The European Commission's Knowledge Centre for Global Food and Nutrition Security

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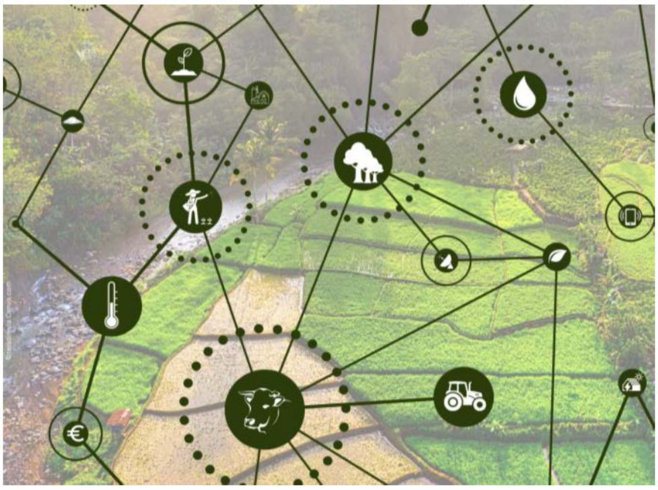
Knowledge Review – Climate-Smart Agriculture in developing countries: definition – practices – adoption



Introduction

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change states that increasing weather and climate extreme events have exposed millions of people to acute food insecurity and reduced water security, with the largest adverse impacts in developing countries.

Adaptation is therefore a necessity, especially in the agricultural sector. Agriculture plays a crucial role in improving economic conditions in developing countries, but due to limited human, institutional, and financial means, many countries lack the capacity to anticipate and respond to the direct and indirect effects of climate change. In this context "**climate-smart agriculture**" has gained momentum as an approach to transform agricultural systems [1].

The objective of this knowledge review is to provide policymakers and practitioners with key knowledge about climate-smart agriculture (**CSA**).

The knowledge contained in this review has been extracted, organised, and synthesized from a selection of 60 recent publications on the subject. **The focus is on smallholder agriculture in developing countries** [1]. The knowledge presented in this review is not exhaustive and does not necessarily reflect the position of the EC.

Rational for CSA

Climate change (CC) makes farming systems more vulnerable to various forms of climate-related risks and deteriorates household income and farmers' livelihoods [2] [3]. It negatively affects crop suitability in several farming systems and agroecological zones, especially where crop production is rainfed [3]. The decrease in water supply and areas suitable for particular crops [3], and the increase in the prevalence of pests, parasites, and diseases (both in fauna and flora) affect **food security** at all geographic scales through the reduction in agricultural productivity and ultimately lowering food availability [4].

Furthermore, the agricultural sector also contributes directly to the emission of 11% to 17% of total greenhouse gases (GHG) emissions globally per year (see figure 1) [5] [6] . This is due to soil and land use change (e.g. deforestation, livestock farming, and fertiliser use) [4].

In sum, agriculture faces several challenges: **(a)** meeting food and socio-economic needs without altering the functioning of natural systems, **(b)** improving resilience to climate change (adaptation) and **(c)** reducing GHG emissions (mitigation) [4].

In this regard, **climate-smart agriculture** [7] is an essential integrative approach to address the interlinked challenges of food security and climate change [2] while addressing the trade-offs between food production and climate objectives [1] [6].

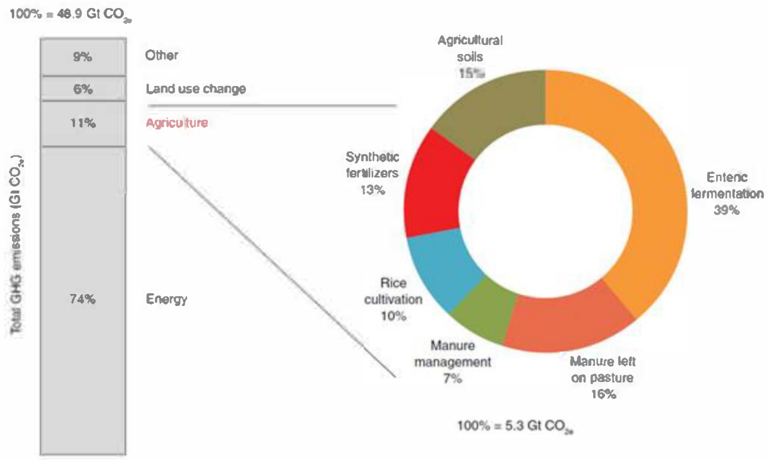


Figure 1 Global Agricultural emissions [7]

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Definition of CSA

Climate-smart agriculture is one approach among others to **sustainable agriculture** (see table 1). It aims at transforming and reorienting agricultural systems [9], and developing the technical, policy, and investment conditions to achieve sustainable agricultural development for food security under the new realities of climate change [10]. The concept was first launched by FAO in 2010 [11], and since then it has been reshaped through inputs and interactions of multiple stakeholders [12].

CSA encompasses innovative farming practices and agricultural technologies [13] to achieve three main pillars, or objectives, of sustainable development (economic, social, and environmental): **(a) sustainably increase agricultural productivity and incomes, enhancing the achievement of food security and development goals; (b) adapt and build resilience to climate change (adaptation); (c) reduce greenhouse gas (GHG) emissions and increase carbon sinks where possible (mitigation)** (see figure 2) [11] [12].

CSA has a strong focus on technologies, policies and financing [16] and some civil society organisations highlight the absence of clear environmental and social criteria for what can –or cannot- be considered "climate-smart", fearing that industrial and environmentally unfriendly approaches to agriculture could also be labelled "climate-smart"[1]. In particular, CSA does not exclude the use of chemical products (herbicides, insecticides, fungicides), genetically modified organisms or industrial monocultures (e.g. biofuels), which has generated criticism and controversy [4].

Figure 2. Climate smart-agriculture - A triple win: Increase in productivity and incomes, adapt and build resilience to climate change; Reduce GHG emissions
(Image based on [16] figure 1)

CSA may be implemented for any type of production and within any geographical scope [11]. The approach considers the three objectives to inform decisions from the local to global scales and over the short and long term [11] and aims to systematically promote and take advantage of **synergetic relationships** between the three pillars, while managing, fully accounting for and reducing trade-offs [9] [16] [17], to obtain solutions adapted to a specific context [11].

Photo by Quang Nguyen Vinh from Pexels

Table 1. Presentation of the main objectives of some of the approaches to sustainable agriculture [10]

Approaches to Sustainable Agriculture	Main objectives and principles
Climate-Smart Agriculture	Use of practices and technologies that create adaptation to climate change; increased productivity and yields; mitigation of climate change (when possible)
Carbon Farming	Use of farm practices that reduce CO_2 emissions and practices that sequester or store carbon to deliver climate mitigation in agriculture
Sustainable intensification	Use of innovations to increase productivity on existing agricultural land to create positive environmental and social impacts
Organic farming	Use natural substances and processes in food production together with responsible use of energy and natural resources to maintain biodiversity and preserve ecological balances
Permaculture	Mimic the patterns and relationships found in nature for food production, intertwining food production needs with sustainable efforts to protect nature and its resources
Regenerative agriculture	Use of farming practices that improve soil health and soil fertility and protect water resources and biodiversity thus preventing land degradation and deforestation
Agroecology	Application of ecological principles to design sustainable agroecosystems to strengthen agro-sustainability and improve food security
Circular agriculture	Minimize inputs of concentrate feed and chemical fertiliser as well as outputs of harmful substances and waste, to preserve and enhance natural resources, create efficient use of resources, and recover value from waste

1 https://www.climatesmartagconcerns.info/rejection-letter.html

CSA Technologies and Practices

CSA is not a single specific agricultural technology or practice that can be universally applied, it is an approach involving different elements embedded in a local context to identify suitable agricultural production technologies and practices [10] [11]. Technologies considered climate-smart are highly diverse but in 2018, a study found that just five technology clusters (water management, crop tolerance to stress, intercropping, organic inputs, and conservation agriculture) accounted for almost 50 percent of all CSA technologies identified by experts as climate-smart across 33 countries. Most technologies considered climate-smart demonstrate synergies between productivity, adaptation, and mitigation pillars, revealing opportunities for co-benefits and potential "triple-wins." Five technology clusters—tree management, improved pastures, silvopasture, conservation agriculture, and water management—are included in the top 10 smartest technologies for all three pillars [17].

Table 2. Description of the main CSA technologies and practices and their potential for climate change adaptation and mitigation

Main technologies and practices	Description	Adaptation	Mitigation	Examples
Integrated Soil Management (ISM) [19] [20]	Combination of agronomic practices that aim to enhance soil health and to increase: soil moisture; soil carbon sequestration; and nutrient retention [21] [22]	ISM improves soil moisture storage capacity and agroecosystem resilience [20]	ISM improves soil carbon sequestration and the improved nutrient retention decreases the use of inorganic fertilisers [18] [19]	Crop diversification and rotation, including intercropping; N-fixing legume crops; Mulching and incorporation of crop residues; Reduced or zero tillage; Animal manure, green manure, and compost [18]–[20] [23]–[25]
Improved Water Management (IWM) [19] [20]	Combination of practices for greater water use efficiency, in particular for irrigated crops, to reduce water use [19] [20]	IWM enhances resilience to droughts and increases in temperature, opening opportunities for dry-season agricultural production [20]	By reducing the amount of water required, farmers reduce their energy consumption for pumping [20]	Laser land levelling; Contour farming; Rainwater harvesting; Supplemental and deficit irrigation; Alternate wetting and drying (AWD) [19] [25] [26] [27] [28]
Improved livestock management and production [19] [20]	Improved livestock management combines feed and nutrition practices with improved breeds, sustainable land management (such as silvopastoral practices), and integrated manure management (*e.g.* livestock and cropland systems recoupling) to increase agriculture productivity whilst decreasing GHG emissions [10] [20]	Improved animal breeds are more resilient to heat, droughts, and diseases; Organic matter and nutrient recycling improve soil health and resilience to climate shocks [10] [20]	Better feed and nutrition by planting better grasses and legumes can reduce GHG emissions from enteric fermentation; Better land management (e.g. silvopastoral systems) will reduce GHG emissions by eliminating the emissions caused by land use change for feed and forage production [20]	Heat-tolerant breeds; Livestock and cropland systems recoupling; Selection of low methane-producing animals; Genome editing; Improved livestock diets and feed additives (that reduce enteric fermentation); Covering manure storage facilities with biogas collectors [10] [19] [20] [29]
Improved seeds and stress-tolerant crop varieties [19] [20]	Use of innovative breeding tools and techniques to increase the rate of genetic gain for important multiple traits, like drought and heat tolerance, tolerance to crop diseases, pests, and poor soil fertility [20] [30]	Crops bred for greater drought, heat, and pest tolerance are more resilient to climate changes [20]	More pest-resilient seeds could reduce the use of chemicals	Use of endemic varieties; Use of improved varieties (such as cross-breeding, genome editing, and GMOs) [19] [29] [31]
Digital agriculture	Digital agriculture entails the use of digital technologies, to make farming more precise, productive, and profitable. Digital tools can provide targeted information and opportunities to farmers to better adapt and mitigate climate change [20] [30]	Digital platforms can give farmers information on climate events, and meteorological forecasts and give them the possibility of making better decisions about the time of performing certain activities (such as irrigation) [30]	Digital technologies, by increasing efficiency in chemical inputs use, decrease the quantity use [20]	Climate information services; Digital tools for better managing water requirements; Digital technologies for managing intercropping; Variable-rate treatments (VRTs); Digital technologies for mechanical management of weeds (e.g. Laser weeding robots) [20] [30]

Main technologies and practices	Description	Adaptation	Mitigation	Examples
Agroforestry	Agroforestry is the intentional integration of trees and shrubs into crops/pasture in a single farming system on the same piece of land [20]	Agroforestry can increase resilience to heat stress, drought, floods, and wind storms by: Improving water management (reduced evaporation, increased water infiltration); Improving microclimate (reduced ambient temperature); Enhancing soil productivity (nutrient cycling, reduced soil erosion, and diminishing the effects of extreme weather events); and create enhanced control of pests and diseases [20]	Agroforestry systems increase carbon stored in vegetation and soils; Agroforestry also helps to reduce pressure on natural forests, thereby reducing emissions associated with land use change (deforestation) and inorganic fertilisers [20]	Silvopasture; Alley cropping; Improved fallow; Windbreaks; Forest farming; Riparian forest buffers [20] [32]
Conservation Agriculture (CA)	CA is a form of ecological farming that is based on three principles (1) minimum soil disturbance; (2) permanent organic soil cover; (3) diverse crop rotations [20] [25]	CA enhances biodiversity and natural biological processes and increases tolerance to changes in temperature and rainfall, which contributes to increased water- and nutrient use efficiency, improved soil structure and aeration, greater water retention, and reduced soil erosion [20] [25]	The improved soil structure increases soil carbon sequestration. No-tillage increases soil organic carbon storage and decreases CO_2 emissions. The use of organic fertilisers reduces GHG emissions from the production and use of synthetic fertilisers [20] [33]	Minimal or no soil tillage; use of manure and other organic fertilisers; cover crops; incorporation of crop residues; crop rotation; permanent soil cover; diversification of plant species [20] [25]

Box 1. Agroecology vs CSA

CSA does not encompass the 13 guiding principles of agroecology. For instance, agroecological principles related to social values, fairness, governance and participation are absent in CSA [16].

Looking at farming practices, while many agroecological practices are classified as climate-smart because they contribute to adaptation and mitigation, not all climate-smart practices and technologies follow agroecological principles [28]. For example, while agroecology aims to reduce or eliminate the dependency on external inputs, CSA aims to optimize their application [16]. For some authors, CSA pays too much attention to innovations and not enough to traditional knowledge/practices and the underlying mechanisms that allowed existing systems to resist or recover from extreme weather events [28].

Several agroecological practices directly contribute to adapting and mitigating climate change: diversification of production, inclusion of landscape elements, reduction of inputs, recycling, promotion of seasonally appropriate diets, etc. [4] [28]. However, while substantial evidence exists for the impacts of agroecological practices (e.g. farm diversification, agroforestry and organic agriculture) on indicators of climate change adaptation, evidence for impacts on mitigation is modest, except for enhanced carbon sequestration in soil and biomass associated with agroecological approaches, notably for agroforestry[2].

In parallel, many agricultural practices considered climate-smart (see table 2) are also present in agroecology: integrated soil management, livestock and cropland recoupling, agroforestry, etc.

Applying agroecological principles on farms adopting CSA practices (or vice-versa) shows great potential for greater performance in all of the three pillars of CSA: productivity, adaptation to, and mitigation of climate change [4].

Case studies

Case study 1. Coffee of the Future – Promoting deforestation-free coffee in Peru and Colombia (2013-2020)[3]

Climate change has reduced coffee yields and has forced growers to seek new lands and adapt to a harsh reality.

In the search for healthier soils, forests have been cleared, water has become scarce, and soils have become eroded. *Solidaridad* and *Norway's International Climate and Forest Initiative (NICFI)*, implemented a programme for climate-smart agriculture in coffee to make it more resilient to climate change, while increasing productivity, cup quality, and forest conservation.

Climate-smart coffee:

- increases the density of coffee bushes per hectare, avoiding deforestation
- introduces shade trees to reduce erosion
- creates more efficient use of fertilisers
- reduces the use and contamination of water

In the first phase of this project, from 2013 to 2016, there was an increase of 20% in productivity and a reduction of more than 27,000 tonnes of CO^2 emissions. By the end of the project, in 2020, more than 10,000 hectares of farmland were under climate-smart production, with more than 5,000 producers producing climate-smart coffee.

2 https://www.theguardian.com/global-development-professionals-network/2014/oct/17/climate-change-agriculture-bad-isnt-good

3 https://www.solidaridadsouthamerica.org/wp-content/uploads/2021/12/Coffee-of-the-Future-2-3.pdf

Case study 2. *Zai* – a conventional farming technique for soil fertility management [34]

The *Zai* technology is designed to rehabilitate degraded lands, conserve soil moisture, and improve farm yield. *Zai* is the term farmers coined to refer to small planting pits (about 20–30 cm in width, 10–20 cm deep) in which organic matter (manure, compost, or dry biomass) is buried before planting the seed in those pits (see figure 3). The organic matter buried in the soil attracts termites and other soil insects, which help maintain soil structure, improve infiltration, and increase soil nutrient, making degraded land available again for cultivation. The deepness of the pit also protects the seedlings from wind damage.

Developed by farmers in Burkina-Faso in the early 1960s, the implementation of this technology successfully contributed to reduce the high level of emigration caused by a big period of drought in the 1970s, as many were abandoning their land because of low yield. Since then, the technology was adopted in other Sahelian countries that receive relatively low levels of rainfall, *e.g.*, Mali, Niger, and Ghana. However, the adoption of the technology has been low despite its diffusion and proven results.

The results of a study conducted in 400 farm households from the Garu and Tempane districts of Ghana, found that to boost the adoption of this agrarian technology, access to extension service should be strengthened through adequate provision of logistics, in-house training, and recruitment of agents.

Also, farm households should be encouraged to engage in non-farm economic activities to complement their farm income and enhance the purchase of productive farm inputs.

Figure 3. Millet growing in Zai pits in Burkina Faso. Photo courtesy of Hamado Sawadogo [4]

Case study 3. Lao People's Democratic Republic – addressing labour scarcity through the gender-sensitive roll-out of drum seeders for rice [35]

Smallholder rice farmers in Lao face many challenges including a decline in the availability of water and agricultural land, lower productivity, and labour scarcity. They also face climate change-induced challenges such as droughts, floods, and the spread of pests and diseases. Against this background, the Laotian Government organized the testing of a drum seeder by smallholder farmers, with technical support from FAO – a drum seeder is a manual technique that is used to seed pre-germinated rice seeds in lowland and irrigated rice production systems (see figure 4) – it is gender-sensitive as it can be adapted for use by both women and men.

Drum seeders enable farmers to:

- reach higher labour productivity
- better cope with erratic weather
- suppress the decline of water availability by profiting from residual soil moisture since drum-seeded rice matures 10 to 15 days earlier than transplanted rice
- largely boost their agricultural incomes reducing the work burden and production costs

The inclusion of women in the utilization of this technology can boost the adoption and amplify its benefits.

Figure 4. Drum seeder - Photo by incaphilippines.blogspot.com)

Case study 4. The Scaling Up Fertiliser Deep Placement and Microdosing Technologies in Mali project (2014-2019) [36]

Fertiliser deep placement (FDP) involves placing a fertiliser briquette into the soil, near the plant's root zone, providing the plant with nutrition throughout its growth cycle. FDP increases the efficiency of nitrogen (N) fertilisers while reducing runoff and greenhouse gas emissions. FDP also reduces weeds, encourages better water management, and ensures the availability of N until the flowering stage. Microdosing technology (MD) is the application of very small amounts of fertiliser directly to plant roots. The method increases fertiliser efficiency, doubling productivity.

These methods do not just increase fertiliser efficiency and productivity of crops, they contribute to reducing agriculture's contribution to climate change by mitigating greenhouse gas emissions associated with fertiliser use.

Generally, FDP reduces fertiliser use by 33%, increases rice yields by 15%, and reduces NO and N2O emissions. Nearly 50,000 farmers involved with FDP-MD experienced 75% to 80% savings in the amount of fertiliser used.

Factors influencing CSA adoption

Adoption of CSA has been shown to offer multiple wins, from increased productivity and incomes to enhanced food security and dietary diversity [6]. While adoption of CSA is largely dependent on farmers' preferences, financial capacity, secure access to land, awareness of climate risks, knowledge (skill, training, and education), the creation of an enabling environment at the country level to facilitate the adoption and implementation of CSA is strategic [2] [18]. This could further help in accessing climate finance, much needed to promote CSA.

[4] https://www.echocommunity.org/resources/3bbc0e7d-5730-4af1-901d-3b3c68c46c48

Enabling environment

The adoption of CSA needs a fostered enabling environment for conducive policies, institutions and finance [15].

National adaptation plans (NAPs) – a tool introduced under the Cancun Adaptation Framework – enable countries to identify medium- and long-term adaptation needs and develop and implement strategies and programmes to address those needs. It is a continuous, progressive, and repetitive process that follows a country-driven, gender-sensitive, participatory, and fully transparent approach[5].

CSA country profiles – CSA country profiles bridge a knowledge gap by providing clarity on CSA terminology, components, relevant issues, and how to contextualize them under different country conditions. The aim is to develop evidence-based interventions and CSA investment plans at national and regional levels. Thus, enhancing the capacities of local institutions and farmers to implement projects in the field [35][6]

Climate Finance

Climate finance plays an essential role in facilitating CSA adoption. Climate finance is often concessional, i.e. financing offered on terms that are more attractive than those offered by the markets [25].
Climate finance refers to local, national, or transnational financing that seeks to support mitigation and adaptation actions that will address climate change[7]. Allocation of climate finance to all sectors has continued to increase since 2000 [38], however high-income countries have not been able to reach their annual goal set at COP 15, that is to mobilize USD 100 billion for adaptation financing in developing countries [39] - funding stood at just USD 83,3 billion in 2020. A report by OECD [40] found that 2023 will most likely be the year the USD 100 billion threshold is passed, and annual funding is projected to surpass the billion goal in 2024 and 2025. However, it is estimated that the funds needed for a climate-positive transformation of food systems plus meeting other Sustainable Development Goals range up to USD 350 billion per year to 2030 and USD 280-500 billion in 2050[8] [29].
Several billion dollars of international funding for climate change in the agriculture sector has been channelled through CSA investment programmes financed by multilateral development banks (MDBs), the International Fund for Agriculture and Developments (IFAD), and others [15] [19] [21]. However, developing and conflict-affected countries are being left behind, when it comes to having access to climate adaptation financing, with donors and international climate funds instead prioritizing relatively stable countries [41]. To achieve better chances to access climate finance, developing countries' governments should set National Adaptation Plans (NAPs) and provide robust data on climate impacts [42].

Photo by Pixabay from Pexels

Box 2. Main climate financing sources

Financial mechanism of the United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC's financial mechanism aims to provide funding to developing country parties to implement the Convention's framework, and it is composed of various operating entities and funds [19].

- Global Environment Facility (GEF) [15] [19] [21]
- Least Developed Countries Fund (LDCF) [19]
- Special Climate Change Fund (SCCF) [19] [21]
- Adaptation Fund (AF) [15] [19] [21]
- Green Climate Fund (GCF) [15] [19] [21]
- Pilot Program for Climate Resilience (PPCR) [21]
- Climate Investment Funds (CIFs) [21]
- Glasgow Financial Alliance for Net Zero (GFANZ)[9]
- South-South Cooperation Grant (SSC) from the Adaptation fund [43].

Note: The GEF administers LDCF and SCCF and hosts the AF.

Market-based funding

Market-based funding is available through a range of voluntary and compliance schemes that allow companies or countries to trade sell and buy credits. Countries can use these schemes to fund their CSA investments [19]:

- The Clean Development Mechanism (CDM) gives out countries that reduce CO_2 emissions certified emission reduction credits (CER). These CERs can be traded and sold [19].
- Voluntary carbon markets allow carbon emitters to offset their emissions by purchasing carbon credits emitted by projects targeted at removing or reducing greenhouse gas from the atmosphere [19] [26].

Farm Level

At the farm level, several factors could positively influence the adoption of CSA.

Secure access to land

Secure land tenure is critical to the sustainability of land use and CSA implementation. If land tenure cannot be protected effectively, farmers and commercial investors will be unwilling to invest [22].

Photo by Quang Nguyen Vinh from Pexels

5 https://unfccc.int/topics/adaptation-and-resilience/workstreams/national-adaptation-plans

6 https://documents1.worldbank.org/curated/en/917051543938012931/pdf/132672-WP-P168692-PUBLIC-4-12-2018-12-27-47-CSAInsightsfromCSAProfiles.pdf

7 https://unfccc.int/topics/introduction-to-climate-finance

8 https://www.unep.org/news-and-stories/story/finance-adaptation

9 https://ukcop26.org/wp-content/uploads/2021/07/COP26-Explained.pdf

Financial support

Many CSA technologies are costly to establish and maintain, requiring significant upfront costs and labour [23]. Even if smallholder farmers are aware of the climate risks and have ideas about how to respond to these risks, liquidity is still an obstacle to adoption [44].

Providing financial incentives together with social protection support [26] [44] can trigger changes in farm-level investments and risk-taking behaviour and increase the adoption of CSA [27] [44]. They directly reduce liquidity constraints and indirectly reduce risk perception.

Agricultural carbon markets, originally conceived to use carbon payments to incentivize land use changes and lower agricultural emissions, have evolved into a potential mechanism to fund climate-smart agriculture initiatives. Carbon payment could incentivize farmers to implement sustainable agricultural land management practices that increase crop productivity and build farmer resiliency to climate change without increasing GHG emissions [53].

Insurance

Climate-smart investment entails risks and costs that oftentimes risk-exposed farmers are unwilling or unable to manage [45]. Along with climate-smart agriculture, agricultural insurance has attracted considerable attention [10]. Index-based insurance (see Box 3), in particular, has been recognized as an important tool to help reduce investment risk and enable vulnerable farmers to cope with climate shocks [46].

CSA and agricultural insurance work in complementary ways, as insurance has the potential to reduce investment risk under certain conditions, particularly in low-income and highly vulnerable regions [2] [45]. However, the de-risking potential of index insurance and its usefulness in promoting CSA are highly dependent on (1) weather and basis risk, (2) the characteristics of the underlying technology (cost, profitability, and protection), and (3) risk exposure and loss. It has been shown that at moderate and high levels of climate risk, farmers need both technology and insurance to manage productive risk. Under these conditions, insurance may function to mitigate the residual risk that technology is unable to mitigate [45].

Access to Training

Access to information is a key element in the adoption of new technologies [2]. Some practices are technical to a level that requires reasonable training or exposure to information [47]. Capacity building is needed for farmers, farmer cooperatives, experts, and decision-makers alike. This is vital to ensure that new and potentially complex, integrated measures are implemented. [26] [48].

Photo by Jo Kassis from Pexels

Access to Market

Subsistence farming alone most of the time does not provide farmers with an incentive strong enough to justify risky investments. Markets are needed to catalyse change [18], [20] [49], because the prospect of generating income from selling surplus produce on domestic or regional markets is a key driver for CSA adoption [18].

Box 3. Index-based insurance — a risk transfer instrument to promote CSA

Index-based insurance [2], [8], [27], [37] helps stabilize smallholder farmers' income, allowing them to continue farming regardless of disaster and weather uncertainties [50]. Index-based insurance payouts are based on triggers that are correlated to losses, rather than actual losses [8], it indemnifies the insured based on the observed value of a specified 'index' or some other closely related variable [2] [27] [37].

Table 3. Advantages and disadvantages of the Index-based insurance

Advantages	Disadvantages
Relies on publicly available information[27]	A payout might not be made even though a loss has occurred [8]
Standardized and transparent [27]	The indemnity provided by index insurance is based on an index rather than on verifiable losses [27]
Cannot be manipulated by the insured [27]	Insured can suffer a significant loss without an insurance contract payout [27]
Is less costly to administer than general insurance [27]	
Automatic payout with little room for fraudulent manipulation [8]	

Farmers organizations

Adoption of CSA can be accelerated through collaboration and cooperation among stakeholders [18] [37] [51].

Farmer Producer organizations (FPOs) can play a central role in better linking smallholders with markets, and overcoming constraints of technology, infrastructure, and inadequate access to assets and information [2] [18] [52].

Photo by Helena Lopes from Pexels

[10] https://agriculture.ec.europa.eu/system/files/2020-04/ext-study-insurance-full-report_2006_en_0.pdf

Box 4. CSA and gender equality

Women are responsible for much of the world's food and agricultural production [10], however, they are less likely to access and control productive resources, and assets and have lower access to agricultural services, land, and decision-making processes [25] [54] [55]. Even though they tend to be at a disadvantage they are just as likely as men, and in some cases even more likely, to adopt some CSA practices, when aware, especially when these are labour-saving practices [2] [24] [25] [27]. CSA interventions need to have a gender-responsive and gender-transformative approach [10] [18] [54]. For example targeting women with extension information about labour-saving CSA practices could be used as an entry point for increasing knowledge about CSA and promoting faster adoption of agro-technology innovations among farmers [2] [24]

Human factor

Implementation of CSA technologies and practices need to take into consideration factors such as age, gender, belief systems, and wealth [24], [56]. For example, younger farmers seem more likely to try new agricultural practices, and labour availability within households and female control of farm resources are major determinants of adoption as well [18], [56].

Women play a major role in agriculture production in developing countries [57], they are responsible for key activities that are usually labour-intensive, such as livestock feeding, rice transplanting, and grain storage [24].

Belief systems play an important role in agricultural decision-making and should be viewed as an opportunity through which to catalyse the dissemination of CSA, for example, traditional leaders can be positioned as agricultural champions and advocate for CSA promotion [58].

Photo by Nilotpal Kalita from Unsplash

Policy recommendations to boost CSA uptake

1. **Develop** CSA country profiles, National Adaptation Plans, and CSA investment plans [20], [22]
2. **Realign** agricultural subsidies to promote CSA adoption [2], [22], [27], [29], [37] and to **provide incentives** for local communities to manage land more sustainably (e.g. payment for ecosystem services) [22], [37].
3. **Implement** stronger land tenure and access rights to natural resources [13], [22], [23], [29], [37].
4. **Strengthen** the contractual power of small-scale farmers (e.g. contract farming and farmer cooperatives) [2], [22].
5. **Promote** climate insurance products and raise awareness of farmers on insurance opportunities [25]. For instance, promote premiums for catastrophic risks that are covered by public subsidies and premiums for recurrent risks that are paid by farmers and other agriculture investors [26].
6. **Strengthen** agricultural research and agricultural extension services, including digital information services (e.g. climate service) [22] [23] [25] [26] [29].
7. **Build** capacity to access climate finance [13] [22] [23] [26].
8. **Promote** the adoption of clean energy sources in agrifood systems (e.g. financial incentives for the use of wind and solar power and decentralized electricity grids) [29].

Best practices

When CSA practices are constructed with farmer input and are targeted in a timely and inclusive manner the probability of adoption of more and/or various farm-level practices increases [59].

Government investments should encourage **cross-sectoral collaboration** among state ministries, departments, and agencies to maximize the benefits of CSA implementation [23] [26].

CSA practices need to address gender and other social inequalities such as farm size, farm location, labour availability, age, gender perception of climate risks, and household resources to avoid the worsening of these inequalities [24] [56]. Awareness of these factors is a key enabling condition for climate-resilient transitions in markets, governance, and control over resources [37].

Improved communication, sharing information between farms over successful practices, create more dialogue through evidence and impact analysis leads to a more effective policy design and implementation of CSA practices [23] [60].

Food security cannot be ensured by introducing CSA in the food production system alone. CSA should encompass the entire value chain, and go for reshaping supply chains, food retail, marketing, and procurement [2].

List of documents analysed

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