

Agriculture and the Elements Influencing its Expansion: A Review



Zinash Nigussie^{1*} and Efrem Asfaw²

¹Department of Climate and Computational Science, Jimma Agricultural Research Center, Ethiopia

²Department of Agricultural Economics, Jimma Agricultural Research Center, Ethiopia

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***Corresponding author:** Zinash Nigussie, Department of Climate and Computational Science, Jimma Agricultural Research Center, Jimma, Ethiopia

Abstract

Agriculture includes the production of crops and cattle in either pure or integrated crop/livestock systems. Although producing food is its main objective, it also produces biomass for use as fuel and material. The production activities that define agricultural production systems include agricultural products, a living thing, and combined food/animal production. Climate and other environmental factors, like soil properties, as well as socioeconomic factors, like density of population, accessibility to land, agricultural policy, and cultivating land and market arrangements, all have an impact. Other factors include organizational forms, like small-scale family farms or large-scale industrial farms. Environmental factors like climate change, erosion, and vegetation can have an impact on agricultural production and farm income. Farm operators' household characteristics can also have an impact, including education, gender, and agricultural production, age, family size, landholding size, and possession of oxen, as well as agricultural production and income. Other factors include agricultural production technologies like chemical fertilizer, improved seeds, irrigation facilities, crop rotation, and intercropping; credit markets and agricultural loans; and physical and institutional infrastructure facilities like roads and extension facilities. Among the adaptive techniques, households and people can better manage the hazards associated with contemporary climatic variability and extremes by addressing the adaption deficit. Improved irrigation, water and soil conservation, and disaster risk reduction are among tactics to aid in this.

Keywords: Agriculture; Adaptation; Climate change

Introduction

In pure or integrated crop/animal production systems, agriculture is the husbandry of animals or the cultivation of crops with the primary goal of producing food, but also providing biomass for material and energy consumption. The primary activity of resource creation and supply in the bio economy, along with forestry, is agricultural production, which also provides the majority of food, starch, sugar, and vegetable oil resources. Currently, agriculture accounts for 33% (about 4900Mha) of the Earth's land area, supporting 2.5 billion people. Cultural landscapes are shaped by agriculture, but it also contributes to biodiversity loss, 13.5% of global greenhouse gas emissions, and the deterioration of land and water resources as well as the products and services provided by connected ecosystems [1].

Agriculture must be practiced in a sustainable manner. "Sustainable intensification" refers to the process of directing agricultural output to retain ecosystem functions and biodiversity

while producing enough food and biomass to feed a growing population. The creation and application of cutting-edge production methods that enable a more effective use of natural resources, such as land and agricultural inputs, can help achieve

sustainable intensification. A knowledge-based strategy is needed for its implementation, where farmers receive training on how to adopt sustainable agricultural production systems and are made aware of the demands of sustainable production. Within an agroecosystem, farming entities carry out agricultural production. Farms are organizations that carry out agricultural production through the breeding of livestock, the cultivation of crops, or a combination of the two. Farms can be broadly classified based on their size, resources, local crop and animal production possibilities, organizational structure, the natural boundaries of the surrounding agroecosystem due to soil types or climate, and interactions with other plant and animal species. According to

conservative estimates, there are currently over 570 million farms worldwide, ranging in size from tiny family farms to massive agro-industrial controlled corporations [2].

The primary characteristics of the Asian Green Revolution of the 1970s were the extensive agricultural support programs offered by the government or donors, including public irrigation schemes, credit subsidies, fertilizer subsidies, floor pricing, and set prices [3]. Bahiigwa et al. [3] went on to say that the Structural Adjustment Program (SAP) of the 1980s and 1990s destroyed the agricultural support policies that Asian countries had enjoyed, making it difficult to repeat the Asian Green Revolution in Africa. The government-sponsored agricultural subsidies were decreased under the Structural Adjustment Program due to the rise of neo-liberal conservative ideology. Limiting the rise of money and credit is one of the program's objectives, which tries to help governments lower their external and internal deficits. As a result, many farmers found it more challenging to obtain services [4].

The primary changes made to the Structural Adjustment Program were to: (1) promote private sector participation in agricultural marketing initiatives; (2) decrease or do away with government subsidies for the marketing of agricultural products and inputs; (3) improve agricultural export diversification; and (4) urge the government to assist NGO sand cooperatives in fulfilling their mandates [5]. Similar to this, sectoral strategies that emphasized the macro fundamentals and emphasized the importance of market forces were rejected by the Washington Consensus and the structural adjustment program [6].

On the other hand, the Washington Consensus disregarded the necessity for government intervention in order to secure growth and development in the agricultural sector in Africa, where there have been significant market failures. There are others who believe that because rain-fed agriculture predominates in Sub-Saharan Africa and other parts of Africa, the continent's green revolution should be planned differently from Asia [6]. Furthermore, irrigation affected income, prices, food security, and growth in addition to facilitating the adoption of Green Revolution technology in Asia, such as rice and wheat varieties [7]. The expansion of the agricultural sector is essential to achieving the Millennium Development Goals of eradicating poverty and hunger [8].

Factors Affecting Agricultural Production and Farm Income

Environmental factors

Environmental conditions have an impact on agricultural production, which in turn affects farm operators' income. This evaluation considers the local soil type, vegetation, rainfall, and erosion as environmental factors. Between 25 and 30 percent of the world's greenhouse gas emissions are attributable to the expansion and intensification of agriculture [6]. According to

Kintomo et al. [9], farm owners' extensive land usage is one of the factors contributing to the decline in environmental quality and production.

Climate change

In essence, agriculture is a weather- and climate-dependent human addition to natural ecosystems. Additionally, it contributes significantly to greenhouse gas emissions caused by humans, which are under closer examination as nations work to fulfill legally required mitigation targets. Changes in seasonality, mean precipitation, water availability, unpredictability, and the introduction of novel infections and diseases are some of the ways that climate change affects agriculture [10]. As temperatures rise, each of these mechanisms is expected to become more important. It is evident that the interactions between these mechanisms where new pests, water availability, and temperature thresholds interact are what will ultimately determine how climate change affects agriculture as a whole [11].

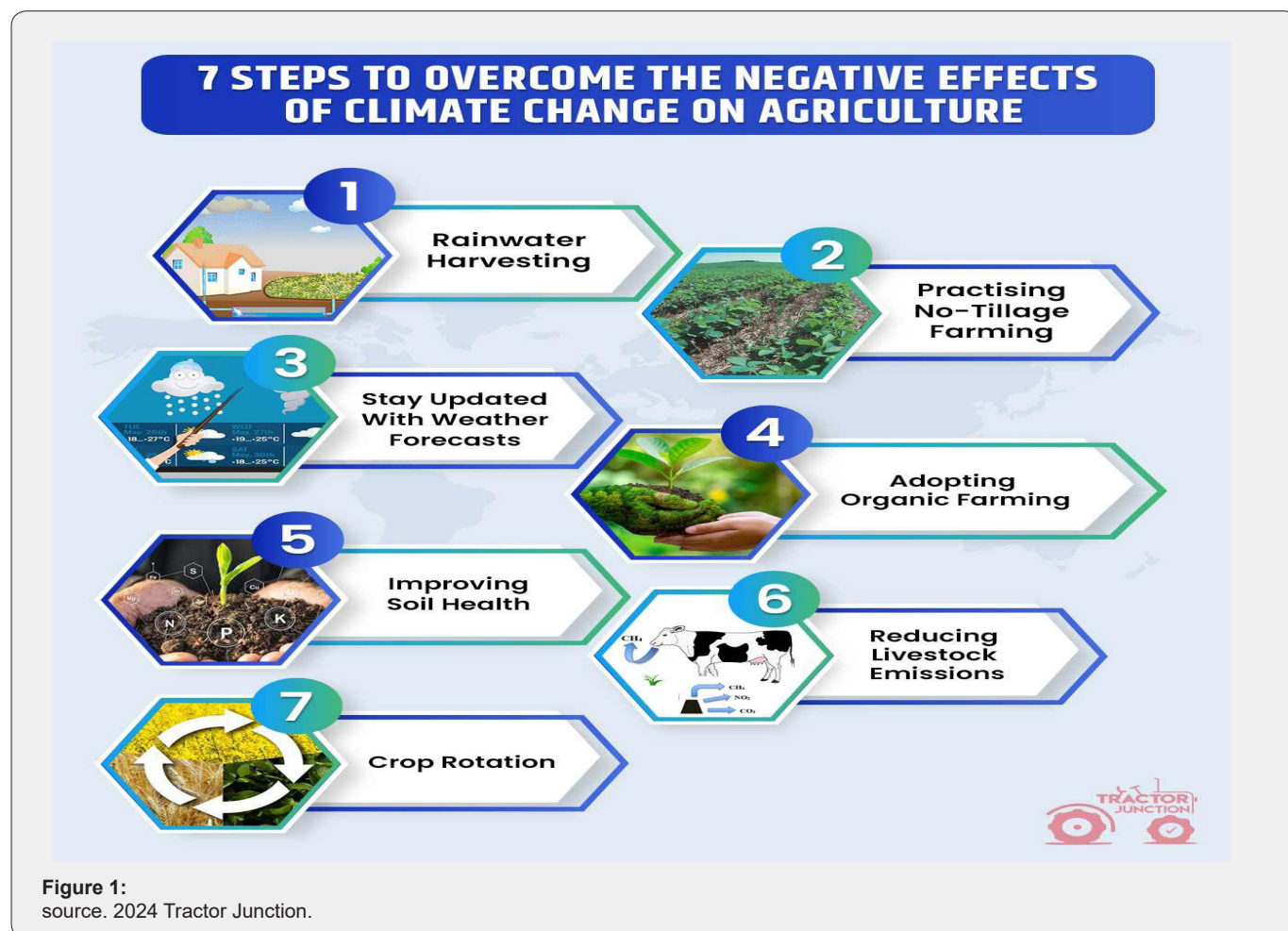
The range of forecasts (1.4-5.8°C by 2100) is caused by uncertainty in future emissions that depend on things like technological advancement, population growth, and other factors, as well as uncertainty in the physical models of climate forcing and response [12]. Numerous pieces of evidence in the IPCC Working Group report on effects, adaptation, and vulnerability [13] imply that these anticipated temperature rises are not without consequences. These include effects on extreme weather, water stress, and diseases and infections that are both more likely and more serious as a result of the anticipated rise in temperature. Stated differently, rising and increasingly harmful effects of climate change on ecosystems, extensive aggregate effects, and the possibility of catastrophic irreversible repercussions are all associated with expected temperature rises for the upcoming century [14].

Furthermore, it is unlikely that the effects of climate change on agricultural output would be felt equally in all areas of the country. Because of their less advantageous geographic location, higher proportion of agriculture in their economy, and less capacity to adjust to climate change, low latitude and poor nations are predicted to be more severely affected by the agricultural effects of global warming. On the other hand, climate change will generally enhance crop output in high latitude areas. According to a recent global comprehensive assessment by Cline [15] including over 100 nations, if global warming continues unchecked, agricultural productivity will decline globally by 15.9% in the 2080s, with developing countries facing a disproportionately bigger decline of 19.7%. Because of the increased uncertainty surrounding the productivity of these primary sectors, countries that rely more heavily on primary sector economic activities are likely to be more affected by climate change. Sea level rise's effects on low-lying coastal areas, changes in the frequency of extreme occurrences like typhoons and droughts, and a reduction in water supply in already water-stressed places are some of the effects [16].

Through energy-intensive procedures such as plant breeding for crops tolerant of heat or water stress, irrigation, and labor substitution in favor of labor, modern agriculture has attempted to reduce the effects of climate and weather uncertainty. Therefore, adaptation in agriculture occurs either through the actions of individual farmers, through the collective actions of farmers and local institutions, or through policy decisions made at the national level that provide funding, support for research and development, knowledge transfer, property rights, and legal frameworks to facilitate individual or group action. Higher temperatures brought on by climate change will be detrimental to the productivity of several agricultural and livestock groups, according to agronomic study. The world's grain crops may be susceptible to even little temperature fluctuations in areas where there is water stress, heat stress, or a combination of the two.

Changes in temperature, precipitation patterns, and atmospheric carbon dioxide concentration will all have an impact on crop agronomy. For example, higher-than-current CO₂

fertilization concentrations (around 380ppmv) are expected to result in improved rice output. However, it is anticipated that a 3–4°C increase in temperature results in a negative net yield gain. Many types of uncertainty surround how climate change may affect agriculture. First, as was already indicated, there are questions over the actual rate and scope of climate change. Second, there are questions concerning how agricultural products may react biologically, such as when fertilizing with CO₂. Third, there are doubts about society's ability to react to anticipated and predicted effects, let alone how it will. Fundamental, intractable uncertainties constrain some areas of climate change research. While many of these uncertainties are simply impossible to quantify, there remains a certain amount of irreducible ignorance in our understanding of the uncertainty around future climate change. Effective adaptation to climate change is sometimes said to be severely hampered by a perceived lack of trustworthy climatic projections. This line of reasoning is frequently employed to support more funding for climate modeling capabilities in an effort to enhance future climate projections [17] (Figure 1).



Agriculture is impacted by climate in a number of ways. A number of significant factors that affect agricultural productivity are temperature, radiation, rainfall, soil moisture, and carbon

dioxide (CO₂) concentration. These factors also have non-linear connections with one another. According to recent studies [18,19], agricultural yields drop at certain thresholds for various climate

variables. For instance, modeling studies covered in previous IPCC reports suggest that crop yields in temperate countries could gain from moderate to medium increases in mean temperature (1–3°C), as well as related increases in CO₂ and changes in rainfall. On the other hand, modest temperature increases of 1–2°C are probably going to negatively affect key cereal yields in low-latitude areas. Any region would be negatively impacted by warming of greater than 3°C [13].

The effect of climate change on soil moisture is determined by the combination of rising temperatures and altered rainfall patterns. It is anticipated that both evaporation and precipitation will rise with warmth. Which force is more dominant would determine the net effect on water availability. According to IPCC assessments, water availability due to climate change is expected to increase by the middle of the twenty-first century at high latitudes and in some wet tropical areas, and decrease across some dry regions at mid-latitudes and in the dry tropics [13]. More severe dry spells may occur in some areas that are already at risk of drought.

Elevations in atmospheric CO₂ levels can boost agricultural yields by promoting photosynthesis in plants and decreasing water loss through respiration. For so-called C3 crops—rice, wheat, soybeans, fine grains, legumes, and the majority of trees—which have a lower rate of photosynthetic efficiency, the carbon fertilization effect is strongest. These effects are substantially less for C4 crops such as maize, millet, sorghum, sugarcane, and many grasses. The impact of increased CO₂ on plant output can also be influenced by other variables, such as the stage of growth of the plant or the administration of water and nitrogen. Compared to estimates from studies conducted under enclosed test conditions, recent research based on experiments with the free air concentration enrichment method suggests a much smaller CO₂ fertilization effect on yield for C3 crops and little or no stimulation for C4 crops [20]. The IPCC reports indicate that when CO₂ levels hit 550 ppm, yields for C3 crops may increase by 10–25% and for C4 crops by 0–10%, respectively, based on examination of recent data [13]. The modeling and experiment study did not account for several limiting constraints, therefore there are still a lot of unknowns around the estimates of the carbon fertilization effect.

One of the most important variables affecting farmers' agricultural output is the amount of rainfall. In rain-fed agriculture, the crops get their moisture and water from the rainfall that percolates into their roots [8]. Because rainfall patterns are unpredictable, rain-fed agriculture is less productive than irrigated agriculture [8]. This is because farmers find rain-fed agriculture to be unreliable. Ethiopia's agriculture is rain-fed, so changes in rainfall will have an impact on output. Drought-related deaths in 1973, 1974, and 1984 demonstrated the close relationship between Ethiopia's economy and environment [21]. In locations with more moisture stress, adaption becomes more difficult as the amount of productivity loss rises with decreasing

rainfall. According to the World Bank, South Africa saw an increase in warmer days in tandem with a decrease in cooler days [22]. The Bank also stated that South Africa receives less rain than the average of 860mm year, with an estimated 450mm on average. According to Rockstrom et al. [8], rainfall is the cause of risk and uncertainty surrounding the results of the harvest season's agricultural production.

Agriculture will be impacted by a few other biological changes brought on by global warming in addition to temperature and carbon concentration. For instance, alterations in climate may result in altered pest and disease patterns, which could lower agricultural output. Increased climatic unpredictability as well as the severity and frequency of extreme events like droughts and floods would also lower agricultural productivity. Estimating the effects of climate change on agricultural productivity is made more challenging by these factors.

Erosion and vegetation

One of the problems with agricultural production is soil erosion, particularly in places with little vegetation cover and fragile soils [23]. Ethiopia's predominately subsistence agricultural system is under serious threats to its sustainability due to soil erosion, which has exacerbated the country's already severe food insecurity crisis [24]. According to Powell et al. (2011), tillage, wind, and water are the main drivers of soil erosion. Farmers in Laos did a research and found that the main causes of significant soil erosion in the region were high elevation locations, steep slopes, frequent cropping, and brief intervals of fallow land [25]. Because steep slopes are difficult to cultivate, Bakker et al. [26] claim that cultivating steep land contributes to soil erosion and drives changes in land use. Restoring natural vegetation and allowing plant biomass to cover the ground can either lessen or increase the amount of soil erosion caused by the removal of permanent vegetation for crop land that is farmed repeatedly.

Household characteristics of farm operators

Numerous factors, including household characteristics, have an impact on farm operators' agricultural output. These factors include, but are not limited to, age, gender, educational attainment, size of family, amount of land owned, and ownership of oxen.

Education and agricultural production

Studies have shown how important education is to agricultural revenue and productivity. For instance, Asfaw & Admassie [27] found that the growth in national income could not be entirely explained by conventional factors of production such as the expansion of labor, capital, or stock. The 1960s saw the recognition of education's role in the rise in the national GDP. A corresponding investment in human capital should be made to support production practices and technology in order to accomplish agricultural development [5]. This is due to the fact that knowledge and information are necessary for farmers to

employ technology, obtain input, alter their methods, and market their produce [28].

According to Burton [29], formal education increases farmers' participation in environmental initiatives and practices that support agriculture's sustainability. According to Asfaw & Admassie [27], education is also seen to promote economic growth by making farmers more productive and eradicating growth-resisting habits like word-of-mouth business practices. The idea that the "knowledge poor will remain income poor" is supported by the likelihood that poor farmers' irrigation returns will remain low if there is inequality in educational endowments [7]. Everyone agrees that gaining knowledge via education has a significant role in promoting economic development [27].

Gender and agricultural production

In a particular culture or place, gender refers to the roles and interactions that are socially established for men and women [30]. Women's and men's equal involvement is crucial to increasing agricultural income and productivity. When it comes to the agricultural labor force involved in production, harvesting, and processing, women typically make up the majority of workers [31]. It is also well known that women farmers generate the majority of the food and are in charge of providing for the necessities of the household [32]. Additionally, studies show that compared to men farmers, women farmers have higher environmental consciousness [29]. However, several research findings suggest that there are gender disparities in the agriculture industry. For example, certain crops are classified as "men's crops" and others as "women's crops" [33]. According to a study done in Ghana by Adeoti et al. [30], men predominated in vegetable production and required more physical strength. Nevertheless, de Brauw et al. [34] found that whereas men dominated 59% of the marketing labor, women in China contributed 64% to the production of livestock. They pointed out that their male colleagues control the profits and that this is feminization of the labor force.

Lack of funding, knowledge, and market access are other obstacles faced by women farmers, preventing them from producing enough to meet their basic needs [31]. Women who lack awareness about their rights are more vulnerable to land grabbing and losing their cultural identity [32]. In the past, there have been other problems that have limited women's involvement and power in the agriculture industry. The custom of fathers transferring farms to their sons, with daughters being disallowed farm ownership, was one of the obstacles [35]. Moreover, women's voice in land ownership was silenced by the belief that land rights were exclusively the property of men [36]. Thus, given the importance of women's contributions to the agricultural industry, it is necessary to identify the particular challenges that they face [34].

Researchers are also curious to look at the production variations across families headed by men and women. Researchers

discovered a range of outcomes in this regard. According to a study by de Brauw et al. [37], families headed by women in China produced an equivalent number of crops as households headed by men. Ragasa et al. [38] found that, under the assumption that all other contributing factors remained equal, there was no productivity difference between plots owned by male and female farmers in the four main regions of Ethiopia (Tigray, Amhara, Oromia, and SNNP). They went on to say that variations in production were caused by variations in plot quality, access to inputs, and quality of extension services. There is no good reason why women should be less productive than men if they have equal access to inputs, information, and technologies. Gender disparities in economic productivity are still a problem in Ethiopia, where most women still experience discrimination. Nonetheless, women now have better rights to manage joint marital property with their husbands thanks to the updated Ethiopian Family Law [34].

Age, family size, landholding size and agricultural production

Other household variables including the age of the farm operator, the size of the family, and the size of the landholding have an impact on agricultural performance. One indicator of farm operators' farming expertise is their age as the head of the household. When growing a variety of crops, farmers rely heavily on their prior understanding of agricultural techniques. Therefore, it is expected of seasoned farmers to increase their holdings' output. It is not without limitations, though, as older farmers are less likely to accept new technologies and lack the necessary physical strength for farming [29,39].

For nations like Ethiopia, where the agricultural sector drives the national economy, land is the most important natural resource. If there was enough family labor, farmers with higher landholding sizes would make more money from their farms. Children that are capable of working the land are in greater demand as a result of an increase in the size of the household must coincide with any growth in the landholding size. Therefore, feeding everyone in the family can be difficult in larger families, which can negatively impact the family's nutritional state [40].

Possession of oxen and agricultural production/ income

Oxen have been acknowledged historically for thousands of years as the earliest draft animals used by humans for labor-intensive tasks like land cultivation and heavy lifting. The ability of farm operators to farm is determined by their ability to own oxen, as farmers without oxen would have to rent their property to other farmers. Farmers would engage in sharecropping in this scenario. Because the yield is split with the oxen owners, this further reduces the household's output and revenue. There are benefits to being an ox owner. Owners of oxen can till and till their land when the timing is perfect. The production of the land is enhanced by this. Furthermore, it is possible to hire oxen for a daily fee to till the ground for different homes. As so, they could potentially provide extra revenue for the proprietors [41].

Agricultural production technologies

Chemical and biological methods are used in agricultural production. These technologies specifically include irrigation, high-yielding varieties of seeds, chemical fertilizers, and technologies that improve soil quality. These technologies are employed by farmers to increase the land's productivity and output. Research also suggests that the introduction of new technologies puts further strain on the meagre resources available to impoverished farmers [42].

Chemical fertilizer

Inspired by the Asian Green Revolution, which was achieved by utilizing high-yielding seed and fertilizer technologies, African governments have advocated for the increased use of agricultural inputs in their own nations [43]. The use of organic and inorganic fertilizer is the starting point for intensification in the Sahel because the application of other technologies, including high-yielding cultivars, will not have a major impact if soil fertility is not increased. Crawford et al. [43] went on to say that input promotion techniques include a variety of goals, including social, political, financial, and economic ones.

The goal of the input promotion strategy's financial component is to raise the net income of farmers, merchants, and other agricultural sector players. Increasing society's overall real income is another aspect of the input promotion strategy's economics. The enhancement of wellbeing indicators, which are challenging to quantify in terms of monetary values, is the social component of the input program. Increasing national food self-sufficiency and nutrition consumption are two of the societal goals. The government's intervention for the purpose of benefit parity gives rise to the input program's political goal. Certain initiatives might be purposefully created to gain political support; as a result, they might favor one or more groups at the expense of others. Records showed that little inorganic fertilizer is used in Sub-Saharan Africa. De Janvry [6], for example, reported that fertilizer consumption in Sub-Saharan Africa (SSA) is just 11kg/ha, but it is 130kg/ha in South Asia and 271kg/ha in East Asia. SSA has the lowest fertilizer application rate globally. Given that SSA applies less fertilizer per hectare of land than is considered optimal, it is evident that increasing the intensity of African agriculture will continue to be a significant development problem. Because to Africa's inadequate fertilizer use, the continent's productivity is below the global average [43].

Demand and availability issues may be the main causes of the low fertilizer use [43]. Farm households may be on the demand side and reject the profitability of using fertilizer, or they may view it as profitable but too financially risky. Farmers may find using fertilizer input to be excessively dangerous because the amount of input used is decided upon prior to the unpredictable start of the rainy season. For example, in Eastern Ethiopia, optimistic forecasts on the upcoming season's rainfall circumstances result in a 41.92kg/ha increase in chemical fertilizer application [44].

The use of yield-augmenting inputs is negatively impacted by weather uncertainty since these inputs are not viable in the absence of sufficient rainfall. Some of the potential causes of the lack of profitability include unresponsive seed varieties, improper application rates, low crop responses due to agro-ecological circumstances, and fertilizer use [43].

Policy interventions, low output prices resulting from high transportation costs, high input prices, or non-competitive marketing agent activity are further potential causes of the lack of profitability. Inability of farmers to pay for products and services because of restricted credit availability to fund fertilizer purchases may be the real issue rather than profitability. Farmer cash flow is usually limited at the start of the rainy season since they are primarily focused on feeding their livestock. Fertilizer access may be restricted on the supply side due to high costs incurred at the point of origin by importers and local manufacturers. Furthermore, bad port, rail, and road infrastructure, transportation costs, non-competitive supplier behavior, and inadequate financing arrangements for importers and merchants to acquire fertilizer can all have an impact on the availability of fertilizer [43]. One consideration when taking on the hazardous endeavor of input usage is the producing season. Risk-taking boosts net returns only during prosperous times [45]. Because of this, farmers ought to have the freedom to decide for themselves how best to maintain the fertility of their own land.

Some argue that relying solely on chemical fertilizers for agricultural production may not be sustainable because doing so reduces the potential benefits of using fertilizers by causing the loss of organic soil contents. The majority of the time, chemical fertilizer application is done without first conducting soil tests, which results in the application of fertilizer that is either excessive or insufficient [46].

Furthermore, Wu [47] discovered that because diammonium phosphate (DAP) exacerbates soil acidity, extension agents in western Kenya did not advise farmers to use it. Water and soil contamination may arise from the uncontrolled use of chemical fertilizers beyond recommended limits.

Improved seeds

Better seed types are essential agricultural inputs that assist farmers achieve higher agricultural yields, especially when combined with chemical fertilizers. Through genetic modification and selective breeding, crop yield and value are increased. Additionally, enhanced seeds provided by the formal sector must meet quality requirements established by national rules [48]. The productivity of land is positively impacted by seeds that meet quality standards. For example, the novel seed varieties accounted for thirty percent of the growth rate in agricultural production. According to a study done in Afghanistan by Kugbei [49], the enhanced wheat seeds produced 33% more than the native seed kinds.

Furthermore, Alemu et al. [50] said that if enhanced seeds are paired with contemporary technology and minor adjustments to farmers' growing practices, they can result in a notable increase in agricultural productivity and production for Ethiopia's small-scale farmers. Farmers are more concerned with the qualities of the seeds than the price because the enhanced seeds are still small. By storing and using the seed varieties for the upcoming production year, farmers can cut expenses [51]. Awotide et al. [52] shown in a study carried out in Nigeria that the timely distribution of enhanced rice seeds to farm operators is a necessary adjunct to poverty alleviation.

Irrigation facilities

Sub-Saharan Africa is home to the world's poorest people, whose primary source of income is rain-fed agriculture [53]. According to Burney and Naylor, the region's weather variability contributed to the low crop yields in Sub-Saharan Africa. According to de Janvry [6], just 3% of agriculture is irrigated, but in South Asia and China, 39% is. One of the lessons learned from the Asian Green Revolution was that better crop types, irrigation, fertilizer, and repeated cultivation over the course of a year could all lead to increased yields [53]. Water is one of the most important tools for reducing poverty and has a big impact on food production, food security, sanitation, hygiene, and the environment [7]. It is essential to use water resources properly and to reduce waste. This is due to the fact that farmer farming techniques and irrigation system efficiency have an impact on the amount of water utilized in agriculture [54]. When water has a value and can be sold by its lawful owners, for example, establishing a system of water trading can be a potent incentive to minimize the amount utilized in agriculture [6]. One of the essential agricultural inputs that improves socioeconomic status by reducing poverty is irrigation. But when irrigation results in issues like sickness, land degradation, water pollution, and the devastation of natural ecosystems and living things, it can also set off socioeconomic upheavals [7]. According to Hussain & Hanjra [7], the potential drawbacks of irrigation primarily affect impoverished populations. The impoverished can boost their output, diversify their sources of income, and become less susceptible to external shocks and the seasonality of agricultural production when they have access to high-quality irrigation.

Poor landless farmers may not immediately gain from irrigation infrastructure because landowners are typically the first to benefit from it. However, over time, they may indirectly benefit from higher employment prospects, more stable earnings, and cheaper food costs. Although irrigation is thought to benefit net food purchasers, it might be detrimental to net food sellers [7]. Using technology that increase output comes at a cost to farmers. On the one hand, farmers might use complimentary technology at little to no financial expense. Mulching and seed priming are two examples of technology that increase agricultural productivity without having an impact on farmers' costs, according to Aune & Bationo [55]. In order to accelerate germination and shorten

the germination period, seeds are primed by soaking them in water. Additionally, they discovered that crop output was raised by applying 500 kg of crop residue per hectare. However, the advantages of mulching have been curtailed due to the competing uses of crop leftovers, including fuel, building materials, and feed [56].

Crop rotation

Farmers in Nigeria employ shifting cultivations as a method of sustainable agriculture because falling soil fertility is a serious concern for Sub-Saharan Africa. Crop rotation is the practice of alternately planting different crops on a certain plot of land on a regular basis. Through the proper application of crop orders, it helps to guarantee the necessary fertility and prevents weeds, insects, and plant diseases. Contrary to continuous monoculture, which involves growing the same crop species on the same plot year after year, shifting cultivations are different. It is not recommended to use fallowing or shifting cultivation techniques to improve soil quality in areas experiencing high population expansion [9]. Crop rotation was abandoned as a result of specialization and the continuous production plan, which resulted in the discontinuation of the practice after many years of practice and expansion during the Green Revolution in South Asia. The same crop is produced continuously throughout time, which leads to an imbalance in soil nutrients and a decrease in land productivity. Furthermore, because plant-specific pests and diseases get established, monoculture results in an unsustainable use of land [57].

In western Kenya, crop consumption of nitrogen surpasses inputs, resulting in nutrient depletion of the soil and decreased land productivity [23]. However, by using legume crops in crop rotation, symbiotic fixation enhances the nitrogen supply and lowers the need for artificial nitrogen fertilizer in the subsequent crop [46,58]. Farmers with limited resources who have unreachable land and use chemical fertilizers less frequently than necessary may benefit from this [58]. For a considerable amount of time, farmers in the Tigray region have maintained fertile soil and increased land productivity by employing the traditional methods of crop rotation, fallowing, manure, and wood ash [59].

Intercropping

Farmers also employ intercropping as a method of agriculture to raise the production and quality of their land. By utilizing resources that a single crop cannot use, intercropping aims to increase the production of agricultural land [42]. A significant percentage of farmers in developing nations engage in intercropping [60]. While fallow rotation and intercropping with leguminous plants have been used to increase soil fertility in western Kenya [61], monoculture has increased crop yield in developed nations at the expense of significant energy costs associated with production and the use of machinery, fertilizers, and pesticides [62].

This is because intercropping was abandoned in industrialized nations because it was ineffective for mechanical farming [60]. Growing crop yield and meeting the world's expanding population's food needs depend increasingly on intercropping [62]. Agriculture's sustainability has also benefited from the intercropping technique [60,62]. Additionally, the kinds that are thought to be complimentary in the usage of resources should be determined in order to ensure yield and quality in intercropping [60]. Wheat output was raised to 39.43 quintals per hectare by intercropping wheat and chickpea at a 30-cm spacing and weeding twice [63].

According to Banik et al. [63], the yield of mono-crop wheat with a 30cm spacing and two weed treatments was 26.71 quintals per hectare. Karlidag & Yildirim [62] conducted a study in Turkey which shown that intercropping early maturing vegetables with strawberries increased productivity and assured efficient use of resources and land when compared to the pure strawberry planting scheme. Moreover, weeds decreased as a result of intercropping maize and legumes. Similar to this, the necessity for intensification and diversity in Africa resulted in the complex intercropping practice replacing mono-cropping systems. Intercropping of annual and perennial crops has proven beneficial for farmers in Ethiopia's southern area. The productivity and profitability of farm operators are impacted by agricultural production technology including irrigation, better seeds, and chemical fertilizer, as was previously mentioned. In addition to these variables, access to financing in rural areas affected farmers' income and productivity [64].

Credit markets/agricultural loans

Agricultural credit is defined as bank financing for input production and distribution, as well as primary production, processing, and trading of agricultural goods. Poor farmers rarely have collateral that banks will accept, so their chances of borrowing money from the official sector are quite slim. Even if they do have valid title papers for the land they farm, rural land markets might not run smoothly enough for the land to be regarded as a "bankable" asset. Microcredit institutions may be able to provide loans to smallholder farmers without requiring collateral. Microcredit programs are frequently linked to group lending, in which members of the group may act to keep one another from defaulting and peer pressure serves as a useful collateral replacement [65].

Divergent opinions exist about how much government should be involved in agricultural development. According to one perspective, there is a risk of corruption and rent-seeking when governments become involved in the economy [66]. Accordingly, the goal of Sub-Saharan Africa's structural adjustment program was to remove or minimize agricultural subsidies, get governments out of the lending and input supply business. This was due to the fact that government support programs including input and commodity subsidies were unfinancially sound and fueled the macroeconomic crises of the 1980s [43]. Stabilization

and structural adjustment programs were adopted during this time due to the slowdown of economic growth and the growing state budget deficit (Estelle et al. 2004).

From the widely held belief that the government "could solve the problem" in the 1960s and 1970s to the belief that the government "is the problem" in the 1980s, the implementation of the structural adjustment program was seen as a paradigm shift [43]. Following the implementation of structural adjustment programs in numerous countries, non-governmental organizations filled the void left by the government's removal of its earlier provision of agricultural loans by offering microfinance services in rural areas. The NGOs' credit was criticized for having too short loan terms and a small loan amount for investments in agriculture [5]. Because of their fear of hazards including drought, pest infestations, and fluctuating prices, farmers were hesitant to implement yield-enhancing technologies [55].

The state's assistance and intervention program to guarantee agricultural transformation was the other issue. Refusing to accept government help is akin to tossing out the baby with the bath water [66]. This is done to prevent rent-seeking and corruption. Proponents of the neo-liberal paradigm contend that the government's role in the economy ought to be restricted to preserving competition among economic actors, enforcing contracts that people willingly participate into, and protecting individuals and their property rights. In a related vein, Aune & Bationo [55] discovered that government initiatives including finance, input distribution, and price guarantees played a significant role in the growth of cotton output in Mali. Even after poor countries were forced to implement structural adjustment plans, developed nations persisted in providing subsidies to the agriculture sector.

Physical and institutional infrastructure facilities

The roads and extension services in the institutional and physical infrastructure are reviewed below.

Roads infrastructure

Major physical infrastructures like roads make it possible for people and things to travel more quickly and easily. Roads lessen segregation by giving people additional ways to access various locations. Therefore, repairing rural roads enables these communities to participate in the market economy and escape poverty. Most impoverished individuals reside in rural areas with inadequate road infrastructure. Farmers are therefore prevented from establishing connections that could enhance their standard of living. Additionally, it raises the cost of transportation for farmers to take advantage of off-farm possibilities, buy consumer items, and sell their produce [67].

Extension facilities

Extension agents' primary responsibility is to assist and motivate farmers in increasing their output. They are in charge of communicating to farmers the results of research institutes

and returning farmers' agricultural difficulties to those same research institutes [68]. Additionally, farmers might influence research institutes' research agendas to emphasize pertinent outputs. Therefore, by bringing research-based knowledge to the agricultural sector, extension agents aim to improve farmers' quality of life. Farmers are influenced to embrace new technologies by the extension agents' communication strategies and platforms. Two main schools of thought about agricultural extension were highlighted by Worth [69]. While the second views extension as a component of the human development agenda, the first views it as the transfer of technology. Worth went on to emphasize how crucial it is for extension agents to understand the purpose of their work, whether it is to advance the agricultural industry or the general public. The conventional and skeptical perspective on extension services and agents holds that they are government agency tasked with disseminating any information requested of them without the necessary incentive or training [70].

According to a research done in China by Hu, et al. [71], extension agents are given tasks including family planning, budget management, election administration, fire safety, legal concerns, and other things that have nothing to do with agricultural extension. Hu et al. [71] also discovered that fewer than one-third of the working hours of extension agents—whose main responsibility is to offer farmers agricultural extension services—were dedicated to extension-related tasks. Agro-ecological circumstances are changing and farmers' demands and concerns are dynamic, fixed packages are becoming less appropriate due to increased climate variability and unpredictability. Farmers may find it difficult to use extension services that adhere to "business as usual" [70]. For extension services to be successful, they must concentrate on the farmers' socioeconomic and agro-ecological circumstances as well as the manner in which the services are provided [72].

Adaptation

Adjustments made to ecological, social, or economic systems in reaction to real or anticipated climate stimuli and their consequences are referred to as adaptations. The term pertains to modifications made to procedures, customs, and frameworks in order to mitigate possible harm or capitalize on prospects linked with climate change. Observation, assessment of climate impacts and susceptibility, planning, execution, monitoring, and evaluation of adaptation efforts are the five general components that comprise adaptation activities. Because of the intricacy and duration of climate change, adaptation must be planned as an ongoing, adaptable process that incorporates input from monitoring and evaluation (M&E) [13].

Among the adaptive strategies, by addressing the adaptation deficit, households and individuals can better manage the risks associated with current climatic variability and extremes. Some strategies to help with this include better irrigation, soil and water conservation, and disaster risk management. The basic goal of

incremental adaptation is to preserve the essential elements and integrity of a system or process at a specific scale. [74], for instance: modifying current farming systems to account for variations in seasonality (e.g., planting schedules) or adapting existing systems to increased water stress (e.g., additional irrigation). Transformational adaptation refers to an adaptation strategy whereby a system's basic characteristics are modified in response to the climate and its impacts. for instance: gradual settlement relocation and Adaptive behaviors that fail to reduce vulnerability but instead enhance it are examples of maladaptation. [74].

Conclusion

Replicating the Asian Green Revolution in Africa is challenging since the Structural Adjustment Program (SAP) of the 1980s and 1990s eliminated the important agricultural support programs that the Asian Green Revolution of the 1970s had in place in Africa [3]. Climate change has an impact on agriculture through changes in water supply, precipitation, seasonality, unpredictability, and the emergence of new illnesses and infections. Climate change will impact agriculture overall based on how these mechanisms interact, and these mechanisms grow increasingly significant as temperatures rise. Plant breeding for crops that can withstand heat or water stress, irrigation, and labor substitution are examples of energy-intensive practices used in modern agriculture to try to mitigate the effects of climate and weather uncertainty [12]. However, the production of several livestock and agricultural groups would suffer from rising temperatures brought on by climate change. A farm operator's age, gender, level of education, family size, land ownership, and ox ownership are all factors that affect their agricultural productivity. There are gender differences in the agricultural sector, despite the fact that education is vital to income and productivity [32,34].

In nations like Ethiopia, where the majority of women continue to face discrimination, gender differences in economic productivity still exist. Agricultural success is also influenced by other household factors, like the size of the landholding, the age of the farm operator, and the size of the family. Although it can help alleviate poverty, water is a necessary agricultural input that can also cause problems including illness, land degradation, water pollution, and the destruction of natural resources. Agricultural production is also influenced by environmental elements as vegetation, rainfall, soil type, and erosion. An estimated 25–30% of global greenhouse gas emissions can be attributed to the growth and intensification of agriculture. Roads and other institutional and physical infrastructure features are crucial for lowering segregation and empowering communities to engage in the market economy [6,9].

By sharing research findings and resolving farmers' agricultural challenges, extension agents are essential in helping and inspiring farmers to boost their output. By providing the agricultural industry with knowledge based on research, they hope to raise the standard of living for farmers. To succeed,

extension agents must be aware of their role and concentrate on the socioeconomic and agro-ecological conditions of farmers. Traditional viewpoints, on the other hand, see extension services as government organizations that provide knowledge without the required funding or training. Less than one-third of extension agents' working hours in China were devoted to extension-related duties, according to research. Adaptation is the process of changing ecological, social, or economic systems in response to climate stimuli and their impacts. It includes watching, evaluating the effects of climate change, and organizing, carrying out, tracking, and evaluating adaptation initiatives. Improved irrigation, water and soil conservation, and disaster risk reduction are examples of adaptation tactics. While transformational adaptation alters a system's fundamental properties in response to climate change and its effects, incremental adaptation seeks to maintain the integrity and important components of a system or process at a particular [70,73].

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