CLIMATE-SMART AGRICULTURE

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Abstract: *A concept called climate-smart agriculture (CSA) seeks to solve the problems caused by climate change while preserving sustainable farming practices. In order to improve food security, promote rural livelihoods, and reduce environmental consequences, it entails integrating climate change adaptation, mitigation, and resilience techniques into agricultural systems.*

***Key words**: sustainable farming, climate resilience, adaptation strategies, carbon sequestration, biodiversity conservation*

INTRODUCTION

Agriculture is not just a significant contributor to climate change, but it is also possibly one of the sectors with the most exposure. Climate change has an influence on agriculture through affecting parameters such as temperature, precipitation, extreme weather, and other variables. These developments are likely to have a big impact on food production and food security since they have the potential to worsen poverty and hunger in many regions of the world.

One of the fundamental principles of CSA is to encourage the adoption of sustainable agriculture practices that are resistant to climate change. These include agroforestry, conservation tillage, growing drought-tolerant plants, water management, and soil preservation.

These methods can help farmers lessen the negative impacts of climate change on their crops and increase yields even in the face of changing weather patterns.

As women are essential to agriculture and food production, CSA also advocates for the inclusion of gender-sensitive practices in all facets of agriculture. To achieve equitable and environmentally friendly agricultural growth, it is crucial to address the unique requirements and difficulties experienced by women farmers.

Several stakeholders, including landowners, governments, the commercial sector, public society, research institutions, and international organizations, must take part in and interact with CSA in order for it to be successful. This cooperative approach aids in ensuring that the solutions created are applicable, efficient, and sustainable locally.

In light of climate change, climate-smart agriculture is an essential strategy for tackling the issues of food security and sustainable growth. CSA works to increase agricultural production, decrease poverty, improve food security, and lower greenhouse gas emissions as well as other environmental consequences by encouraging environmentally friendly farming techniques, low-carbon technology, and gender-sensitive methods[11].

The learning and operational planning of farmers to handle conflict and disasters at the farm level is the main emphasis of this study. An improved knowledge of sustainable management will result from awareness of coping strategies and the consequences of risks from climate change. The learning and operational planning of farmers to handle conflict and disasters at the farm level is one of the main emphasis of this paper. An improved knowledge of sustainable management will result from awareness of coping strategies and the consequences of risks from climate change[3,4, 19]. The main objective of Climate-Smart Agriculture (CSA) is to use contemporary agricultural technology and advancements to produce high yields and resilient systems, including inorganic fertilizers, pesticides, foods, food supplements, high yield varieties, land management, and irrigation methods. This was essential to meet the food needs of a growing population and to encourage the economic growth needed to reduce poverty.

According to a Mathews study, it is essential to comprehend the advantages and disadvantages of prospective CSA choices in order to successfully and efficiently improve the welfare of small-scale producers in both short- and long-term efforts [13]. According to Hellin and Fisher's (2019) study, agricultural researchers have created a number of agricultural technologies and approaches, collectively known as CSA, as part of actions for climate change adaptation and mitigation. A larger and more substantial agenda would be required by climate-smart strategies, including assistance for farm households' ability to develop non-agricultural sources of income. In light of the effects of climate change, studies show that the idea of CSA has emerged as a potential remedy for increased agricultural output and low family incomes. This study addresses the viability of utilizing CSA activities to assist sustainable agriculture in order to attain global food and nutritional stability [10].

In particular, livelihoods that are predominantly focused on natural resources are significantly affected by climate change [18]. The output of crops, cattle, and fish are all significantly impacted by climate change. Additionally, climate change may reduce the availability of new employment prospects. For instance, the chance for agroecological tourism, which might serve as an extra sustainable livelihood option for the impoverished rural people, may be limited by the destruction to physical capital (such as infrastructure) owing to recurrent natural disasters [17]. Small-scale farmers are crucial to agricultural output all around the world [1].

The bulk of these rural communities, however, are deemed to be disadvantaged and socially excluded, and they struggle with food scarcity and poverty. Simply said, the CSA presumptions and goals need to be changed to VSA, which places small-scale producers and their lives at the center of all agricultural activities while also addressing food security and mitigating climate change.

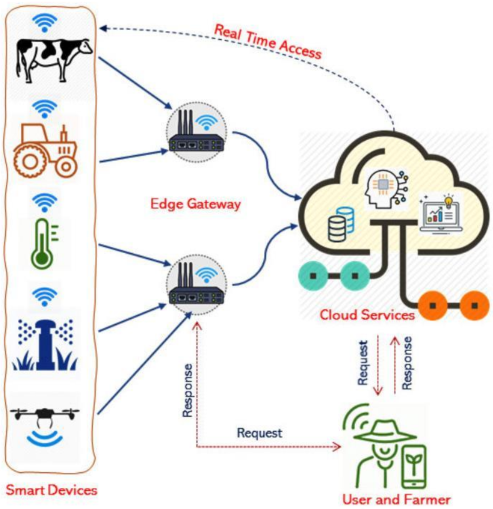

Figure 1. A model of end-to-end engagement in smart farming between different stakeholders

Source: Gupta et al. (2020)

Figure 1 depicts an end-to-end link between various people involved in the smart agricultural ecosystem. Physical sensors and animals in the industry generate data and receive commands from user apps. These on-farm devices are connected to gatewaysupported edge nodes that provide communication between in-farm gadgets, filtering sensor data, and real-time farming analytics. This provides security and data privacy.

In-depth research into stable agricultural technologies, like the drones now employed for field spraying, might contribute to the development of the smart agricultural ecosystem and the fight against climate change. The context in which these inventions are employed, however, is frequently ignored while doing study on them. Specific elements of the intricate ecology of smart farming, such agricultural machinery, labor sharing, and administrative choices, are influenced by the outside world. Smart farming-specific safety techniques are required due to domain-specific challenges such location, user ability set, insider threats, and produced data. As a consequence, additional study is necessary before the community accepts smart farm technology broadly [9].

Agricultural practitioners must invest in research and development of technologies and good practices in order to implement and scale up CSA. The role of public finance in providing the necessary support and incentives for farmers to make necessary investments is also critical.

As a result, farmers should be regarded as the most important source of human capital [8]. Small-scale farmers, who are operating near or below the poverty line might not always have the assets and encouragement to prioritize sustainable approaches due to lack of necessary government supports [12].

According to a study in the CSA literature, low-income nations with small-scale subsistence farmers are yet to be able to escape poverty or improve the lives of these farmers, despite the fact that numerous research have been done on CSA. More significantly, relatively few research on CSA aim to enhance small-scale farmers' lives in rural regions and boost participatory-rural programs.

Designing the conceptual framework

This study contributes to the design of a conceptual framework that consists of five main elements:

1. predicting and responding to climate occurrences
2. measuring the repercussions
3. identifying small-scale farmers' coping strategies,
4. evaluating small-scale farmers' livelihood capitals, and
5. adapting to climate change incidents. These five main elements help to close this gap and identify different levels of potential interventions as well as the development of VSA elements.

According to some theories, both climate change and associated pressures will reduce a state's ability to provide resources and jobs for those impacted, reducing rural populations' ability to adapt to the effects of climate change.

Additionally, a lack of knowledge and information flow will result in an unfair distribution of limited resources, which will cause conflict and social unrest. This potential circumstance is particularly significant in developing fields where knowledge and technology have not yet been sufficiently established [16].

Farmers' small-scale adaptation choices to climate change show that various stresses speed up adaptation [6]. Decisions made by small-scale farmers in response to climate change suggest that a variety of stresses drive adaptation.

The opinions of consumers and qualitative elements like community, education, ethnicity, age, funding, and structural variables are taken into account when making decisions on climate change adaptation.

Meanwhile, small-scale farmers have a wide range of adaptation capabilities, such as knowledge, networks, and management techniques that have long enabled small-scale systems to adjust to environmental and socioeconomic change in an ever-shifting world.

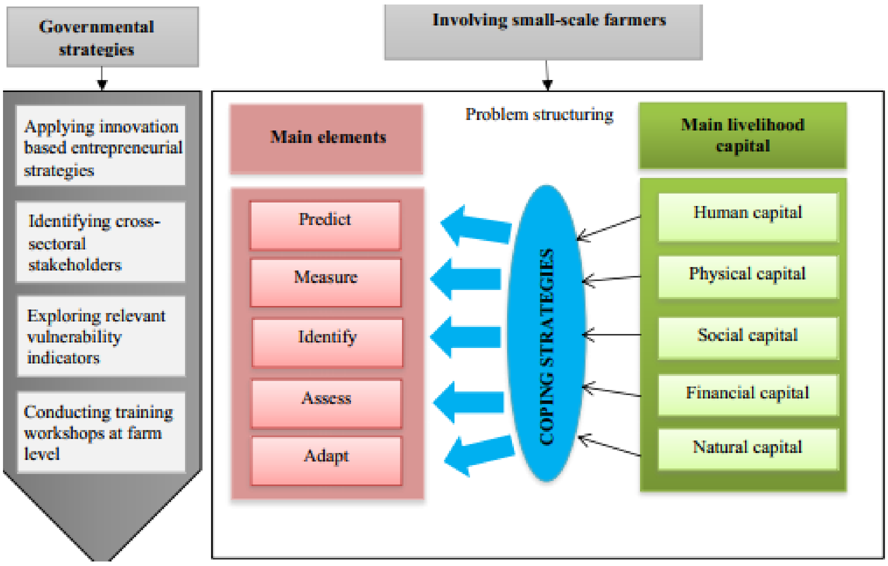

Figure 2. The proposed VSA conceptual framework

Disadvantaged individuals often have low levels of engagement in both local and national institutions in a socially and economically divided society due to their lack of social networks and poor political influence [14].

According to Jome Poor and Kioomars (2012), vulnerability can be defined as having an adverse (and occasionally a favorable) effect on the resources and options for livelihood of the poor. According to the Asian Development Bank (2017), vulnerability includes two components: external variables like shocks, seasonality, and trends, and internal elements like carelessness brought on by inability and incompetence to cope with these issues.

When harm to the poor is severe, shocks like droughts, cold and frosts, storms, floods, soil salinity, pests, and illnesses can immediately destroy people's capital and lead them to give up their houses and possessions (such land) as a form of coping.

Human resource: According to the Asian Development Bank (2017), this capital shows the knowledge and skills, employment prospects, adaptability, and health that farmers need to pursue and meet their aspirations for a living. The quantity and quality of labor that is available at the home level also has a bearing on factors including household size, skill level, leadership potential, and health condition [12].

Furthermore, the move to more environmentally friendly and sustainable agricultural output is facilitated by human capital development.

Physical capital: Among the essential supplies and goods required to maintain farmers' livelihoods is physical material. Infrastructure involves physical condition upgrades that facilitate people meeting their fundamental needs and increase efficiency.
According to Brandt et al. (2017), physical capital primarily refers to farm structures, various types of infrastructure, and equipment utilized in agricultural production that aids farmers in determining predicted earnings and/or the severity of climate change incidents[5].

Societal assets: Networks and unions are examples of social capital, which people acquire to further their livelihood objectives. Social capital may increase a person's self-assurance, teamwork skills, and access to more expansive, inclusive frameworks like political or civic institutions. Involvement in larger groups, which frequently include reciprocal adherence to rules, regulations, and sanctions, is facilitated by social capital. An unofficial foundation for the protection of the poor will be provided via reciprocal trust and transactions that encourage cooperation and lower transaction costs [2].

Financial capital : refers to the availability of funds and investment opportunities that motivate farmers to adopt a variety of adaptation strategies. It comes from two main sources: (1) cash, bank deposits, or cashable assets like livestock and jewelry that are readily available commodities; (2) regular cash inflows such as wages, retirement benefits, or other government transfers and remittances.

Natural capital: In terms of the way these resources and services serve for people's livelihood, natural capital refers to resources including land and production resources, water resources, animals, ecosystems, natural goods and plants, and environmental facilities [2].

MATERIALS AND METHODS

The writers of this scientific study have pursued numerous steps in regards to the logistics of the work in order to accomplish the purpose of the paper, which is to highlight some particular approaches and aspects of Climate-smart agriculture:

-data gathering;

-data analysis;

-and, last but not least, data interpretation.

To further the paper's goal, authors used a multicriteria analysis and a variety of information sources.

RESEARCH RESULTS

Climate-smart agriculture employs various practices and techniques to enhance carbon sequestration, which refers to the capture and long-term storage of carbon dioxide from the atmosphere. This is crucial for mitigating climate change since carbon dioxide is a major greenhouse gas responsible for global warming.

Here are some of the key solutions of CSA:

1. Increasing resistance to weather extremes and lowering vulnerability to crop failure through crop diversification and integrated agricultural systems that use a variety of crops and animals.

2. Conservation agricultural techniques that minimize soil disturbance, enhance soil health and water retention, and lower greenhouse gas emissions. Some examples of these techniques are:

- decreased tillage: by reducing soil disturbance through no-till farming or decreased plowing, you may improve soil structure, lessen erosion, and increase soil moisture retention.
- cover cropping: by planting cover crops, such legumes, in between major crops, you may create a barrier on the soil's surface that prevents erosion and boosts soil fertility.
- crop rotation-can assist to increase soil fertility and decrease the accumulation of pests and illnesses on a certain farm
- mulching: applying organic material to the soil's surface, such as straw or leaves, helps lower water evaporation, control soil temperature, and enhance soil fertility.
- agroforestry: adding trees to agricultural settings can have a number of advantages, such as increased soil fertility and carbon sequestration.

3. Techniques for managing water resources that increase water use effectiveness while lowering the likelihood of drought and water shortages. Some of these tactics consist of:

- Improvements in irrigation efficiency may be made by using precise irrigation techniques like drip irrigation or sprinkler irrigation, which dramatically minimize water waste.
- Watershed management: Using conservation tillage and cover crops, for example, can minimize runoff, enhance water retention in the soil, and lessen the likelihood of a drought.
- Rainwater harvesting: During dry spells, collecting and storing rainwater for later use can improve the amount of water available for irrigation.
- Crop selection and management: By selecting crops that are compatible with the soil types and local climate, as well as by employing best management methods such soil and water conservation, it is possible to lower the risk of drought and increase water usage effectiveness.It is possible to guarantee that water is used effectively and sustainably by coordinating and optimizing water usage across several sectors and stakeholders, including agriculture, industry, and home consumption.
- Reusing and recycling water-The demand for fresh water may be decreased and water usage efficiency can be increased by reusing and recycling treated wastewater for irrigation.

4. The use of crops that are resistant to climate change, such as drought-resistant kinds that are better adapted to shifting weather patterns.

- Crops that can tolerate water stress and continue to produce in arid circumstances, such sorghum, millet, and cassava, are some examples of climate-resilient crops.
- Crops that have been bred or developed to be more resistant to high temperatures, such as maize, rice, and soybean.
- Rice and maize are examples of flood-tolerant crops, whereas barley, rice, and wheat are examples of salt-tolerant crops that may flourish in locations where soil salinization is a problem owing to increased evaporation from rising sea levels.
- Crops that can grow and produce at milder temperatures, such as potatoes and barley, making them suited for high altitudes or colder climes.
- Crops that can endure temporary flooding and thrive in flooded areas, such as maize and rice.

5. The integration of trees into agricultural landscapes is known as agroforestry, and it can have a number of advantages, such as increased soil fertility and carbon sequestration.

6. Better methods for managing cattle that make them more resilient and able to adapt to a changing environment. Some examples of these techniques are:

- ❖ Breeds that are climate-resilient: Using livestock breeds that are well-adapted to regional climatic circumstances, such as heat-tolerant breeds in hot regions and cold-tolerant breeds in colder regions, can increase the resilience of livestock systems. Examples of cattle breeds that are climate-resilient include:
  - Cattle: Zebu breeds, such as the Nelore and Sahiwal, are well-adapted to hot and humid conditions and are drought-tolerant.
  - Sheep: Breeds such as the Karakul and the Namaqua are well-adapted to harsh arid and semi-arid conditions and can withstand extreme heat and cold.
  - Pigs: Large black and Berkshire pigs are known for their ability to adapt to a wide range of climatic conditions and are often used in crossbreeding programs to improve the hardiness of other breeds.
  - Poultry: Native breeds, such as the Rhode Island Red, are known for their hardiness and resilience and are well-suited to local climatic conditions.

  - Goats: Breeds such as the Boer and the Spanish are known for their ability to thrive in hot and arid conditions and can tolerate a wide range of temperatures and weather conditions.
- Improved nutrition: Providing balanced diets and improved feed quality to livestock can increase their resilience to environmental stress and improve their health and productivity.
- Improved herd management: Implementing best practices in herd management, such as regular vaccination, deworming, and parasite control, can improve the health and productivity of livestock and reduce the risk of disease outbreaks.
- Water management: Implementing water management strategies, such as rainwater harvesting and efficient irrigation systems, can ensure that livestock have access to adequate water supplies, even during dry periods.
- Adaptive grazing management: Adapting grazing management practices, such as rotating grazing lands, to changing climatic conditions can reduce the risk of land degradation and improve the resilience of grazing systems.
- Livestock insurance: Implementing livestock insurance programs can provide a safety net for farmers in the event of losses due to weather extremes or other environmental shocks.

CONCLUSIONS

CSA provides a framework for sustainable agricultural practices that contribute to climate change response at various levels, from the farm to the global scale. CSA works to increase agricultural production, decrease poverty, improve food security, and lower greenhouse gas emissions as well as other environmental consequences by encouraging environmentally friendly farming techniques, low-carbon technology, and gender-sensitive methods. [7]

Agricultural practitioners must invest in research and development of technologies and good practices in order to implement and scale up CSA. The role of public finance in providing the necessary support and incentives for farmers to make necessary investments is also critical.

The encouragement of environmentally friendly land use strategies is a key component of CSA. This covers the preservation of natural forests, wetlands, and other habitats that offer crucial ecosystem services including soil fertility, carbon sequestration, and water management. Sustainable land use techniques can also aid in lowering the danger of desertification and land degradation, two important concerns to global food security. [20]

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