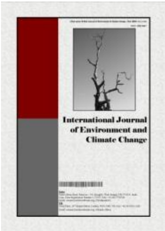

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A Review of Climate-smart Agriculture is a New Approach to Farming System

Sumana Balo [a*φ] and Debasis Mahata [b#]

[a] Department of Soil Science and Agricultural Chemistry, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal - 736165, India.
[b] Uttar Dinajpur Krishi Vigyan Kendra, Uttar Banga Krishi Viswavidyalaya, Chopra, Uttar Dinajpur, West Bengal - 733207, India.

Authors' contributions

This work was carried out in collaboration between authors. Both authors read and approved the final manuscript.

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ABSTRACT

"Climate Smart Agriculture" (CSA) was born out of the converging needs of food security, human population, biofuel and adaptation, climate change mitigation, agricultural resources, and oil prices, and food pricing. This study analyses the ideas and concepts that drive community-based agriculture using the World Bank's framework. It claims that, even though the CSA promotes better multidisciplinary approach to agriculture, it operates inside a politically neutral structure that is just focused on increasing output. Depoliticization of the global food system legitimizes present policy aims and reduces power, inequality and access difficulties. Climate-Smart Agriculture (CSA) and Sustainable Intensification (SI) are mutually beneficial. SI aids in adjusting to climate change while simultaneously decreasing emissions per unit of production. CSA includes the advantages of "climate-smart food system", "climate-proof farms", and "climate- smart soils.

Keywords: Agriculture; CSA; food security; sustainability; climate resilience.

[φ]PhD, Research Scholar,
[#]Subject Matter Specialist;
**Corresponding author: E-mail: balosumanaagri@gmail.com;*

1. INTRODUCTION

A plan for converting the food and agricultural sectors into ones that are more ecologically friendly and climate-resilient is known as "climate-smart agriculture" (CSA) [1]. Sustainable agricultural production and incomes; decreasing and/or eliminating greenhouse gas emissions, and resilience and climate change adaptation, when practicable, are the three major goals of this program [2]. CSA is defined as "agriculture that sustainably improves production, boosts resilience and mitigation (mitigation) when practicable, and facilitates the fulfilment of national food security and development objectives". Food security and development are recognized as the primary CSA goals, adaptation, mitigation, and productivity, are highlighted as the three interconnected pillars required to achieve this aim [3,4].

1.1 The 3 Pillars of Climate Smart Agriculture

- **Productivity:** Fisheries, cattle, and farms are all part of the CSA's mission to sustainably enhance agricultural output and incomes without damaging the environment. Consequently, food and nutritional security will be improved for all pople worldwide. One of the key concepts in productivity growth is sustainable intensification (SI) [1,5].
- **Adaptation:** One of the key goals of CSA is to minimise dependency of farmers on particular hazards while simultaneously increasing their ability to adapt and thrive in the face of shocks and longer-term pressures via greater resilience. Farmers and others rely on ecosystems for a variety of services, and protecting those services is a top priority. Adapting to climate change and maintaining output depend on these services [5,6].
- **Mitigation:** Global demand for agricultural products grows as production resources shrink. Climate change poses extra problems. Agricultural sustainability requires a more productive, input-efficient, and environmentally friendly production system. Reforming the whole system necessitates changes to national and local governments, as well as institutions and policies. We studied whether Climate-Smart Agriculture (CSA) may benefit India in its adaptation, mitigation, and food security initiatives. We recommended Climate-Smart Communities (CSVs) as a technique of integrating CSA into development planning (CSVs). The advantages of CSAs for productivity, adaptation, and climate change mitigation were proved by on-farm action research in India's CSVs. Our research indicates that CSA has the potential to aid in the areas of food security, adaptation, and mitigation of climate change. Incorporating CSA approaches into development planning via CSVs would bring reciprocal advantages by aiding in the construction of Local Adaptation Plans of Action (LAPA) as well as state and national climate change action plans. Gaining agricultural

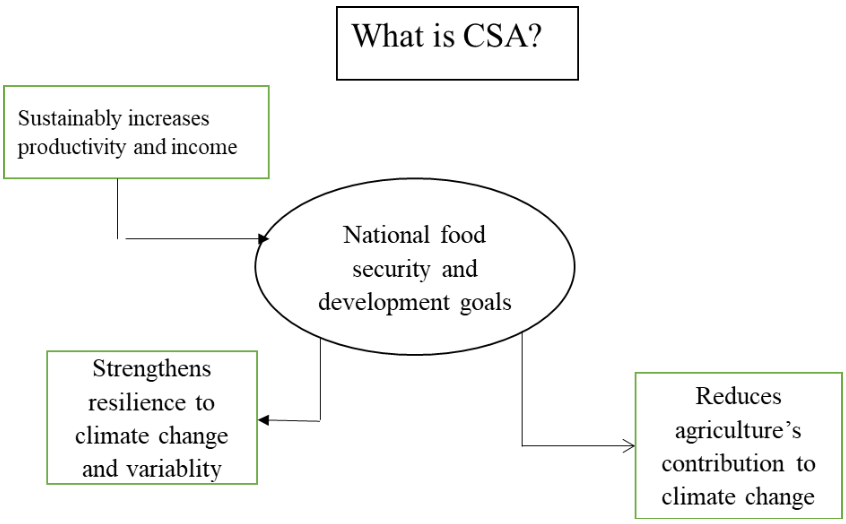

Fig. 1. Schematic representation of CSA

sustainability in the face of climatic unpredictability is facilitated by enhancing agricultural research and development processes. CSA should work to reduce or eradicate carbon emission (GHG) whenever and wherever practicable. Agriculturally induced deforestation must be prevented. Also, this maintaincarbon sinks that absorb CO2 from the air [5].

2. CAUSES OF CSA ADAPTATION

2.1 Global Warming

On the ideas of higher production and long-term viability, CSA is similar to other sustainable agriculture techniques. It differs, however, in that it expressly addresses adaptation and mitigation issues while also trying to provide food security for all people. Climate change CSA is an acronym for community-supported agriculture, and it refers to a kind of sustainable agriculture that also aims to minimise greenhouse gas emissions [7].

2.2 Synergies, Trade-offs and Outcomes

CSA must go beyond the farm level to find solutions to the three issues of production, adaptability, and mitigation. The interactions between production, mitigation, and adaptation, and which occur at various levels, including the broader socio-ecological ramifications, must be considered in this process. Interventions on the farm/community level by CSAs, for example, impact current landscape systems, socially, and biologically. Similarly, a productivity-enhancing CSA should evaluate how it impacts adaptation and mitigation, and how to meet all three objectives efficiently. Farmers and decision-makers must understand the interplay of the three pillars and levels. From the farm to the legislature, CSA seeks to develop metrics and prioritisation tools that highlight these synergies and trade-offs [3,7].

2.3 New Financing Sources

Consequently, there is a massive investment gap to satisfy food security requirements. CSA enables agricultural productivity to access climate funding for adaptation and mitigation. This involves money from the Least Developed Countries Fund, the Clean Development Mechanism, Adaptation Fund, the Voluntary Carbon Market, and the Special Climate Fund, among other sources. The targeted contribution provided expressly for CSA by the upcoming Green Climate Fund and the Global Environment Facility Trust Fund (GEF) is the most promising of all [3,7.

3. ADVANTAGES OF CSA

- ❖ **CSA addresses climate change:** Instead of traditional farming, climate change is considered while developing sustainable agricultural systems in CSA [7].
- ❖ **CSA maintains ecosystems services:** Farmers rely on ecosystems for important services such as clean air, food, water, and materials. Interventions by the CSA must not exacerbate their deterioration.. As a result, CSA employs a landscape strategy for planning and management, which is inspired by but goes beyond the narrow sectoral plans that demonstrated fragmented and conflicting land uses [6].
- ❖ **CSA has many entrance points:** It's not a collection of methods or tools. It may be entered at a number of different places, including research and development of new tools and techniques, creation of new climate change models and scenarios, advancements in information technology, and the establishment of supportive institutional and political frameworks. Therefore, it involves adjustments to the environment, the food system, government policies, and the economic value chain [7].
- ❖ **The concept of CSA is context-dependent:** As a general rule, there are no interferences that are climate-smart in every location or at every period. At the landscape level, within or among ecosystems, as well as in diverse institutional and political configurations, interventions must take into consideration the interactions between various aspects [1,2].
- ❖ **CSA empowers women and minorities:** The initiatives must include the poorest and most vulnerable populations to accomplish food security objectives and improve resilience. These communities are often found on marginal areas, which are particularly susceptible to climatic catastrophes such as drought and flooding. As a result, they are the most vulnerable to climate change. Another important feature of CSA is gender. Women often have limited access and legal rights to the land

on which they farm, as well as other productive and economic resources that may aid in the development of their resilience to natural disasters such as droughts and floods. CSA fosters the participation of all local, regional, and national stakeholders in decision-making [8].

- **CSA improves soil fertility:** It is critical to develop technologies that increase agricultural productivity, mitigate climate change, and ensure food security. Climate-smart agriculture practises have sparked a lot of interest (CSA). The impact of CSA practises on agricultural productivity, soil fertility, and carbon sequestration has been determined. Soil water conservation structures combined with biological measures, hedgerow planting, agricultural residue management, grazing management, crop rotation, and perennial crop-based agroforestry systems are examples of CSA techniques. CSA methods, according to studies, increase productivity by 30-45%. (p 0.05). Carbon is stored three to seven times more per metre in CSA landscapes than in control landscapes. Soil pH, total nitrogen, and plant-available phosphorus increased as a result of CSA treatments. Under CSA, the NDWI revealed increased soil moisture. According to the study, CSA practises may boost crop output, minimise nutrient depletion, and decrease GHG emissions by sequestering soil carbon [9].
- **CSA promotes organic farming:** Seasonal fluctuation affected the agronomic development and yield of three crops grown using organically improved fertilisers (maize, soybean, and yam). Despite the fact that the negative impacts were more pronounced during the dry season, particularly on maize and yam, the beneficial benefits reported for certain fertilisers in any season should be viewed as strategies to reduce environmental stress on crops in order to sustain climate-smart agriculture. The rate of application was another crucial factor affecting the efficacy of fertiliser on plants. Rock-Based fertiliser (RB) applied at a rate of 2.5 t ha-1 enhanced maize and soybean growth throughout both seasons. In addition, the optimal rates of RB fertiliser for yam growth were 2.5 t ha-1 (rainy season) and 3 t ha-1 (dry season) (dry season). During the dry season, spraying 2.0 t ha-1 of plant-based PB might reduce the likelihood of poor maize yield. In both seasons, the PB rate of 2.5 t ha-1 was beneficial for soybeans. Both Synthetic Chemical (SC) and Plant-Based (PB) fertilisers may simultaneously increase plant height and leaf area. In addition, both SC and RB increased the retention of organic carbon and potassium in the soil where they were applied. Manganese was the only heavy metal found in the SC (corn and yam) and Organic mixed (soybean) plots, suggesting that contamination with heavy metals was unlikely.

4. CLIMATE-SMART FARMING ANCESTORS

In the absence of a shift in the planning and investment approach, humans risk misallocating human and financial resources, generating unsustainable agricultural systems, and contributing to climate change. This 'lose–lose' situation may be avoided by including climate change into the design and implementation of sustainable farming methods. CSA explores synergies and trade-offs across food security, adaptation, and mitigation to help inform and reorient policy [8]. Without such initiatives, the IPCC projects that agricultural and food systems would be less resilient, putting food security in jeopardy. One of the biggest threats to agriculture is climate change. The decision points in the opportunity space affect the course taken: CSA paths increase system resilience and reduce food security risks, while business as usual reduces system resilience and increases food security risks. The CSA emphasises gathering facts to identify feasible solutions and essential enablers. It gives methods for analysing alternative technologies and practises in terms of their impact on national development and food security goals. Oxygen, plant nutrition cycles, and carbon and may be regulated to improve the soil's ability to withstand extreme weather events like droughts and floods, as well as its ability to sequester carbon. Supply-side reforms must be accompanied by initiatives to shift consumption habits, decrease waste, and generate positive incentives across the manufacturing chain World Bank [10].

5. WHAT IS REQUIRED FOR THE SUCCESSFUL DEPLOYMENT OF CSA?

World Food Programme (WFP) and United Nations Environment Program (UNEP) immediate action has been addressed climate change's effect on agriculture. It is difficult for national and local decision-makers to get their hands on the evidence that they need to make sound decisions. Different policies and technologies, at all sizes, need tools to assess their effects. Barriers to the adoption of climate-change-responsive agricultural practises, as well as methods of surmounting these obstacles, remain largely unidentified in the research base.To better understand what works in diverse agro-ecosystems and agricultural methods and why, more thorough investigations are required. To boost people's adaptive ability, CSA is focusing on developing national and local institutions so that they have better access to resources, especially information [11].

6. POLICY AND ADAPTATION OF CSA

According to the World Food Programme (WFP) and the United Nations Environment Program (UNEP), urgent action is needed in four areas to alleviate the effect of climate change on agriculture. As a result, decision-makers at the national and local levels lack sufficient information to make sound decisions [12]. Tools are required to assess the effects of various policies and technology of all sizes, from the local to the global. There is a significant knowledge gap when it comes to figuring out how to get farmers to embrace climate-smart agriculture methods. The CSA's efforts to rid its framework of the social economic aspects of food production also produce considerable contradictions inside its conceptual machinery. Global food security can be improved by adopting a more revolutionary strategy, it outlines four critical stages in which the politics of food emerges [13].

- **Tension 1: Metrics omitted:** The Climate Smart Agriculture Strategy (CSA) of the World Bank is intended to offer a planning framework for determining the most cost-effective investments for increasing agricultural production in the face of climate change. The criteria that support CSA's triple-win scenarios are critical to its content. Surprisingly, no specific criteria for CSA performance are established. Within the CSA, the World Bank's focus on 'triple-win' scenarios merely exorcises complicated political factors in a way that is very supportive of the existing quo. The Bank's stance differs from that of other agencies, which are more aware of the trade-offs and value judgments that come with CSA. It shows how four unique agricultural aims production – the pursuit of profit; the contribution of agriculture to local communities in both environmental and economic terms the production of food, fibre, or fuel for sale or subsistence; and the preservation of ecologically sustainable foundations for future growth; – are expressly complex and potentially conflictual [11,12].
- **Tension 2: A resiliency black hole:** With regards to the World Bank's concept of "resilience," it is filled with philosophical and social inconsistencies that are difficult to reconcile. The World Bank never explicitly defines resilience, leaving the meaning of the phrase up to interpretation. We need to think about resilience from a political standpoint, not only as an abstract moral aim that applies to all social groups equally, but rather as a practical question of who benefits and who pays for it daily [13]. Advantage keeping non-optimally constructed agroecological systems may extend to their long-term social and ecological worth, as well as their resilience to shocks and pressures. Given the uncertainties of sea-change climatic changes, traditional mixed agricultural methods intentionally foster both variety and redundancy. According to the International Institute for Economic Cooperation and Development, yield maximisation may be in constant conflict with wider sustainability goals, and simple technological remedies may not be achievable or appropriate (IIED). The idea of reducing the intensification imperative to improve resilience, on the other hand, does not sit well with the CSA paradigm, which prioritises productivity gains [14,15].
- **Tension 3: Pick-and-mix agriculture:** For more than a decade, current agriculture-development practises have increasingly relied on a pattern of success tales rather than significant research. Nobody thinks about who gets to define and assess success, or for what purposes. This is exacerbated by the CSA's core principles' inherent ambiguity and a lack of a clear commitment to a participatory approach. Simplified narratives of success are utilised in the CSA literature to replace the causality analysis is a difficult task [16]. Model instances of 'triple-win' solutions are often taken out of their historical settings,

stripped of their socio-political nuances, and trimmed to eliminate the messy reality of unintended consequences. Not only are the success stories chosen for the Council for Sustainable Agriculture (CSA) intended for worldwide consumption, but the tales are also included in the World Bank's country profiles, which are compiled from information about countries. In some cases, farmers in Peru are praised for employing CSA practises that are derived from 'ancient Andean agriculture,' according to the World Bank, CIAT, and CATIE [17]; in others, the Bank bemoans the lack of transformation of subsistence farming into an agricultural system that is technological and efficient, with a focus on raising earnings, reducing poverty, and ensuring food security [18]. The nature of agricultural technology and agroecological practises means that they are inexorably intertwined, and it is hard to overlook the conflicts that arise between them, as Tittonell says. Because of competing pressures, intensification often results in the substitution of outside inputs for the ecosystem services supplied by biodiverse landscapes, resulting in the loss of biodiversity, localization, and nutrient cycling in the process. An important part of the Agricultural Modernization Approach (CSA) of the World Bank is built on the idea that smallholder farmers are 'excluded' from competitive market forces, and that their access to new biotechnological and environmental benefits is conditional on their inclusion in value chains. Even though many smallholders have a strong connection to the market, this might have a detrimental effect on them [19].

- **Tension 4: Consumption is lacking:** There is strong resistance to accept that farming should be rated based on its productivity and resilience. Similarly, do not reflect on current spending habits in the same way [20,21]. Despite their socio-ecological inefficiencies, conativelysumer sovereignty drives global food production toward elite consumption needs – notably the meatification of diets — CSA avoids discussing this. An example a triple-win situation may be seen in the case of reduced gasoline use, improved soil health, and reduced erosion. Using glyphosate in favour of more potent herbicides has resulted in lower toxicity for the product. Concerning reductionism, however, arises from Argentina's designation as CSA's model instance. First, the Bank may offer glyphosate-driven monocropping as a model technology since it's more productive and emits fewer pollutants than the ecologically damaging industrial farming methods that came before it. It ignores the intensive consolidation of land ownership and evictions of smallholders, continued use of carbon-intensive and chemical-intensive technologies, the massive loss of biodiversity caused by cropland expansion into forested areas, and the escalating environmental conflicts caused by groundwater contamination, glyphosate-resistant plants, and soil degradation. The produce of Argentinean soy fields, which represent 45 % of farmland, is used to support industrial cattle, a practice with severe environmental consequences [22,23].

7. CSA AND FOOD SECURITY

- Agriculture, food processing, food distribution, and food consumption are all part of the food system. The global food system is driven by inherent potential, the biophysical environment, and socioeconomic factors. Food safety issues, pest and disease outbreaks, life cycle GHG emissions, and various supply and demand constraints all pose constant threats to the global food chain. Dietary changes, rising human population, and competition for land, water, and energy all pose threats to food system integrity and price volatility. Food security results from a functional food system and its inherent potential [24]. Food security refers to a country's ability to obtain enough food to meet its dietary energy requirements [25]. Food security was defined by the World Food Summit in 1996 as "physical, social, and economic access to sufficient, safe, and nutritious food to meet dietary requirements and food preferences for an active and healthy life." Food security is defined by usage, availability, stability, and accessibility. Food security is fundamentally nutritional.
- Availability It refers to "the availability of adequate amounts of appropriate quality food, whether produced domestically or imported". As the world's population rises,

so does the agricultural system's ability to supply food demand [26].

- ❖ It comprises "individual access to enough resources for obtaining appropriate meals for a balanced diet". Changes in actual income and food costs, as well as transportation of food grains and consumer buying power, all have a significant impact on this dimension [27].
- ❖ Stability: It mentions the availability of households, food to people, and the general public at all times [24,25].
- ❖ Health care, food, food safety, cleanliness, sanitation, and water are all reflected in this dimension. Nutritional well-being is the goal of this aspect of food security [26].
- ❖ A safety net for the body's nutritional needs Food security necessitates a level of nutritional safety. Food security can be achieved while simultaneously increasing the climatic resilience of crops like nutri-cereals and pulses. Aside from improving soil fertility, pulse crops also help farmers and cultivators in rural areas to maintain their livelihoods. The agricultural system is more resilient and adaptable when it has a wide variety of crops and farms [28].

Risk and uncertainty are inherent in climate change and food systems, particularly food security. Climate change has a widespread influence on all aspects of food security, including food accessibility, food costs, consumption, food production, and use. Perceiving climate change's consequences necessitates mitigation and adaptation measures incorporating environmentally friendly technology, sound land use planning, and efficient use of agricultural inputs. It is essential to have climate-smart agriculture to ensure global food security, improve rural lives, and strengthen the agricultural system and its stakeholders [29-33].

8. CLIMATE RESILIENT PATHWAYS IN AGRICULTURE

The future of agriculture is at a turning point. Growth and development in agriculture are necessary to cope with rising declining soil fertility, food demand, land and water usage conflicts as well as the effects of global change, including climate change. We need a paradigm change in agricultural planning, innovation in food systems, and risk management to meet the demands of the greening of agriculture growth. There are several growth paths for agriculture because of the numerous biotic and abiotic challenges it faces. CSA, on the other hand, is more resilient and less vulnerable to food insecurity [1]. The dynamics of change make existing vulnerabilities much worse. The CSA method, on the other hand, tries to lessen the effect of change drivers via strategies of adaptation and mitigation. Agriculture that is more in tune with the changing climate includes practises such as climate- smart agronomy, integrated agricultural systems, conservation agriculture, agro-forestry, managing crop waste, and agroforestry. The food supply chain and landscape are used to spread CSA ideas from farm to global level. The concept of an ecosystem drives CSA. Cultivating Sustainable Agriculture (CSA) relies on incorporating mitigation and adaptation strategies into the agricultural development trajectory. A human-mediated approach to reducing or eliminating greenhouse gas emissions (GHGs) via enhancing GHG sequestration is referred to as climate change mitigation. Crop and soil ecosystems have a significant impact on climate change mitigation options and tactics [34-36]. When methanogens operate on soil organic matter in lowland paddy cultivation, for example, under anaerobic circumstances, methane is created. Methane emissions may be reduced if adequate mitigating techniques are used. Irrigation for certain crops and regions Reduced methane emissions may be achieved by mid-season aeration. Ruminant methane emissions may be lowered by feeding them a protein-rich diet. Local knowledge and adaptive agricultural types are among the methods [37,38].

9. SUSTAINABILITY-FOCUSED INTENSIFICATION IN ACTION

Mitigation and adaptation can be achieved in a variety of ways, such as improving soil quality, which provides regulator essential such as carbon sequestration, filtering, buffering, moderating the hydrological cycle, plant nutrient cycles, and regulating the carbon, oxygen, enhancing drought and flooding resilience, and improving soil biodiversity. SI is made up of all these elements [44]. Four CSA instances are briefly shown here.

Table 1. Climate change threats and required climate smart agricultural practices

Climate Change indicator	Impact on Agriculture	CSA practice required	References
Extreme weather events	Loss of Crop	Improved extreme weather events prediction and early warning system	Araus and Cairns, [39]
Increased flooding and waterlogging	Loss of crop or Reduce Crop yield	New crop varieties with high moisture tolerance	Törnqvist, and Jarsjö, [40]
Less precipitation	Reduce crop yield in rain-fed agriculture	Improved irrigation Technique	Armanuos et al. [41]
Saltwater intrusion	Reduce irrigation water	A barrier to saltwater intrusion	Hall, A. E. [42]
High Temperature	Reduce Crop yield	New crop varieties with greater heat tolerance	Jaramillo et al. [43]

- **Banana-coffee intercropping:** Climate change would have a significant impact on Arabica coffee is cultivated at higher elevations where temperatures are lower. Temperature rises have an impact on crop physiology as well as pest and disease pressure. In the 1950s, coffee production increased fast over the globe, and many governments have subsequently encouraged high input monocropping techniques for smallholders. Contrarily, in East Arica, combining bananas with other crops has been demonstrated to increase plot revenue by over 50 percent, regardless of whether the land is fertilised or not. Coffee is produced on trees that thrive in partial shade. Bananas offer shade while also reducing the occurrence of coffee leaf rust. Banana intercropping has the potential to store an additional 15–30 metric tonnes of carbon per hectare, which might assist to slow the rate of global warming [45,46].
- **Livestock systems intensification:** Viable livestock intensification might greatly aid both mitigation and adaptation. These systems vary greatly in terms of production and efficiency. Within the same agro-ecological zone, worldwide economic modelling research explored changes caused by economic incentives coming from alterations in demand and relative factor prices between now and 2030. Transitioning to more efficient, intensive systems will enhance meat and milk output per ha and per kg DM of feed by up to 30%, and family income by comparable amounts. These modifications would also reduce emissions by 736 Mt CO_2 equivalent per year (almost 10% of total agricultural emissions), largely by avoiding converting 162 Mha of natural land. Despite obstacles including lack of access to markets and funding, encouraging transitions to more productive systems in suitable locations may significantly improve mitigation, adaptation, and food supplies. Next is an example of how intensification may be done [47,48].
- **Agroforestry may be used to increase the rations of livestock.:** Higher-quality ruminant diets result in lower methane emissions per unit of milk and meat, as well as increased meat and milk productivity. Feeding the leaves of trees like *Leucaena leucocephala*, which is abundantly cultivated in the tropics, is one technique to increase cattle productivity. Even a modest quantity of Leucaena leaves added to dairy calves may triple milk output per day, quadruple weight growth per day, significantly increase farm revenue, and cut methane production per kg of meat and milk by 2 and 4 times, respectively. At the same time, agroforestry trees have the potential to boost carbon sequestration. As enhanced diets would significantly lower the number of ruminants required to meet future milk and meat demand, widespread adoption of this option offers significant mitigation potential [47,49].
- **Stone bunds and zaï*:*** Water may be collected and runoff erosion can be reduced by building stone bunds that follow contours. Crop yields of millet or sorghum might quadruple to more than 1 t per ha if new land management practises

such as za pits are used (shallow bowls filled with compost or manure where crops are cultivated). Improved land management has been demonstrated to boost soil fertility as well as ground water levels. Farmers may thus boost their revenue and dietary variety by growing vegetables near wells. Stone bunds have the ability to improve nutrition while also giving farmers greater flexibility in the face of unexpected weather (adaptation to wetter or drier climates). Increasing manure fertility improves soil fertility, and increased tree cover provides further mitigation. As a result, it is a climate-safe method to long-term intensification. As shown by these examples, sustainable intensification assists in both adaptation and mitigation by increasing resource efficiency and lowering emissions per unit of production. CSA features such as crop and livestock insurance and weather data may aid SI adoption, despite the fact that SI is a minor component of the adaptation agenda. Although a sustainability emphasis may be incompatible with intensification (in that it may result in increased GHG emissions in absolute terms as well as per unit of production), CSA and SI do not imply any trade-offs. Other activities that contribute to long-term food and nutritional security include reducing overconsumption, reducing food waste, improving diets, and maintaining adequate animal welfare standards [50].

10. CONCLUSION

Many sections of the globe have poor crop yields and inadequate resilience to unfavourable circumstances [51-54]. Climate change is projected to reduce productivity and increase inconsistency. Many nations have intended to use Climate Smart Agriculture (CSA) to enhance agriculture. In this regard, the Bank expressly incorporates CSA into its long-standing modernisation narrative, which focuses on expanding supply via liberalisation, technical improvement, and the spread of modern production practises to underdeveloped countries. With the correct practises, regulations, and investments, agriculture can progress toward CSA, lowering food insecurity and poverty while also helping to reduce the danger of climate change to food security. This strategy acknowledges and accommodates the fact that approaches to combating and adapting to climate change vary from country to country. Research must focus on identifying and supporting climate-smart initiatives that may help mitigate the negative social and cultural effects of climate change, such as land loss and forced migration, while also bolstering rural communities, smallholder livelihoods, and employment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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