Climate-Smart Agriculture in Rwanda

Climate-smart agriculture (CSA) considerations

(A)(P) CSA practices bring important adaptation and productivity benefits to agriculture in Rwanda. Investing in land husbandry, water harvesting, and hillside irrigation can increase resilience to climate change, reduce water erosion and soil loss, halt land degradation, and increase land productivity.

(P)(M) For crops that require higher nitrogen fertilizer levels (such as rice, maize, potatoes), deep placement of large, coated granules (pellets) can increase fertilizer use efficiency and thus contribute to reductions in agricultural greenhouse gas (GHG) emissions.

(A)(M)(P) There is also a high potential for emissions mitigation through zero grazing and the use of droppings for household biogas production in intensive livestock systems. While these practices promote pasture and resource use efficiency, reducing GHG emissions and increasing productivity, they also reduce the risk of deforestation and thus increase chances to sequester carbon.

(A) Terracing, the establishment and maintenance of agro-forestry nurseries, and post-harvest activities can increase resource availability and use, while also building smallholder farmers' resilience through the creation of new job opportunities.

(A) Adaptation **(M)** Mitigation **(P)** Productivity
(Institutions) Institutions **($)** Finance

(Institutions) Agricultural research and extension institutions in Rwanda have been working together towards promoting climate-resilient crop varieties and good management practices. However, mainstreaming CSA into policies and programmes and increasing adoption of site-specific CSA practices and technologies requires stronger cooperation and integration between these actors and climate change-related stakeholders.

(Institutions)($) Crops and livestock farmers in Rwanda can access agricultural loans made available through The Development Bank of Rwanda (BRD), which offers small- and medium-size enterprises (SMEs) on- and off-farm credit guarantees, lines of credit, matching grants, as well as advisory services. If complemented with more flexible initiatives that are more accessible to small-scale farmers (such as weather index-based insurances and micro-finance opportunities), such schemes can enhance coverage against risks throughout the country and increase farmers' potential to cope with increasing weather and climate events.

($) Adoption of CSA practices largely depends on farmers' opportunity to invest in adequate agricultural infrastructure. Government-led subsidy programmes for irrigation equipment and hillside water harvesting structures are examples of existing mechanisms that can enable CSA adoption. Such initiatives need to be strengthened and scaled-out, in order to make sure they reach out to a larger number of farmers in vulnerable regions of the country.

The climate-smart agriculture (CSA) concept reflects an ambition to improve the integration of agriculture development and climate responsiveness. It aims to achieve food security and broader development goals under a changing climate and increasing food demand. CSA initiatives sustainably increase productivity, enhance resilience, and reduce/remove greenhouse gases (GHGs), and require planning to address tradeoffs and synergies between these three pillars: **productivity, adaptation, and mitigation** [1]. The priorities of different countries and stakeholders are reflected to achieve more efficient, effective, and equitable food systems that address challenges in environmental, social, and economic dimensions across productive landscapes. While the concept is new, and still evolving, many of the practices that make up CSA already exist worldwide and are used by farmers to cope with various production risks [2]. Mainstreaming CSA requires critical stocktaking of ongoing and promising practices for the future, and of institutional and financial enablers for CSA adoption. This country profile provides a snapshot of a developing baseline created to initiate discussion, both within countries and globally, about entry points for investing in CSA at scale.

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National context:
Key facts on agriculture and climate change

Economic relevance of agriculture

Agriculture accounts for a third of the country's gross domestic product (GDP) (2009–2013 average) [3].[1] Economic growth projections are thought to depend heavily on the performance of the agriculture sector, which employs more than 80% of the country's population [4] (See Annex II). The sector also plays a key role for national food self-sufficiency; more than 90% of the food produced nationally is consumed in the country. Although agriculture contributes greatly to the country's export revenues, Rwanda remains a net agricultural importer. Tea and coffee are leading export commodities concentrating more than 90% of the export crops value. However, production of rice, maize, and beans does not meet the national demand, and therefore imports of these agricultural products are significantly higher [4] (See Annex III).

Economic Relevance of Agriculture

Contribution of agriculture to national GDP

33% Rwanda [3]
31.8% Region* [3]

Total agricultural imports [4]
US$195 million

10% Wheat
7.25% Rice
4.77% Maize
1.22% Cattle
1.19% Beans

Total agricultural exports [4]
US$163 million

39.8% Tea
35.5% Coffee
2.77% Cattle
0.95% Beans
0.3% Maize

* Burundi, Kenya, Tanzania and Uganda

Land use

Rwanda is a small country with an area of 2,633,800 ha, of which 76.62% (1.9 million ha) is dedicated to agriculture. Around 62.9% of the country's land is arable, where crops such as wheat, maize, and rice are grown. Permanent crops, such as coffee and tea, as well as flowering shrubs, fruit trees, and nut trees occupy around 9.5% of the country's land-use surface. The remaining 44.2% of land includes permanent meadows and pastures, forests and woodlands, built-on areas, roads, barren land, etc. The main crops grown in the country are beans, banana, cassava, and maize, accounting for 18.1%, 17.3%, 9.2%, and 9.5% of total harvested area (2008–2012 averages) [4] (See Annex IV). There is a tendency for agricultural intensification

People and Agriculture

11 million people are living in Rwanda [3]

75% of the population is living in rural areas [3]

Shared Prosperity [3]

5.6 million (51%) live on less than US$4/day

38% are in rural areas

Jobs [4]

4.5 million people are actively employed in primary production agriculture

89%

43% 57%

Scale [5]

3.5% of total production units are large scale (>5 ha)

72.4% of total production units are small scale (<1 ha)

Nutrition [4]

The prevalence of people undernourished is **34.3%**

due to heavy demographic pressure, resulting in a large amount of very small and scattered farms. Small-scale farmers (less than 1 ha) account for 72.4% of total farmers in the country. Since more than 70% of agricultural land is on hills or the side of hills, commercial agriculture is more difficult [5].
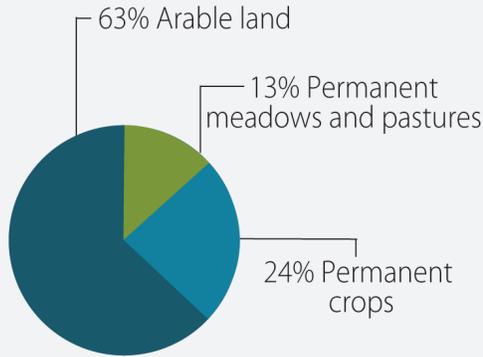
Agricultural production systems

Rwanda has a diversity of agriculture production systems spread throughout its various agro-ecological zones. The northern and western highlands are predominantly dedicated to monocrop cultivation, such as potatoes, tea, maize, wheat, climbing beans, and pyrethrum. The eastern lowlands are popular for banana, maize, bush bean, sorghum, and cassava production. In the central and southern regions, farmers cultivate sweet potatoes, bush beans, tea, coffee, and wheat.

Cereals, roots and tubers, and banana are considered main food crops and are usually grown in association with legumes (common bean, ground nuts, soybean, field peas, etc). Livestock farming is both small- and large-scale and includes cattle, sheep, goats, rabbits, pigs, chicken, etc., usually reared under zero-grazing systems. However, farmers with relatively large land endowments (above 5 ha per farm)

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1   This represents a slight decline since 2005 due to developments in the service sector.
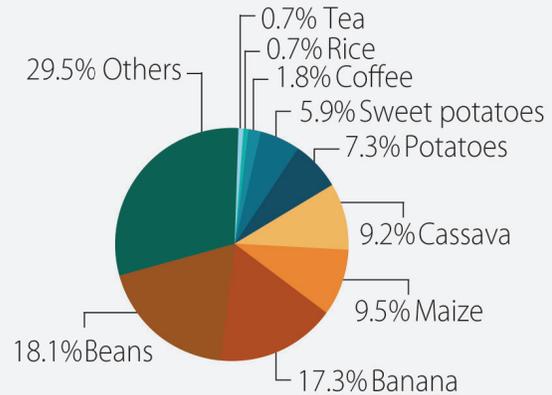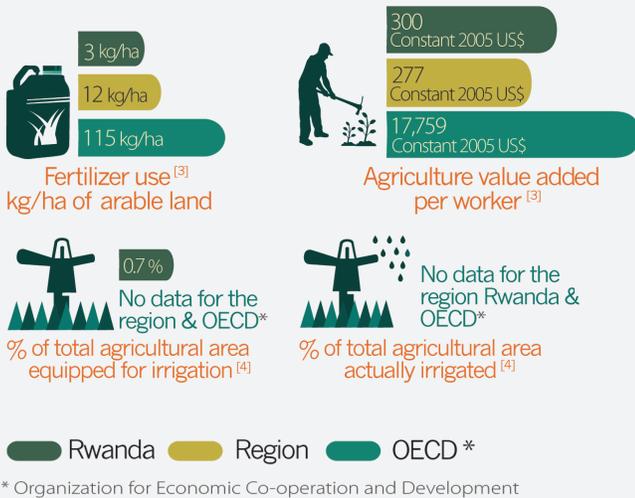
Land Use [5]

% of total land

- 63% Arable land
- 13% Permanent meadows and pastures
- 24% Permanent crops

Main Crops [5]

% of total harvested area

- 0.7% Tea
- 0.7% Rice
- 1.8% Coffee
- 5.9% Sweet potatoes
- 7.3% Potatoes
- 9.2% Cassava
- 9.5% Maize
- 17.3% Banana
- 18.1% Beans
- 29.5% Others

* Sum of areas are under (a) arable land (b) permanent crops and (c) permanent meadows and pastures. The FAO statistics do not take into account bodies of water.
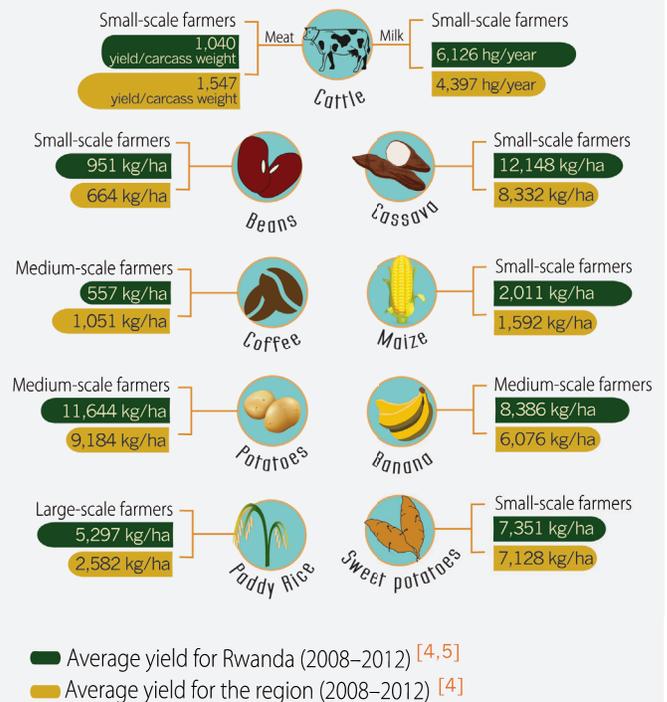
Productivity Indicators

Fertilizer use [3]
kg/ha of arable land
- 3 kg/ha
- 12 kg/ha
- 115 kg/ha

Agriculture value added per worker [3]
- 300 Constant 2005 US$
- 277 Constant 2005 US$
- 17,759 Constant 2005 US$

% of total agricultural area equipped for irrigation [4]
- 0.7 %
- No data for the region & OECD*

% of total agricultural area actually irrigated [4]
- No data for the region Rwanda & OECD*

🟩 Rwanda 🟨 Region 🟩 OECD *

* Organization for Economic Co-operation and Development

Important Agricultural Production Systems

Cattle
- Small-scale farmers — Meat: 1,040 yield/carcass weight; 1,547 yield/carcass weight
- Small-scale farmers — Milk: 6,126 hg/year; 4,397 hg/year

Beans
- Small-scale farmers: 951 kg/ha; 664 kg/ha

Cassava
- Small-scale farmers: 12,148 kg/ha; 8,332 kg/ha

Coffee
- Medium-scale farmers: 557 kg/ha; 1,051 kg/ha

Maize
- Small-scale farmers: 2,011 kg/ha; 1,592 kg/ha

Potatoes
- Medium-scale farmers: 11,644 kg/ha; 9,184 kg/ha

Banana
- Medium-scale farmers: 8,386 kg/ha; 6,076 kg/ha

Paddy Rice
- Large-scale farmers: 5,297 kg/ha; 2,582 kg/ha

Sweet potatoes
- Small-scale farmers: 7,351 kg/ha; 7,128 kg/ha

🟩 Average yield for Rwanda (2008–2012) [4,5]
🟨 Average yield for the region (2008–2012) [4]

in the eastern savannah (Nyagatare, Gatsibo, and Kayonza districts), keep their animals in semi-extensive systems using paddocks.

Sugar cane is grown in Nyabugogo and Nyabarongo swamps located in Gasabo, Gicumbi, Kamonyi, and Bugesera districts. Irrigated rice is grown throughout the country in swamps and extension of rice areas is ongoing. Agriculture industries include tea, coffee, pyrethrum, and sugar processing plants. Other industries are producing maize flour, soybean oil, packed milk and its sub-products, etc.
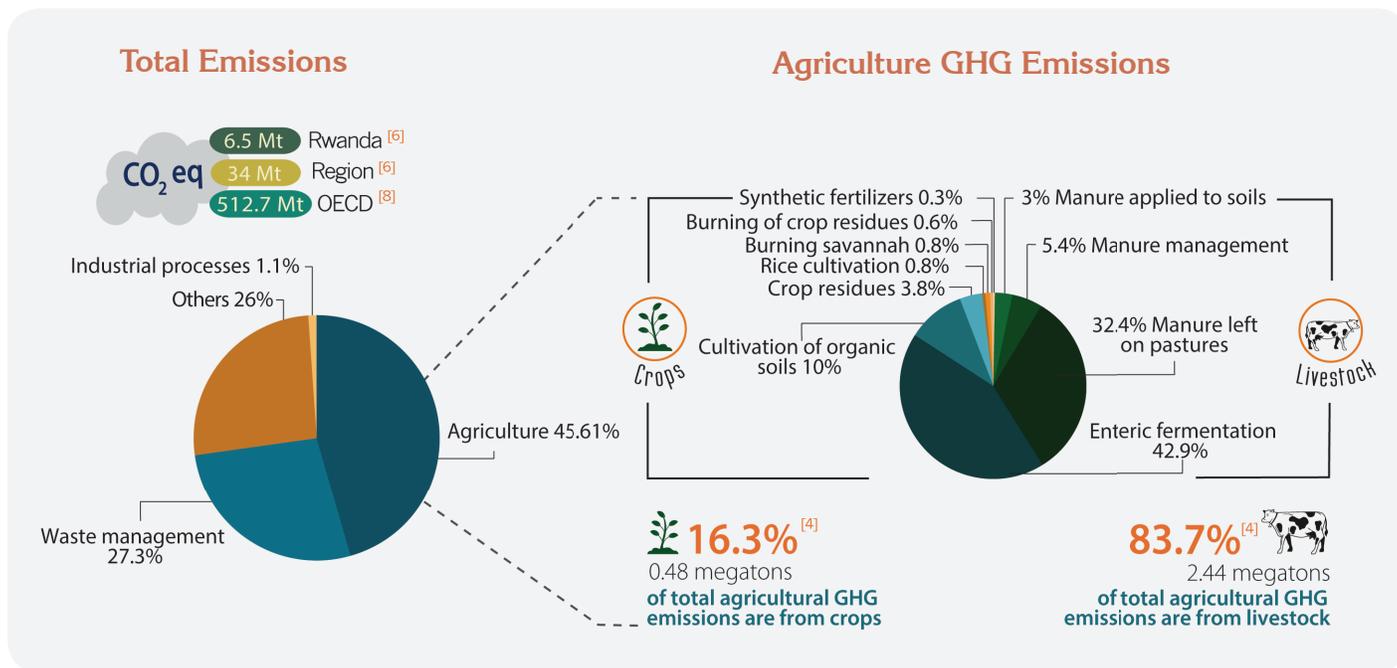
Agricultural greenhouse gas emissions

Total greenhouse gas (GHG) emissions in Rwanda are relatively low compared to regional and global averages, but trends show a slight increase since 2010 [6]. Looking at in-county sectoral statistics, agriculture contributes significantly (45.6%) to the country's total GHG emissions.

Most of agricultural emissions come from livestock-related activities, such as enteric fermentation (42.9%), manure left on pastures (32.4%). Emissions from cropland are mostly related to cultivation of organic soils (10.2%), crop residues (3.8%), rice cultivation (0.8%), and burning of savannah (0.8%) (2008–2012 averages) [4]. Nonetheless, historical trends show that the land use, land-use change, and forestry (LULUCF) sector emissions have been smaller than values of gases sequestered by the sector, resulting in net negative emissions in 2000 and 2007 scenarios [7].

Total Emissions

CO_2 eq
- 6.5 Mt Rwanda [6]
- 34 Mt Region [6]
- 512.7 Mt OECD [8]

Industrial processes 1.1%
Others 26%
Agriculture 45.61%
Waste management 27.3%

Agriculture GHG Emissions

Synthetic fertilizers 0.3%
Burning of crop residues 0.6%
Burning savannah 0.8%
Rice cultivation 0.8%
Crop residues 3.8%
Cultivation of organic soils 10%

3% Manure applied to soils
5.4% Manure management
32.4% Manure left on pastures
Enteric fermentation 42.9%

Crops

Livestock

16.3% [4]
0.48 megatons
of total agricultural GHG emissions are from crops

83.7% [4]
2.44 megatons
of total agricultural GHG emissions are from livestock

Challenges for the agricultural sector

Despite current efforts to increase efficiency of the agriculture sector and improve farmers' livelihoods, several factors challenge the developments in the agriculture sector.

- Rwandan agriculture is mostly rain-fed, and therefore more exposed to weather-related risks, especially to severe, frequent, and prolonged dry spells occurring during the cropping seasons. Farmers in drought-prone areas lack the knowledge, skills, and the adequate infrastructure to cope with such harsh conditions, experiencing severe losses in agricultural production and household income.

- Pests and diseases have greatly affected agricultural production throughout the country, triggering losses in yields and income, but also an increased use of agro-chemicals. The banana Xanthomonas wilt (BXW) has already destroyed important banana sites in the West (Rubavu district) and is now moving towards the Eastern Province, a national banana production hub. The cassava brown streak disease (CBSD) has caused shortage of planting materials, while fungal and bacterial diseases in Irish potato in the Northern Province have generated an increased use of agro-chemicals to help avoid production losses.

- The expansion of agricultural activities into more fragile environments such as steeper hill slopes and wetlands, as a response to increased food demand, has triggered land fragmentation and reduction of farm size, over-exploitation of soil resources (nutrients), habitat loss, soil erosion and degradation.[2]

- Declines in soil fertility, mainly due to the lack of nutrient replenishment, have also brought about important losses in agricultural yields.

- The predominance of small-scale subsistence farming impacts economy at both household and national level. The small land size per household is insufficient for supporting household food needs throughout the year and for providing income-generating activities to its members. This, in turn, leads to greater imports of staple crops, creating imbalances in the national food export/import ratio.

2 Land degradation through soil erosion and declining soil fertility has long been recognized as a major problem in Rwanda, especially affecting the Southwest of the country. Furthermore, in low rainfall areas in the East, crops fail due to sub-optimal water-use efficiency requiring adequate technologies to soil and water conservation practices.

- Moreover, the lack of adequate incentives[3] for engaging in agricultural activities has caused rural-to-urban exodus (especially among the youth), alongside a reorientation of the population towards off-farm activities.

Agriculture and climate change

The Rwandan agricultural sector is highly vulnerable to climate and weather-related risks, including prolonged droughts (especially in the eastern and southeastern regions), erratic rains, floods, hailstorms and mudslides (particularly in the northern and western regions). Recent events provide clear evidence of the disastrous impacts of extreme events on agricultural production. For instance, erratic rainfall in 2008 caused maize yield losses of 37% in the eastern provinces and 26% in the southern provinces.[4] Milk production losses are estimated at 60% in times of a drought [9].

Research indicates that rainfall patterns are becoming more irregular and unpredictable with shorter rainy seasons negatively affecting Rwandan agriculture. Crop- and livestock-suitable areas, the length of the growing seasons, and potential yields are all expected to decrease [10].

Moreover, estimates from the Fourth IPCC Assessment Report indicate that average surface temperature in Africa has increased by 0.2 to 2.0 °C in the last four decades
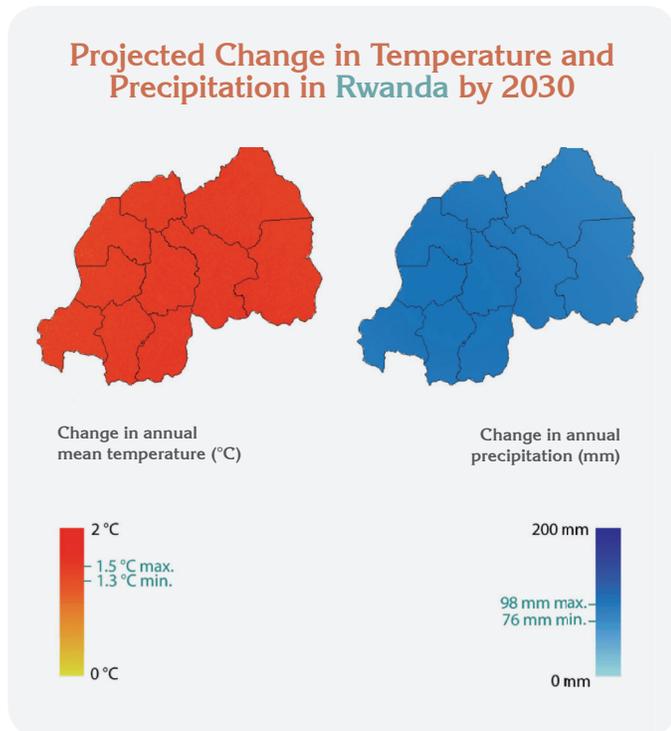
(1970–2004), suggesting an overall increase in annual temperatures (by 1.0° C–2.0° C) over the next century (2010–2100) in Rwanda [11]. Medium-term climate projections based on RCP 4.5 emissions scenario [12] and downscaled using the Delta Method [13] for Rwanda indicate a general increase in annual mean temperature (by up to 1.5°C) and in total annual precipitation rates by 2030.[5]

CSA technologies and practices

CSA technologies and practices present opportunities for addressing climate change challenges, as well as for economic growth and development of agriculture sectors. For this profile, practices are considered CSA if they maintain or achieve increases in productivity as well as at least one of the other objectives (adaptation and/or mitigation). Hundreds of technologies and approaches around the world fall under the heading of CSA [2].

With the aim of transforming the agricultural sector from subsistence-based to fully commercialized farming by 2020 [14], national policies and strategies have been directed towards mainstreaming climate change adaptation and mitigation in the agriculture sector. However, despite the wide array of climate-smart options available to Rwandan farmers (as illustrated in the graphic below and in Annex V), there is a clear need for incentivizing CSA scale-out throughout the country, since adoption levels of practices with high climate-smartness scores are generally low among small-scale farmers.

Practices aimed at boosting resilience of the sector that stood out in the analysis mostly refer to improved management of pastures (the use of climate-smart *Brachiaria* grasses), the use of improved crop varieties (especially through the use of crop residues for bean cultivation), pest- and disease-resistant varieties of coffee, soil conservation techniques for cassava, maize, and tea/banana systems), and mulching (banana and coffee/banana system), among others. Almost all practices illustrated in Table 1 have important mitigation benefits. Such practices refer, among others, to mulching, crop rotations, intercropping, hedgerows on contour bunds, zero grazing, improved pastures (use of *Brachiaria* grasses), soil conservation techniques, and efficient use of fertilizers, especially through the deep placement of large, slow-release nitrogen pellets. The implementation of this practice, facilitated by the International Fertilizer Development Center (IFDC) in partnership with the Ministry of Agriculture and

Projected Change in Temperature and Precipitation in Rwanda by 2030

Change in annual mean temperature (°C)

2 °C
1.5 °C max.
1.3 °C min.
0 °C

Change in annual precipitation (mm)

200 mm
98 mm max.
76 mm min.
0 mm

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3 An illustrative example of a disincentive is the low prices that farmers receive commercializing crops such as coffee, tea, pyrethrum, potato, rice, and compared to the cost of production. This creates high investment losses for the farmers, favoring profit for the next actors along the commodity value chain.
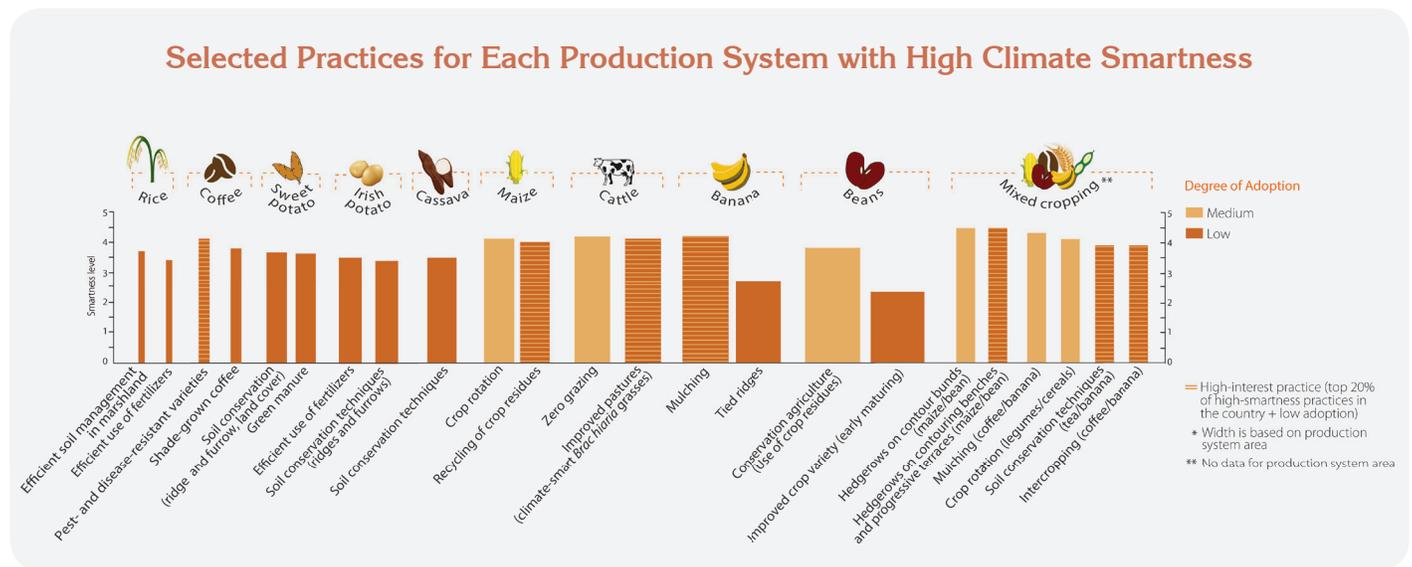
4 Maize requires constant moisture for optimum growth and thus is very vulnerable to drought.

5 However, changes in precipitation are more uncertain and are small compared to interannual variability.

Animal Resources (MINAGRI) and the Rwanda Agriculture Board (RAB), has triggered significant yield improvements and reduced labor requirements. However, adoption levels throughout the country remain low due to the lack of adequate infrastructure (machinery) to produce the pellets.[6]

An overall look at the CSA options that stood out in the analysis indicates that, in general, such practices are mostly (65%) adopted by medium-scale farmers who already have some possibility to access technologies and production inputs via advisory services, credits, loans, and insurances. Of all types of small-scale farmers, livestock farmers are the ones most likely to adopt CSA practices (See Table I

and Annex V). Currently, several governmental and non-governmental initiatives are directed towards promoting new income sources for resource-poor farmers and boosting livestock productivity, such as the Government's 'One cow per poor family' programme (where more than 200,000 Rwandan farmers have received free cows) and research initiatives to identify drought-adapted forage grasses (including *Brachiaria*) that can produce higher cattle milk and meat yields.[7] While such initiatives show an increased public and private interest in mainstreaming CSA, they also bring to light the need to better target CSA investments, towards resource-poor, subsistence farmers, in such a way that barriers to adoption of practices are overcome.

This graph displays the smartest CSA practices for each of the key production systems in Rwanda. Both ongoing and potentially applicable practices are displayed, and practices of high interest for further investigation or scaling out are visualized. Climate smartness is ranked from 1 (very low positive impact) to 5 (very high positive impact).

Table 1. Detailed smartness assessment for top ongoing CSA practices by production system as implemented in Rwanda

The assessment of a practice's climate smartness uses the average of the rankings for each of six smartness categories: water, carbon, nitrogen, energy, weather, and knowledge. Categories emphasize the integrated components related to achieving increased adaptation, mitigation, and productivity. For more information, see Annex V.

	CSA Practice	Climate Smartness	Adaptation	Mitigation	Productivity
Rice (0.7% of total harvested area)	Efficient soil management in marshland ■ Low adoption (<30%)	3.7	Adequate source, timing, amount and placement of fertilizers can reduce negative effects of excessive fertilization. Reduces soil salinity and nutrient leaching.	Reduced emissions of greenhouse gases (GHG) such as methane and nitrous oxide.	Reduces production costs. Maintains or increases yield.

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6 At the moment there are only two pellet-producing machines in the entire country.

7 The 'Climate-smart *Brachiaria*' project, led by the International Center for Tropical Agriculture (CIAT) and the Biosciences eastern and central Africa – International Livestock Research Institute (BecA-ILRI), in cooperation with farmers and the Rwanda Agriculture Board (RAB), aims to increase the adoption of *Brachiaria* cultivar Mulato II, which proved large increases in milk and meat yields and high potential to mitigate climate change effects.

	CSA Practice	Climate Smartness	Adaptation	Mitigation	Productivity
Rice (0.7% of total harvested area)	Efficient use of fertilizers ◼ Low adoption (<30%)	3.4	Reduces deep percolation of fertilizers and subsequent water pollution and eutrophication.	Lowers the production and emission of methane and other gases from irrigated rice ecosystems	Improves soil fertility and productivity
Coffee (1.8% of total harvested area)	Pest- and disease-resistant varieties ◼ Low adoption (<30%)	4.1	Reduces incidence of pests and diseases, which can reduce yields losses.	Reduced use of nitrogen fertilizer, thus reducing nitrogen dioxide emissions.	Lack of pests can enhance coffee quality, leading to higher income for farmers. Greater yields.
	Shade-grown coffee ◼ Low adoption (<30%)	3.8	Reduces temperature in coffee canopy, which can increase crop productivity and quality. By introducing fruit and/or woody trees (as a diversification strategy), it can contribute to increased resilience.	Contributes to carbon sequestration in the system, especially when woody species are introduced in agroforestry systems.	Intercropping with fruit and/or woody trees may bring new income-generating crops without affecting the yield of the main crop (coffee).
Sweet potato (5.9% of total harvested area)	Soil conservation techniques (ridge and furrow, land cover) ◼ Low adoption (<30%)	3.7	In-situ soil moisture conservation by water retention. Prevents erosion.	Promotes carbon sinks through increased accumulation of dry matter.	Increases productivity through improved soil quality and water availability.
	Green manure ◼ (Medium adoption (30–60%)	3.6	Improves soil moisture content avoiding water stress during dry seasons. Builds soil fertility by improving physical and chemical soil characteristics.	Helps build soil fertility. Use of leguminous species reduces nitrogen fertilizer needs by fixing atmospheric nitrogen.	Improved soil fertility favors productivity.

Water   Energy

CO_2 Carbon   Climate

N_2O Nitrogen   Knowledge

5
4
3
2
1
0

Calculations based on qualitative ranking, where positive change was noted as 5=very high; 4=high; 3=moderate; 2=low; 1=very low; 0=no change, not applicable, or no data.

	CSA Practice	Climate Smartness	Adaptation	Mitigation	Productivity
Irish potato (7.3% of total harvested area)	Efficient use of fertilizers ■ Low adoption (<30%)	3.5	Adequate timing, amount, and placement of fertilizers can reduce negative effects of excessive fertilization. Reduces soil salinity and nutrient leaching.	Adequate fertilizer management can reduce nitrogen fertilizer-related nitrous oxide emissions (N_2O) in the atmosphere.	Reduces production costs. Maintains or increases yield.
	Soil conservation techniques ■ Low adoption (<30%)	3.4	Soil structure conservation reduces erosion and enhances in-situ moisture conservation.	Maintains or improves soil carbon stocks and organic matter content.	Improves land productivity and fertilizer use efficiency.
Cassava (9.2% of total harvested area)	Soil conservation techniques (ridges and furrows) ■ Low adoption (<30%)	3.5	Contributes to soil moisture conservation.	Maintains or improves soil carbon stocks and organic matter content.	Increases productivity through improved soil quality and water availability.
Maize (9.5% of total harvested area)	Crop rotation ■ Medium adoption (30–60%)	4.1	Diminishes crop diseases incidence. Contributes to smarter use of nutrients and reduces nitrogen fertilizer when leguminous species are introduced.	Improves soil structure and reduces nitrogen-related GHG emissions.	Lowers production costs while increasing productivity.
	Recycling of crop residues ■ Low adoption (<30%)	4.0	Reduces on-farm organic waste. Improves soil moisture conservation.	Maintains or improves soil carbon stocks and soil organic matter content.	Improves soil fertility and productivity
Cattle (13.2% of total land use area)	Zero grazing ■ Medium adoption (30-60%)	4.2	Reduces heat stress through shading, increasing the efficient use of pastures and other natural resources.	Increases digestibility of feeds and reduces GHG emissions such as methane (CH_4).	Increases milk and meat production.
	Improved pastures (climate-smart *Brachiaria* grasses) ■ Low adoption (<30%)	4.1	Ensures fodder supply during drought periods.	*Brachiaria* is highly digestible feed, thus contributing to reductions in methane emissions from enteric fermentation.	High land productivity. Greater yield stability.

	CSA Practice	Climate Smartness	Adaptation	Mitigation	Productivity
Banana (17.3% of total harvested area)	Mulching ■ Low adoption (<30%)	4.2	Improves soil structure, conserves soil moisture and reduces erosion. Allows efficient use of fertilizers.	Limits the release of greenhouse gases (GHG) in the atmosphere.	Enhanced yield and reduction in production costs.
	Tied ridges ■ Low adoption (<30%)	2.7	Tied ridges increase water retention, which allows for increased water availability for the roots (through percolation).	Not applicable	Yield increases are reported in specific contexts.
Beans (18.1% of total harvested area)	Conservation agriculture (use of crop residues) ■ Medium adoption (30–60%)	3.8	Builds soil organic matter. Reduces soil degradation. Conserves soil moisture.	Increased carbon stocks in soils. Emissions of GHG stored in soils can be avoided by reducing tillage.	Improves soil fertility and subsequently productivity.
	Improved crop variety (early maturing) ■ Low adoption (<30%)	2.3	Improves water and fertilizer use efficiency	Not applicable	Ensures production despite short periods of rains. Contributes to reductions in production costs
Mixed cropping	Hedgerows on contour bunds (maize/bean) ■ Medium adoption (30–60%)	4.5	Reduces water runoff and soil erosion. Produces sticks for beans, fodder, and fuel wood at farm level.	Maintains or improves soil carbon stocks and soil organic matter content. Can also promote carbon capture if using woody species.	Improves soil fertility, maintains productivity.
	Hedgerows on contouring benches and progressive terraces (maize/bean) ■ Low adoption (<30%)	4.5	Reduces water runoff and soil erosion. Produces sticks for beans, fodder, and fuel wood at farm level.	Maintains or improves soil carbon stocks and soil organic matter content. Can also promote carbon capture if using woody species.	Improves soil fertility, maintains productivity.
	Mulching (coffee/banana) ■ Medium adoption (30–60%)	4.3	Increases soil water holding capacity and reduces water losses through evaporation. Reduces soil erosion.	Maintains or improves soil carbon stocks and soil organic matter content.	Increases in yield in specific contexts. Higher incomes.
	Crop rotation (legumes/cereals) ■ Medium adoption (30–60%)	4.1	Crop rotation and species diversification can reduce crop disease incidence. Promotes smarter use of nutrients and reduced nitrogen fertilizer.	Improves soil structure and reduces GHG emissions. Lower nitrogen fertilizer are required by using leguminous species.	Lowers production costs while increasing productivity.

Case Study:
Land husbandry, water harvesting, and hillside irrigation for a climate-smart agriculture sector

Increased population density[8] and a high dependence on agriculture for food security and income has led to the advancement of the agricultural frontier towards steeper slopes that exceed recommended slopes thresholds for cultivation.[9] This has triggered severe soil erosion rates[10] and overall decreases in agricultural productivity, challenging the livelihoods of subsistence farmers. In the context of prolonged droughts and unreliable rainfall patterns, the vulnerability of Rwandan farmers has increased drastically in the past decades.

In response to these challenges, the Government of Rwanda, with the joint support of the World Bank (WB), the International Development Agency (IDA), the Global Agriculture and Food Security Program (GAFSP),[11] the United States Agency for International Development (USAID), and the Canadian International Development Agency (CIDA), has initiated a US$113.3 million project aimed at enhancing hillside agriculture resilience to climate change and variability through increased productivity and income. The project (also known as the Land Husbandry, Water Harvesting, and Hillside Irrigation [LWH] Project) started in 2009, and has been implemented in 101 pilot watersheds covering 30,250 ha of land in the Eastern, Western, Southern, and Northern provinces (equivalent to 1.6% of the country's arable land) [15].

The initiative focused on the introduction of land conservation and irrigation practices and technologies on both rain-fed and irrigated areas. These included land husbandry activities (soil bunds, terraces, cut-off drains, water ways, afforestation and reforestation activities), as well as the establishment of hillside water ponds for small-scale irrigation and water harvesting, among others.[12] In order to achieve mitigation goals, the LWH initiative promoted the use of hydropower electricity in irrigation (with negligible greenhouse gas emissions) and hand-operated pumps for the functioning of hillside water ponds.

The LWH also included trainings on compost making, establishment and maintenance of tree nurseries, maintenance of water trenches (to avoid siltation and maintenance of valley dams), post-harvest production

Photography: Neil Palmer (CIAT)

handling, product marketing, and business planning, aimed at building capacity, resilience, and incentives for small-scale farmers. Micro-enterprises for compost production (the primary source of fertilizer used on LWH sites) have also been created.

A total of 2,689 households and more than 100,000 people benefited from the programme. Land-husbandry activities created jobs for around 22,000 farmers across an estimated area of 12,940 ha. Hillside irrigation was established on 1,869 ha, while 6,632,817 trees were planted for terraces embankment protection. Additionally, to collect and reduce post-harvest losses, 28 storage facilities and 24 drying areas were constructed. Improvement of soil fertility enabled yield increases by 3 times for soybeans and maize, 4 times for beans, and 10 times for Irish potatoes [15].

The project further facilitated the creation of farmers groups and cooperatives that have been linked to micro-finance institutions (local savings and credit cooperatives) later in the process, as well as of water user associations to ensure ownership of water distribution, and collect water fees. However, while the LWH has offered many Rwandan farmers an opportunity to carry out agricultural activities despite the harsh environmental and climate conditions, the challenge yet to be resolved relates to scaling out such initiatives, making sure that adoption rates of CSA practices are increased, reaching a larger number of farmers located on the plateau and hillsides difficult to irrigate.

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8   Rwanda is one of the most populated countries in Africa, with a density of 416 persons/square km.
9   Nearly 40–50% of the country's land is on 16–40% slope [16].
10 Every year, the country is thought to lose approximately 1.4 million tons of fertile soil [16].
11 GAFSP is a multi-lateral mechanism to improve incomes and food and nutrition security in low-income countries by boosting agricultural productivity. GAFSP is based on public and private sector financing.
12 Other irrigation technologies included: center-pivot irrigation, drip irrigation, sprinkler irrigation, and furrow irrigation with high water-use efficiency.

Institutions and policies for CSA

Rwanda has been formally engaging in international climate change policy by ratifying the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 (Presidential Order No. 021/01 of 30 May 1995) and the Kyoto protocol in 2003 (Law No. 36/2003 of 29 December 2003). The country also submitted the Initial and the Second National Communication under the UNFCCC in 2005 and 2012 respectively.[13] In addition to these efforts, Rwanda submitted its first National Adaptation Programme of Action (NAPA) in 2006. In 2009, the Climate Change and International Obligations Unit (CCIOU) was established within the Rwanda Environmental Management Authority (REMA),[14] with the mandate to oversee its Designated National Authority (DNA) and coordinate carbon market activities. Subsequently, in 2010, the Government established its National Implementing Entity (NIE) under the Ministry of Natural Resources (MINIRENA), to facilitate access to financial resources from the UNFCCC Adaptation Fund (AF).

Rwanda has taken a proactive approach in mainstreaming climate change into its development policies and strategies. Main national development documents, such as Vision 2020, the Economic Development and Poverty Reduction Strategy (EDPRS), the Strategic Plan for the Transformation of Agriculture in Rwanda (SPTAR), and the Irrigation Master Plan (IMP), recognize climate change and variability as the greatest challenge and threat to the development agenda. The NAPA highlights six priority adaptation options (1) integrated water resource management (IWRM), (2) early warning and agro-meteorological information systems with rapid response mechanisms, (3) promotion of non-agricultural income-generating activities, (4) intensive agro-animal husbandry activities, (5) promotion of drought-resistant varieties, and (6) development of energy sources alternative to firewood [17]. In accordance to these priority areas, several NAPA projects have been implemented[15] and relate to:

- Promotion of techniques for land conservation and protection against erosion and floods in areas vulnerable to climate change.
- Creation of early warning systems and installation and rehabilitation of hydrological and meteorological stations to increase resilience to variabilities and changes in climate.

Primary Focus of Institutions Engaged in CSA

- Development of irrigation systems in areas exposed to prolonged droughts.
- District-level support in planning and implementing measures, practices, and technologies related to land conservation, water harvesting, and promotion of climate-adapted crop varieties.
- Promotion of practices and services aimed at increasing the adaptive capacity of the "Imidugudu" groups located in climate-vulnerable regions, such as potable water and sanitation facilities, as well as use of alternative energy, and the promotion of non-farming jobs.
- Enhanced food and medicine distribution during climate extreme events.
- Preparation and implementation of a woody combustible substitution national strategy to combat deforestation and erosion.

At national level, activities related to climate change in the agriculture sector are led by MINAGRI and refer to irrigation infrastructure, supply, and use of agricultural inputs (inorganic fertilizers, pesticides, and herbicides), sustainable management of natural resources, transformation and

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13 The Third National Communication is scheduled to be submitted in 2017.

14 MINIRENA operates through three national institutions: Rwanda Environmental Management Authority (REMA), Rwanda Natural Resource Authority (RNRA), and Rwanda Meteorological Agency (RMA).

15 The implementation of the NAPA projects has been facilitated by the Ministry of Agriculture and Animal Husbandry (MINAGRI), the Ministry of Lands, Environment, Forestry, Water and Mining (MINILA), the Ministry of Natural Resources (MINIRENA), the Rwanda Agriculture Board (RAB), RNRA, REMA, and RMA.

competitiveness of agricultural products, rainwater harvesting (hillside irrigation), and land reform. In their policies and strategies, MINILA and MIRENA (including REMA, RNRA, and RMA) are supportive of mitigation and adaptation efforts in the agriculture sector, as evidenced in the Five-Year Strategic Plan for the Environment and Natural Resource Sector 2014–2018 (SPENR) [18] and in the National Environment Policy (NEP) [19].[16] Functioning under MINAGRI, RAB's mandate is to carry out research and extension work on topics related to agriculture and climate change.[17] CSA work in Rwanda is also promoted by international research organizations (International Institute of Tropical Agriculture [IITA], World Agroforestry Center [ICRAF], International Center for Tropical Agriculture [CIAT], Bioversity International, and the International Fertilizer Research Center [IFDC]), and non-governmental organizations (Caritas Rwanda, Catholic Relief Services [CRS], Adventist Development and Relief Agency [ADRA-Rwanda], World Vision, Vi-Life, and the Japan International Cooperation Agency [JICA]. Additionally, the National

Agricultural Export Development Board (NAEB) oversees the implementation of green development technologies in the tea, coffee, and pyrethrum agro-industries and acts as an umbrella for the post-harvest production handlers in these industries.

Local farmers unions such as INGABO, and the Rwandan Farmers Federation (IMBARAGA) are actively engaged in activities related to increased productivity and resilience for small-scale farmers.

Mitigation-related activities are led by REMA through its designated national authority (DNA). The National Strategy for Climate Change and Low-Carbon Development (NCCLCDS) for Rwanda "Green Growth and Climate Resilience," developed in 2011, has identified three major areas of impact for a more efficient, resilient, and low-emissions agriculture sector development: (i) reduced dependency on inorganic fertilizers, (ii) irrigation infrastructure, and (iii) agro-forestry [20].

Enabling Policy Environment for CSA

Policies listed are related to maintaining and/or enhancing **agricultural productivity** and at least one of the other CSA pillars:

- Productivity and Adaptation
- Productivity and Mitigation
- Productivity, Adaptation, and Mitigation
- ( ) Acting entity

› NAPA (REMA) › NDMP (MIDMAR)
› NAP (MINAGRI)

› Vision 2020 (GOR) › EDPRS II (MINECOFIN)
› ECCP (MINIRENA/REMA) › NEP (MINIRENA/REMA)
› NCCLCDS (REMA) › SPENR (MINIRENA)
› SPAT (MINAGRI/RAB)

Actively implemented

› NAMA (REMA)

› UNFCCC-NC I, II (REMA)

Legally formalized

› UNFCCC-NC III (REMA)

In formulation

ECCP Environment and Climate Change Policy **EDPRS II** Economic Development and Poverty Reduction Strategy Phase II (2013) **NCCLCDS** National Strategy for Climate Change and Low-Carbon Development "Green Growth and Climate Resilience" (2011) **NAMA** Nationally Appropriate Mitigation Action **NAP** National Adaptation Plan **NAPA** National Adaptation Programme of Action (2004) **NDMP** The National Disaster Management Policy (2012) **NEP** National Environmental Policy **SPAT** Strategic Plan for Agriculture Transformation (2009) **SPENR** Five-Year Strategic Plan for the Environment and Natural Resource Sector 2014-2018 (2013) **UNFCCC-NC I, II, III** National Communications under the United Nations Framework Convention on Climate Change (2005, 2012, 2017) **Vision 2020** Vision 2020 Development Programme (2000)

16 The NEP identifies several strategic action areas for the sustainable growth in the agriculture, livestock, and fishery sectors, namely public awareness related to the environmental impacts of agricultural inputs; measures to ensure that animal breeding does not exceed actual land grazing capacity; promotion of off-land animal breeding around towns and along roads; use of efficient irrigation systems; regulation of improved fishing techniques; creation of non-agricultural job opportunities to reduce pressure on land, water, and forest resources.

17 Projects implemented by RAB include: the Land Husbandry, Water Harvesting, and Hillside Irrigation (LWH) project, the Rural Sector Support Project (RSSP), the Bugesera Agricultural Development Support Project (PADAB), the Kirehe Community-Based Watershed Management Project (KWAMP), the One Cow per Poor Family project, and the Post-harvest and Agribusiness Support Project (PASP).

Financing CSA

National finance

To address environmental pressures and climate change impacts on the agriculture sector, the Government developed a cross-sector Green Growth and Climate Resilience Strategy to operationalize the National Fund for the Environment and Climate Change in 2012 (FONERWA). As of September 2014, FONERWA was able to mobilize 59 billion Rwandan francs (equivalent to US$84.3 million) originating from the Government of Rwanda, The UK Department for International Development (DFID), the Government of Germany (through the German Development Bank [KFW]), and the United Nations Development Programme (UNDP). Currently, FONERWA is supporting 23 projects on sustainable agriculture activities advanced by public, private, and non-governmental actors [21].

In 2010, MINAGRI initiated the weather-based index insurance program (*Hinga Urushngiwe*, in Kinyarwanda language) aimed at covering crop damage as a result of deficit or excesses in weather conditions, such as temperature, sunlight, wind speed, or rainfall resulting in yield losses during the length of the crop growth cycle up to physiological maturity. The scheme is designed to help farmers repay loans in the event of unreliable weather conditions and is tailored to meet specific risks identified by farmers. For instance, an index covering deficit rainfall can be created in the case of perceived drought, and measured throughout the season at the farmer's nearest station. The farmer pays a non-refundable premium to the insurance company as part of the loan package; payouts are then calculated based on observed excesses or deficits relative to the identified risks. In Rwanda, the weather-based index insurance mainly targets traditional export crops (tea and coffee), but also others such as Irish potato, maize, rice, cassava, soybeans, and beans. MINAGRI has since partnered with MicroEnsure (2011) and the Syngenta Foundation for Sustainable Agriculture (2012) for the implementation of this insurance scheme [21].

Additionally, the Development Bank of Rwanda (BRD, its French acronym), the leading institution financing the agro-industry sector, issues loans to farmers at interest rates slightly lower than those of other commercial banks in the country (14–16% interest rate, compared to 19–20%). BRD also offers advisory services and technical support and training to farmers, as well as a variety of guarantee funds to cover risks, channeled through the Business Development Fund (BDF). However, while completion of land titling throughout the country has eased access to credits for some categories of farmers, small-scale farmers' access to financing opportunities is generally limited by the strict requirements related to farmers' financial capital (in general, commercial banks only offer insurances to agri-businesses worth more than US$15,000) and depending on the size of productive land (loans are usually offered to producers owning 10 ha or more of land). Grass-root, informal savings and credit groups initiatives such as IBIMINA and the community savings and credit cooperatives (Umurenge SACCOs) may constitute examples of financial inclusion that should be taken at scales in the effort to streamline access to financial instruments for agricultural production.

International finance

CSA finance from international resource mainly comes from multilateral, bilateral, and private actors, such as the International Fund for Agricultural Development (IFAD), World Food Programme (WFP), Canadian International Development Agency (CIDA), United States Agency for

Funds for Agriculture and Climate Change

AF Adaptation Fund **BMGF** Bill & Melinda Gates Foundation **BPR** People's Bank of Rwanda **BRD** Development Bank of Rwanda **CF** The Clinton Foundation **FAO** Food and Agriculture Organization of the United Nations **FONERWA** Rwanda's Fund for the Environment and Climate Change **GEF** Global Environment Facility **GIZ** German Agency for International Cooperation **IFAD** International Fund for Agricultural Development **JICA** Japan International Cooperation Agency **KCB** Kenya Commercial Bank - Rwanda **KFW** German Development Bank **MINECOFIN** Ministry of Economic Development and Finance **NDF** Nordic Development Fund **SIDA** Swedish International Development Cooperation Agency **Umerenge SACCOs** Community Savings and Credit Cooperative **UNDP** United Nations Development Programme **UNEP** United Nations Environmental Programme **UNREDD+** United Nations Programme for Reducing Emissions from Deforestation and Forest Degradation **USAID-FTF** United States Agency for International Development - Feed the Future Programme

Access to Finance Rwanda
· BPR · BRD · FONERWA ·
· KCB · Kilimo Salama ·
· MINECOFIN · SONARWA ·
· Umerenge SACCOs ·

National Funds

International Funds

AF · BMGF · CF· FAO · GEF · GIZ · IFAD · JICA · KFW · NDF · OXFAM · Rockefeller Foundation · SIDA · UNDP · UNEP · UNREDD+ · USAID FTF · WB ·

★ Accessed funds

International Development (USAID), Global Agriculture and Food Security Program (GAFSP), African Development Bank (ADB), Belgium Technical Agency (BTC), and the UK Department for International Development (DFID). These actors support initiatives related to (i) landscape development, including integrated watershed management, marshland and hillside irrigation, and crop/livestock intensification; (ii) climate-resilient export value chains, post-harvest activities and agribusiness development; and (iii) nutrition and social and economic inclusion of the most vulnerable populations, including women empowerment. Funding from the Global Environmental Facility (GEF), the Adaptation Fund (AF), and the United Nations Development Programme (UNDP) mainly targets adaptation and climate vulnerability-reduction activities.

Potential finance

Several national and international institutions provide funding for CSA-related activities in Rwanda through policies, projects, and programmes aimed at increasing farmers' resilience and at the development of a low-emissions agricultural sector. The increasingly severe climate hazards, coupled with harsh environmental conditions that have challenged agricultural production, have created increased momentum for public and private actors to issue credits, loans, and other insurance schemes that help farmers cope with climate change. However, given the high transaction costs that remain uncovered by the premium and the on-farm losses monitoring requirements, such schemes are hardly accessed by the majority of small-scale, vulnerable farmers. Increasing the reach and flexibility of existing credits and loan schemes, coupled with strengthened micro-insurance programmes, through national and international

mechanisms, can contribute to more effective management of severe weather impacts, while supporting farmers in their effort to invest in increasing farm productivity (buying certified seeds, fertilizers, etc.).

Outlook

With the aim of promoting sustainable intensification of the agriculture sector, the Government of Rwanda has made efforts to mainstream climate change adaptation and mitigation in its agricultural policies, strategies, and action plans. Likewise, private and non-governmental actors at national and international levels have been supporting various initiatives to increase agriculture productivity and income for small-scale farmers located in vulnerable regions. Given the increasing exposure of the country to adverse climate and weather risks, due to its topographic configuration and demographic pressure, there is a strong need to continue investing in incentives for the adoption of CSA practices and technologies aimed at soil and water conservation, such as terracing and irrigation. Likewise, scaling out existing credit, loans, and insurance schemes, in such a way that they can reach a larger number of farmers and a wider variety of production systems, can have an important contribution to boosting resilience of the sector and ensuring national food security. Moreover, a strengthened focus of policies, action plans (such as the NAMA, currently in formulation), and practices that contribute to reductions of GHG emissions from agricultural activities (especially livestock) and promote carbon sequestration are key mitigation entry points that would ensure development of a climate-smart agriculture sector in Rwanda.

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Annex I: Acronyms
Annex II: Evolution of employment in Rwanda's main economic sectors
Annex III: Evolution of main agricultural exports and imports in Rwanda
Annex IV: Selection of important production systems
Annex V: CSA practices in Rwanda (detailed list)