assessment of yields, which aid in balancing supply and demand, is another crucial component of crop management. Machine learning models for particular crops in an area may be developed using remote sensing technology, NDVI models, and environmental factors to forecast precise yield estimates. Governments often employ these sorts of improvements in yield predictions, which eliminates or reduces the need for expensive crop cutting studies.

One of the important applications of AI/ML is the grading of agricultural commodities, including both horticultural crops like fruits and vegetables as well as field crops like grains and pulses. This will soon become a need throughout value chains. Think of using a sensor to measure the curcumin level of turmeric in real time. AI/ML algorithms may be taught to learn the different quality characteristics simply by scanning the product using hyper spectral imaging. The way we trade and assess commodities is about to change as a result of this sort of fast quality testing, which is now available for many crops.

Management of water

Water is the most valuable resource of all. Water consumption may be estimated daily, weekly, and monthly with the use of machine learning algorithms and IoT sensors on the ground. This is a big technological leap from the prevalent drip irrigation technologies, and it is already revolutionizing certain industries, including vineyards.

Managing price sensitivity

Farmers' earnings have been negatively impacted by price volatility and a lack of market knowledge for decades. Fortunately, AI/ML models are already being created that calculate price forecasts for various crops by taking into account historical trends, current cropping patterns, and demand predictions. The ability to operate farming like the majority of contemporary firms will be given to farmers as a result. Thousands of data points on temperature, soil, water use, weather, etc. are generated daily by farms. This data is used in real-time by artificial intelligence and machine learning models to get insightful knowledge, such as when to plant seeds, which crops to choose, which hybrid seeds to choose for higher yields, and other things.

Precision agriculture, often known as artificial intelligence systems, is assisting in enhancing the overall quality and accuracy of harvests. AI technology aids in the detection of pests, plant diseases, and undernutrition in farms. Artificial intelligence (AI) sensors can identify and target weeds before deciding which herbicide to use in the area. This lowers the need for herbicides and lowers costs. Many technical firms created robots that accurately monitor weeds with spray guns by using computer vision and artificial intelligence. These robots may reduce the amount of pesticides that are typically sprayed on crops by 80% and the cost of herbicides by 90%. By substantially reducing the amount of pesticides required in the fields, these smart AI sprayers may increase the quality of agricultural output while also bringing about economic efficiency.

The role of farmers as AI engineers in the future of agriculture?

Technology has been used in agriculture for a very long time to increase productivity and lessen the amount of demanding manual work needed for farming. Since the advent of farming, humankind and agriculture have evolved together, from better plows through irrigation, tractors to contemporary AI. Computer vision's expanding and more accessible availability might represent a big advancement in this area. Given the significant changes in our climate, ecology, and food demands worldwide, AI has the potential to improve 21st-century agriculture by:

- Increasing the productivity of labor, time, and resources
- Improving the sustainability of the environment

Real-time monitoring is provided to encourage improved product quality and health. Of course, the agriculture sector will need to change as a result. Agriculture will need to make significant technological and pedagogical expenditures if farmers are to effectively integrate their expertise of their "field" into AI training. However, agricultural ingenuity and adaptability are nothing new. The newest methods for farmers to utilize new technology to fulfill rising global food needs and improve food security include computer vision and agricultural robots.

Agricultural efficiency are raised, crop yields are improved, and food production costs are decreased thanks to AI, machine learning (ML), and Internet of Things (IoT) sensors that offer real-time data for algorithms. The world's population will rise by 2 billion people by 2050, necessitating a 60% increase in food output in order to feed them, according to the United Nations' population and hunger forecast figures. According to the Economic Research Service of the U.S. Department of Agriculture, the business of cultivating, processing, and distributing food in the United States alone is worth $1.7 trillion. By 2050, there will be an extra 2 billion people on the planet, and AI and ML have the ability to assist fill that gap. One of the most fertile sectors for artificial intelligence and machine learning is agriculture.

Imagine managing, excelling at, and monitoring at least 40 crucial activities simultaneously across a large agricultural region, generally measured in the hundreds of acres. A excellent challenge for machine learning is understanding how production is affected by the weather, seasonal sunshine, animal, bird, and insect migration patterns, crop usage of specific fertilizers and pesticides, planting and irrigation cycles, and several other factors. The importance of high-quality data for crop cycles has never been greater. In order to increase agricultural yields and quality, farmers, co-ops, and agricultural development firms are stepping up their data-centric strategies and broadening the breadth and scale of their usage of AI and machine learning.

Every agricultural field is monitored using real-time video feeds powered by AI and machine learning, which can detect animal or human breaches and quickly send out an alarm. Artificial intelligence (AI) and machine learning decrease the likelihood that domestic and wild animals may accidently harm crops or commit a break-in or burglary at a distant farm site. Everyone interested in farming can secure the perimeters of their fields and buildings thanks to the quick developments in video analytics powered by AI and machine learning algorithms. Systems for video surveillance using artificial intelligence and machine learning can scale for both small-scale farms and industrial-scale agricultural operations. Surveillance systems that use machine learning may be designed or educated over time to distinguish between people and vehicles. Leading provider of AI and machine learning-based surveillance, Twenty20 Solutions has successfully used machine learning to identify personnel who work on-site to secure distant sites, improve crops, and prevent trespassers.

By using drone visual analytics data and real-time sensor data, AI and machine learning enhance agricultural production forecast. The volume of data being gathered by intelligent sensors and drones broadcasting live video gives agricultural professionals access to brand-new data sets they have never had before. To assess growth trends for each crop over time, it is now able to integrate in-ground sensor data of moisture, fertilizer, and natural nutrient levels. The ideal technique for combining enormous data sets and offering constraint-based guidance for maximizing agricultural yields is machine learning. Here's an illustration of how artificial intelligence, machine learning, in-ground sensors, infrared vision, and real-time video analytics work together to provide farmers fresh perspectives on how to increase crop health and yields.

A farming method called yield mapping uses supervised machine learning algorithms to uncover patterns in massive data sets and recognize their orthogonality in real time, both of which are crucial for crop planning. Prior to the beginning of the vegetative cycle, it is feasible to estimate the prospective yield rates of a specific field. Agricultural experts can now forecast the potential soil yields for a specific crop using a mix of machine learning approaches to assess 3D mapping, social condition data from sensors, and soil color data collected by drones. To get the most precise data collection, many flights are made.

Large-scale agricultural enterprises, international organizations, and the UN are pioneering the use of in-ground sensors and drone data together to enhance pest control. Agricultural teams employing AI may detect and spot insect infestations before they happen utilizing infrared camera data from drones paired with sensors on fields that can monitor plants' relative health levels. As an example, consider how the UN and PwC are collaborating to assess data palm plantations in Asia for possible pest infestations.

Due of the current labor scarcity in agriculture, smart tractors, agribots, and robots powered by AI and machine learning are becoming a practical alternative for many distant agricultural operations. When large-scale agricultural firms run out of workers, they use robots to tend to hundreds of acres of crops and add a layer of protection to the perimeter of distant places. Self-propelled robotic technology that can be programmed to apply fertilizer evenly along each row of crops lowers operational costs and increases field output. The dashboard of the in-use VineScout robot serves as an illustration of how swiftly agriculture robot intelligence has increased.

Today, it is essential to improve the track-and-traceability of agricultural supply chains by reducing obstacles to bringing fresher, safer goods to market. Track-and-traceability adoption was driven by the pandemic across all agricultural supply chains in 2020, and it will continue to be increased this year. A well-managed track-and-trace system increases visibility and control across supply chains, which reduces inventory loss. Modern track-and-trace systems can distinguish between batch, lot, and container level material allocations in incoming shipments. The majority of cutting-edge track-and-trace systems depend on sophisticated sensors to learn more about the state of each shipment. In manufacturing, RFID and IoT sensors are getting more prevalent. At a trial project conducted by Walmart, track-and-trace performance in a distribution center was made more efficient by 16 times compared to manual approaches.

One of the most popular applications of AI and machine learning in agriculture nowadays is to optimize the proper mixture of biodegradable pesticides and restrict their application to just the field regions that require treatment. This helps to lower costs while improving yields. A planting area's most diseased regions may now be found utilizing intelligent sensors in conjunction with visual data streams from drones in agricultural AI applications. The best combination of insecticides may then be determined using supervised machine learning algorithms to lessen the possibility of pests spreading and infecting healthy crops.

In determining pricing strategies for a particular crop, price forecasting for crops based on yield rates that assist anticipate total quantities produced is crucial. Agricultural businesses, co-ops, and farmers may better bargain for the highest potential price for their harvests by understanding crop output rates and quality levels. What the pricing approach will be depends on whether the price elasticity curve for a certain crop is inelastic, unitary, or highly elastic, taking into account the whole demand for that crop. Knowing this information alone prevents agricultural firms from losing millions of dollars in income each year.

There are several ways AI may help increase agricultural efficiency, like locating irrigation leaks, adjusting irrigation systems, and monitoring how much frequent crop watering increases output rates. In many areas of North America, including those where agriculture is the main source of income, water is the scarcest resource. Its effective use may determine whether a farm or agricultural enterprise continues to be successful. The ideal quantity of water a specific field or crop will require to obtain an acceptable production level is often determined using linear programming. Supervised machine learning methods are perfect for making sure that crops and fields get enough water to maximize harvests while minimizing water waste.

One of the fastest-growing applications of AI and machine learning in agriculture is the monitoring of livestock health, including vital signs, daily activity levels, and food consumption. The best way to care for livestock over the long run is to understand how each species of livestock responds to nutrition and boarding circumstances. Producing more milk requires the use of AI and machine learning to comprehend what makes every day cows content and satisfied. This field offers completely fresh insights into how farms might be more lucrative for many farms that depend on cows and other animals.

CONCLUSION

In conclusion, AI will be a potent instrument that can assist organizations deal with the growing complexity in contemporary agriculture and it greatly alleviates the shortage of resources and manpower. It is past time for large corporations to make an investment here. AI will be a potent instrument that can assist organizations deal with the growing complexity in contemporary agriculture and it greatly alleviates the shortage of resources and manpower. It is past time for large corporations to make an investment here. The answer is probably no for the time being, but AI will complement and challenge decision-making processes and advance agricultural methods in the near future. Such technology advancements are anticipated to result in improved agricultural techniques, yields, and qualitatively better farmer lifestyles. Technologies have undoubtedly contributed to the scientific management of agriculture and the assessment of input requirements and output forecasting. At a time when the agricultural system is becoming more complicated and the need to produce more with less is greater than ever, these technologies are very necessary. Additionally, it supports the effective operation and operation of farms of all sizes. Farmers will now have the resources and information needed to maximize every acre of land.

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