Stakeholder engagement workshop - report

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Executive Summary

This Deliverable 1.3 reports findings from online stakeholder engagement workshop ***“Validating African climate service and research infrastructure needs and challenges”***, held in the beginning of July 2024. Stakeholders from organisations working with climate services around Africa were invited to share their experiences on providing and using climate services, to identify most pressing challenges and needs that emerge on different sectors, and to map requirements for a sustainable pan-African research infrastructure for climate services. Two duplicate workshops were held to facilitate both anglophone and francophone stakeholders. Combined, 54 participants attended the workshops. In this report, the two duplicate events are discussed as one, and term “workshop” is used to refer to both. Findings from the workshop are valuable for the on-going and future activities of KADI project. Participated stakeholders’ views are integrated to the pan-African research infrastructure design. When current gaps, challenges and needs related to climate services and research infrastructures are understood, they can be efficiently considered in the design work done in KADI WP3.

This report is divided to five chapters. First, the workshop objectives and relations to other KADI activities are introduced, followed by two chapters that reveal how the workshop was organized, and introduce participants of the workshop. The fourth chapter is the most important for those readers who will utilize the workshop findings, as it explores in more detail the participants’ viewpoints and experiences on climate services and research infrastructures in Africa. Finally, suggestions are given for the way forward in KADI project, based on the experiences from the workshop.

CONTENTS

1. Introduction and objectives of workshop

KADI WP1, in collaboration with WP4, organised an online stakeholder workshop in July 2024. The workshop aims to discuss, validate and improve findings from WP1 activities to date, engaging both existing project actors and additional key stakeholders identified by other work packages.

In addition to this, an opportunity was provided for participants to become stakeholder champions, who would continue to engage with and participate in KADI project activities. Two duplicate workshop events were organised to facilitate both anglophone and francophone stakeholders. In contrast to the original plans set out in WP1 and WP4, the workshop was held completely online rather than on-site at multiple locations. This was done in order to facilitate broader stakeholder engagement with participants across Africa and Europe, and with sustainability and financial constraints in mind. In-person connections with key stakeholders will, however, be secured at the KADI Annual Meeting in October 2024 taking place in Nairobi, Kenya.

WP1 has previously identified core elements, such as “Observations, measurements and monitoring”, “Skills development and capacity building” and “Feedback mechanisms” that form research infrastructures (RI) providing climate services (CS). The elements were identified via literature reviews, and discussions within the KADI team, as well as with external actors. A primary objective of the stakeholder workshop was to assess the relevance and to validate the elements identified in the work to date, and to potentially highlight any missing elements or their characteristics for inclusion in future WP3 activities. The goal was also to understand which of the elements are most crucial and why, to enable an operational and sustainable RI in an African context on different sectors and geographical scales.

The second main objective in the workshop was to confirm climate service needs of different sectors and organisations, such as public decision-making bodies, research institutes, and meteorology agencies. Understanding what kinds of challenges and needs there are when mitigating, adapting to and building resilience in the face of climate change is at the core of designing research infrastructures with concrete impact. Answering to true needs and co-designing the services with all relevant actors enables climate service uptake and long-term sustainability. Thus, time was allocated to confirm whether the stakeholders invited to the workshop align with the already identified needs, and to hear more about and record the stakeholders’ own, their organisations’, and sectors’ current challenges.

The third and final objective of the workshop was to use the outputs of this workshop to further inform the design and implementation of research infrastructure design for climate services as part of WP3, and to identify actors who were willing to become stakeholder champions and work with the KADI team for the duration of the project. On-going and sustainable dialogue with actors who can provide their expertise in all stages of a climate-related RI lifecycle is of the utmost importance. Also, it is important to have already established connections to key stakeholders and organisations across Africa who are strategically placed to avail of future funding opportunities when implementing such RI

2. Workshop delivery

The workshop was held online using the Zoom platform on July 1st for English-speaking, and on July 8th for French-speaking participants. Prior to the workshop, participants were given a background information package that introduced the project and the topics that would be covered during the workshop. The full background package can be found in Appendix A. The duration of the workshop was four hours, starting at 9 am SAST/GMT continuing until 1 pm SAST/GMT (Table 1). This timeframe was set based on project team experience and defining a suitable duration of online workshop events when securing the attendance and engagement of participants.

The program consisted of an introduction, two interactive activities, and final remarks. Presentations about KADI as a project, and background information for research infrastructures and climate services were given at the outset of the workshop. Presentations however were kept at minimum to secure time for interactivity and discussions with the online participants. Online tools Mentimeter and Flinga were used to facilitate participant engagement and to document the findings from the workshop. Ethical clearance for this workshop and all stakeholder engagement activities was granted to the University of Pretoria (reference number: NAS084/2023). The meeting was recorded under the regulations set out by the EU General Data Protection Regulation (GDPR).

Table 1. Workshop program was divided to four steps of which steps 2 and 3 were the most important, covering themes of climate service need and critical research infrastructure elements.

Time (SAST/GMT)	Section
9-9:45	**Step 1: Introductions and icebreakers** An introduction to the project and the key topics of research infrastructures and climate services. Icebreakers using Flinga (https://flinga.fi) and Mentimeter (https://www.mentimeter.com) will get participants familiar with the online interactive tools.
9:45-10:45	**Step 2: Climate service needs** This discussion aims to scope stakeholders' current relationship to climate services, as well as the most critical challenges and needs related to climate services.
10:45-11	**Break**
11-12	**Step 3: Critical research infrastructure elements** This discussion aims to validate our work regarding research infrastructure elements and scoping the stakeholders' experiences with the elements. KADI climate service pilots' system maps are used as examples.
12-12:15	**Break**
12:15-13	**Step 4: Stakeholder champions and closing remarks** This discussion aims to summarise the workshop discussion and findings. We will facilitate a way for the participants to show their interest in continuing communication with the KADI teams now and in the future as a stakeholder champion.

Flinga is a free online whiteboard that allows participants to add messages and virtual post-it notes to the board. Participants do not need any registration to use the tool. Flinga was used to structure the meeting discussions, to allow stakeholders answer questions, and to present some key figures related to our work, such as the city pilots' system maps, network graph illustrating critical research infrastructure elements, and the stakeholder engagement figure (Figure 1).

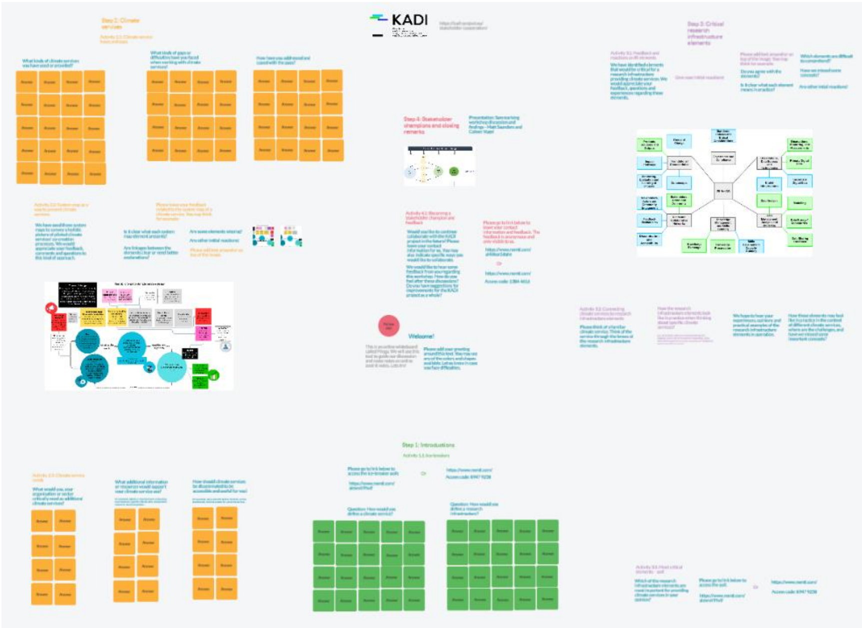

Figure 1. Overview of Flinga board before the workshop. Different sections are color coded to distinguish them from each other. Images were attached

Mentimeter is an online tool that was used to survey the online participants as part of the workshop activities (Figure 2). It was used to gather background information from the participants and to encourage engagement during the meeting activities. Responses to Mentimeter questions are seen live by everyone participating in the poll which encourages wider thinking. Towards the end of the meeting, the tool was also used to collect anonymous feedback from the participants.

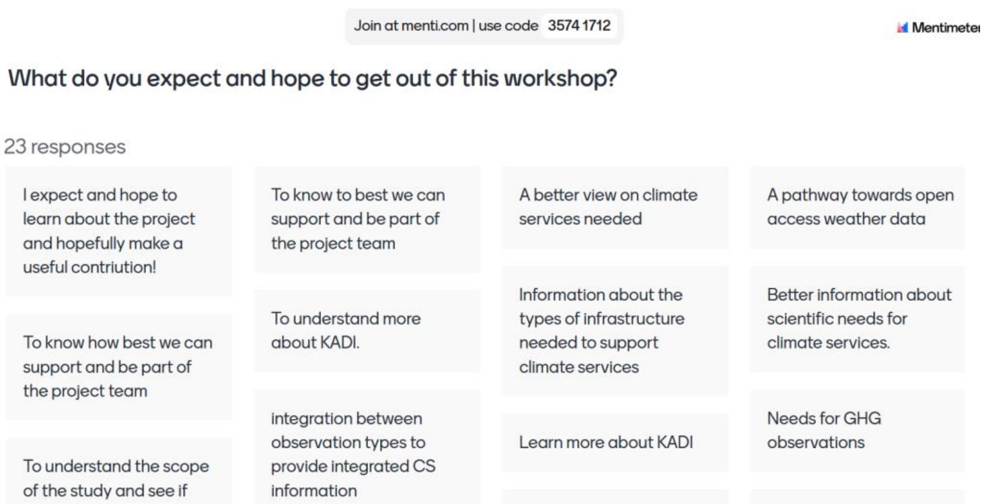

Figure 2. Responses to Mentimeter polls appear live to the screen.

KADI WP2 city pilots' system maps were used as examples when illustrating how climate services are related to research infrastructures. All city pilot climate services contain elements that are critical for functioning research infrastructures – such as observations, primary and secondary digital data, knowledge exchange elements, co-creation activities, and dissemination pieces. During the English version of the workshop the Nairobi city pilot's system map was presented in more detail, and similarly the Abidjan pilot's system map during the French version. The system maps aimed to connect the two parts of the workshop – climate services and research infrastructures. All three system maps were added to the online Flinga whiteboard for participants to look at, and for this report they can be found from Appendix B.

3. Participants

WP1 was provided with key stakeholder contact information from other KADI work packages and teams, which led to the development of a contact list with a total of 90 individuals who were to be invited for this workshop. Invitations were sent out at the end of May 2024 for English speaking stakeholders, and in mid-June for the French speaking stakeholders. Reminders were sent out a week before the workshop. Invitees were requested to register for the workshop via a Google Form. A LinkedIn post with a registration link was published on the KADI account a few days before the workshop to allow registration for those who were not on the invitation list but would like to partake in the event. A total 20 and 34 stakeholders joined the English and French workshop, respectively. Organisations represented in both workshops are listed in Table 2.

Table 2. Participants represented a large variety of organisations – academic and research institutes, meteorological organisations, governmental bodies, and NGOs.

Represented organisations	
English workshop	***French workshop***
Agencia Estatal de Meteorología (AEMET)	Abidjan District
Alliance for Collaboration on Climate and Earth Systems Science (ACCESS)	African Centre of Meteorological Applications for Development (ACMAD)
Egyptian Meteorological Authority	African Field Epidemiology Network (AFENET)
Finnish Meteorological Institute	Airport, Aeronautics, and Meteorological Operations and Development Company (SODEXAM)
Forestry South Africa	General Directorate of Meteorology, Morocco
Group on Earth Observations (GEO)	Institute of Tropical Geography (IGT)
International Livestock Research Institute (ILRI)	Ivorian Antipollution Center (CIAPOL)
Kenya Red Cross	Ministry of Environment, Côte d'Ivoire
Nairobi City County	National Drinking Water Office (ONEP)
Nigerian Meteorological Agency	National Institute of Public Hygiene (INHP), Côte d'Ivoire
South African Weather Service	Ministry of water, sanitation and hygiene (MINHAS), Côte d'Ivoire
Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL)	University of Abomey-calavi (Benin)
Stellenbosch University	University Peleforo GON COULIBALY, Korhogo
UN Climate Change (UNFCCC)	West Africa Coastal Areas Program (WACA)
University of Douala	
University of Nairobi	
Western Indian Ocean Marine Science Association (WIOMSA)	

Workshop participants represented also a diverse set of professions and expertise. During the icebreaker exercises at the beginning of workshop, the participants were asked to write at least one of their areas of expertise, and the depth and breadth of the participants skills are highlighted in Figure 3. Air quality and air pollution, climate related expertise, meteorology, and greenhouse gas observations were among the most mentioned areas. Other expertise areas covered everything from public health to extreme events, geography, climate change mitigation and social sciences. Diverse expertise areas brought different viewpoints to the discussion of climate services and how they are utilised and provided on different sectors.

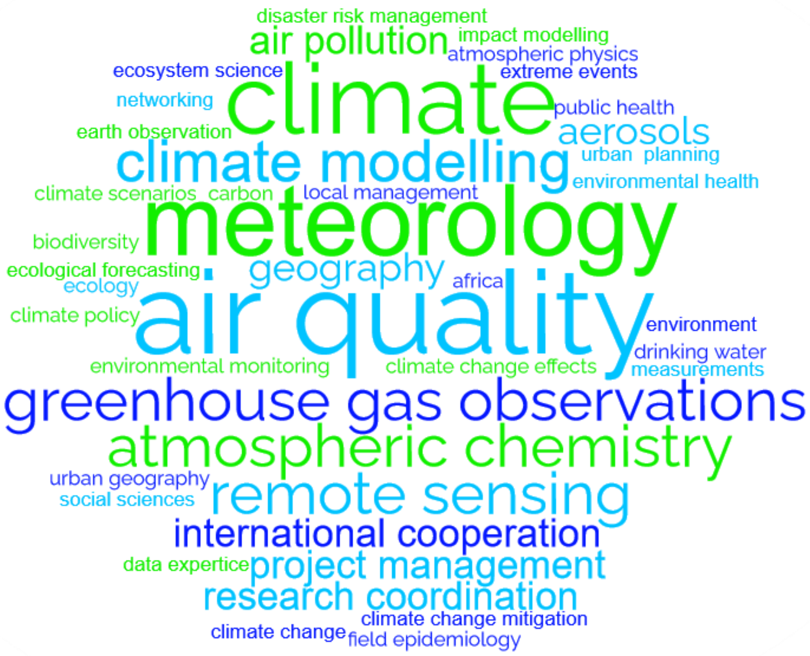

Figure 3. Word cloud of the workshop participants' expertise areas was produced during Mentimeter polls in the beginning of workshop.

4. Outcomes

4.1 Climate service experiences

First discussion theme concentrated on the participants' relationship to climate services, and the most pressing issues with regards to infrastructure and information gaps they are currently facing. Participants listed climate services they are using or providing on the Flinga whiteboard board, which then were discussed in more detail. Table 1 contains all mentioned climate services, grouped to categories. A significant proportion of the climate services mentioned relate to air quality, carbon exchange and greenhouse gases, and climate change. However, everything from early warning systems for disease outbreaks to agriculture, hydrometeorology and health related climate services were also mentioned.

Table 3. Participants use or provide a variety of climate services. Climate services are written in the table exactly as workshop participants added them to the online Flinga whiteboard, and categorised.

Category	Climate service
Air quality and aerosols	Air quality and air pollution observations
	Air quality impacts
	Aerosol, gas and deposition measurements in West and Central Africa
	Measuring chemical species, aerosols and cloud particles in the atmosphere
Carbon and greenhouse gases	Carbon and water exchange in Kenya
	Greenhouse gas emissions and related measurements
	Development of emission factors for National Inventory Reporting
	Carbon exchange in South Africa
Climate and climate change	Climate and climate change studies related to different sectors
	Weather data for climate change attribution studies
	Metro (city) level climate impact outlook
	Climate report
	Intraseasonal and seasonal climate analysis
Data and observations	Weather and climate data
	Meteorological observations
	Evapotranspiration measurements
Early warning	Early warning for disease outbreaks
	Climate forecast for Flood Early Action Protocol - EAPs
	Early warning for El Niño Southern Oscillation (ENSO)
Agriculture	Climate services in relation to cocoa farming
	Seasonal and intra-seasonal climate forecasts for agriculture
Health	Training environmentalists in field epidemiology and data management

Category	Climate service
	Urban hygiene
Hydrometeorology	Flood prediction
	Reducing the risks associated with extreme rainfall in cities (EVIDENCE)

The rich set of climate services that the workshop participants are affiliated with – whether as providers, users, or both – shows the large opportunity space of climate services in different sectors. Climate services vary from raw climate data provision to very specific and tailored services, such as climate forecasts for floods and developing emission factors for National Inventory Reporting. There is a tremendous amount of expertise in organisations around Africa in relation to climate services, and examples given by the participants revealed also the concrete impacts climate services can have e.g. on improving peoples' health and well-being. Below, two highlighted stories to health-related climate services from a service user's and provider's perspective.

Climate service example 1:

Rainfall forecasts for water-borne disease control in Nairobi

The County Government of Nairobi utilises extreme rainfall predictions provided by the Kenya Meteorological Department to control water-borne diseases that often follow extreme and continuous rainfall events. In March, April and May 2024 the city area experienced strong rainfall events which led to stagnant water on streets, and contaminated water resources. Now, the local government uses the climate service to prepare for such events and health risks that might follow. Health services stay informed for possible need for increased amount of medication, and the locations where medicine supplies must be sufficient to treat those affected by water-borne diseases.

Workshop participant, County Government of Nairobi

Climate service example 2:

Science-based malaria outbreak prediction in South Africa

An international research team developed a malaria prediction methodology that is based on seasonal climate forecasts and historical data in South Africa. The malaria outlook ties together climate variability and disease incidence, and as a result predictions of malaria outbreaks for the coming season can be made – whether e.g. number of cases that above average should be expected. The predictions are used by a governmental institute that conducts malaria outlooks in South Africa to prepare and plan their resource allocation for the coming season.

Workshop participant, Alliance for Collaboration on Climate and Earth Systems Science (ACCESS)

Other climate services were also discussed in more detail. One discussion and a great partner for KADI took place with a representative from the African Centre of Meteorological Applications for Development (ACMAD). ACMAD provides assistance to all African countries' national meteorological offices in utilising climate services and information for informed decision-making on agricultural, water management, risk management, and health sectors. They also develop a user interface platform that connects climate service providers, users and researchers and improves accessibility of climate data and derived products. ACMAD's activities – whether it is climate service development, stakeholder network creation, or policy strengthening – are undertaken on multiple scales from continental to regional and national. The regular regional climate outlook forums are also organised by ACMAD, together with other major organisations, such as the WMO and national meteorological offices. As ACMAD has already been identified as a potential partner stakeholder for KADI work packages (Deliverable 5.1), their involvement to this workshop was very much welcome, and the expertise and networks of ACMAD's staff can be of great assistance for KADI project.

4.2 Climate service needs and challenges

After the first task, participants were asked about challenges they face when working with climate services. Participants added challenges as virtual post-it notes to the Flinga whiteboard, and they are listed as such to Table 4. Similar challenges are grouped to categories. The challenges were discussed in more detail, and participants shared further insight of how the challenges materialise in their work. The challenges mentioned reveal the needs participants have to improve their possibilities to utilise and provide climate information for climate actions. Information gathered through this workshop task is very useful for the KADI research infrastructure design work. There is now a possibility to take the challenges and needs into consideration when designing operational and sustainable research infrastructures for different contexts and scales in Africa. Note that the discussion below the table does not cover each challenge separately. Selected challenges were discussed with the participants in more detail, but due to time constraints it was not possible to cover all individual challenges mentioned.

Table 4. Challenges and difficulties when working with climate services are manifold.

Category	Challenges
Data accessibility	Access to observation data
	Open data access for essential observations
	Old data not digitised
	Data access
	Data availability and access
Other data-related challenges	Lack of data infrastructures
	Inadequate spatial and temporal coverage
	Harmonised/standardised data products
	Data processing
	Acquisition of observation data
Human capacity	Lack of technical capacity among local actors
	Technicians for maintaining observations
	Staff training
	Collaboration with data centres (experts) to manage databases
Technical resources	Small community of instrument suppliers
	Access to digital tools
Stakeholder engagement and communication	Too little stakeholder engagement (including users)
	Involvement of local/national authorities

Category	Challenges
	Fast, appropriate communication
	Communication of results
Standards and policies	Limited calibration and meteorological support
	Absence of central organisation (lack of implementation)
	Effective coordination of climate services
Funding	Maintaining long term financial support for observational networks
	Equipment costs
	Cost of implementing a service (Financial and Human Resources) and long-term operation
Awareness	Awareness of the services
	Satellite data is not very known
Sustainability	Maintenance of the network
	Service sustainability
Other	Ignorance

Data accessibility. Access to climate related data is one major issue across Africa, raised also by several workshop participants. Systematic observations and climate data acquisition is scarce, or existing data is often scattered around data infrastructures with heterogeneous data standards or limited by paywalls. Organisations that would need reliable climate data for their climate actions may be forced to purchase licences from private businesses to access the data. Open data policies are not too widely adopted as a principle, whether working in the public or private sector. Openly available data is essential for building climate services and ensuring increased value and benefit from the observed climate data.

> *"In South Africa there is a lot of climate data, databases and data systems that exist, but they are not coordinated. Also in some cases, data is treated as commodity, which means it is intellectual property and owned by service providers, some of them being state organisations. There is often dispute when data is requested for use, and it is often very complicated to get the data – which shouldn't be the case. The data should be open and available to download. This is often the case for climate data, but for other data types and sources as well. A lot of regulatory obstacles, such as privacy issues, other information rules and laws as well as the fact that people need to make money out of their data. So, without centralised and well organised data coordination it is very hard to do e.g. research or develop data-driven products."* - Workshop participant, South Africa

Other data-related challenges. Beyond data accessibility, there are also various other structural data-related challenges of which the participants mentioned a few. Lack of data infrastructures that support everything from data acquisition to storage, management and sharing of climate related data is closely related to difficulties in data accessibility. One characteristic of data infrastructures in Africa is that they often are project-related, meaning that they are designed, developed and maintained only during a specific (internationally funded) project. In such cases, support for long-term sustainable maintenance of the infrastructure is rarely possible without specific strategies to do so, and with strong local stakeholder cooperation. Available climate data is also often concentrated on certain areas. Observation networks cover only few populated areas, and large proportions of the continent do not have any ground observation sites. Observations might also be collected only for a short period of time, once again due to short-lived projects, and thus the spatial and temporal coverage of climate-related data around African continent is weak. Commonly agreed and followed data standards would assist in the production of harmonized and compatible data products across geographical scales.

Human capacity and technical resources. Another recurring theme raised by the participants is the lack of sufficient human capacity and technical resources to support climate services. Although there is great deal of expertise to maintain and operate observation networks, and provide and use climate information and services, it is often concentrated on research institutes and similar organisations. Increased capacity in the public sector and private businesses to contribute in providing climate services, and utilising them in various purposes is called for. Increased technical capacity to manage different kinds of data products, operate observation instrument, use e.g. cloud services, supercomputers, and AI assistants, and so on would strengthen the local management of climate data and lower thresholds to use it for various purposes. However, integrating such skills development to education requires that education institutes have access to the needed digital infrastructures, which currently is not always the case.

Stakeholder engagement and communication. Overall, need for better stakeholder engagement and more effective communication between actors in climate service life cycle is something that participants agreed on. For example, stronger relationships from research institutes developing climate information related products and solutions towards governmental bodies is called for. In many cases, the scientific knowledge that is turned into useful and usable climate services ends up in use by various governmental offices on different sectors in the society. Systematic dialogue between these actors enhances effectiveness and impact of climate services, and prevents the knowledge ending up on shelves, unused.

> *"The most effective means for outreach mechanisms we have seen happening in most African countries is to leverage existing mechanisms. There are projects that have been existing in communities for years – they have operational databases and activities happening. For example, in Nigeria there is an International Fund for Agricultural Development (IFAD) project for climate change adaptation going on, which covers several geopolitical zones of the country. They have been there for several years, mapped out and interacting with agricultural communities. What we did at the Nigerian MET office was just to include climate services as part of the project's extension package. We trained their extension officers regarding climate services who then get to the field to discuss and explain impacts of weather and climate early warning systems with the communities as well as collect valuable feedback – better than any scientist in the met-service office could. At the MET office we call this strategy to leverage enabling agencies."* – Workshop participant, Nigerian Meteorological Agency

All in all, it is important to keep in mind that climate actions – adaptation, mitigation and resilience building – are not done in silos, but in collaboration with multiple players with different roles and expertise. However, the societies' needs for climate services are very heterogeneous in temporal, geographical and thematic scales. Climate service providers might not be able to tailor services to meet all specific needs, but what is possible is to develop such services that can then be further refined by users to meet their needs. This might require awareness building and skills development activities to ensure the services are known, and their potential for different use cases is understood.

Standards and policies. As climate services as a concept have gained significant momentum during the last decade, common global, regional and national standards and policies have not kept up with the pace. Lack of standards and policies in establishing and maintaining observation networks, data management, outreach, communication and feedback mechanisms, and more is a hindering challenge for actors working with climate services. This category is the one that mirrors itself to all other challenge categories identified in the stakeholder engagement workshop and this report.

> *"From my experience one critical challenge with climate services is lack of effective coordination at country level, both on horizontal level between climate service providers, and vertically between national, sub-national and the user community levels. Some countries do have National Frameworks for Climate Services, but some don't. Nonetheless, lack of proper implementation of user interfaces, lack of flexible outreach mechanisms, ineffective usage of climate services such as early warning services, and absence of impact monitoring systems can be seen in all countries. One good strategy to start building common climate service policies is to downscale the Global Framework for Climate Services to national frameworks with solid inclusion and communication strategies towards climate service producers, researchers, and user communities." – Workshop participant, UNFCCC*

Organisations typically developing and providing climate services, such as national meteorological agencies, are crucial when agreeing on common standards and policies. Good and contextually appropriate practices should be shared, standardised and reinforced. However, there is lack of effective central body in Africa that would be responsible for the development, implementation and coordination of standards and policies which weakens the overall framework for climate services. National meteorological agencies in Africa have great deal of experience in practices for designing contextually wise climate services. Countries are still in different stages in adopting climate services in their climate strategies, which creates inequalities between nations in utilising climate services as a resource to adapt to climate change.

> *"A good example comes from Nigerian MET office – they were able to integrate co-designing strategies to climate services and products that are used by multiple societal sectors, such as agriculture, water management, and environmental resource management. Now, sectoral stakeholders are included in the science-making. When science, maps and charts are created, continuous feedback is asked from the sectors to further develop the MET office's advisory products, which then become national products "owned by all sectors". Crucial things to understand are also how the scientific information will affect the sectors' activities: a social economic impact of climate services on each sector is monitored and reported. Then, for example on agricultural sector, the MET office does follow-up and evaluation on climate service use and their impact during growing seasons. We have noticed that well-functioning climate services lead to performance increases which builds the sectoral stakeholders' trust and confidence. We should be doing science for service, not science for science. Social scientists are needed to be able to get the messages to the last mile." – Workshop participant, Nigerian Meteorological Agency*

Funding. Securing sustainable financial resources to operate and maintain observation networks, to manage large amounts of data, and further refine it to useful and usable products and services is a struggle for many players in the field of climate services. Measurement equipment costs are high and even the community of instrument suppliers is small. This hinders the establishment of sufficient observation networks without a tremendous contribution of governments and international organisations. Even after an observation network is operational in terms of physical infrastructure, maintenance costs will follow, including training skilled personnel.

Sustainability. Countries with solid strategies to utilise climate information and services on societal sectors are in advantage when looking at the sustainability of climate services. Political will to invest in climate observation infrastructures, efficient digital infrastructures, data access, education and skills development, and cooperation between public and private sectors lays grounds on sustainable climate services. National observation networks provide high-quality data for research institutes and national meteorological agencies, education institutes provide needed skills for new professionals, and private businesses can rely on secured access to climate services integrated to their own activities. As mentioned before, short-time project related work is often a barrier for sustainability. Data might be collected only during project funding, and sustainable continuation of climate observations is not secured in the long run.

Long-term sustainability of climate services depends on financial, technical, political and societal factors. All of the challenges identified during the workshop highlight a complex interplay between these factors that hinder the effective delivery and utilisation of climate services in Africa. Addressing these gaps will require coordinated efforts to improve data accessibility, build human capacity, enhance communication, secure long-term funding, and ensure the sustainability of services. Each of these areas presents an opportunity for targeted interventions to strengthen climate services and their impact across the continent.

Based on these workshop activities and participants' needs regarding climate services, the pan-African research infrastructure for climate services design should consider following things:

- What standards and policies for climate data collection, processing, management and service delivery are already in place, where are the gaps? How global standards and policies are compatible with local contexts across Africa?
- How is data accessibility ensured? Where and how open data principles (e.g. FAIR) can be applied? How to break down the silos caused by project-based data and ensure open, harmonised and standardised data products across geographical scales?
- What is the state of human capacity and skills to ensure sustainable local maintenance of observation networks, data and digital infrastructures, and usage of climate services? Are higher education institutes answering the needs of the industry? How skills development of those already working in the industry could support uptake of e.g. cutting-edge digital tools, such as cloud services, supercomputers, and AI?
- Who are the local players to secure sustainability of each critical research infrastructure element? How consistent funding and institutional support can be secured so that a sustainable pan-African research infrastructure is achievable?
- What are the sustainable funding mechanisms for a pan-African research infrastructure? What is the role of international organisations, local governments, and even the private sector?

4.3 Research infrastructure elements

In this section of the workshop, we presented the network graph with critical elements of a research infrastructure that provides climate services, identified during previous WP1 work. The participants had received a background information package before the meeting where each element was explained (see Appendix 1). During the workshop, we requested comments from the participants related to the elements. For example, what concepts or challenges are related to the elements, are we missing some crucial elements, and whether they have experiences to share about some of the elements working in practice. Interestingly, this part of the workshop was livelier during the French version of the workshop than the English version. The discussion in this section revolved around similar thematics as in the previous ones – policies, data accessibility, and funding, but now the focus was to tie them to already identified RI elements.

Table 5 below contains comments and notes the workshop participants left to the already identified critical research infrastructure elements. The comments raise questions, things to consider when designing a research infrastructure, point out current gaps, and give suggestions. One added research infrastructure element, *"Funding and financing mechanisms"* that was not previously identified as an element is now included in the table in red. Narratives of mostly discussed issues are written out below the table. However, not all comments were discussed out loud, but they should still be scrutinised when learning from the workshop results.

Table 5. Workshop participants left comments around the network graph of research infrastructure elements. Those comments are compiled to this table and connected to the element the comment is related to.

Category	RI element	Comment
Governance and compliance	**Standards, policies and ethical considerations**	Need for strengthening the political framework, laws, etc. related to research infrastructures for climate services
		Now, there is a disconnection between the formulation of laws and research. Research and the formulation of laws must be able to feed off each other
		Consider the role of Open Science policies in RI design
		Integrating different data policies (regional/national)
		Role of RI in policy
	Funding and financing mechanisms	Sustainable funding sources must be identified to support the CS Infrastructures
		Integrating financing mechanisms during creation, then for long-term operation
		Funding the production of primary and secondary data
Observations, data sources and technologies	**Observations, monitoring and measurements**	All climate services stem from the availability of observations
		Possibilities of low-cost sensors to observe, monitor and measure climate parameters
	Primary digital data	Additional methods to collect digital data via participatory science and citizen science
	Secondary digital data	-
	Digital infrastructures	Technical platform which enables easy access to information is needed
		Need for facilitated access to supercomputers
		Local and global infrastructures – ensuring their complementarity to each other
Data management, analysis and modelling	**Data analysis**	Define time scales and range
	Modelling	Harmonization of modelling procedures would increase compatibility of methods and results across Africa
		Standardized localized parametrization for models is needed
		Down-scaling global, continental or regional models requires stronger observation networks in Africa

Category	RI element	Comment
	Data storage / repositories	-
	Data sharing and reuse	Data licensing as a means to standardize data sharing protocols, to ensure recognition, and to facilitate open data sharing (CC etc.)
		Make data accessible? Open source subsidy of data production structures
		Establish a system of access to data after authorization
Knowledge management and skills building	**Knowledge exchange**	Citizen science can create knowledge exchange beyond traditional scientific expertise
	Knowledge preservation	Continuity of RI management should be secured with skilled personnel
	Skills development and capacity building	Africa needs investments in the human capacity for making observations and managing data and data products
		A capacity building plan is required that is periodically updated in light of progress
		Urgent need for capacity building of supercomputer users
		How does a research infrastructure for climate services provide its variety of actors to learn from and with the services?
Users and collaborative networks	**Stakeholders, actors and community**	Define and operationalize a framework for collaboration between stakeholders, which identifies stakeholders, the strengths of each stakeholder, functional links and interactions
	Stakeholder, actor and community engagement	-
	Feedback mechanisms	Response options for users / stakeholders
	Dissemination and accessibility	Integrating FAIR data principles to RI design
		Popularizing science through different channels for the sake of accessibility
Foundational characteristics	**Theory of Change**	-
	Products, solutions and outputs	Range of scales (geographical, temporal) must be considered when developing climate services and other data products – user needs vary, and it is important to distinguish e.g. between short-term climate hazards and long-term events that might also be devastating to people
	Impact pathways	-
	Monitoring, evaluation and learning of impacts	Cascading information flows

Category	RI element	Comment
	Co-concepts	Integrating and appreciating local knowledge when co-designing and operating context appropriate research infrastructures

Access to research infrastructure and tools. One of the primary issues highlighted during the meeting was the need for enhanced access to advanced research infrastructures, such as supercomputers and specialized databases. Participants emphasized the importance of making these tools more accessible to researchers across various institutions, particularly in developing regions. The availability of funding to support these infrastructures was also a concern, as some institutions may lack the necessary resources to fully contribute to large-scale projects. Additionally, the potential for creating systems that allow remote access to these tools was discussed, ensuring broader participation in research activities.

Collaboration and stakeholder engagement. The discussion underscored the significance of collaboration between different research institutions and stakeholders. Participants recognized the need for creating robust partnerships to leverage shared resources and expertise, especially in projects that span multiple countries or regions. There was also a call for involving local communities and integrating community-based approaches into research methodologies. This collaborative approach is seen as essential for addressing complex, multidisciplinary challenges, such as those related to climate change and public health.

Governance and ethical considerations. Governance of research infrastructure was another critical topic. The participants pointed out the necessity of aligning research activities with existing legal frameworks and ensuring compliance with ethical standards. Strengthening the governance of research projects, particularly in terms of ethical oversight, was deemed crucial to maintaining the integrity of scientific work. Suggestions were made to enhance the ethical training of researchers and to develop governance structures that can effectively oversee large-scale, multi-institutional projects.

Data management and accessibility. Effective data management was a recurring theme throughout the discussion. The participants highlighted the importance of ensuring that research data is of high quality, properly calibrated, and originates from accredited services. There was a consensus on the need to establish systems for the secure storage and sharing of data, with particular emphasis on the accessibility of data to researchers who have obtained the necessary authorization. Collaborating with data experts and utilizing specialized platforms for data management were proposed as ways to improve the efficiency and reliability of research data handling.

Integration of emerging technologies. The meeting also touched upon the integration of emerging technologies in research infrastructure. This includes the use of low-cost sensors for environmental monitoring and the incorporation of citizen science into data collection efforts. Participants discussed the potential benefits of these technologies in expanding the scope of research and making scientific inquiry more inclusive. The role of digital infrastructure in facilitating real-time data analysis and collaboration was also highlighted as a critical factor in modern research.

Financial mechanisms and sustainability. Another important point of discussion was the sustainability of research infrastructures through adequate financial support. The participants debated where financial mechanisms should be integrated—either at the initial stages of research infrastructure development or as part of ongoing operations. The long-term viability of these infrastructures was a concern, with suggestions to ensure consistent funding streams, possibly through international cooperation or public-private partnerships.

4.3 Voting most crucial RI elements

As a final activity, participants were asked to vote on the most critical RI elements in their opinion. All elements shown in the network figure were set as options, and the participants could select a maximum five. Elements that got two or more votes are displayed in Figure 4. Observations, monitoring and measurements are clearly seen as the most important element for an RI providing climate services. Other elements that received many votes are related to data sharing and storing, but also on knowledge exchange and capacity building. The latter two were mentioned several times during the workshop, such as the need for skilled people in all stages of climate services' life cycles being crucial for them to be successfully utilised in climate actions.

This voting can be used as an indicator of what are the elements that should be given special attention to when designing the pan-African research infrastructure for climate services. However, the voting results may reflect the current challenges related to climate service provision and use. For example, there is a major gap to accessing climate related data in Africa, and thus the elements related to data acquisition, sharing and storing might be emphasized.

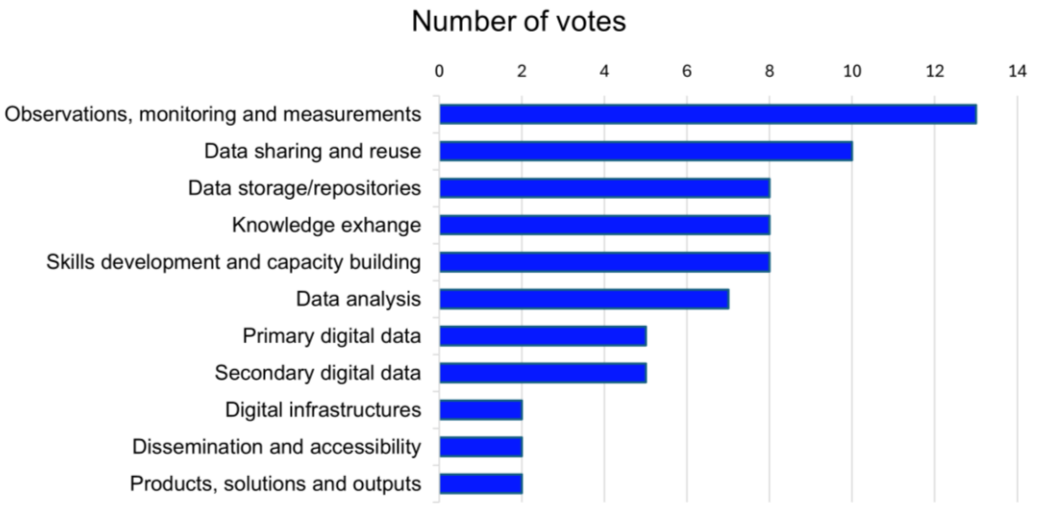

Figure 5. Graph of the voting exercise. Only those elements that got two or more votes are represented. All remaining elements got one vote, except "Theory of change", "Feedback mechanisms" and "Monitoring, evaluation and learning" that were not voted at all.

4.4 Stakeholder champions

Throughout the workshop, several participants stated their availability for future contacting. For example, the Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL) which was already identified as crucial stakeholder and cooperation partner for KADI should be kept in the loop of KADI activities. Despite of shared history, current SASSCAL experts might not be informed about the KADI project and shared interests.

At the end of the workshop, participants were guided to a Mentimeter poll where they could express their interest for future contacting and possible collaboration. Thirteen individuals submitted their contact information, covering the following organisations: Abidjan District, African Field Epidemiology Network (AFENET), Finnish Meteorological Institute, General Directorate of Meteorology of Morocco, Ministry of Environment of Côte d'Ivoire, National Institute of Public Hygiene of Côte d'Ivoire (INHP), Nigerian Meteorological Agency, South African Weather Service, University of Douala, and Université Félix

Houphouët-Boigny (UFHB). The workshop organising team encourages communication towards all workshop participants or their represented organisations, and those who registered but were not able to partake the event.

5. Way forward

This workshop report provides concrete information about climate service related needs that could be addressed with a well-thought design of a pan-African research infrastructure. The design work is carried out in KADI WP3, and this report can and should be used to validate or develop the design done so far. Stakeholders from various organisations with a relationship to climate services in Africa took part in the workshop. Their expertise and best possible contextual knowledge are valuable to be integrated in the whole KADI project throughout next activities. For full transparency, communicating how these findings from the stakeholder engagement workshop affected the research infrastructure design is also important and should be included in possible future WP3 reports and/or presentations.

The findings from the stakeholder engagement workshop will also inform activities in KADI WP4. This report reveals some of the key knowledge gaps related to developing, maintaining and using climate information and services, which can be used when carrying out knowledge exchange and training activities, especially in Task 4.2. Stakeholders who attended this workshop might also have valuable additional inputs regarding capacity building needs that were not covered in this event, and thus continuing with the dialogue with the stakeholders in upcoming events and activities should be considered.

All in all, further communication with stakeholders should be secured to maintain iterative feedback loops across KADI activities. Some of the stakeholders participated in this workshop might also have key roles in the pan-African research infrastructure design, whether as operating observation networks, managing climate data infrastructures, maintaining dialogue channels with local governments and citizens, or providing training. Identifying these stakeholder champions should still continue. Inviting some of the actors from this workshop to future activities builds further trust and allows also concentrating to other discussion points. Four-hour online workshop can only give so much room, and from this experience there is still a lot of knowledge to be shared.

As a final notice, KADI WP1 should review the work done so far, and update any outputs with new information gained from this workshop. For example, the network graph presenting critical research infrastructure elements could be updated with added elements related to funding and human resources. Also, standards and policies were in the centre of the discussions in the workshop – perhaps these would benefit of more detailed attention in the graph.

> *”The workshop was very interesting and insightful. It brought out the gaps and challenges of the climate services in Africa. I wish this project can reach every country so as to have a robust CS.”*
>
> *“The Nigerian Meteorological Agency will also be looking forward to working with KADI to help us develop products, especially products for the energy sector and other relevant sectors”*
>
> *“Très bon atelier à travers des discussions enrichissantes!”*

Appendix

Appendix A. Full background package sent to stakeholders

Workshop Background Information

Overall goal of KADI

The overall goal of the Knowledge and climate services from an African observation and Data research Infrastructure (KADI) project is to create a blueprint for an African-based research infrastructure that supports and provides climate services. There are numerous key aspects of a research infrastructure that provides climate services and solutions. KADI will investigate the climate services needs of different stakeholders across Africa, focusing on the scope and definition of an observational and modelling research infrastructure.

What is a research infrastructure?

A *research infrastructure* is the physical and digital tools that researchers use to conduct innovative research and provide unique infrastructures, such as laboratory equipment, data repositories, and knowledge-based resources. Research infrastructures have been defined in various ways throughout the literature, but the key elements are summarised in Figure 1.

Figure 1. Traditional RI elements identified based on the review of relevant literature.

What is a climate service?

Climate services are the tools that utilise and translate climate data into information that helps people make informed climate-related decsions. Climate services in Africa have had a particular focus on *hard* infrastructure such as measurements and modelling outputs. There has been less of a focus on the *softer* infrastructures that provide additional information and contexts such as impact, collaboration and learning . In addition, climate services are often seen as one-directional, with scientific information providing a service. The focus on *hard* infrastructures have left gaps in climate services (e.g., how they are developed, how they are implemented, how their impact is assessed). KADI aims to address these issues by creating a Pan-African research infrastructure that supports a broader view of both research infrastructure and climate services. We will also focus on identifying concrete climate service needs emerging in different sectors and geographical scales, and co-developing the climate services with stakeholders which will ensure they meet their specific needs and are implemented sustainably.

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KADI work packages

The KADI project consists of three major parts that integrate six work packages (WPs) shown in Figure 2:

1. *Concept design:* A compilation of climate services needs in WP1 will develop a solid base for the design of the research infrastructure in WP3. The climate service pilots in WP2 will test the concept by providing experience to co-design the requirements of climate services (WP1) with technical feasibility (WP3).
2. *Knowledge sharing:* Knowledge exchange between Africa and Europe by organising workshops and training (WP4) to help both continents learn from each other.
3. *Policy support:* Integrating the new research infrastructure with existing observation and modelling systems in Africa, Europe and across the globe to ensure longevity and sustainable funding (WP5).

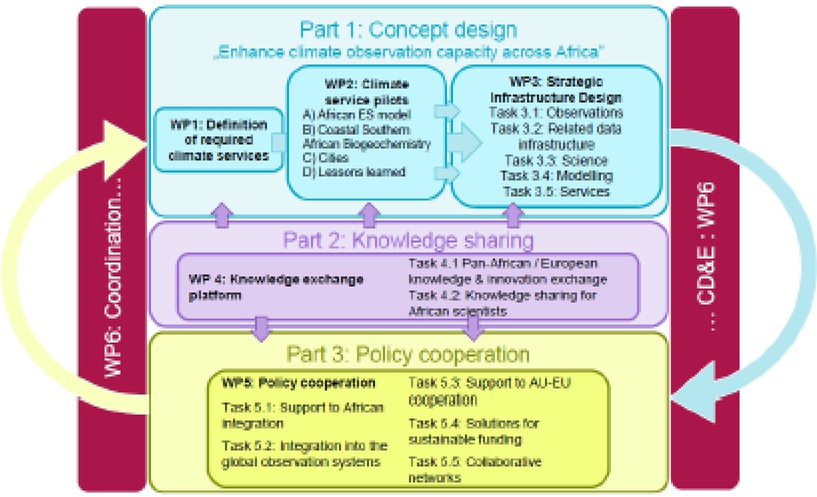

Figure 2. Overview of KADI work packages and their interlinkages.

Goal of WP1

The goal of WP1 is to identify the climate services needs in Africa that can be addressed with a research infrastructure. We will identify, analyse and characterise climate service needs at multiple scales and contexts in Africa. Then, through collaborative engagement of key stakeholders, these services will be validated with their potential data and infrastructure designs through four climate service pilots:

- *Earth System Modelling*: Focuses on evaluation and improvements of parameterisations of land-surface characteristics and land-atmosphere fluxes in an Earth Systems Model.
- *Coastal Biogeochemistry*: Quantifying key components of the coastal carbon cycle that are relevant to the regulation of climate change, and focuses on carbon cycling and other greenhouse gas measurements.
- *Cities*: Local climate solutions for rapidly growing cities with case studies in three African cities, Abidjan, Côte d'Ivoire, Nairobi, Kenya, and Dar es Salaam, Tanzania.
- *Long-term climate and atmospheric composition observation*: Assess the value and derive lessons-learned of the existing long-term climate and atmospheric composition observations provided by national meteorological services, using the Kenyan Meteorological Department (KMD) as a case study.

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Critical elements of a needs-based research infrastructure

We have identified elements that are critical to achieve a needs-based RI design that has an impact on the society when adapting to and coping with changing climate, and when building resilience against climate risks (Figure 3). The traditional (green) and added elements (blue) stem from the review of academic literature, not only concentrating on research infrastructure, but also contextual literature of climate services that operate in Africa, and best practices identified (Table 1). They are also identified via discussions with experts that are KADI project partners, and with the KADI pilot stakeholders. Many of these added elements can be seen as the softer side of the research infrastructure coin, where the importance of, for example impact, collaboration and learning, are highlighted.

Table 1. Descriptions of the key elements of a needs-based research infrastructure (RI) to support climate services.

RI element	Description
Foundational characteristics	
Theory of change	Communicates how the scientific research activities and outputs from the RI have long-term impact on the society.
Products, solutions and outputs	Key RI outputs in diverse forms, such as innovative research results and publications, new methods and data processing pathways, training materials, data/information dashboards, projections and models.
Impact pathways	Practical steps needed to achieve RI's long-term impacts.
Monitoring, evaluating and learning (MEL) of impacts	Systematic way to examine RI's performance and impact throughout its lifecycle, and adjust the RI activities based on the examination.
Co-concepts	Genuinely working together with and listening to different actors throughout the RI lifecycle.
Observations, data sources and technologies	
Observations, measurements, and monitoring	Key RI activities for collecting data.
Primary digital data	Date collected and managed by the RI.
Secondary digital data	Supportive data that adds context to primary data.
Digital infrastructures	Physical hardware and software that enable RI activities.
Data management, analysis and modelling	
Data analysis	Methods used to make sense of data.
Modelling	Using models to understand, predict or test simplified versions of real-world events.
Data storage/repositories	Managing, storing, accessing and sharing datasets.
Data sharing and reuse	Openly sharing data and products that the RI produces. Sharing requires an interface or another technology that allows access for future users. an API that is accessible for the further data users.
Knowledge management and skills building	
Knowledge exchange	RIs facilitate multi-directional flow of knowledge between researchers, policy-makers, industries, businesses, and citizens.
Knowledge preservation	RIs ensuring that research outputs, data and methods are protected and preserved.
Skill development/capacity building	RIs can provide training events, materials, and campaigns tailored to different stakeholders at various stages of the life cycle.
Users and collaborative networks	
Stakeholder, actors and community	RIs have stakeholders, actors and community members with different roles, such as giving the need and demand for services, producing, and maintaining infrastructure elements, and/or benefiting from the products and solutions.
Stakeholder, actors and community engagement	Engaging the stakeholders, actors, and community to the RI activities in all stages of its lifecycle.

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RI element	Description
Feedback mechanisms	Established processes to collect and respond to input.
Dissemination and accessibility	Activities for sharing the RI products, solutions, and outputs widely available with actors/stakeholders.
Governance and compliance	
Standards, policies and ethical considerations	Ethical guidelines for using RI resources responsibly.

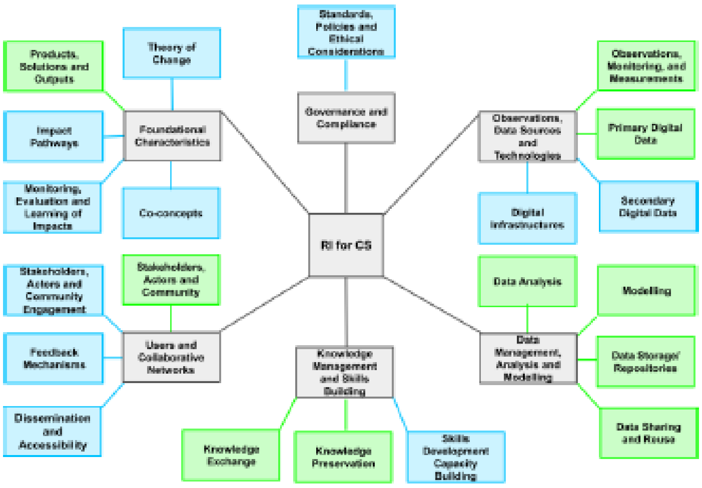

Figure 3. Critical elements of a research infrastructure for climate services.

System mapping of KADI climate service pilots

System mapping refers to value flow from the climate service need, to the structure of the climate service itself, and finally to the outcomes and impacts of the climate service (Figure 4). We used the KADI climate service pilots as examples to visualise each KADI climate service pilot as an operative system so they inform the research infrastructure design work, and that it is easier to compare pilots as operative climate services. This way WP3 can obtain information from the pilots of how climate services that operate in different scales and sectors can be functional. With the visualisation, we can articulate how the climate observations/data are transformed to useful and usable climate services that answer the needs of different actors, and also show services potential impacts.

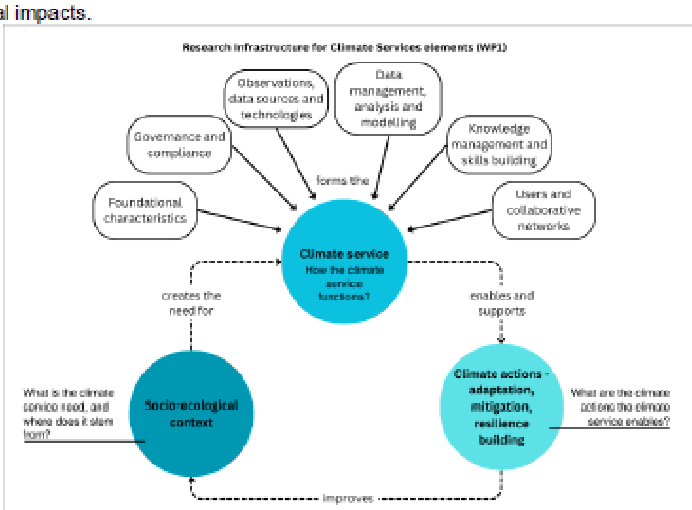

Figure 4. Simplified system map of a climate service that answers a need, and thus enables climate actions.

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Appendix B. KADI city pilots’ climate service system maps

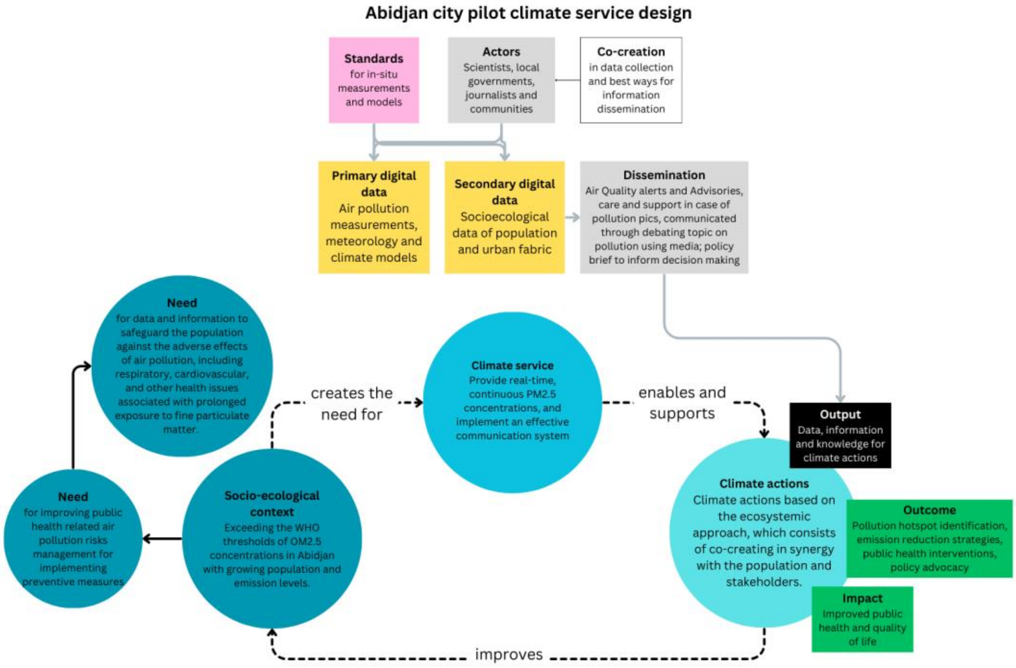

Figure 1. Abidjan climate service pilot system map.

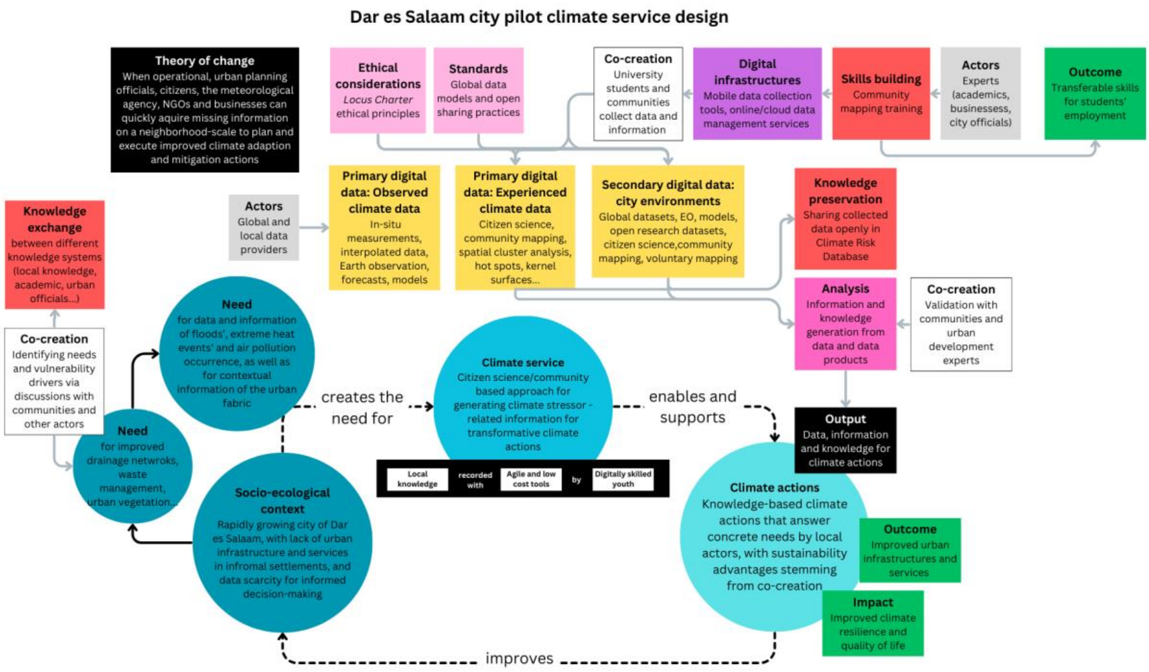

Figure 2. Dar es Salaam climate service pilot system map.

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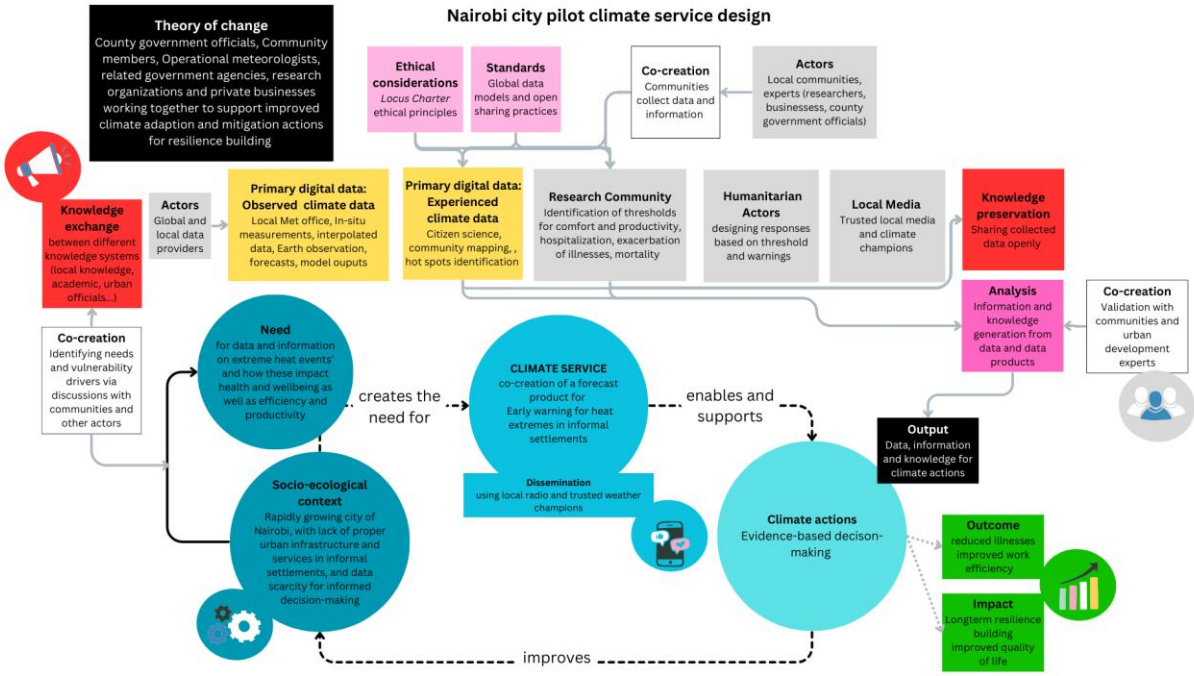

Figure 3. Nairobi climate service pilot system map.