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Climate Services for Agriculture: Empowering Farmers to Manage Risk and Adapt to a Changing Climate in Rwanda

FINAL PROJECT REPORT

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Cover Photo: RCSA project coordinator discusses new downscaled seasonal forecast format with farmers during project visit to pilot districts, March 2017. Photo: A. Nyandwi (Ministry of Agriculture)

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EXECUTIVE SUMMARY

A consortium of national and international partners worked from 2016 to 2020 to strengthen the climate information available to the Rwanda's farmers and agriculture sector through the *Rwanda Climate Services for Agriculture* (RCSA) project, funded by the US Agency for International Development (USAID). It was launched at a workshop in Kigali on World Meteorological Day, March 23, 2016, with the goal to transform Rwanda's rural farming communities and agricultural economy through improved climate services and climate risk management. Efforts towards this goal were organized around four target outcomes:

1. Climate services for farmers;
2. Climate services for government and institutions;
3. Climate information provision; and
4. Climate services governance.

Achievements

***Twigire Muhinzi* scaled participatory climate communication and planning to 113,000 farmers**. RCSA adopted the Participatory Integrated Climate Services for Agriculture (PICSA) approach to build farmers' capacity, and scaled it up through the *Twigire Muhinzi* extension service and farmer organizations. PICSA is a participatory climate communication, training and planning process, developed by the University of Reading, that supports farmers to improve farm and livelihood decision making with local climate information combined with participatory resource mapping, activity calendars and budgeting activities. The project partnered with four local NGOs to train 2,111 local agricultural extension staff and volunteer Farmer Promoters in PICSA who, in turn, trained and facilitated 112,767 farmers to use climate services. PICSA significantly improved crop productivity, incomes, food security, women's empowerment and subjective measures of wellbeing.

Radio Huguka brought interactive climate service radio programming to 3 million farmers. An estimated 3.1 million farmers listen to Radio Huguka – a community radio network that supports agriculture and rural communities. The project partnered with Radio Huguka to develop climate service programming in several standard and interactive formats: weekly interactive 60-minute live talk shows that farmer participate in by phone or SMS; weekly "*Urubuto Ntera*" 20-minute prerecorded educational program; weather forecasts and 2-3-minute stories broadcast three times daily with the news; and coverage of special events by the RCSA team and partners. While radio is typically a one-way communication channel, innovative programming makes communication more interactive and hence responsive to farmers' context-specific needs.

Radio Listeners Clubs combine the reach of broadcast media with the power of social learning. The RCSA project partnered with Radio Huguka to pilot 225 Radio Listener Clubs in November 2018. Farmer Promoters were trained to lead their village groups in weekly meetings to listen to and discuss climate service radio programs, participate in live call-in shows on a rotating basis, share and record their plans to act on the information they have heard, and share the information with other farmers in their *Twigire Muhinzi* village groups. Building on existing PICSA groups, Radio Listener Clubs facilitate access to real-time weather information and ongoing group learning. RLC participation was associated with substantially greater productivity, income and food security benefits than participation in PICSA alone.

Rwanda recovered its lost climate history. Although farmers can understand, use and benefit from information derived from local daily weather records, gaps in historical records are a significant challenge for climate services that have proven effective, and have made it more difficult for them to go beyond a pilot scale. In addition to the usual developing country data challenges, Rwanda suffered a near-complete loss of its observing system in the nearly 15 years following the 1994 Genocide. With project support, the IRI worked with Meteo Rwanda to fill the long gap by merging quality-controlled data from available meteorological stations with proxy data from satellites and climate model reanalysis, and by using recent and pre-1994 records to calibrate the satellite and reanalysis data during the gap. The resulting high-resolution gridded data, going

back more than three decades for rainfall and five decades for temperature, serve as a foundation for Meteo Rwanda's localized climate information.

Meteo Rwanda provides cutting-edge online climate tools for agriculture. Meteo Rwanda to develop one of the most advanced suites of online climate information tools and products for agriculture in Sub-Saharan Africa. A rich suite of historical, monitored and forecast products and tools is built on high-resolution gridded data, and made available through online "Maprooms" that open with a map view of the variable and time of year of interest. For any location, users can easily analyze the timing of the start and end of the rainfed growing season; and agriculturally important season rainfall characteristics such as frequency of rain days, and risk of damaging dry spells and extreme rainfall events. Soil water balance modeling tools increase the value of climate data for analyzing drought impacts on crops. Smallholder farmers are benefitting from localized climate graphs designed and formatted for PICSA use, and available to extension personnel for their selected location.

Rwanda's Next Generation seasonal forecasts overcome longstanding obstacles to use. Using the IRI's NextGen system, Rwanda was the first country in Africa to follow the World Meteorological Organization's 2017 recommendation to switch to seasonal forecast methods that are objective, traceable and reproducible, using multiple climate models. Although the WMO recommendation was meant to improve forecast quality, the major breakthrough from an agricultural perspective is the improved way of presenting the forecasts that solves the main weaknesses of the conventions that most National Meteorological Services and Regional Climate Outlook Forums have used for two decades.

Climate services support local government to manage risk. Two of Meteo Rwanda's Maproom tools target government decision makers. A Climate Summary for Local Governments provides one-stop access to a range of information products, averaged over their sector, district or province. Soil water balance modeling translates meteorological data into indicators, such as the Water Requirements Satisfaction Index (WRSI), that relate closely to crop yields under drought conditions. Workshops trained about 150 government agricultural professionals to use climate information. Examples of local government using climate services to benefit farmers include a District Agronomist in Western province distributing maize hybrid seed that better matched the local climate to 88,000 farmers, and a District Agronomist in Eastern Province pumping water into a reservoir to protect 188 farmers' crops from the risk of prolonged dry spells through supplemental irrigation.

Stronger national institutions provide more effective services. RCSA project strengthened the capacity of Rwanda's national institutions through sponsorship of advanced degrees, training events, and joint implementation and research activities. In addition to more than 40 short-term training events, the project made a long-term investment in human capacity by sponsoring M.Sc. degrees for ten young professionals: 7 from Meteo Rwanda and 3 from RAB. The majority of RCSA capacity investment targeted Meteo Rwanda as the country's main provider of weather and climate information. An assessment of several African National Meteorology Services, midway through the project, provided independent evidence that RCSA investments targeted the priority gaps and raised Meteo Rwanda's climate services to a high level relative to its peers.

Rwanda initiated a multi-sectoral climate service policy and institutional framework. RCSA partnered with the UN Global Framework for Climate (GFCS) to facilitate a Rwanda National Framework for Climate Services (NFCS) under the UN intergovernmental Global Framework for Climate (GFCS). The process was launched with a workshop in December 2017, officiated by the Minister of Environment. The RCSA team laid the groundwork by brokering dialog between Meteo Rwanda and the GFCS Secretariat, sponsoring the launch workshop, and developing terms of reference for Steering and Advisory Committees to continue the multi-year process. Once ratified, the NFCS is expected to provide the policy framework, governance structure, and political buy-in needed to support sustained multi-sector climate services.

Farmers tested climate-informed crop management through 120 on-farm trials. To supplement survey-based evaluation of project interventions, and to provide farmers with a tangible demonstration of how climate services can impact their production and income, the RCSA project worked with *Twigire Muhinzi* to implement a network of 120 farmer-managed field trials. A team of scientists developed an experimental protocol, in the

Kinyarwanda language, to ensure that the trials were managed and recorded in a rigorous manner. In 10×10m plots, participating farmers tested crop management options that were introduced through the PICSA process and informed by local climate information, compared with their usual practices. The trials, which were launched with a Field Day in September 2017 and continued for four growing seasons, demonstrated that farmers can achieve substantial increases in their yields and net income.

The influence of project investments extends beyond Rwanda's borders. Rwanda's climate services for agriculture are unprecedented in several respects. It was the first country in Africa to make participatory climate communication, training and planning processes work for farmers at a national scale; and the first to implement a NextGen objective, multi-model seasonal forecast system that fulfills WMO recommendations. Meteo Rwanda's online Maprooms are among the most advanced climate information systems for agriculture in Africa, and have been adopted by five other countries and the regional climate center for Eastern Africa. It has been used as a case study in several academic, policy and guidance publications. RCSA was recognized with the first Africa-wide Climate Smart Agriculture Project of the Year Award.

Impacts

A final project evaluation used a mix of quantitative and qualitative analyses to assess the influence of the RCSA interventions, in particular PICSA and Radio Listeners Clubs (RLCs), on farmers' awareness, access and use of climate information; and resulting welfare impacts. The quantitative evaluation was based on a survey of 1,525 farmers sampled from 15 districts. The qualitative component used 32 focus groups and 24 key informant interviews to provide deeper understanding of how women and men have used and benefitted from climate services as a result of project interventions.

Farms are more productive and profitable and households are more food secure. PICSA participation increased the farmgate value of crop production by an average of 24% (from a mean of $165 for the control sample), and net income from crops by 30% (from a control sample mean of $115), relative to non-participating communities. The combination of PICSA and RLCs was associated with a 47% average increase in the value of crop production, and a 56% increase in income from crops. This translates to an estimated $3.87 million per year increase in farm net income from crops, and $4.54 million per year farmgate value of crop production, aggregated across the 112,767 farmers who participated in PICSA. Participation in PICSA and RLCs extended the time that harvests met household subsistence needs, and significantly increased the diversity of their diets.

Participating farmers recognize a range of benefits. Participating households used their increased agricultural incomes for long-term investments, particularly school fees and health insurance. In assessments of the first two years of PICSA rollout, the majority of respondents reported that, as a result of the training they received, they had greater confidence in their farming decisions, ability to cope with adverse weather conditions, ability to pay for family healthcare and children's school, and social standing within their households and community.

Women farmers are empowered. Participation in either RLCs or PICSA largely eliminated a gender gap in the use of climate information for management that is apparent in the control sample, and diminished gender inequities in overall investment in their farms, coping capacity, and confidence in planning. Women who had participated in PICSA and RLCs reported greater ability to cope with adverse weather conditions and confidence in planning compared to women who had not participated in the interventions. Results also show benefits related to women's empowerment, in the form of increased participation and influence in household decision making, and increased social standing in their communities.

Farmer-scientists demonstrate yields and income benefits. Through a network of field trials, farmers demonstrated that they could increase yields by 47% for maize and 53% for beans, and net income from crops by 52% for maize and 66% for beans, averaged across 120 farms and two years.

Sustainability

The RCSA project sought to develop capacities that would sustain after project funding ended. The project team sees encouraging signs of improved capacity to provide, support and use climate services. However, important gaps in capacity to sustain the progress achieved through the project warrant six follow-up actions:

Table 1. Gaps in capacity to sustain RCSA achievements, and recommended actions to address gaps.

Gap	Recommendation
Meteo Rwanda seasonal forecast and Maproom development capacity	Extend modest IRI technical support for Meteo Rwanda.
Agricultural extension support for farmers' climate risk management	Mainstream climate services in government agricultural policy, planning and extension strategy.
	Invest in human and digital resources, and extend modest UoR technical input, to train and support communication intermediaries.
	Exploit local government offices as digital climate information and education hubs.
Climate risk management knowledge of government agricultural professionals	
	Develop training in climate risk management for local agricultural professionals.
Climate service delivery through radio	Invest in human resources to oversee climate service radio programming and coordination with Radio Listener Clubs

Lessons learned

The project's successes and its challenges suggest six lessons that are relevant to agricultural climate service investments elsewhere.

1. Well-designed climate services are an effective way to improve farmers' yields, income and well-being.
2. Tradeoffs among effectiveness, scalability and sustainability goals should be recognized, discussed among key project stakeholders, and integrated into project design and implementation.
3. Early commitment and ownership on the part of policy makers are crucial for sustainability.
4. Gaps in National Meteorological Service capacity to produce actionable information, and gaps in agricultural sector capacity to communicate and use climate information, are mutually reinforcing and should be addressed in parallel.
5. Scaling climate services that empower farming populations is achievable with serious attention to integrated communication channels.
6. For complex information at a climate time scale, mainstreaming participatory communication processes in effective agricultural extension or other intermediary institutions is key to empowering farmers at scale.

Rwanda Climate Services for Agriculture (RCSA) is a collaborative effort of Meteo-Rwanda, Ministry of Agriculture (MINAGRI), Rwanda Agriculture Board (RAB), International Center for Tropical Agriculture (CIAT), International Livestock Research Institute (ILRI), World Agroforestry Centre (ICRAF), International Research Institute for Climate and Society (IRI) at Columbia University, University of Reading (UoR), Radio Huguka, Caritas (Kibungo, Butare and Kibuye), and Development Rural du Nord (DERN); supported by the Rwanda Mission of the United States Agency for International Development (USAID-Rwanda), and coordinated by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

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ACRONYMS

AICP	Agricultural Information and Communication Program
AIDF	Aid & International Development Forum
AIMS	African Institute for Mathematical Studies
ANOVA	analysis of variance – a statistical method for detecting treatment differences among samples
APROJUMAP	Association pour la PROmotion des JUMelages et de l'Amitié entre les Peuples
CCAFS	CGIAR research program on Climate Change, Agriculture and Food Security
CIAT	International Centre for Tropical Agriculture (Spanish acronym), now Alliance Bioversity-CIAT
CRS	Catholic Relief Services
DACA	Digital Agro Climate Advisory smartphone app
DERN	Development Rural du Nord
ENACTS	Enhancing National Climate Services – NMS capacity development initiative of the IRI
ESRI	Environmental Systems Research Institute
FFS	Farmer Field School
FONERWA	Rwanda Green Fund
FRI	Farm Radio International
GFCS	Global Framework for Climate Services
HDD	household dietary diversity index
ICPAC	IGAD Climate Prediction and Applications Center
ICRAF	World Agroforestry Center (formerly International Center for Research on Agroforestry)
IGAD	Intergovernmental Authority on Development
IRI	International Research Institute for Climate and Society
MIDIMAR	Ministry of Disaster Management and Refugee Affairs
MINAGRI	Ministry of Agriculture and Animal Resources
MINALOC	Ministry of Local Government
MINEDUC	Ministry of Education
NAEB	National Agricultural Export Development Board
NFCS	National Framework for Climate Services
NGO	non-governmental organization
NMS	National Meteorological Service
PABRA	Pan-Africa Bean Research Alliance
PASP	Post-Harvest and Agribusiness Support Project
PICSA	Participatory Integrated Climate Services in Agriculture
RAB	Rwanda Agricultural Board
RCOF	Regional Climate Outlook Forum
RCSA	Rwanda Climate Services for Agriculture
RLC	Radio Listeners Club
RYAF	Rwanda Youth in Agribusiness Forum
SEDO	Socio-economic Development Officer
UoR	University of Reading
USAID	United States Agency for International Development
WISER	Weather and Climate Information Services for Africa
WMO	World Meteorological Organization

INTRODUCTION

Climate risk is an obstacle to efforts to improve the livelihoods of farmers. Extreme events, such as droughts and flooding, can erode their capacity to build a better life by depleting their productive assets and human capital, while the uncertainty associated with climate variability is a disincentive to investing in agricultural innovation. Climate change is intensifying this challenge because it is increasing the frequency and severity of extreme events. In order to manage climate-related risks, those risks must first be understood, anticipated and planned for. Effective climate services can inform a range of short- and long-term decisions, contributing to the productivity, incomes and welfare of smallholder farmers and the resilience of the agricultural economy.

The Rwanda Climate Services for Agriculture (RCSA) project, funded by the US Agency for International Development (USAID), comprised a consortium of national and international partners that worked from 2016 to 2020 to strengthen the climate information available to Rwanda's farmers and agriculture sector. The project's goal was to transform Rwanda's rural farming communities and agricultural economy through improved climate services and climate risk management. Efforts toward this goal were organized around four target outcomes:

- **Outcome 1: Climate services for farmers**. Agricultural extension and other relevant intermediary organizations and communicators provide farmers across Rwanda's 30 districts with decision-relevant climate information and advisory services, and support them to use the information to better manage risk.
- **Outcome 2: Climate services for government and institutions**. Agricultural and food security decision-makers in MINAGRI and in other relevant government institutions are using climate information to respond more effectively to climate-related risks, and to inform decisions that build the resilience of farmers.
- **Outcome 3: Climate information provision**. Meteo Rwanda is designing, delivering, and incorporating user feedback into a growing suite of weather and climate information products (historic, monitored, forecast) and services tailored to the needs of agricultural and food security decision-makers.
- **Outcome 4: Climate services governance**. A national climate services governance structure ensures sustained co-production, assessment and improvement of climate service for agriculture and food security; and facilitates a formal interface and effective dialog between the key agencies involved.

> *"A joint initiative … has rebuilt 15 years of lost climate data. The program has also helped our national weather agency build an advanced online climate information system for Rwandan farmers. These results could only have been achieved with sustained partnership over many years."*
>
> (His Excellency President Paul Kagame)

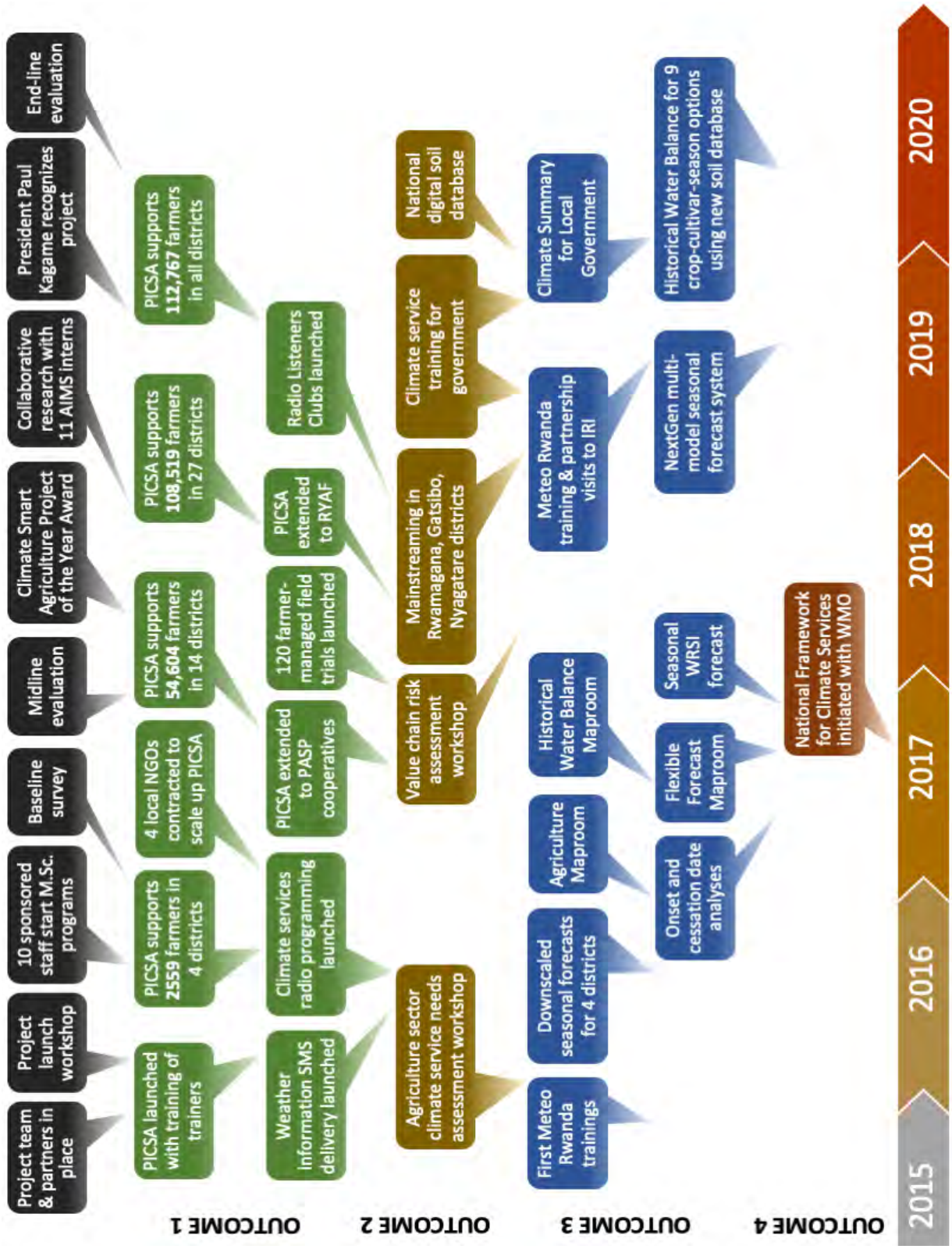
The project was launched on March 23, 2016, on World Meteorological Day. Approximately 100 representatives from key government agencies in Rwanda, research organizations, farmers, development partners, non-governmental organizations and media attended the launch workshop in Kigali.

The Rwanda Climate Services for Agriculture project is a collaborative effort of Meteo-Rwanda, Ministry of Agriculture (MINAGRI), Rwanda Agriculture Board (RAB), International Center for Tropical Agriculture (CIAT), International Livestock Research Institute (ILRI), World Agroforestry Centre (ICRAF), International Research Institute for Climate and Society (IRI) at Columbia University, University of Reading (UoR), Radio Huguka, Caritas (Caritas Kibungo, Caritas Butare and Caritas Kibuye), and Development Rural du Nord (DERN). The project is supported by the Rwanda Mission of USAID, and coordinated by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

This report summarizes key achievements, impacts, lessons and outputs for the duration of the project.

PROJECT ACHIEVEMENTS

Timeline of project milestones



Twigire Muhinzi scales up participatory climate communication and planning

Face-to-face participatory climate communication and planning processes have been implemented in Rwanda at a scale that is unprecedented in Africa.

The RCSA project adopted the Participatory Integrated Climate Services for Agriculture (PICSA) approach as the primary channel for building farmers' capacity, and scaled it up through the *Twigire Muhinzi* agricultural extension service, Post-Harvest and Agribusiness Support Project (PASP) farmer cooperatives and members of the Rwanda Youth in Agribusiness Forum (RYAF). PICSA is a structured participatory climate communication, training and planning process, developed by the University of Reading, that brings together groups of farmers and intermediaries trained in the process. It combines location-specific climate information with participatory tools, including resource mapping, activity calendars and budgeting activities to empower farmers to make better-informed crop, livestock and livelihood decisions.

Table 2. Cumulative PICSA milestones.

Year	Districts	Trained	
		Facilitators	Farmers
2016	4	96	2559
2017	14	895	54,604
2018	27	1900	108,519
2019	30	2111	112,767

Rwanda's innovative *Twigire Muhinzi* extension service combines agricultural professionals with volunteer Farmer Promoters and Field School Facilitators who are trusted members of the communities they serve. The project's training-of-trainers approach provided advanced instruction to equip professionals to train and support Farmer Promoters, local extension staff and other intermediaries who, in turn, trained and facilitated farmer groups to use climate services.

> *"PICSA came on time. Forecasts, historical data, prediction: they were things I knew but didn't understand how to apply. Now I can share this with my neighbors so that others can see and learn."* (Mukamazimpaka Mwamimi, Farmer Promoter, Nyarugenge District)

As expansion to new locations accelerated, four local NGOs (Caritas Kibungo, Caritas Kibuye, Caritas Butare and DERN) were contracted to facilitate the training and support implementation in farming communities in their respective provinces. Throughout the project, PICSA trainings were facilitated twice annually, before the start of each planting season. Refresher workshops deepened the skills and confidence of the professionals and Farmer Promoters who facilitate and support farmers.

> *"As a single mother, I have to work hard to provide for my children. I grow and sell beans, maize, Irish and sweet potatoes and depend a lot on rain. … The training was very informative as I have learned more about climate change and its impacts on the farming process, how and when to plant and the type of crops to plant. I also like meeting new people and discovering new things that I did not know."* (Kubwimana Generoze, Farmer, Huye District)

PICSA training, Kigali, Feb 2019. Photo: S. Samuel (CCAFS)

Interactive climate service radio programming reaches 3 million farmers

"With more than half of the global population still not connected to the internet, radio continues to be the world's most accessible mass medium" (Kevin Perkins, FRI)

Radio can reach rural populations at low cost. It is accessible to 98% of Rwandans. An estimated 3.1 million farmers[1] listen to Radio Huguka – a community radio network that supports agriculture and rural communities. The RCSA project partnered with Radio Huguka to support Rwanda's farmers with climate information and educational programming.

Through project support, Radio Huguka provides climate services through a range of program formats.

Interactive 60-minute live talk shows and debates, broadcast weekly, provide opportunity for farmers to ask questions and share their experiences by phone or SMS. The talk shows are developed by a team representing Meteo Rwanda, RAB, MINAGRI and CIAT, and cover topics such as basic climate concepts, and the use of climate information for disaster management, crop management, fodder management and pest control.

"*Urubuto Ntera*" is a 20-minute prerecorded educational program broadcast every week focused on providing farmers with information and knowledge needed to manage climate-related risks.

> *"With more than half of the global population still not connected to the internet, radio continues to be the world's most accessible mass medium. Indeed, in the rural African communities served by our broadcasting partners, it's the communication tool that people count on most."* (Kevin Perkins, Executive Director, Farm Radio International)

Climate-related content also includes daily weather forecasts and 2-3-minute news reports broadcast three times per day as part of the news. Radio Huguka also broadcasts special events, such as 2-hour community talk show and debate organized by the RCSA project, in partnership with RAB, Meteo Rwanda and Caritas Kibuye in Birambo Center, Karongi District, Western Province, in December 2018.

Although conventional radio programming is largely a one-way communication channel, innovative programming can make communication more interactive and engaging, and hence better able to respond to farmers' context-specific needs.

Radio Huguka studio.


Radio used by a RLC, Aug 2019. Photo: Y. Munyangeri

[1] Based on UNESCO 2016 listenership estimate adjusted for rural population growth.

Radio Listeners Clubs combine benefits of radio and agricultural extension

Radio Listener Clubs integrate information at weather and climate time scales, and combine the reach of broadcast media with the richness of group interaction.

The RCSA project partnered with Radio Huguka to pilot 225 Radio Listener Clubs in November 2018. The Clubs aim to combine the benefits of the broadcast media and group interaction facilitated by agricultural extension. Farmer Promoters, who were already trained and involved in the PICSA process, were trained to lead their village groups in weekly meetings to listen to and discuss climate service radio programs, participate in call-in shows, share and record their plans to act on the information they have heard, and share the information with other farmers in their *Twigire Muhinzi* village groups.

Farmers participate in climate service call-in shows and live debates with experts, and by calling or texting messages and questions. As journalists facilitate the talk shows, experts from the Ministry of Agriculture and Animal Resources (MINAGRI), the Rwanda Agriculture Board (RAB) and the Rwanda Meteorology Agency (Meteo Rwanda) respond to farmers' inquiries.

To ensure equitable participation among farmers, Radio Listener Clubs participate in call-in shows and live debates with experts on a rotating basis. At least three clubs participate and directly share their views during a given broadcast. The clubs also enable farmers to influence the content by choosing the topics for future programs.

Problem raised by Abahuje Tunza RLC leader: *"In our region, we don't know techniques for storing fodder during the dry season, so we are happy to learn from experts or farmers from other regions."*

Solution offered by listener in Western Province: *"We have an old technique that we use to store livestock food by putting the grass in a pit and covering it with shrubs and soil to keep them from drying."*

The project team visited the Abahuje Tunza club, located in Southern Province. Around 25 club members met at a member's home to listen to the broadcast through a small radio. The farmers learned about the use of climate information for agricultural livelihoods. The club leader shared a challenge on the live broadcast: "*In our region, we don't know techniques for storing fodder during the dry season, so we are happy to learn from experts or farmers from other regions.*" A farmer from Western Province called in to offer a solution: "*We have an old technique that we use to store livestock food by putting the grass in a pit and covering it with shrubs and soil to keep them from drying*."

When the COVID-19 pandemic prevented Listeners Club members from meeting in person, the radio journalist adapted by calling at least two club members so they can participate live on the talk show, on a rotating basis, while others follow and can text their feedback from their own homes.

Abahuje Tuza RLC, Aug 2019. Photo: Y. Muhyangeri (CIAT).

The Radio Listener Club experience demonstrates that broadcast media, mobile phones and face-to-face communication through agricultural extension are not so much alternatives, but complementary channels for delivering rural climate services. Radio Listener Clubs are integrating information at weather and climate time scales and combining the reach of broadcast media with the richness of group interaction.

Rwanda recovered its lost climate history

Countries, like people, rely on stories of the past to guide them in the present and help them prepare for the future. Rwanda recovered the missing pages of its climate story.

In addition to the data challenges that many developing countries share, Rwanda suffered a near-complete loss of its meteorological observing system in the decade following the 1994 Rwanda Genocide. After the war and genocide against the Tutsi ended in 1994, Didace Musoni was charged with resurrecting Rwanda's meteorological agency (Meteo Rwanda). He took a series of trips through the countryside to check on the stations and was disheartened by what he saw. “Many of these stations had been abandoned,” says Musoni, who is still a top official at Meteo Rwanda. “The fencing would be torn. Instruments were destroyed.” Many of the volunteers who had manned the stations had been murdered in the genocide. Most of the rest had fled.

> *“That period was totally lost. Many of these stations had been abandoned. The fencing would be torn. Instruments were destroyed. It is data that will never, never, never be recovered.”* (Didace Musoni, Meteo Rwanda)

As the nation rebuilt, Meteo Rwanda was eventually able to rebuild its observing network to exceed the level before 1994. However, for nearly fifteen years following the genocide against the Tutsi, Rwanda has almost no record of what its weather was like. “That period was totally lost,” says Musoni. “It is data that will never, never, never be recovered.”

Tufa Dinku from the International Research Institute for Climate and Society (IRI), leads the Enhancing National Climate Services (ENACTS) initiative, which works with National Meteorological Services to improve the quality, accessibility, and usefulness of the climate information they provide. When Dinku first started working with Meteo Rwanda, he found the decade-long data gap daunting. Determined to find a solution, Dinku worked with Meteo Rwanda to successfully fill the long gap in Rwanda’s climate history, by merging available, quality-controlled daily observations from meteorological stations with proxy data from satellites and climate model reanalysis. The resulting high-resolution gridded data, going back more than three decades for rainfall and five decades for temperature, serve as a foundation for a suite of online, high-resolution climate information “Maproom” tools and products.

> *“My first reaction was, 'It cannot be this bad.' So I went back to the data and then I said, 'Wow. This is true. It's really this bad.'”* (Tufa Dinku, IRI)

Automatic rain gauge. Photo: A. Myandwi (MINAGRI)

The resulting historical gridded data are of higher quality than similar global products from advanced institutions in the Global North because the quality of a merged product is a function of the amount of observational data that they incorporate, and Meteo Rwanda, like other NMS, stewards much more data than are available to external organizations.

Countries, like people, rely on stories of the past to guide them in the present and help them prepare for the unknown. The genocide against Tutsi in Rwanda ripped out many pages of stories, climate among them. It took half a generation for the meteorological observing system to recover to pre-1994 levels, leaving a costly gap in Rwanda’s climate history. With its climate history now reconstructed, Rwanda is emerging as a leader in agricultural climate services across Africa.

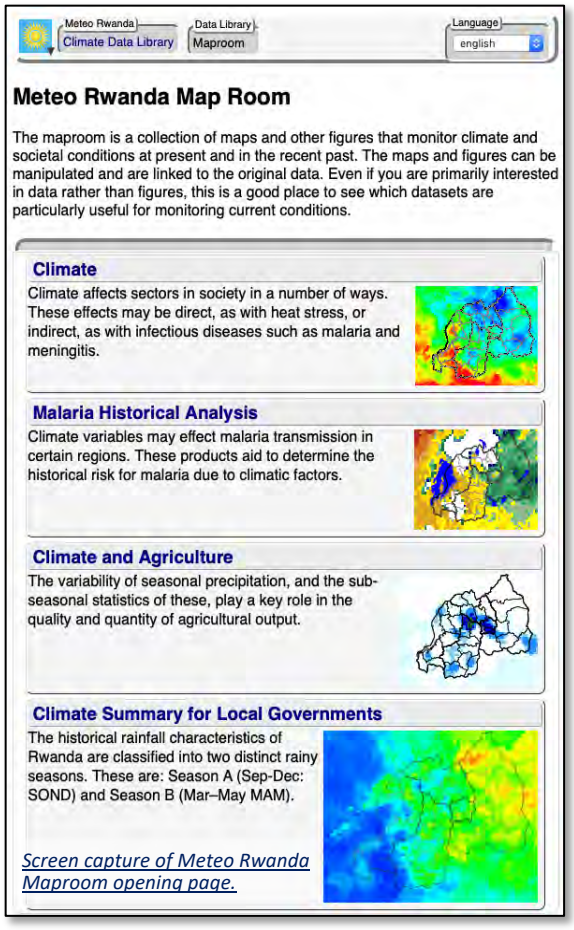
Meteo Rwanda provides cutting-edge online climate tools for agriculture

Smallholder farmers can understand information products derived through custom analysis of local historical daily weather records, and act on it in ways that improve their wellbeing. Until recently, participatory approaches that have proven effective rarely moved beyond a pilot scale due in part to gaps in historical records and the limited resources of National Meteorological Services to process and analyze those data. At the start of the RCSA project, Meteo-Rwanda faced similar resource challenges as other African NMSs, but also faced a 15-year data gap from breakdown in its observing system following the civil war and genocide.

Once the data gap was filled by merging available station records with satellite remote sensing and climate model reanalysis data, the resulting 4 km gridded data became a foundation for a rich suite of historical, monitored and forecast climate information products made freely available through online "Maprooms."

Meteo Rwanda's Maprooms open with a map view of statistics (mean, standard deviation or probability of exceeding a user-selected quantity or percentile) of the variable and time of year of interest. Users can access additional location-specific analyses for any grid cell location or administrative polygon. Historical analyses allow decision makers to access information at their location about the seasonal cycles, trends and variability of rainfall and temperature that affect agriculture. They can easily analyze the timing of the start and end of the rainfed growing season. They can also access agriculturally important characteristics of rainfall, such as frequency of rain days, risk of damaging dry spells and extreme rainfall events during the growing season. Soil water balance modeling tools increase the value of climate data for analyzing drought impacts on rainfed crops. Time series, probability-of-exceedance and other graph formats provide several different perspectives on climate risks at their locations.

Smallholder farmers are benefitting from Meteo Rwanda's Maprooms, although not by accessing them online directly. Improvements to the graphics capabilities of the underlying Data Library allow the Maprooms to serve as a portal for extension personnel to access all of the graphs used in the PICSA process, in a format suitable for farmer workshops, and for their selected location. The ability for extension personnel to generate climate information graphs on demand for their location, without placing additional demands on Meteo Rwanda staff, has been one of the keys to scaling up participatory communication and planning process.



Screen capture of Meteo Rwanda Maproom opening page.

The RCSA project worked with District Agronomists and Meteo Rwanda to develop a Climate Summary for Local government that provides graphic summaries of various rainfall characteristics averaged over a selected Province, District or Sector, on a single web page.

Meteo Rwanda now provides one of the most advanced suites of online climate information tools and products for agricultural decision makers available in Sub-Saharan Africa. Many of the Maproom tools developed in Rwanda have since been adopted by the National Meteorological Services of Ethiopia, Senegal, Bangladesh, Colombia and Guatemala; and by the IGAD Climate Prediction and Applications Centre (ICPAC), the regional climate center for East Africa.

Next Generation seasonal forecasts overcome obstacles to use

Rwanda was the first country in Africa to implement Next Generation objective seasonal forecast methods and a transformative forecast presentation

Seasonal forecasts, supported by Regional Climate Outlook Forums (RCOFs) since 1996, have been a major information source for climate services across Africa. The RCOFs and most National Meteorological Services use subjective processes to arrive at a consensus among different forecasts, and express the resulting forecast as tercile probabilities that rainfall in the upcoming season will fall in "below-normal," "normal" or "above-normal" categories.

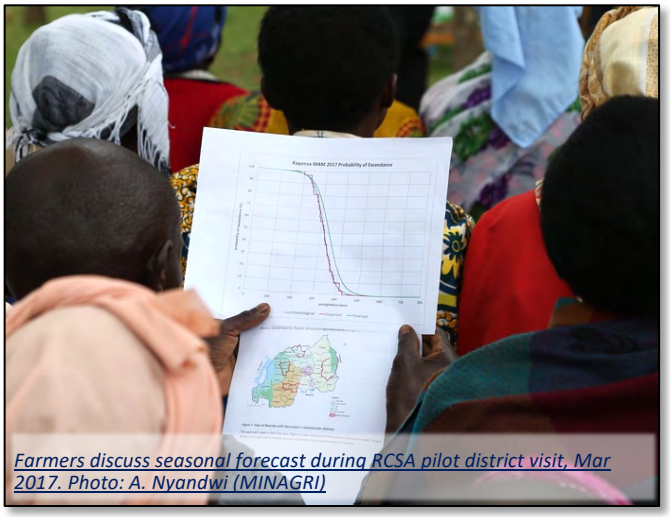
These forecasts are difficult to use because they lack information about what the forecast means for local conditions, forecast categories are arbitrary and difficult to understand, and they seldom include rainfall characteristics beyond seasonal totals that are important for agriculture (e.g., start date, dry spells, length of season). Seasonal forecasts can be made more useful by switching to objective forecast methods, using local historical climate data to calibrate and downscale forecasts, and presenting probability distributions of the forecast along with the climatological distribution.

Using the IRI's NextGen approach, Rwanda was the first country in Africa to follow the World Meteorological Organization's 2017 recommendation to switch to seasonal forecast methods that are objective, traceable and reproducible, using multiple climate models. Although the WMO recommendation was meant to improve forecast quality, the major breakthrough from an agricultural perspective is the improved way of presenting the forecasts that solves the main weaknesses of the tercile convention.

CONSTRAINT	SOLUTION
Lack of information about local climate	Downscale forecasts
	Present forecasts with local climatology
Categories arbitrary	Provide full forecast probability distribution
Categories difficult to understand	
Ambiguous uncertainty	
Limited relevance of seasonal averages alone	Expand suite of forecast variables
	Translate into impacts, management options

Meteo Rwanda's Seasonal Rainfall Forecast Maproom opens with a map view that provides several options for viewing what the forecast means across the country. A local decision maker can access downscaled forecast information by selecting their grid cell location.

By replacing the tercile categories with a full forecast probability distribution, the forecast shows the likelihood of experiencing seasonal rainfall above or below any decision-relevant threshold. Presenting the forecast distribution alongside the local historical distribution helps users to relate the forecast to their personal experience with climate variability—with the added benefit of building awareness of the past behavior of their local climate. It also shows how the forecast shifts the likelihood that seasonal rainfall will be above or below any relevant threshold. The shape of the forecast distribution helps users understand how much confidence they should place in the forecast.

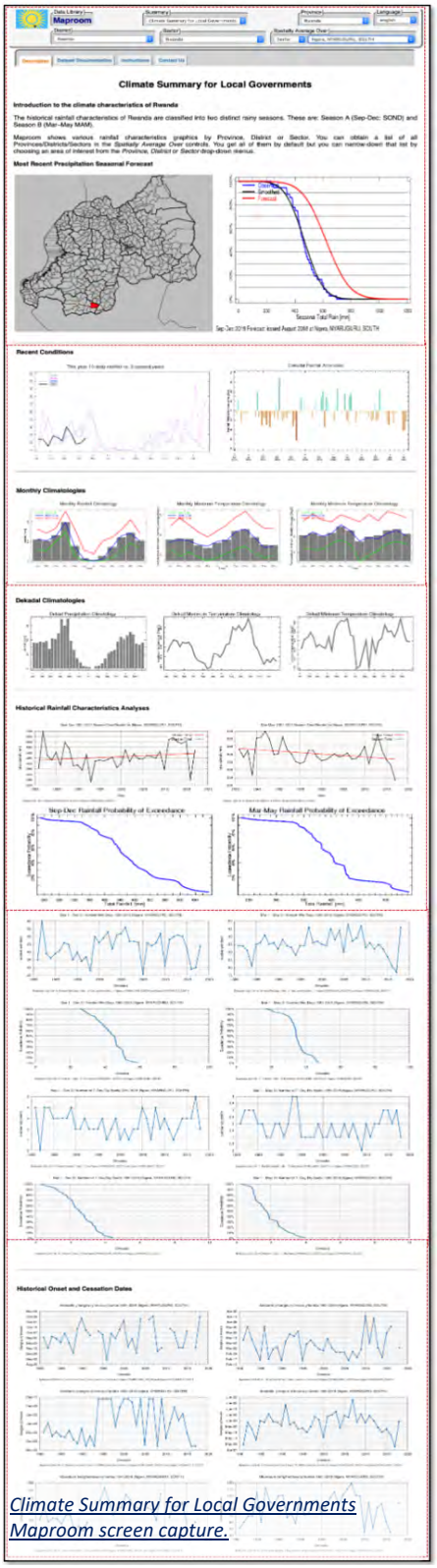


Farmers discuss seasonal forecast during RCSA pilot district visit, Mar 2017. Photo: A. Nyandwi (MINAGRI)

Farmers can best take advantage of the new forecasts when they are bundled with a training and planning workshops. The seasonal forecasts are shared with farmers and community leaders who have already been trained in PICSA, through short workshops across the country, just before the start of each growing season, with support from local NGO partners.

Climate services support local government to manage risk

Local government officials use climate information to improve their services to farmers.



Climate Summary for Local Governments Maproom screen capture.

From analysis of local historical climate information, District Agronomists in Western Province realized that the crop seed varieties that had been distributed to farmers were not well adapted to local conditions. They identified maize hybrids that better matched the local climate, and distributed the improved seed to 87,872 farmers.

In Eastern Province, the Bugesera District Agronomist used climate information to calculate how much irrigation water would be needed to meet crop requirements during anticipated drought conditions. Based on this calculation, authorities pumped from a lake into a lined reservoir, or "damsheet," to provide supplemental irrigation water to 188 farmers to protect their crops through prolonged dry spells.

The RCSA project worked with Meteo Rwanda to develop a Climate Summary for Local Governments that provides one-stop access to a range of information products, averaged over their sector, district or province, including: the most recent seasonal forecast; monitoring graphs comparing recent rainfall with prior years; summaries of the annual seasonal cycle; and a range of historical rainfall analyses.

Soil-water-balance modeling adds value to climate data by capturing the dynamic interactions between crop water requirements and supply. For nine crop-cultivar-season combinations, Historical Water Balance Maprooms translate rainfall and temperature data into soil water content and water balance-based agricultural drought indicators such as the Water Requirements Satisfaction Index (WRSI). WRSI is more strongly and linearly related to crop yields than drought indexes based on rainfall alone, and is used widely for food security early warning. An experimental WRSI seasonal forecast demonstrates the potential to forecast agricultural drought before the start of the growing season.

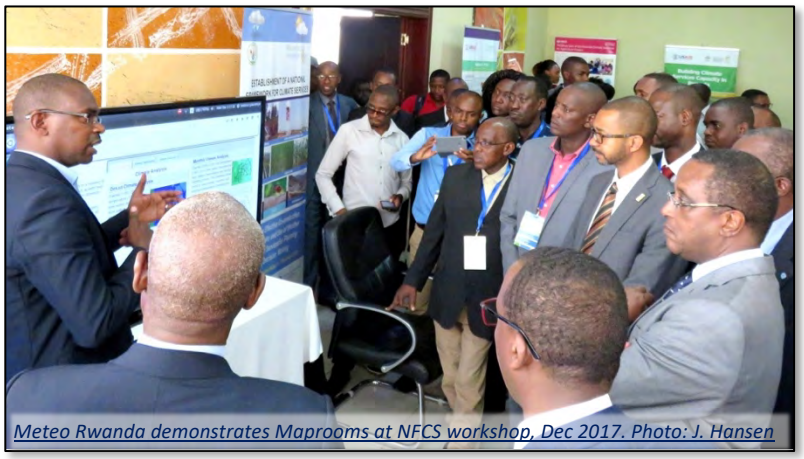
Inconsistencies discovered between the SoilGrids pan-African soil database and water-holding capacity measured in an early Rwanda soil survey led the project team and RAB to re-sample soil profiles, measure soil physical and chemical properties, and estimate physical properties across the landscape. RAB endorsed the resulting national soil database and digital map in a validation workshop in June 2019.

A series of workshops in 2019 trained about 150 national and local agricultural professionals to understand and use information and analyses available in Meteo Rwanda's Maprooms. Participants represented MINAGRI, RAB, Eastern Agric Grain Council, One Acre Fund, Rwanda National Police, NGOs, media, academia, provincial directors of agriculture, and District Agronomists from all 30 districts. The trainings were a collaborative effort, with WISER and FONERWA projects contributing to workshop expenses, and content largely developed by RCSA.

Stronger national institutions provide more effective services

Through a combination of sponsorship of advanced degrees, training events, exchange visits, and joint implementation and research activities, the RCSA project sought to sustainably strengthen the capacity of Rwanda's national institutions. The majority of this effort focused on Meteo Rwanda – the country's lead institution for climate services and main provider of weather and climate information.

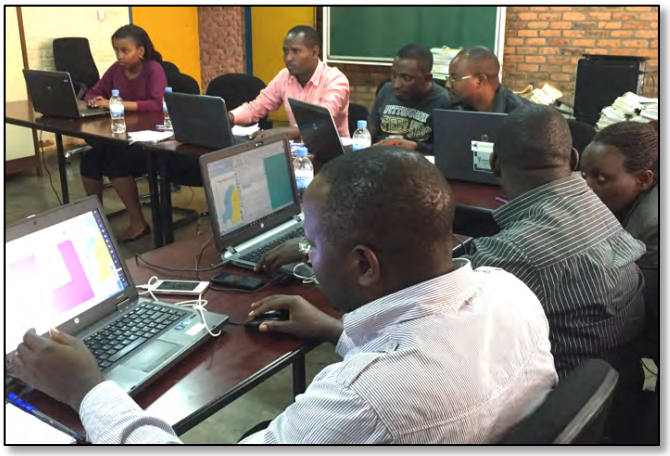
While farmers were the priority target of the project's investment in capacity development – with 112,767 farmers trained and supported to use climate information through PICSA – it also conducted more than 40 training workshops and exchanges that aimed to enhance the capacity of farmer intermediaries (23 training events), Meteo Rwanda (13), institutional and government users (4) and media (1). The project made a long-term investment in the capacity of two partner government agencies by sponsoring ten young professionals – 7 from Meteo Rwanda and 3 from RAB – to earn M.Sc. degrees from three African universities.



Meteo Rwanda demonstrates Maprooms at NFCS workshop, Dec 2017. Photo: J. Hansen

In November 2018, the Director-General of Meto Rwanda raised concern that his staff might not have the skills needed to sustain the technical advances and maintain the growing suite of online Maprooms once the project ends. In response, the IRI hosted staggered training visits for four Meteo Rwanda staff. The 14 person-weeks of training and mentoring strengthened skills in seasonal forecasting, data and Maproom tools that are crucial for Meteo Rwanda to sustain and improve new services that were developed through the project. Desire Kagabo and the new Director-General joined the final week for presentations on the training and discussions about continued partnership and sustainability needs. Costs were shared strategically with the WISER Rwanda project.

The USAID Learning Agenda on Climate Services in Sub-Saharan Africa conducted an assessment of the capacity of seven African National Meteorological Services (Senegal, Ethiopia, Rwanda, Malawi, Mali, Cote d'Ivoire and Niger) roughly mid-way through the project. The study rated services (*Basic*, *Essential* or *Full Climate Services*) for each of the five pillars of the Global Framework for Climate Services. The study found Meteo Rwanda met most of the criteria for Full Climate Services in its *Climate Services Information System* and *User Interface Platform*. The assessment that "…the Rwanda NMHS is currently a top performing African NMHS" in its Climate Services Information System can be attributed to RCSA investment in Meteo Rwanda's Climate Maprooms. We expect that a current assessment would show further improvements in Meteo Rwanda's climate as a result of RCSA investments that at least partially addressed the study's recommendations to address capacity gaps by: increasing staff with advanced academic qualifications, improving the range and availability of online climate information products, training staff in user engagement, and developing the capacity of forecasters through M.Sc. degrees and short training.



Rwanda initiated a multi-sectoral climate service policy framework

RCSA initially planned to develop a project-based mechanism to coordinate climate services for the agricultural sector. It became clear early that embedding Rwanda's climate services in the UN Global Framework for Climate (GFCS) would provide a better foundation for the policy framework, governance structure, and high-level political buy-in needed to support sustained multi-sector climate services.

Minister of Environment opens NFCS workshop, Dec 2017. Photo: J. Hansen (IRI)

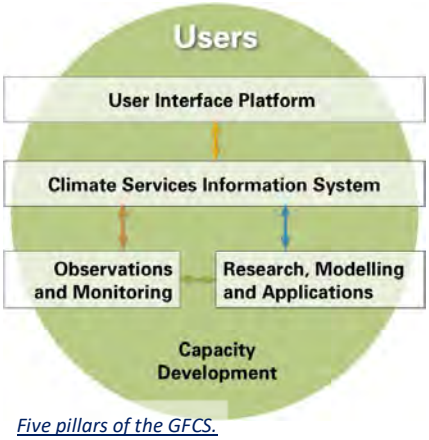
GFCS is an intergovernmental framework that aims to improve management of climate risks and adaptation to climate change by mainstreaming climate services into planning, policy and practice on global to national scales. Priority sectors for the GFCS are agriculture and food security, disaster risk reduction, energy, health and water resources management. It was established in 2009 as an outcome of the Third World Climate Conference. Through the World Meteorological Organization (WMO), the GFCS provides guidelines and technical support for countries to develop National Frameworks for Climate Services (NFCS) -- national coordinating mechanisms to facilitate the development and delivery of climate services for priority sectors.

Farmer shares poster about her experience with climate services with Minister of Environment. Photo: T. Muchaba

Following project team discussions with the Director-General of Meteo Rwanda and the Africa Director of the GFCS, Meteo Rwanda formally requested the WMO to support creation of a National Framework for Climate Services for Rwanda in June 2017.

The NFCS development process was launched with an inception workshop in Bugesera District, December 2017, that brought together 119 participants from several climate-sensitive sectors. The Minister of Environment, officiated. Most of the meeting was devoted to working groups discussions, focused first on types of climate products and services. A second round of working groups began to define roadmaps to develop climate services for disaster risk reduction, health, energy, communication, hydrology and agriculture and food security; and the meteorology, and institutional framework and policies needed to support these. An exhibition included nine farmers who shared their experience using climate information with workshop participants.

Before closing, participants voted to establish a Steering Committee to oversee further development of Rwanda's NFCS. Its implementation will be anchored on the five GFCS pillars: (1) User Interface Platform; (2) Climate Services Information System; (3) Observations and Monitoring; (4) Research, Modelling and Prediction; and (5) Capacity Development. It is expected to contribute to the existing Government of Rwanda Sustainable Development Goals (SDGs), National strategy for Transformation (NST), and Green Growth and Climate Resilience strategy.



Five pillars of the GFCS.

Farmer-managed field trials demonstrated benefits of climate services

Farmer-researchers demonstrated how climate services can impact their production and income through a network of 120 on-farm trials.

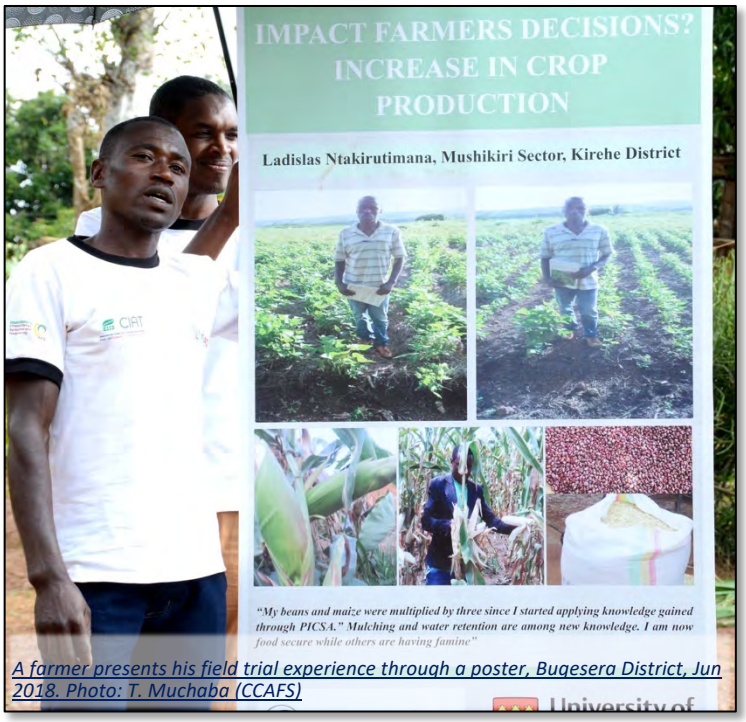
To supplement survey-based evaluation of project interventions, and to provide farmers with a tangible demonstration of how climate services can impact their production and income, the RCSA project worked with *Twigire Muhinzi* to implement a network of 120 farmer-managed field trials. This is the most extensive effort that we are aware of in the developing world to engage farmers in assessing impacts of climate services through controlled field trials.

Weighing farmer-managed trial harvest, Bugesera District, Jun 2018. Photo: T. Muchaba (CCAFS)

> *"I now adhere to the planting time once I get the seasonal forecast and I always look for improved seeds. … The difference with applying climate information and agronomic advisories that came with PICSA training is obvious in my plots, and I urge all my neighbors to follow my example."* (Ngendahimana Jean Paul, Farmer Promoter, Bugesera District)

A team of scientists developed an experimental protocol, in the Kinyarwanda language, to ensure that the trials were managed and recorded in a rigorous manner, including a field book notebook for participating farmers to record information about management of the fields and steps used in the trial.

The project trained 78 local partners and farmer representatives from eight districts on the protocol, and launched the trials with a Field Day in September 2017. In 10×10m plots, participating farmers used crop management options that were identified during the PICSA process and informed by historical rainfall analyses and forecasts. Depending on the location, climate-informed practices included use of inorganic fertilizer, certified seeds, ridges, mulching and optimum plant spacing. These practices were compared to 10×10m control plots with the same crop, but farmers' usual practices without considering climate information.



A farmer presents his field trial experience through a poster, Bugesera District, Jun 2018. Photo: T. Muchaba (CCAFS)

Farmers implemented their trials for four growing seasons: for maize in September-December 2017 and 2018, and beans in March-May 2018 and 2019. Partner NGOs (Caritas Butare, Caritas Kibungo, Caritas Kibuye and DERN) supervised the trials, supported by regular visits by the project team to monitor progress and verify that the trials followed the protocol.

Climate-based management increased yields by 47% for maize and 53% for beans, and net income from crops by 52% for maize and 66% for beans, averaged across 120 farms and two years. A journal article detailing results is under development.

Influence beyond Rwanda

Rwanda's climate services for agriculture are unprecedented in several respects, and its impact extends far beyond its borders.

Rwanda provides the first demonstration that intensive, face-to-face climate communication, capacity building and planning processes can work for farmers at a national scale, through agricultural extension.

Rwanda was the first country in Africa to implement an objective seasonal forecast system based on the IRI's NextGen multi-model ensemble and statistical downscaling methods. Climate Maprooms developed with Meteo Rwanda have been adopted by the National Meteorological Services of Ethiopia, Senegal, Bangladesh, Colombia and Guatemala; and regionally by the IGAD Climate Prediction and Applications Centre (ICPAC), the Eastern Africa regional climate center.

First in Africa to:

- scale up participatory climate communication processes for farmers nationally
- implement NextGen objective multi-model seasonal forecast system
- receive *CSA Project of the Year Award*

Rwanda's leadership in climate services for agriculture was recognized by the first Climate Smart Agriculture Project of the Year Award. The Climate Smart Agriculture Project of the Year Award recognizes outstanding projects that bring together multiple stakeholders in the agriculture ecosystem—from governments, donors, and NGOs to the private sector—to form new partnerships that improve productivity, resilience, and efficiency while lowering carbon output. More than 50 nominations were judged on creative approach to solving real challenges; proven impact and ability to demonstrate environmental, climate, social and economic impact; the longevity of the projects; and potential for self-sufficiency. Dr. Desire Kagabo received the award on behalf of the Rwanda Climate Services for Agriculture project at the inaugural Africa Climate Smart Agriculture Summit 2018, held by the Aid & International Development Forum, on May 18, 2018.

Lessons from Rwanda's experience are informing the design of the Accelerating Impacts of CGIAR Climate Research in Africa (AICCRA) project in six African countries, and have been shared as case studies in several publications, including:

- a background paper on climate services commissioned by the Global Commission on Adaptation to inform its flagship report, "Adapt Now: A Global Call for Leadership on Climate Resilience,"
- a guidance manual on co-production in African weather and climate services,
- 10 best bet innovations for adaptation in agriculture – a UNFCCC Technical Guidelines supplement, and
- journal article and brief on climate service good practice for Africa's farmers, produced through the USAID Learning Agenda on Climate Services in Sub-Saharan Africa.

Rwanda's achievements were possible because of support by a strong set of government, local and international partners; and generous support from USAID at the level needed to strengthen Rwanda's capacity to produce, deliver and use climate services. This investment of human and financial resources, and innovative solutions such as ENACTS, NextGen forecasting and PICSA, have made climate services work for farmers at a national scale in ways that have previously only been demonstrated a pilot scale.

IMPACTS

A final project evaluation used a mix of quantitative and qualitative analyses to assess the influence of the RCSA interventions — in particular PICSA and Radio Listeners Clubs (RLCs) — on farmers' use of climate information and resulting welfare impacts.

The quantitative evaluation[2] was based on a survey of 1,525 farmers from 15 districts. Sampling aimed to provide balanced representation by sex (51.0% men, 49.0% women) and across provinces and districts. Indicators included household characteristics, perceived climate risks, climate information access and use, farm management decisions, and objective and subjective wellbeing measures. Sampling represented a 2×2 factorial experimental design, allowing the influence of PICSA and RLCs to be compared, alone and in combination, with the control. ANOVA was used to determine whether intervention and control groups show average differences in productivity, income or food security that cannot be explained by random variability among farmers. Although the sampling strategy and analysis controlled for bias associated with location, there is a possibility of self-selection bias – which results when participant farmers are different, on average, than farmers in the control group, in ways that affect the metric that is being tested. For the PICSA sample, self-selection bias is expected to be quite small because nearly all farmers in selected *Muhinzi* Groups participated in the PICSA training and planning process. The risk of self-selection bias is greater for RLCs, as weekly participation placed greater demands on farmers' time and hence may have favored farmers with greater motivation or fewer time constraints.

Table 3. Quantitative survey sample sizes by climate service intervention.

	+ PICSA	– PICSA	TOTAL
+ RLC	182	321	503
– RLC	395	627	1,022
TOTAL	577	948	1,525

The qualitative evaluation[3] used focus group discussions and key informant interviews to deepen understanding of how women and men have accessed, used and benefitted from climate services as a result of project interventions. One men's group and one women's group were sampled for each of four treatment (early and late PICSA participants, participants of PICSA and RLCs, and a control group that participated in neither) categories, replicated for each of the four provinces, for a total of 32 focus groups. A male and female key informant interview was carried out for each treatment category in three provinces, for a total of 24.

The effectiveness, outcomes and perceived benefits of early implementation of PICSA were assessed using questionnaires administered to 215 participant households randomly sampled from 4 pilot districts in March 2017[4], and 502 households in 10 districts in May 2018.[5]

A network of 120 farmer-managed field trials served both as a demonstration to farmers and a robust comparison of climate-informed crop management options that were identified during the PICSA process, and farmers' normal practices. Farmers grew crops using both sets of practices, on 10×10m plots, and measured and recorded results following a strict protocol. The trials were implemented over four growing seasons: for maize in September-December 2017 and 2018, and beans in March-May 2018 and 2019.

[2] Birachi et al., 2020. Rwanda Climate Services for Agriculture: Evaluation of farmers' awareness, use and impacts.
[3] Gumucio et al., 2020. Rwanda Climate Services for Agriculture: Qualitative Evaluation through a Gender Lens.
[4] Clarkson et al., 2020. Participatory Integrated Climate Services for Agriculture (PICSA) as part of Rwanda Climate Services for Agriculture: Findings from quantitative evaluation of 2016/17 PICSA implementation.
[5] Clarkson et al., 2020. Participatory Integrated Climate Services for Agriculture (PICSA) as part of Rwanda Climate Services for Agriculture: Findings from quantitative evaluation of 2018/19 PICSA implementation.

Farms are more productive and profitable

PICSA participation significantly increased the farmgate value of crop production by an average of 24% (from a mean of $165 for the control sample), and net income from crops by 30% (from a control sample mean of $115), relative to non-participating communities. The combination of PICSA and RLCs was associated with a 47% average increase in the value of crop production, and a 56% increase in income from crops. The mean impact measured in the evaluation survey translates to an estimated $3.87 million per year increase in net income from crops, and $4.54 million per year farmgate value of crop production, aggregated across the 112,767 farmers who participated in PICSA. This underestimates total benefit to farmers and the economy, as it does not consider impacts of livestock or other livelihood responses. The survey sampled participants across enough of the districts where PICSA was implemented to allow the crop productivity and improvements to be aggregated with a reasonable degree of confidence. Although the combination of PICSA and RLCs showed higher average crop productivity and livelihood impacts, it is difficult to estimate the aggregate impact of RLCs, alone or in combination, due to the fluctuating and uncertain numbers of farmers who participate in the RLCs.

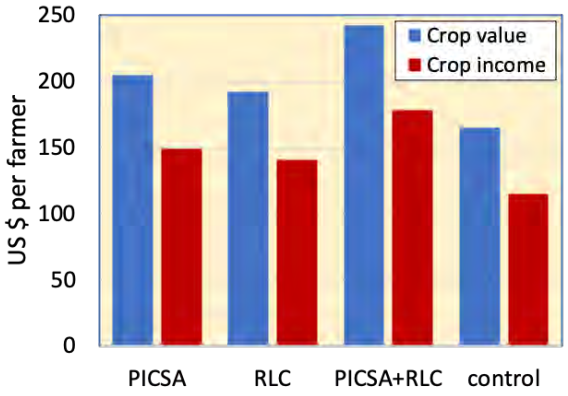


Figure 1. Average crop income and value for participant and non-participant farmers (Birachi et al., 2020).

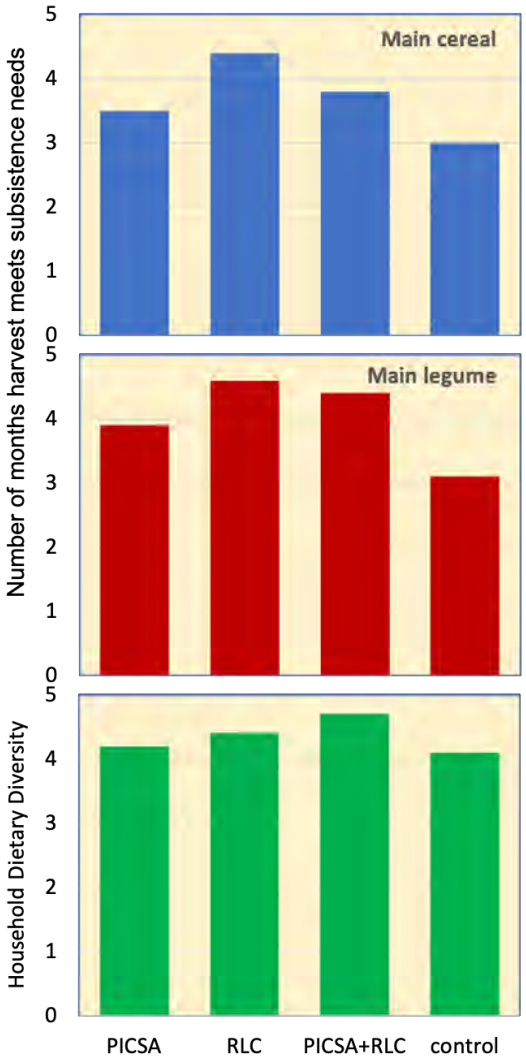


Figure 2. Average period that harvest meets subsistence needs, and dietary diversity, for participant and non-participant farm households (Birachi et al., 2020).

Households are more food secure

Participation in PICSA and RLCs significantly increased extended the amount of time farmers' primary cereal and pulse crops met their household subsistence needs. The difference from the control group was greatest (47% increase from mean of 3.0 months for the main cereal, 48% increase from 3.1 months for the main legume) for RLC participants. Participation in PICSA and RLCs was also associated with modest but statistically significant increases in Household Dietary Diversity (HDD) score. As with crop value and income, impact of PICSA and RLC participation in combination (15% increase from mean of 4.1) was greater than the impact of either intervention alone on HDD.

Farmers recognize a range of benefits

Participating households reported using their increased agricultural incomes to make a range of long-term investments, particularly school fees, and health insurance. PICSA monitoring provides evidence of additional perceived benefits. The majority of respondents reported that, as a result of the training they received, had greater confidence in their farming decisions (96% in 2016/7, 93% in 2017/8),

ability to cope with adverse weather conditions (93% in 2016/7, 76% in 2017/8), ability to provide for family healthcare (81% in 2017/8) and pay for children's school fees (74% in 2017/8), and social standing within households (93% in 2016/7 92% in 2017/8) and their wider community (93% in 2016/7, 91% in 2017/8).

Women farmers are empowered

The qualitative study showed that participation in project PICSA and RLC interventions largely eliminated a gender gap in the use of weather and climate information for management that is apparent in the control sample. It also diminished gender inequities in overall investment in their farms, coping capacity, and confidence in planning. Women who had participated in PICSA and RLCs reported greater ability to cope with adverse weather conditions and confidence in planning compared to women who had not participated in the interventions. A subsequent gender-focused analysis of the quantitative survey confirmed that RLC participation eliminated significant disparities in awareness, access and use of climate information that exist between women and men smallholder farmers in the control sample.[6]

Results also show benefits related to women's empowerment, in the form of increased participation in household decision making and increased social standing in their communities. Focus groups of women RLC participants in Northern and Southern Province referred to "talking with actions" to describe how gaining new knowledge, and using that knowledge to improve their farms' performance, enhanced their husbands' confidence in their advice and hence their participation and influence in decision making.

Farmer-scientists demonstrate yields and income benefits

A network of field trials engaged farmers to compare the yields and net income that they could achieve from climate-informed crop management options identified through the PICSA process, with the performance of their normal practices. The climate-informed management practices increased yields by 47% for maize and 53% for beans, averaged across all participating farmers and two seasons. The average improvement was even greater for net income per unit area: 52% for maize and 66% for beans.

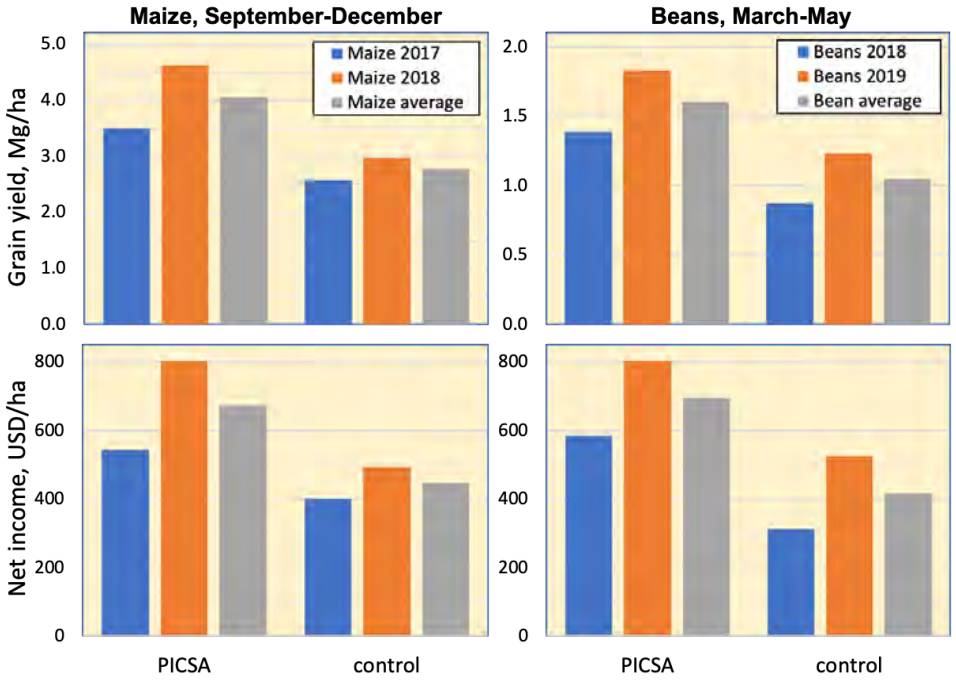


Figure 3. Average yields and net income from farmer-managed plots.

[6] Ingabire C. 2021. Closing gender gaps in farmers' access to climate information: The case of Radio listeners clubs in Rwanda. CCAFS InfoNote. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). In press.

SUSTAINABILITY

The RCSA project aimed to develop capacities that would sustain after project funding ended. Although it is too early to assess the degree to which this was achieved, the project team sees encouraging evidence of increased capacity across Rwanda to provide, support and use climate services. Other ongoing initiatives are further strengthening capacity for sustained agricultural climate services in Rwanda:

- **Digital Agro Climate Advisory (DACA) smartphone app developed through IBPMA project**. With financial support from Pan-Africa Bean Research Alliance (PABRA) through its Improving Bean Productivity and Markets (IBPMA) project, a Digital Agro Climate Advisory (DACA) app was developed to provide extension workers and farmers with easy access to climate information, and advisories about suitable crop cultivars, timing of planting and crop management options. DACA supports more than 110,000 farmers.
- **APROJUMAP partnership in Nyanza, Huye and Nyamagabe Districts**. Building on the RCSA project's successful engagement of local NGOs, the Association pour la PROmotion des JUMelages et de l'Amitié entre les Peuples (APROJUMAP), a rural development organization working in southern Rwanda, requested CIAT and PABRA to conduct a 5 days training in climate risk management for its stakeholders. The May 2021 workshop trained about 30 participants to support delivery of climate services to a projected 50,000 farmers in the Nyanza, Huye and Nyamagabe Districts.

Yet a few important gaps and concerns remain about the ability to sustain the progress achieved through the project (Table 4).

Table 4. Gaps in capacity to sustain RCSA achievements, and recommended actions to address gaps.

Gap	Recommendation
Meteo Rwanda seasonal forecast and Maproom development capacity	Extend modest IRI technical support for Meteo Rwanda.
Agricultural extension support for farmers' climate risk management	Mainstream climate services in government agricultural policy, planning and extension strategy.
	Invest in human and digital resources, and extend modest UoR technical input, to train and support communication intermediaries.
	Exploit local government offices as digital climate information and education hubs.
Climate risk management knowledge of government agricultural professionals	Develop training in climate risk management for local agricultural professionals.
Climate service delivery through radio	Invest in human resources to oversee climate service radio programming and coordination with Radio Listener Clubs

Recommendations

1. **Extend modest IRI technical support for Meteo Rwanda.** The project supported Meteo Rwanda to use a range of advanced tools and methods to improve and expand its suite of online, localized climate information products and tools for agriculture. Meteo Rwanda launched a Next Generation objective, multi-model, downscaled seasonal forecast system late in the project. Soil water balance tools, designed to support agricultural drought analysis and food security early warning, were only partially implemented. While Meteo Rwanda has greatly increased its capacity, it still needs a modest level of continuing technical support from IRI to maintain and develop its suite of climate Maprooms, fully implement its NextGen seasonal forecasting system, and further develop its soil water balance tools.
2. **Mainstream climate services in government agricultural policy, planning and extension strategy.** Sustaining the progress made in supporting farmers with PICSA and RLCs will require integrating climate services into agricultural policy, and specifically into the work plans and performance targets of staff at different levels of the extension service. The project team had expected that evidence of project successes

would lead to policy commitment to sustain climate services for the agricultural sector. The team worked with Meteo Rwanda to plan a showcase event to present farmers' demands and evidence of project impacts, and engage key government decision-makers in crafting a vision for climate services to contribute to a more resilient and prosperous agricultural sector. Unfortunately, the showcase event did not happen for reasons beyond the project team's control, leaving a gap in policy-level commitment to sustaining delivery of climate services to farmers through agricultural extension, and using climate services for government agricultural planning.

3. **Invest in human and digital resources, and extend modest UoR technical input, to train and support communication intermediaries.** A large project effort, enabled by *Twigire Muhinzi* and supported by four local NGOs, made it possible to train more than 2000 agricultural professionals and volunteer farmer extension workers, and more than 120,000 farmers -- about 4% of Rwanda's farmers. The demonstrated impacts justify further investment to scale out the PICSA process. Reaching all remaining sectors would require training and supporting 12,700 additional Farmer Promoters and Farmer Field School Facilitators. This can be achieved over two years if a core team of 40 dedicated expert trainers, working in pairs, facilitates 5 trainings per agricultural season for 3-5 Sector Agronomists and 30-35 volunteer farmer extension workers. These trained intermediaries would require short refresher training on a yearly basis to deepen their skills and ensure quality. The unit cost of a training program could be reduced by developing high-quality video and digital training and self-learning resources. A within country M&E process will be necessary to evaluate effectiveness, inform government ministries and enable continued learning and improvement. A modest level of technical support from UoR is needed to help MINAGRI and RAB embed the PICSA approach in agricultural extension strategy, deepen the capacity of the existing pool of trained intermediaries, and implement a sustainable training program for *Twigire Muhinzi*.

4. **Exploit local government offices as digital climate information and education hubs.** The Government of Rwanda's investment in rural internet connectivity and IT infrastructure provides an opportunity to make Meteo Rwanda Maprooms, and other digital information and educational resources in video and text format, available to support agricultural extension personnel (Agronomists, SEDOs, Farmer Promoters, Farmer Field School Facilitators) at the district and sector level. The WISER Rwanda project, which coordinated closely with RCSA, aimed to pilot a network of digital information hubs in 70 sector government offices, to support local decision makers with livestreamed content from Meteo Rwanda and access to a range of digital resources. However, the funder decided that it would not be feasible to procure and install the digital display systems before the project ended due to COVID-19 supply chain disruptions.

5. **Develop training in climate risk management for local agricultural professionals.** A short course on climate information and climate risk management would deepen the capacity of agricultural professionals, from the national to sector levels, to incorporate climate services into planning and risk management, and strengthen the support and guidance they provide farmers. Existing training programs could potentially be adapted and tailored to the needs of Rwanda's agriculture sector. For example, the IRI is developing a 2-week short course for Ethiopia's agricultural extension service, covering climate basics, climate information available through the NMS, understanding climate-sensitive agricultural decisions, and integrating climate services into agricultural extension. Video and digital e-learning materials would reduce the unit cost of training.

6. **Invest in human resources to oversee climate service radio programming and coordination with Radio Listener Clubs.** The RCSA project team supported Radio Huguka to develop weekly "*Urubuto Ntera*" 20-minute educational programs and interactive 60-minute live talk shows and debates, and helped coordinate farmer input into the content of programs through RLCs. Dedicated human resources from MINAGRI and/or the media are needed to sustain programming. The reach and impact could be increased by extending climate services radio programming geographically through additional radio networks.

LESSONS LEARNED

The project's successes, impacts and challenges suggest six lessons that are relevant to agricultural climate service investments elsewhere.

1. **Well-designed climate services are an effective way to improve farmers' yields, income and well-being.** RCSA evaluation contributes to a small but growing body of evidence of the impacts of climate services on farmers. Importantly, it demonstrated substantial added value of investing in improved practices in the production and communication of climate information in a context in which basic weather and seasonal forecasts were already publicly available, indicating that good practice matters.

2. **Tradeoffs among effectiveness, scalability and sustainability goals should be recognized, discussed among key project stakeholders, and integrated into project design and implementation.** There are potential tradeoffs among effectiveness (*What impact do services have on decision-making and well-being?*), scalability (*How many individuals benefit?*) and sustainability (*What happens after project funding ends?*) climate service goals. Some trade-offs are inevitable, and require compromises that manage those trade-offs. While the RCSA team considered all three goals when designing the project, early prioritized operational agencies. This resulted in operational approaches that proved effective and that scaled up. Unfortunately end-of-project activities that aimed to foster a dialog about sustainability were constrained by COVID-19 and other factors. This left a gap in awareness and ownership on the part of policy-level stakeholders whose support is needed to sustain project innovations.

3. **Early commitment and ownership on the part of policy makers are crucial for sustainability.** The technical agencies and extension personnel that the RCSA project engaged sit at a middle level between farmers and high-level policy stakeholders. The project team expected to secure policy commitment as project generated evidence of success, but this proved to be difficult particularly in the case of the Ministry of Agriculture. Evidence is necessary but not sufficient.

4. **Gaps in National Meteorological Service capacity to produce actionable information, and gaps in agricultural sector capacity to communicate and use climate information, are mutually reinforcing and best addressed in parallel**. Responses to needs assessment questions in the RCSA baseline survey tended to reinforce the status quo rather than guiding improvements, as farmers have difficulty expressing demand for new information or services that they've had little or no exposure to. At the same time, NMS have difficulty justifying new services or additional resources when user demand is not well developed. Balanced investment in the capacity of Meteo Rwanda to improve the information available; and in the capacity of farmers, through *Twigire Muhinzi* and Radio Huguka, to understand and use information; contributed to the project's impact. The PICSA process helped define products that Meteo Rwanda needed to develop. PICSA also built farmers' capacity to understand and act on Meteo Rwanda products, and better articulate their needs to service providers and policy makers. As a negative project example, it was challenging to introduce improved seasonal forecast products into the PICSA process when they were not yet fully operational at Meteo Rwanda, and to persuade Meteo Rwanda to change their forecast presentation after users had already been trained in the old convention.

5. **Scaling climate services that empower farming populations is achievable with serious attention to integrated communication channels.** Different communication strategies are needed for information at weather vs. climate time scales, to accommodate gender- and age-based differences in preferences, and to support differing functions (e.g., awareness, climate literacy, climate-based farm and livelihood planning) within climate services. The RCSA project aimed to strategically combine participatory planning (i.e., PICSA) facilitated by agricultural extension, seasonal forecast workshops, interactive radio programming, Radio Listener Clubs and SMS communication channels. The majority of project effort went into PICSA and radio programming, leaving a need for further development to scale and sustain communication through Radio Listener Clubs and mobile phones.

6. **For complex information at a climate time scale, mainstreaming participatory communication processes in effective agricultural extension or other intermediary institutions is key to empowering farmers at scale.** While the Rwanda experience demonstrates the feasibility of scaling up the delivery of rural climate services through participatory processes, it has benefitted from factors that are not necessarily present across sub-Saharan Africa including: a strong national agricultural extension system; effective partnerships among the government's agricultural extension system, local partner NGOs and international research organizations; integration of partner NGOs' activities into local government planning and accountability processes; and a high degree of trust between the local NGO partners and farmers. Digital and broadcast media communication channels alone are less effective, but can strengthen and complement institutional communication channels.

OUTPUTS

Capacity development

Advanced degrees

Name	Sex	Agency	University	Thesis
Mbati Mathieu	M	Meteo-Rwanda	Nairobi	Towards improving the skill of seasonal rainfall prediction over Rwanda
Blandine Mukamana	F	Meteo-Rwanda	Dar es Salaam	Geospatial assessment of suitable climatic conditions for maize and beans production. Case study of Nyanza District, Rwanda
Joseph Sebaziga Ndakize	M	Meteo-Rwanda	Rwanda	Spatial-temporal variability and projected rainfall over Rwanda
Prosper Ayabagabo	M	Meteo-Rwanda	Nairobi	Empirical Analysis of Seasonal Rainfall Variability and its Associated Effects on Major Food Crop Yields in Rwanda
Aminadab Tuyisenge	M	Meteo-Rwanda	Nairobi	Determination of Drought Characteristics Over Rwanda
Alexis Nzeyimana*	M	Meteo-Rwanda	Nairobi	Enhancing the smallholder farmers' resilience through effective Climate Information Services' communication in Rwanda. Case study: Ruhango District
Herve Murenzi	M	Meteo-Rwanda	Nairobi	Investigating the effect of climate variability and change on maize yield in Rwanda
Neo Justin Ntezimana*	M	RAB	Nairobi	Assessing the use of CIS by seed producers for climate change mitigation and adaptation in Rwanda
Irandagiye Laetitia	F	RAB	Nairobi	Effect of Uptake of Climate Information Services on Food Crops Productivity in Rwanda
Claude Rugimbana	M	RAB	Nairobi	Predicting Maize (Zea Mays) Yields in Eastern Province of Rwanda Using Aquacrop Model

* Expected graduation date September 2021

Training events

Title	Dates	Target audience	Participants
Training program on ENACTS climate time series, data library and maprooms	30 Nov-18 Dec 2015	Meteo Rwanda	16 (4 F)
PICSA Trainer of Trainers	Jun 2016		33
PICSA Trainer of Trainers	Q3 2016		63
ENACTS, Data Library, Maproom and GIS Training	21-29 July 2016	Meteo Rwanda	14 (3 F)
Training and Development of Downscaled Seasonal Forecasts for Pilot Districts	22-26 Aug 2016	Meteo Rwanda	11 (1 F)
Training on understanding, communicating, and using the downscaled seasonal forecast	2 Sep 2016	Meteo Rwanda, RAB, local government, farmers' organization, media	28 (5 F)
PICSA expert trainer training	2 Oct 2016		25
Meteo Rwanda staff (Mr. Floribert Vuguziga) extended training visit to IRI	2 Nov-10 Dec 2016	Meteo Rwanda	1

Title	Dates	Target audience	Participants
Training in development and use of Growing Season Onset and Downscaled Seasonal Forecast Maprooms	1-10 Mar 2017	Meteo Rwanda, RAB, MINAGRI	12 (1 F)
Meteo Rwanda staff training visit to Israel	15-25 May 2017	Meteo Rwanda	1
PICSA training of trainers	12-16 Jun 2017	RAB, PASP, AICP/MINAGRI, DERN, Caritas Kibuye, Caritas Kibungo, Caritas Butare, Radio Huguka	68
PICSA Specialist Intermediary Training in Nyamata	Jun 2017	MINAGRI, MINALOC, Meteo Rwanda, RAB, DERN, One Acre Fund, local NGOs	36 (8 F)
PICSA Intermediary Training in Muhanga, Nyanza District	Jul 2017	Farmer Promoters, Sector Agronomists, SEDOs	80 (26 F)
Training on IRI Climate Data Tools and developing a method for integrating climate data	14 Aug-Sep 1 2017	Meteo Rwanda	16 (4 F)
Training on seasonal forecasting using the IRI Climate Predictability Tool and Data Library	28 Aug-18 Sep 2017	Meteo Rwanda, RAB	19 (5 F)
Training on ENACTS Data Library and Maproom software	6-13 Jan 2018	Meteo Rwanda	10 (2 F)
Training on Seasonal Rainfall Forecasts for March-May 2018 and September-December 2017 Verification	14-17 Feb 2018	Meteo Rwanda	19 (4 F)
Training workshop for journalists	27-28 Mar 2018	MINAGRI Agriculture Information and Communication Program (AICP), Media, Youth Engage in Agriculture Network	27
PICSA intermediary training, Rutsiro District	Q2 2018	Agronomists, SEDOs, FFS Facilitators, Farmer Promoters	87
PICSA intermediary training, Ngoma District	Q2 2018	Agronomists, SEDOs, Farmer Promoters	66
PICSA intermediary training, Gicumbi, Rulindo District	Q2 2018	Agronomists, SEDOs, FFS Facilitators, Farmer Promoters	134
PICSA intermediary training, Nyagatare, Rwamagana, Gatisbo Districts	Q3 2018	Agronomists, SEDOs, Farmer Promoters	197
PICSA intermediary training, Rutsiro, Karongi, Nyamasheke, Rusizi Districts	Q3 2018	Agronomists, Farmer Promoters	38
PICSA intermediary training,Nyanza, Muhanga, Ruhango, Gisagara Districts	Q3 2018	Agronomists, SEDOs, Farmer Promoters	229
PICSA intermediary training, Ngororero, Buera Districts	Q3 2018	Agronomists, SEDOs, FFS Facilitators, Farmer Promoters	130
PICSA refresher training for Post-Harvest and Agribusiness Support Project (PASP) cooperatives	16-17 Aug 2018	PASP staff, cooperative representatives	59 (14F)
PICSA training for Rwanda Youth in Agribusiness Forum (RYAF)	18-21 Sep 2018	PASP staff, RYAF members	91
Radio Listeners Clubs training of trainers	7-9 Nov 2018		15
Radio Listeners Clubs facilitators training	13 Nov 2018		225
PICSA Refresher Training, Southern Province	Q1 2019	Farmer Promoters	439
PICSA Refresher Training, Kayonza District	Q1 2019	Farmer Promoters	66
PICSA Refresher Training, Western Province	Q1 2019	Agronomists, SEDOs, FFS Facilitators, Farmer Promoters	49

Title	Dates	Target audience	Participants
PICSA Refresher Training, Northern Province	Q1 2019	Agronomists, SEDOs, FFS Facilitators, Farmer Promoters	568
PICSA Refresher Training, Southern Province	Q2, 2019	Farmer Promoters, SEDOs, FFS Facilitators, Sector Agronomists	500
PICSA refresher training, Western Province	Q2, 2019	Farmer Promoters, SEDOs, FFS Facilitators, Agronomists	125
Maproom training for District Agronomists*	14-15 Mar 2019	District Agronomists	
Maproom training for local government**	Apr 2019	District Agronomists, Sector Agronomists, SEDOs, MINAGRI, RAB	100
Meteo Rwanda extended staff training and partnership visits to IRI	17 Jun-26 Jul 2019	Meteo Rwanda	6
Meteo Rwanda training on basics of satellite and radar meteorology	12-23 Aug 2019	Meteo Rwanda	10
Training of Agriculture Practitioners on the Navigation and Use of ENACTS Maprooms*	9-11 Dec 2019	MINAGRI, RAB, Eastern Agric. Grain Council, One Acre Fund	28
Meteo Rwanda CDT training	Q4 2019	Meteo Rwanda	11

* Co-funded by WISER Rwanda project. **Co-funded by FOWERNA.

Engagement and planning events

Title	Dates	Target audience	Participants
Year-1 pilot district selection workshop	19 Feb 2016	RAB, MINAGRI, MINALOC, MIDIMAR, MINEDUC, Meteo Rwanda, CIAT	12
Farmer needs assessment workshop	10-11 Mar 2016	RAB, Meteo Rwanda, MINALOC, ACRE Africa, Safe, CRS	39
Institutional needs assessment workshop			40
Project planning workshop	21-22 Mar 2016	Core project partners	19
Launch of ENACTS and RCSA project	23 Mar 2016	government, academia, farmer representatives, development partners, NGOs, media	113
M&E design workshop	11 Jun 2016	Project team	
Strengthening Climate Services for Agricultural Transformation in Africa (AASW7 side event)	14 Jun 2016		50
Stakeholder planning workshop Y2	6-7 Mar 2017	Project team, Meteo Rwanda, RAB, MINAGRI, DERN, Radio Huguka, AICP, CARITAS	39
National Consultative Workshop for Setting Up a National Framework for Climate Services (NFCS) in Rwanda	5-7 Dec 2017		119
Open field day, Bugesara District	June 2018		35
Project booth at 13th National Agriculture Show	26 Jun-3 Jul 2018		
Talk show on farmers' experiences with climate services broadcast by RTV and Radio Rwanda	17 Jul 2018		
Adaptation Workshop for Climate Vulnerability Risk Assessment for Selected Commodity Value Chains	30-31 Aug 2018		27

Title	Dates	Target audience	Participants
Climate services community debate, Karongi District, Western Province, broadcast nationally	19 Dec 2018	Local government, Farmer Promoters, farming community	120
CIAT-Rwanda project team visit to UoR	June 2019	Project team	2
Project booth at 14th National Agriculture Show	18-28 Jun 2019		
Digital Soil Water Holding Capacity Map validation workshop	20 Jun 2019	RAB, CIAT, Meteo Rwanda, ESRI. Univ. Rwanda, Water for Growth, MINAGRI, insurance companies	
Profiling Digital Agriculture Opportunities in Rwanda	Aug 2019	CGIAR Big Data Platform, MINAGRI, MINICT, RISA, RCA, Knowledge Lab, ICRAF, AIMS	41
Adaptation Workshop for Climate Vulnerability Risk Assessment for Selected Commodity Value Chains	30-31 Aug 2019	PASP, RYAF, MINAGRI, RAB, NAEB, Meteo Rwanda, Africa Improved Foods Ltd., Business Development Fund, farmer organizations	
Climate Summary for Local Government Maproom planning workshop	5 Sep 2019		10

Tools

Updated Data Library soil-plant-water balance Data Library function that accepts gridded soil information: http://iridl.ldeo.columbia.edu/dochelp/Documentation/details/index.html?func=:Water_Balance

Pan-African soil database used for Total Available Water input needed for soil water balance simulations: http://iridl.ldeo.columbia.edu/expert/SOURCES/.SoilGrids/

New CDT functions to enable Meteo Rwanda to generate PICSA graphs, and for spatial data analysis and climate extreme analysis.

An authorization system enables Meteo Rwanda to share its merged datasets with users, particularly government ministries.

Updated national soil profile database and water holding capacity digital map.

Batch download of the full set of graphs (time series and probability-of-exceedance graphs of: season total rainfall, onset and cessation dates, growing season length, and dynamic rainfall total between onset and cessation; seasonal forecast from a past El Nino and La Nina year) used in PICSA, formatted for workshop use in a PDF report, for any user-selected grid cell location, accessible through the Historical Onset and Cessation Date Maproom.

Meteo Rwanda climate Maproom tools, summary of their content, and climate parameters ("R" = rainfall, "T" = temperatures) used.

Maproom tool	Summary	R	T
Historical Climate Analysis			
Dekad Climate Analysis	seasonal climate cycles, anomaly time series		
Monthly Climate Analysis			
Seasonal Climate Analysis	seasonal climate variables expressed as anomaly time series, trends, probability of exceedance		
Seasonal Trend Analysis	seasonal climate variables expressed as trend analyses and maps		
Daily Precipitation Analysis	rainfall total, number of rain days, mean intensity, wet/dry spell frequencies, expressed as maps, time series and probability of exceedance		

Maproom tool	Summary	R	T
Historical Onset and Cessation Date	rainfed agricultural season onset and cessation dates based on user-defined thresholds, expressed as time series tables and graphs, and probability of exceedance		
Historical Seasonal Totals	rainfed agricultural season length and dynamic rainfall total between calculated onset and cessation dates		
Extreme Rainfall Analysis	history of extreme monthly and seasonal rainfall characteristics		
Extreme Temperature Analysis			
Historical Water Balance	Seasonal Water Requirements Satisfaction Index, mean soil moisture, effective precipitation and crop water stress, derived from daily soil water balance for 9 crop-cultivar-season combinations		
Climate Prediction			
Flexible Seasonal NextGen Forecast	three-month precipitation forecast using next-generation objective, multi-model forecast methodology		
Probability of Rainfall Tercile Conditioned on ENSO	historical probability of seasonal average climate falling within the upper, middle or lower one-third ("tercile") of the 1961-2014 historical distribution, conditioned on El Nino/Southern Oscillation phase during the same season.		
Probability of Temperature Tercile Conditioned on ENSO			
Probability of Rainfall Tercile Conditioned on IOD	historical probability of seasonal average climate falling within the upper, middle or lower one-third ("tercile") of the 1961-2014 historical distribution, conditioned on Indian Ocean Dipole phase during the same season.		
Probability of Temperature Tercile Conditioned on IOD			
Climate Monitoring			
Climate Monitoring	summaries of recent 10-daily rainfall relative to prior years		
Seasonal SPI	Standardized Precipitation Index, an indicator of extreme high or low rainfall conditions, expressed as maps and time series		
Monthly SPI			
Multiple Time Scales			
Climate Summary for Local Government	graphic summaries of various rainfall characteristics averaged over a selected Province, District or Sector		

Publications

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Smallholder farmers say access to climate information bearing fruit, The New Times, April 6, 2018.

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