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Perspective

Enhancing national climate services: How systems thinking can accelerate locally led adaptation

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SUMMARY

Making agriculture resilient to the trends and shocks of a changing and varying climate requires effective use of climate information. However, in many places around the world, collection of climate data has been seriously inadequate and, even when available, poorly accessible, of inconsistent quality, and divorced from foundational capacity building that underpins its use by decision makers at all levels. The Enhancing National Climate Services (ENACTS) initiative of the International Research Institute for Climate and Society (IRI), Columbia University (US) has been intentional about addressing these challenges holistically through its recognition that national meteorological services can and should do more than merely produce climate data. In this perspective, we highlight two recent projects in East Africa that acknowledged ENACTS early as one component in a broader climate services ecosystem. In doing so, we illustrate how the social, political, institutional, and cultural systems surrounding climate information can be just as important as the data themselves in setting up lasting yet adaptive climate services.

INTRODUCTION

Climate change is expected to impede and undo development gains by increasing the frequency and severity of extreme events, shifting suitability zones for crops and diseases, and endangering coastal areas with sea level rise.[1] These events threaten essential sectors, such as agriculture, forestry, water resources, tourism, transportation, energy, and health.

Because 80% of the world's cultivated land is rainfed and contributes to about 60% of the total crop production,[2] however, agriculture is widely regarded as the most climate-sensitive human activity. Changing precipitation patterns, including droughts, threaten both the food security and livelihoods of millions of farmers around the world who rely on rainfall for their production, as well as an increasingly urbanizing population, which also depends upon these crops for basic sustenance. In areas like Africa, which are the most affected by such climatic changes but possess the least adaptive capacity to manage the associated risks,[3] solutions to mitigate the negative effects of climate change and variability and adapt to anticipated changes are in particular and dire need.

Climate services, defined by the Climate Services Partnership (2021) as "production, translation, transfer, and use of climate knowledge and information in climate-informed decision making and climate-smart policy and planning," aim to meet this need by supporting adaptation at all levels of society. Toward this end, the growing literature on climate services[4–12] recognizes the need to provide climate information that is salient, accessible, legitimate, credible, equitable, and integrated[6,13–16] and systems to support its efficient delivery.[6] In simple terms, climate services should provide "useful" climate information to help decision makers, including those at the highest levels (such as policy makers or government officials) all the way down to those at the most grassroots level (such as farmers or pastoralists), adapt to a changing climate. At their core, they necessitate a systems approach. However, in practice, such an approach is not always adhered to, and the generation of high-quality climate information is often prioritized to the detriment of other important steps for ensuring useful climate services.

The Enhancing National Climate Services (ENACTS) initiative of the International Research Institute for Climate and Society (IRI), Columbia University (US), is one effort that has addressed climate data gaps by introducing a methodology to blend rainfall and temperature observations collected by national weather services with freely available global products derived from satellite data. Beyond this, however, it has been intentional in ensuring these data are transformed and tailored into actionable and decision-relevant information for a wide variety of users, in making this information freely accessible, and in promoting the broad dissemination, appropriate communication, and capacity building that underpin its ultimate effectiveness.[17] This holistic approach to improving the availability, access, and use of climate information that moves beyond the generation of mere data to acknowledging the human and social systems of which it is a part has been key for both the scalability and sustainability of the initiative. Moreover, it has been foundational in ensuring climate services are locally led.

In what follows, we highlight two recent projects in East Africa that recognized ENACTS early as one component in a

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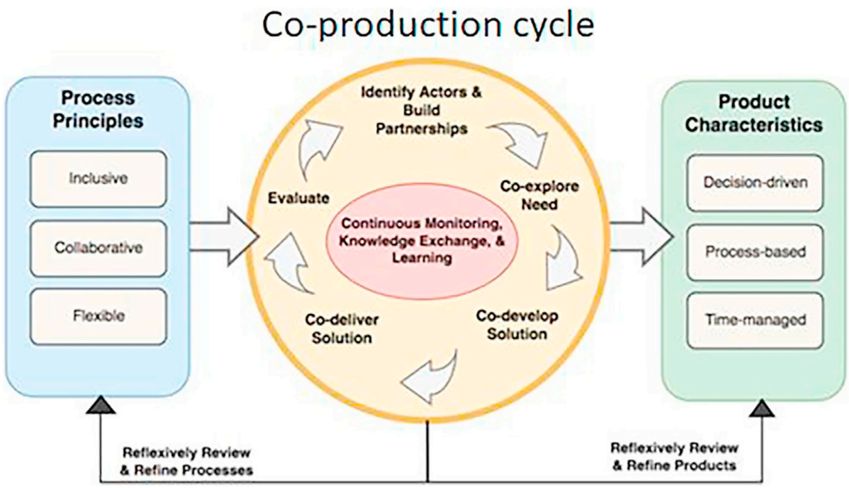

Figure 1. The co-production cycle

The co-production cycle is an iterative process motivated by principles of inclusion, collaboration, and elasticity and results in decision-relevant products. Source: reprinted from reference 18.

broader climate services ecosystem and dedicated significant resources to translating, propagating, communicating, and building capacity around the climate information that emerged from the initiative. In doing so, we illustrate how the social, political, institutional, and cultural systems surrounding climate information can be just as important as the data themselves and why setting up supportive and enabling partnerships and architecture is essential for lasting yet adaptive climate services.

USEFUL, USABLE, AND USED CLIMATE INFORMATION

An important mechanism for ensuring the usefulness of climate information is the process of co-production (see Figure 1). Instead of a one-way push of scientific information to users, co-production involves a two-way iterative and collaborative process of knowledge construction between those who generate climate information and those who use it.[18] In other words, merely providing or making climate information available is not sufficient. Beyond information, climate services "provide people and organizations with timely, tailored climate-related knowledge and information *that they can use* to reduce climate-related losses and enhance benefits"[19] (emphasis added).

However, even when researchers or meteorological agencies strive to produce information that users need, significant barriers may still remain that inhibit that useful information from actually being usable.[15,18] The way theoretically useful information is transformed into sector- and decision-relevant knowledge (translated) and communicated to users (transferred) and the degree to which the user has the capacity to actually understand and act on the information (use) all affect whether and the degree to which the information enables climate adaptation (see Figure 2).

Failure to consider this wider scope of climate information communication, delivery, and user capacities has often resulted in information that, although potentially useful, is not actually usable or even used by decision makers.[21–25] As such, in practice, consideration of all four pillars of climate services and a move beyond mere co-generation or co-production (the first pillar of climate services) are essential for services that are useful, usable, and used for climate risk management.

CLIMATE SERVICES ECOSYSTEMS

In addition to how climate services relate and respond to users' needs, and also important in climate risk management due to the nature of risks that often span multiple and diverse sectors simultaneously, is how climate services relate to and can reinforce each other. Although information can be tailored and made useful and usable for one sector or decision maker using the pillars approach described above, for instance, that does not preclude it from being useful and usable for other sectors. In contrast, an ecosystem of climate services, whereby common solutions can be shared across different sectors with shared aims and where links and interactions with non-climate-related solutions can be made, can improve resilience to crises and lend efficiency and value by optimally orchestrating available solutions.[26] The information and products derived from the ENACTS approach and data, for example, are available and valuable not only to the food security and agricultural sectors but also to the water-resource management, health, energy, and disaster-risk reduction and management sectors with which they intersect. As such, a shared collection of climate services with applicability to more than one sector can provide a more robust system to manage risks and shocks.[26]

BEYOND GENERATION: THE ENACTS APPROACH

To emphasize the other three pillars of climate services is not to underplay the importance of generating high-quality climate information. Availability of robust climate data is a critical first step in planning for, and managing, the risks of climate variability and change. However, it must also be accompanied by measures to ensure equitable access and effective use of climate information and knowledge.

In many parts of Africa, agencies—in particular, the National Meteorological Services (NMS)—which are mandated with collecting and providing weather, water, and climate information, struggle to do so as a result of long-term under-investment, a narrow commercial base, inadequate resource models, and even civil unrest (see Figure 3), among other reasons.[27] The case of Rwanda provides perhaps the most poignant example of civil unrest. The civil war and genocide that devastated the country in 1994, including its meteorological observation system, led to a gap in the weather record of almost 15 years.[28,29] Here, and in most other Africa nations dependent upon rain-fed agriculture for their livelihoods and economic well-being, these patchy climate data are extremely problematic, as data

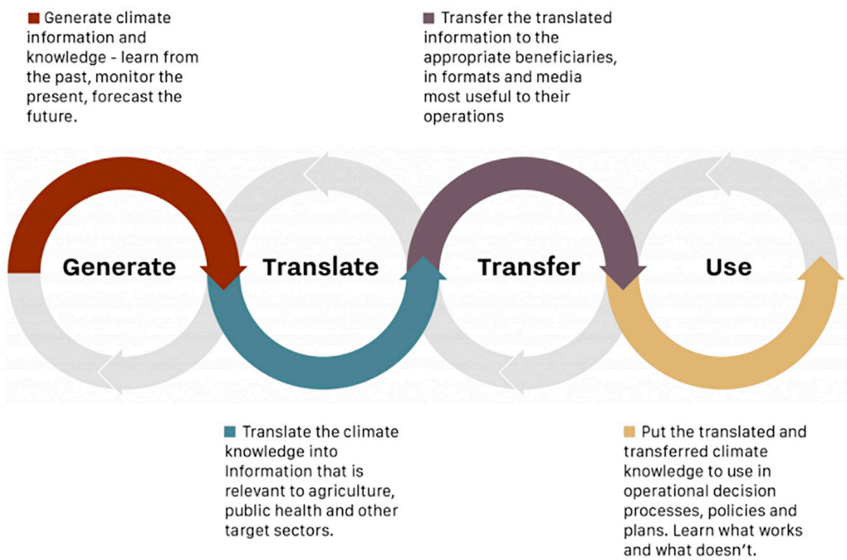

Figure 2. The four pillars of climate services

The four pillars of climate services include the generation, translation, transfer, and use of climate information. Source: reprinted from Fiondella, 2021.[20]

are a critical input for decisions and programs designed to build resilience of those highly affected by climate variability and change but with poor adaptive capacity.

The ENACTS approach, which aims to improve the availability, access, and use of climate information for enhanced climate services for national and local decision making, addresses this foundational data quantity and quality gap in the 22 countries where it has been launched (see Figure 4). Through its development of a merging method of on-the-ground station data with satellite rainfall estimates and climate model reanalysis products, ENACTS enables countries to fill temporal and spatial gaps in the observational record, while ensuring quality control of rainfall and temperature observations.[27] In the aforementioned example of Rwanda, these methods have allowed the reconstruction of missing rainfall and temperature data to shed light on climatological patterns over the last 30 years.[30] Because historical climate data are important for helping scientists predict future conditions and manage climate risk, it is difficult to overstate the significance of ENACTS in increasing the availability of climate information in the developing countries where the initiative is active.

However, moving beyond availability to address issues of access and use (see Figure 5) is what truly establishes the relevance of ENACTS toward national and local decision making for climate adaptation and transforms useful information into services that are actually both usable and used. In other words, improving availability of quality climate data and information is necessary but not sufficient in the development of effective, decision-relevant, sustainable, and locally led climate services. Simply putting high-quality information into the world does not automatically ensure it is easily accessed, understood, or able to be used.[32–34] Rather, intentional efforts to both promote the translation (contextualization) and transfer (communication) of this information alongside capacity building for its use are needed.

For ENACTS, a major part of facilitating the access and wider use of climate information in decision making by governments, as well as in the public and private sectors, has been the co-creation of climate information products tailored to the requirements of different users, whether they be at the local, national, or international level. A key platform for supporting this has been the IRI's Climate Data Library (https://iridl.ldeo.columbia.edu/index.html?Set-Language=en), which is a powerful and freely accessible online platform that allows users to view, analyze, download, and share hundreds of terabytes of multidisciplinary climate-related data through a standard web browser.[35] Information and communications technology (ICT) solutions like this, and especially co-created map visualizations,[36] such as the IRI's interactive maproom visuals and graphs of climate data (exemplified in Figure 6), can play a large role in making climate information more usable by translating past, present, or future conditions into expected impacts and management advisories for different decision makers.[6,8]

It is important to note that such co-production processes are neither mere one-time consultations with users nor just opportunities for feedback on products but rather iterative interactions that establish relationships, trust, and ongoing conversations between producers and users toward developing services that are usable, useful, and likely to be used.[6,18,37] As a testament to this point, a review of empirical evidence on the use of climate science, focusing on forecast use over two decades, found that climate science usability is a function of both the context of potential use and of the process of scientific production itself and that nearly every case of successful use of climate knowledge has involved some kind of iteration between knowledge producers and users.[21]

Beyond this process-focused, human-centered, and decision-relevant approach to minimize mismatch between what scientists might think is useful and what is actually usable in practice, the ENACTS initiative also promotes use of climate service products through awareness-raising activities, targeted capacity building, and sustained engagement with the user community. In what follows, we highlight two different contexts in which the ENACTS initiative was implemented to underscore and make more concrete the importance of all four pillars in the development of climate services, as well as to share specific mechanisms and approaches that have been demonstrated to improve the efficacy, relevance, scalability, and sustainability of those services.

SCALING AND SUSTAINABILITY: THE CASE OF ICPAC

The capacity building and strategic partnership undertaken through the Kenya-based Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre (ICPAC) and the recently concluded Weather and Climate

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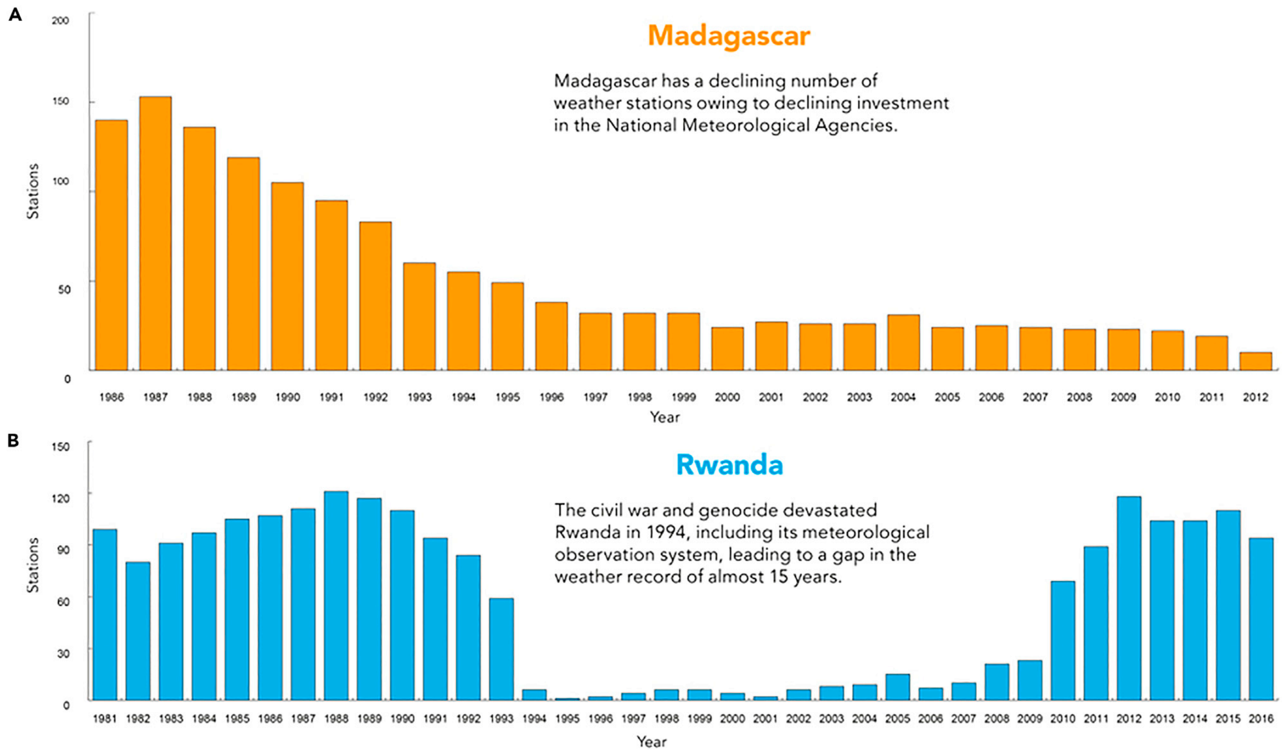

Figure 3. Examples of weather and climate data challenges in Africa
The case of Madagascar (A) demonstrates underinvestment whereas that of Rwanda (B) exhibits the impact of civil unrest on the availability of climate observations. Source: reprinted from ENACTS: Risk, Resilience, and the Revitalisation of Climate Services in the Developing World, 2020.

Information Services for Africa (WISER) program (2015–2020) underscore the importance of moving beyond the generation of good data or products to acknowledging the human, institutional, and social systems of which they are a part when promoting effective climate services. In particular, the case exemplifies how use can be accelerated through integration with local and regional networks and the impact that targeted capacity building can have toward not only the extension of existing climate services but also sustaining the co-production of new products and relationships to meet continuously evolving needs.

The WISER program was started by the UK's Department for International Development (now the Foreign, Commonwealth & Development Office) in 2015 with a mission to improve the quality, accessibility, and use of weather and climate information services at all levels of decision making for sustainable development in Africa.[38,39]

Toward these ends, the IRI, where the ENACTS initiative was initiated, has worked with ICPAC since 2016 to promote the ENACTS approach at the East Africa regional level and extend it to member countries in the Greater Horn of Africa.[29] Improving the availability of quality climate information through a combination of quality-controlled national meteorological observations with global climate observations was a key component for the member states involved with the initiative. However, it was the capacity building around understanding and even the process of co-developing the maproom visualizations of climate data themselves that enabled such decision-relevant information and the co-production processes behind them to spread as quickly as they did across East Africa. As a baseline for discussion and example of what is possible to jump-start the co-design process with national meteorological services and their users, maproom products were co-developed in-house at the IRI with consultation between climate scientists and sectoral experts (users), such as those in the fields of agriculture and health. These first iterations of these products were developed in-house before further discussions with national meteorological services and users of particular countries due to the "you don't know what you don't know" paradox, whereby users can have difficulty articulating their needs if they are unaware of what is feasible in the technological realm. The initial maprooms developed through IRI and its sectoral experts served as jumping-off points for detailed discussions with national meteorological services and in-country users on how they might be tailored to particular needs and inform specific decisions. At a regional level, ICPAC has adopted a similar approach: the Greater Horn of Africa Climate Outlook Forums (GHACOFs), which bring together climate scientists and meteorologists with experts from multiple sectors, such as agriculture, health, and water, have served as platforms whereby ICPAC has been able to introduce promising maprooms for discussion in the region. The first flexible forecast maproom, which responded to user needs to more completely communicate probabilities and answer questions about climate extremes,[40] for example, was introduced at the 2018 GHACOF and has now been adapted for and incorporated in numerous country maprooms in the region.

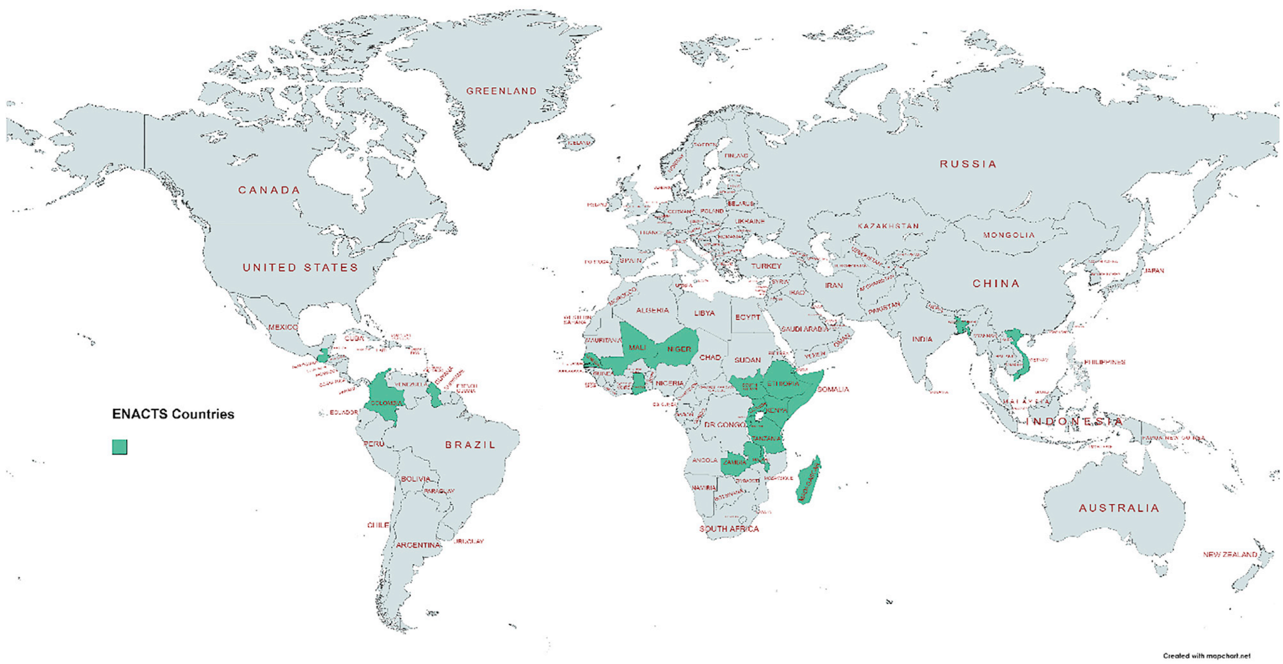

Figure 4. ENACTS countries across the world

Investments in terms of time and resources for ensuring that ICPAC fully understood the use of the IRI's ENACTS-related Climate Data Tool,[41] which helps technicians organize and conduct quality control of station-*observed* data as well as how to develop maproom visualizations, allowed ICPAC to reach such a standard of competency that by 2019, it had successfully developed its own suite of country-specific maprooms (http://digilib.icpac.net/), independent of IRI support, to facilitate adaptation-related decision making in the region. In particular, using the same co-production processes demonstrated during capacity building with the WISER program, the ICPAC team co-developed maproom visualizations first with users in Burundi (http://digilib.icpac.net/maproom_burundi/) and Djibouti (http://digilib.icpac.net/maproom_djibouti/) to communicate key information for agriculture, climatology (past climate), climate monitoring, and climate forecasting, and then went on to do the same with Somalia (http://digilib.icpac.net/maproom_somalia/) and South Sudan (http://digilib.icpac.net/maproom_southsudan/). Beyond merely repeating or emulating processes or functionalities of the maproom visualizations co-developed earlier in the project, the visualizations co-developed through ICPAC support even included additional functionalities for analyzing climate projections. As such, the first-ever climate change maprooms (http://digilib.icpac.net/maproom/Climatology/index.html#tabs-4) within ICPAC and East Africa at the regional level were developed, which also later went on to be added to the country maprooms for South Sudan (http://digilib.icpac.net/maproom_southsudan/Climatology/index.html#tabs-4), Somalia (http://digilib.icpac.net/maproom_somalia/Climatology/index.html#tabs-4), Kenya (http://kmddl.meteo.go.ke:8081/maproom/Climatology/index.html#tabs-4), and Uganda (https://datalib.unma.go.ug/maproom/index.html).

The experience with the relatively rapid rollout of a series of decision-support visualizations (maprooms) over the course of just a year (see Figure 7), following intentional capacity building related to the co-development and especially tailoring of these visualizations for different users, demonstrates the catalytic role that investments in the translation (contextualization), transfer (communication), and use (training) pillars can make in advancing, sustaining, and cascading the benefits climate services. Moreover, it highlights the importance and power of looking beyond the generation of quality data to the human and institutional networks in which those data are couched, to ensure that data are translated to information and information is in turn translated to useful services. Although emphasis continues to be placed on the generation of high-quality data in the development of climate services and much of the literature, the consideration of the wider social and institutional systems in which those data sit, such as regional climate centers, and how they might be leveraged to transform data into services, has improved the capacity of eight ENACTS countries in the East African region—South Sudan, Somalia, Djibouti, Kenya, Ethiopia, Uganda, Rwanda, and Tanzania—to make well-informed, timely decisions in the face of climate variability and change.

Next, we examine a case from one of these East African countries, Rwanda, to illustrate how data integration with and strengthening of local systems can bolster climate service delivery and the parts participatory processes and capacity building play in making this happen.

INTEGRATING WITH AND STRENGTHENING LOCAL SYSTEMS

The recently concluded US Agency for International Development (USAID)-funded Rwanda Climate Services for Agriculture

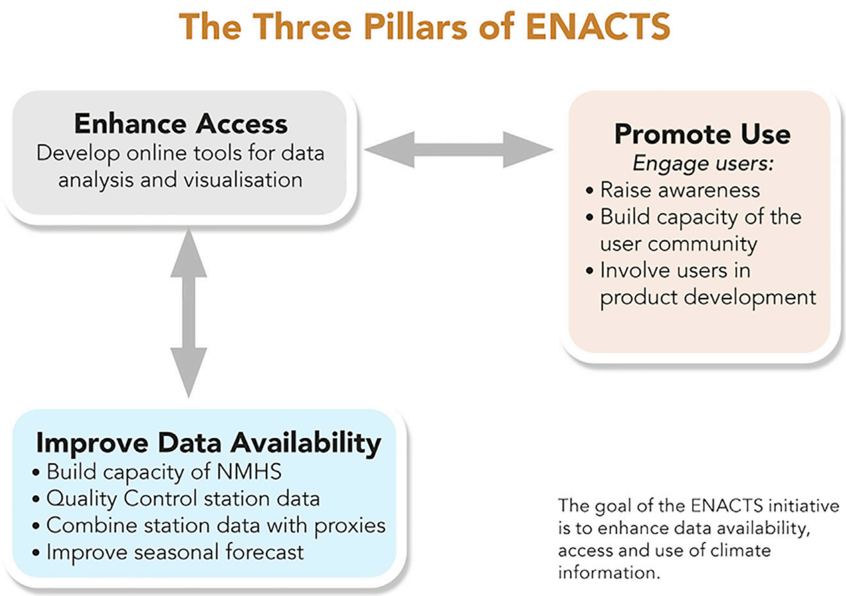

Figure 5. The three pillars of ENACTS
The three pillars of the ENACTS approach entail improving availability of climate information, enhancing access to it, and promoting its use. Source: reprinted from ENACTS: Risk, Resilience, and the Revitalisation of Climate Services in the Developing World, 2020.

(RCSA) project (2016–2020) aimed to develop climate services for farmers and institutional decision makers across the country's agriculture sector, alongside strengthening the capacity of the national meteorological service, Meteo Rwanda, to provide information to enable the anticipation and management of climate-related risks.[42] In doing so, it invested in capacity building for both the supply and demand sides of climate services, and adopted a face-to-face approach, called Participatory Integrated Climate Services for Agriculture (PICSA), developed by the University of Reading (UK),[43] within Rwanda's Twigire Muhinzi agricultural extension service, as the primary delivery mechanism of climate information for farmers.[44]

Within this project, the ENACTS approach was used to help Meteo Rwanda overcome the significant 15-year gap in the country's meteorological records following the years of civil war and genocide, mentioned earlier in this paper. By combining quality-controlled station records with proxies (satellite data for precipitation and climate model reanalysis data for temperature) that are freely available from global sources, ENACTS was able to provide long-term (more than 35 years for rainfall and 50 years for temperature) daily and decadal (10-day) gridded time series data at a 4-km resolution.[45] What is more, Meteo Rwanda's datasets appear to actually be of higher quality than the best global products.[37,45–47] These innovations and recoveries, made possible through the ENACTS approach, have been a huge stride in climate information availability for the country, but it is the ensuing activities around access and use that have allowed the information to become locally relevant services at scale.

In particular, the visualizations and automation of analyses (maprooms) derived from the gridded datasets, the participatory approaches used in both co-producing and communicating those analyses, and the foundational capacity building with special attention to underserved groups like women have facilitated the upscaling of downscaled (location-specific, 4-km resolution) climate information products to more than 113,000 farmers.[37,48] As a result, farmers have realized a range of benefits, with a majority of participating households from the RCSA project reporting that as a result of the training they received, they had greater confidence in their farming decisions (96%), ability to cope with adverse weather conditions (93%), and ability to provide family health care (81%) and pay children's school fees (74%). In terms of farm productivity and profitability, participation in PICSA also significantly increased the farm gate value of crop production by an average of 24%.[48]

High-resolution visualizations and analyses

Regarding visualizations and automation of analyses, major challenges in Rwanda, as in many African countries, are limited human capital, lack of financial resources, and poor technical capacity.[49] The advent of ENACTS, however, has enabled the transformation of the aforementioned data into a rich suite of downloadable visualizations and analytical tools, known as maprooms, that are freely and openly accessible on the web. Historical maps and location-specific analyses allow those in the agriculture sector to more easily visualize things like frequency of rainy days, wet and dry spells, and the onset and duration of the rainy season, while downscaled seasonal rainfall forecasts at high resolution also provide locally relevant information to facilitate agricultural planning.[37] The degree of automation has enabled Meteo Rwanda to routinely and regularly provide locally relevant and specific analyses and forecasts at both national scale and subnational scales without straining its human resources. Such advances have eliminated the geographic constraint to data access for those who do not live near a meteorological station as well as time and resource constraints related to having to wait for meteorologists to manually conduct such analyses for each site, when such information may be urgently needed for planning or response. Within the context of PICSA, this has meant having the ability to download already formatted, location-specific graphs (see Figure 8) outlining historical climate information for any selected location.[37]

Participatory processes and capacity building

The full effect of the ability to freely access this high-quality, locally relevant information, however, would not be complete without the capacity building and participatory approaches that accompanied it. The RCSA project enabled Rwanda to become the first country in Africa to make participatory climate

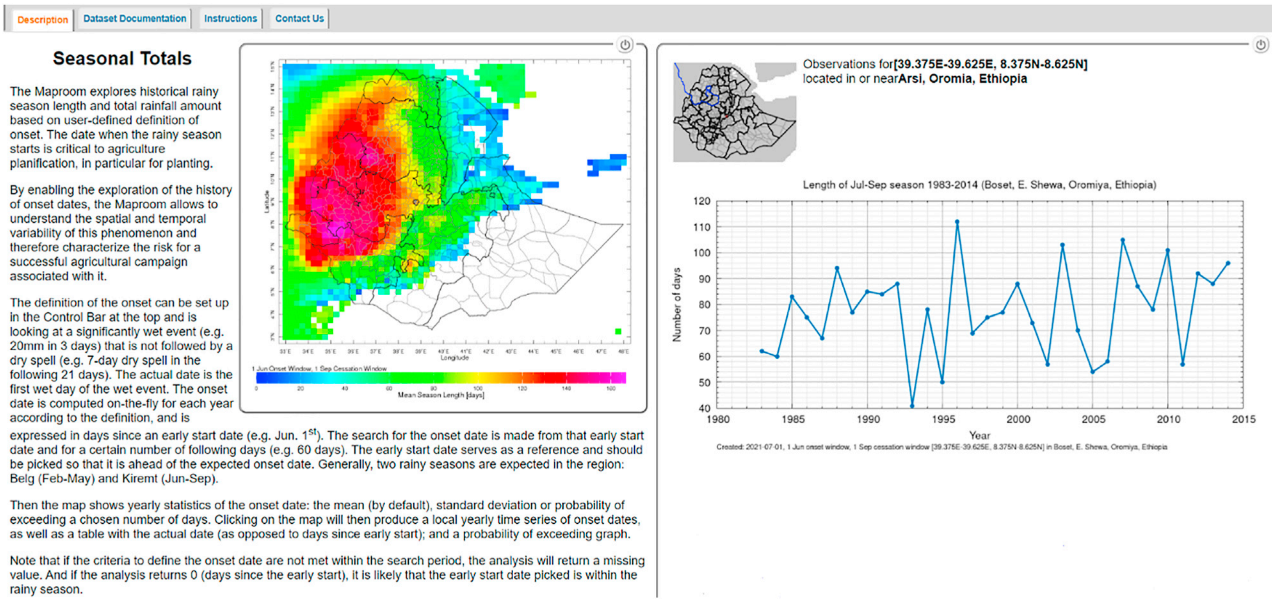

Figure 6. A screenshot of one of the maproom visualizations of Ethiopia's National Meteorological Agency

This maproom shows an example of a co-produced, interactive product that details historical seasonal totals of rainfall and rainy season length, to inform decisions related to agricultural planning. Source: National Meteorological Agency, 2021.[31]

communication, training, and planning processes work for farmers at a national scale.[48] Structured participatory communication processes around the use of historical climate data to inform and support farmers' agricultural and livelihood decisions that form the backbone of the PICSA approach helped to make ENACTS climate data and products not only understandable but also actionable and used. By designing communication and training activities to help farmers relate downscaled seasonal forecasts in probability of exceedance format to their own memory of historical climate variability, the marriage of ENACTS products with the PICSA approach resulted in more than 90% of participating farmers adjusting their management practices.[44] Moreover, in assessments of the first two years of PICSA rollout, the overwhelming majority of respondents (96% in 2016/7 and 93% in 2017/8), reported that, as a result of training they received, they had greater confidence in their farming decisions.[48] These outcomes in a project context demonstrate that participatory communication processes can be effective at increasing farmers' understanding and willingness to actually act on complex climate information, as do controlled studies in Zimbabwe[51] and Burkina Faso.[52]

On the capacity building front, the project's efforts targeted mutually reinforcing capacities on both the demand and supply sides that have historically impeded the development and use of climate services. On the demand side, as already discussed, priority was placed not only on the ability of Meteo Rwanda to provide high-quality, useful information but also on understanding, articulating, and responding to the demands of the users it serves. This was done through more than 40 short-term training events as well as investments in human capacity through the education sponsorship of 10 master of science degrees from Meteo Rwanda and the Rwanda Agriculture Board.[48] On the user side, participatory interactions and learning processes during the engagement with climate information with PICSA demonstrated and supported the idea that such processes can increase farmers' understanding and capacity to express their needs.[45]

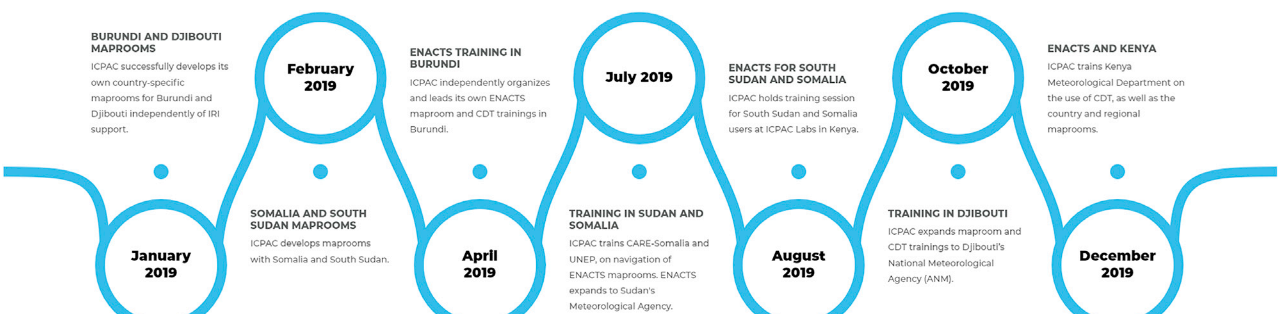

Figure 7. Timeline of ENACTS rollout across East Africa

Quick roll-out of ENACTS across East Africa was enabled following targeted capacity building at the regional level through ICPAC.

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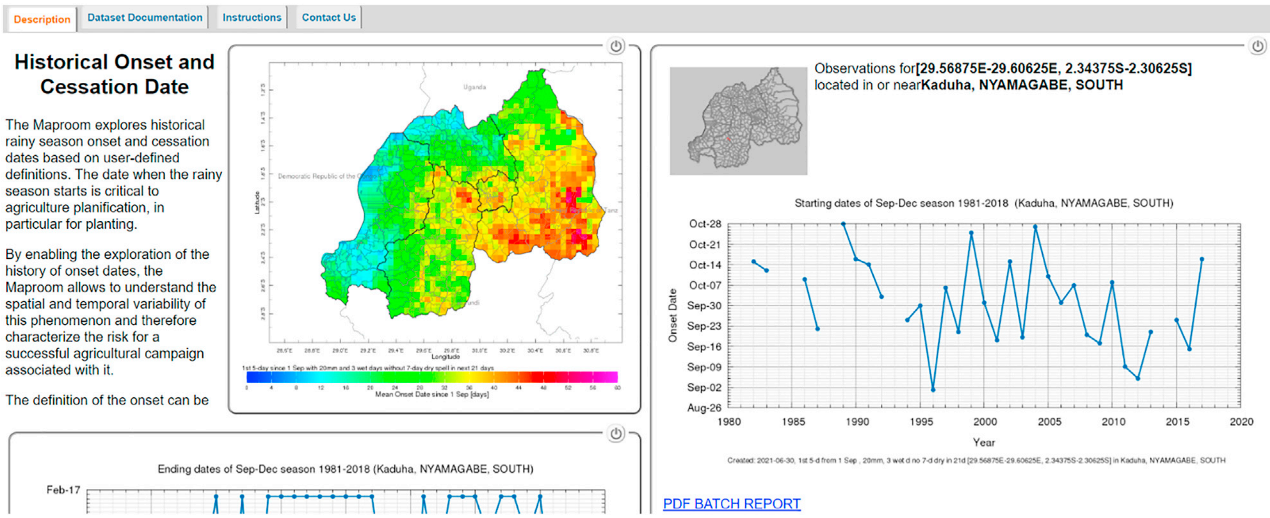

Figure 8. Maproom to visualize historical onset and cessation dates in Rwanda
A screenshot of Meteo Rwanda's Historical Onset and Cessation Date maproom, where a batch download of the full set of graphs (season total rainfall, onset and cessation dates, growing season length, dynamic rainfall total between onset and cessation, and seasonal forecast from a past El Niño and La Niña year) used in the PICSA approach can be easily downloaded, already formatted for workshop use in a PDF report, for any user-selected grid cell location. Source: Meteo Rwanda, 2021.[50]

Women, in particular, who account for more than 60% of the agricultural labor force and perform the bulk of farm work related to ploughing, planting, and harvesting in Rwanda,[53] benefited from such processes as participation in PICSA and radio listener clubs eliminated the gender gap in the use of weather and climate information for management that was present in the control sample.[48] These experiences tell the fuller story of how, far from a conventional linear service delivery model that places meteorological services on one side and users passively on another, participatory, inclusive, repeated interactions and co-production processes between those who use climate information products and those who produce them can result in locally relevant, actionable information to improve and inform adaptive decisions.

CONCLUSION AND RECOMMENDATIONS

To stand a chance of meeting the immense challenges created by year-to-year climate variability and long-term climate change, governments, organizations, and communities need valid, reliable, and actionable climate information upon which to base decisions. Although supporting solutions to make this kind of information available through national meteorological services is essential, it is not sufficient in ensuring the information is useful, usable, or used. Actions to promote accessibility and use—or, in the terminology of the climate service pillars, "translation, transfer, and use"—are necessary to make this happen.

The ENACTS initiative, despite fundamentally transforming the capacity of 22 primarily African countries to produce high-quality downscaled climate information, acknowledges improved data availability as just one and the first step toward producing effective climate services. Intentional actions to then evolve these data into information, and information into services through improvements in accessibility and use, are also necessary. Co-productive, participatory, inclusive processes that leverage technology, decision-relevant visualizations and analyses, and automation while also integrating with supportive institutional structures and partnerships, such as those of regional climate centers or extension systems, all play a role in not only developing but also sustaining locally relevant and owned climate services.

As the two case studies outlined in this paper illustrate, to promote effective climate services is to promote sustained relationships and trust, not just isolated interactions, between those who produce and those who use climate information. The terminology of "producers" and "users" prevalent across the literature in fact betrays the role that users play in producing or co-producing useful climate information to inform management decisions. Nonetheless, it is apparent from these case studies that it is not only important that the climate services community move beyond an emphasis on mere generation of climate data, but it is also important how this is done, because it can impact the scale and efficacy of such services.

Some practical guidance and lessons toward these ends gleaned from both the regional-level scaling of climate services in East Africa through the implementation of ENACTS at ICPAC as well as the national and subnational levels in the context of the RCSA project include the following:

- Access and use of climate information can be improved and scaled through integration with both technological systems (e.g., maproom visualizations or platforms like the Data Library) and also social and institutional systems (e.g., regional climate centers, such as ICPAC, or agricultural extension systems).
- Participatory processes, especially around communication (transfer) of climate information, can improve understanding and use of climate information, which, in turn can improve the ability of users to articulate demand for services that actually meet their needs, rather than those perceived to meet their needs by the scientific or producer community.

- Co-production is foundational for both locally led and locally owned climate services and important for ensuring climate services are both useful and usable. Capacity building, however, may still be necessary, to ensure services are used.
- Focused and targeted capacity building at a regional level can quickly cascade climate information products across countries as well as result in new and sustained innovations.

Building resilience is vital if countries and communities are to cope with the challenges of climate variability and change. In parts of the world, like Africa, which are expected to bear the brunt of the impacts of a shifting climate but are currently the least equipped with adaptive capacities to manage new risks, this task is especially pressing. By enabling high-quality climate services through the improved availability, access, *and* use of climate information, the ENACTS initiative and approach are equipping decision makers from the national all the way down to the most grassroots levels with the skills, resources, and capacities they need to plan for and manage an uncertain climate, while harnessing new opportunities through adaptation.

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DECLARATION OF INTERESTS

The authors declare no competing interests.

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