Strengthening the climate resilience of health systems in Africa

Workshop report

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The Academy of Medical Sciences

ASSAf
ACADEMY OF SCIENCE OF SOUTH AFRICA

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Strengthening the climate resilience of health systems in Africa

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Executive summary

Africa is warming rapidly, in some regions at twice the speed of the planet as a whole.[1] This is expected to intensify aridity on the continent, although uncertainties persist regarding rainfall patterns.[2] More frequent and enduring droughts, unprecedentedly intense heatwaves and disastrous flooding events are predicted.[3] African healthcare systems will have to contend with these developments. To help them do so there is a need for a multidisciplinary approach that combines legislative frameworks, accurate scientific evidence, community and indigenous knowledge, and innovative ideas.

In March 2024, the UK Academy of Medical Sciences, and the Academy of Science of South Africa (ASSAf) held a 2-day workshop, exploring adaptation and resilience strategies required for the strengthening of health systems in Africa in the face of climate change, providing opportunities for participants to discuss research and policy needs.

The workshop provided insights into the current state of climate change adaptation and resilience within the healthcare sector, emphasising the critical role of robust research in informing evidence-based policy implementation for enhanced resilience in Africa's future. During keynote addresses and breakout sessions, workshop participants engaged in discussions exploring research gaps and opportunities aimed at enhancing the effectiveness of interventions and approaches within the key tracks of Policy, Research, Data and Community Engagement. These discussions generated outcomes in four main areas:

The need to break down silos across the various levels of the public health sector, and across Africa
A recurring theme relating to the data, research, community engagement and policy tracks was that various sectors involved in climate change adaptation and resilience, notably within the health sector, operate independently and lack cohesive collaboration. To overcome this challenge, participants suggested implementing a coordinated regional climate intervention programme for Africa to cultivate collaboration and synergy among stakeholders. This would enhance the effectiveness of efforts to address climate-related challenges comprehensively and would strengthen coordination among the African Union and regional partners, while also enhancing Africa's common position in global climate negotiations.

The need for multidisciplinary training and development, coupled with implementation research
Participants reaffirmed the importance of multidisciplinary training and development to foster and enhance intersectoral collaboration, as well as implementation studies to assess how this can be achieved. This includes the development of community-driven methodologies and the formation of 'communities of practice'. In this regard it is important to note that research institutions are increasingly adopting multidisciplinary approaches, often partnering with humanitarian organisations, to bridge the gap between scientific practice and societal needs. These collaborative efforts involve various stakeholders, including those in climate, local government, medical, service provision, public health, non-governmental organisation (NGO) and end-user sectors.

Leadership in public engagement on climate change advocacy programmes
A key theme that emerged was that the entrenched financial and educational disparities across Africa lead to a lack of awareness about climate change. Participants noted the importance of advocacy programmes to

1. https://www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_Africa.pdf
2. https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-9/
3. https://reliefweb.int/report/world/cred-crunch-newsletter-issue-no-69-december-2022-interplay-drought-flood-extreme-events-africa-over-last-twenty-years-2002-2021

overcome this, highlighting the need to integrate climate change into educational curricula, especially within vulnerable sectors and universities. Furthermore, participants suggested establishing early warning and early response systems within communities, to enhance their preparedness for extreme events. Additionally, participants recommended enhancing climate change literacy in sectors vulnerable to climate change, with a gender equity focus, and integrating climate change awareness into governmental policies and decision-making frameworks.

Creative solutions to strengthen climate change resilience and adaptation measures within healthcare systems

A notable theme that emerged from the workshop was the need to explore innovative strategies to enhance climate change resilience and adaptation within African healthcare systems. It was emphasised that there is an urgent need to transform these systems to make them climate-resilient, low-carbon, sustainable and equitable, while also better preparing communities and vulnerable populations – such as pregnant women and children – for climate change impacts, such as extreme heat. A pertinent example was shared from Rwanda, where drones have been used to deliver vaccines to maintain a cold chain, which is not possible using traditional road transport systems. Discussions also encompassed building modification, cooling and green space initiatives, managing medical waste and addressing the carbon footprint of healthcare systems.

Introduction

There is a pressing need to implement climate change adaptation measures within African health systems and to safeguard health system resilience, especially amid resource constraints and ever-shifting environmental conditions on the continent.

In this context, in March 2024, the UK Academy of Medical Sciences and the Academy of Science of South Africa (ASSAf) held a 2-day workshop to explore adaptation and resilience strategies to strengthen the ability of health systems in Africa to face climate change. Participants reviewed evidence on climate adaptation and resilience in the healthcare sector across Africa, identified innovations and interventions that can strengthen health systems' resilience, and highlighted priority research areas and opportunities for collaboration.

Participants in the workshop 'Strengthening the climate resilience of health systems in Africa', 06 March 2024, Johannesburg, South Africa

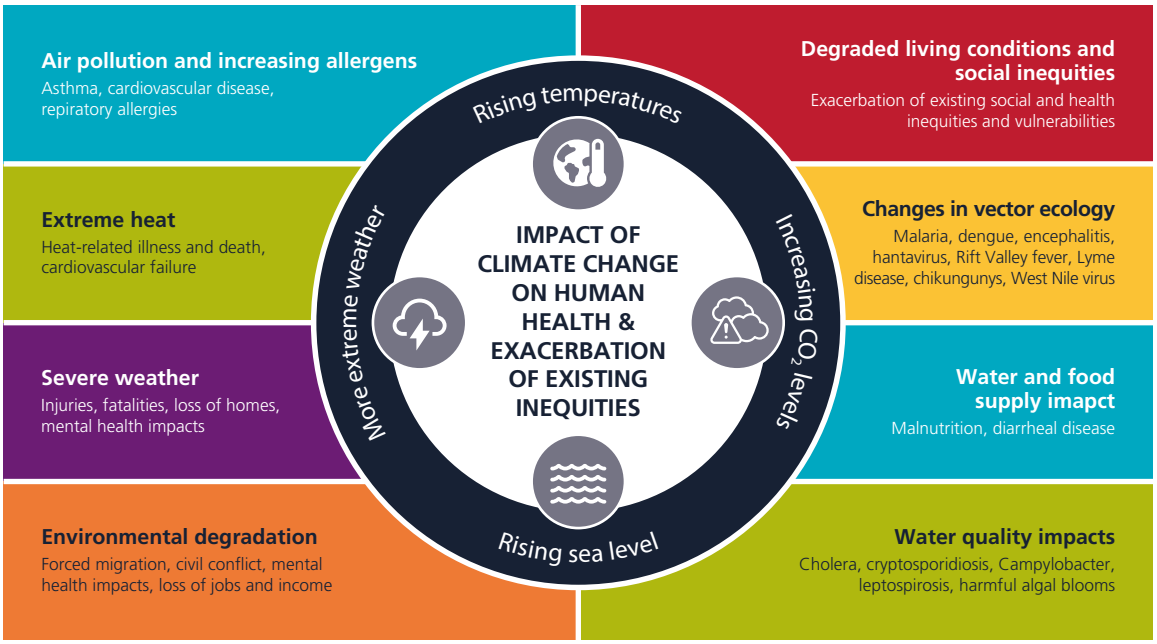
Healthcare systems in Africa

Healthcare employees, research and political will

In his opening statement, Professor Ashley Woodcock from the University of Manchester highlighted the value of every healthcare employee, the importance of research and the need for political will in adopting climate change resilience strategies. He explained that healthcare workers, including clinicians, specialists and nurses, play an important role in responding to climate change. However, he suggested that their knowledge is inadequately utilised in societal responses to the problem, and they are rarely leveraged as climate ambassadors. Professor Woodcock argued that there is a need for collaboration, knowledge exchange and workforce capacity building to address the many ways in which climate change endangers health, and to guide leaders, educators, policymakers and others in creating a more resilient and just health system.[4]

The state of resilience and adaptation to climate change in the African healthcare sector

Professor Coleen Vogel from the Global Change Institute at the University of Witwatersrand emphasised the urgent need to develop adaptation action plans for cities. She explained that these should apply innovative, interdisciplinary approaches to enhance activities such as disaster management and the response to extreme weather events. She highlighted the myriad adaptation solutions that are needed for the multitude of impacts caused by climate change, ranging from degraded living conditions to changes in vector ecology. Professor Vogel explained that extreme weather events, such as floods and prolonged droughts, are predicted to become more frequent in the long term across Africa. She explained that these occurrences, coupled with rising temperatures, will exacerbate existing inequalities on the continent, as summarised in the figure below.



4. Sorensen CJ & Fried LP (2024). *Defining roles and responsibilities of the health workforce to respond to the climate crisis.* JAMA Netw Open **7**(3), e241435. doi:10.1001/jamanetworkopen.2024.1435

Professor Vogel described the grave threat that extreme events will pose to public health, with the predicted morbidity and mortality. Heatwaves will escalate in frequency and intensity, with marked regional variations in heat-related fatalities. At the same time, the many food-borne, water-borne and vector-borne diseases will intensify across all temperature scenarios, unless substantial adaptation measures are implemented. Seasonal changes will expand the geographical reach of vector-borne diseases, such as dengue fever, putting millions of people at risk. She also highlighted that mental health challenges and cognitive dissonance are an overlooked health impact of climate change, with anxiety and stress increasing in areas already burdened by the impacts of climate change.

Professor Vogel reviewed recent local extreme weather events in South Africa, such as the catastrophic flooding in Johannesburg. Highlighting the importance of early warning systems, she explained that greater radar coverage would have made it possible to predict this flooding, but resource restrictions meant this did not happen. She also described the severe floods and landslides caused by heavy rainfall in South Africa's Kwazulu-Natal Province in April and May 2022. The consequences were severe: more than 400 people died, over 40,000 were reported missing, thousands were forced to evacuate their homes, 4,000 houses were destroyed and 8,000 were badly damaged. The estimated cost was 17 billion rand (equivalent to US$ 1 billion). Many deaths resulted from individuals living in areas at risk of flooding, underscoring the need for better urban planning and land management. Professor Vogel showed the impact of severe deficiencies in service delivery and how this exacerbates vulnerabilities and compromises the well-being of affected communities.

Professor Vogel then discussed the urgent need to develop and implement comprehensive and transdisciplinary climate action plans to enable climate adaptation, through the application of specific epistemology and knowledge frameworks.

She highlighted the Johannesburg climate action plan and the positive role of champions with a long-term vision. However, she also explained the obstacle of city government departments (responsible for city parks and disaster management) working in silos. The lack of communication requires collaborative networks, incentivised to promote effective change. She described the impact of youth involvement through the South African Institute of International Affairs; this was so effective that the youths were asked to provide the foreword to the Johannesburg climate action plan document.

Finally, Professor Vogel explained that the World Meteorological Organization (WMO), alongside other major international organisations, recently published a report entitled '2023 State of Climate Services for Health', which points to the need for more climate information and services to support health systems.[5]

Mitigating the impacts of climate change on healthcare facilities and practices

In his presentation, Dr Lokotola from Stellenbosch University began by discussing the multifaceted effects of climate change on human populations, giving the examples of drought-related displacement and human migration. He explained that flooding in particular can pose a significant risk to healthcare facilities, with facilities becoming unsafe during severe weather events.

Dr Lokotola went on to discuss the carbon footprint of patient care practices, in the form of the energy used for equipment, lighting and ventilation, as well as greenhouse gas emissions related to anaesthetics (which account for 2%–5% of hospital emissions). Waste in the health sector is often being overlooked as a contributor to environmental damage, being composed of 60% high-energy disposal waste and 20%–30% hospital waste.[6] Dr Lokotola noted that the Hippocratic oath requires clinicians to give care without causing harm,[7] and so they need to find ways to care for patients with minimal harm to the environment.

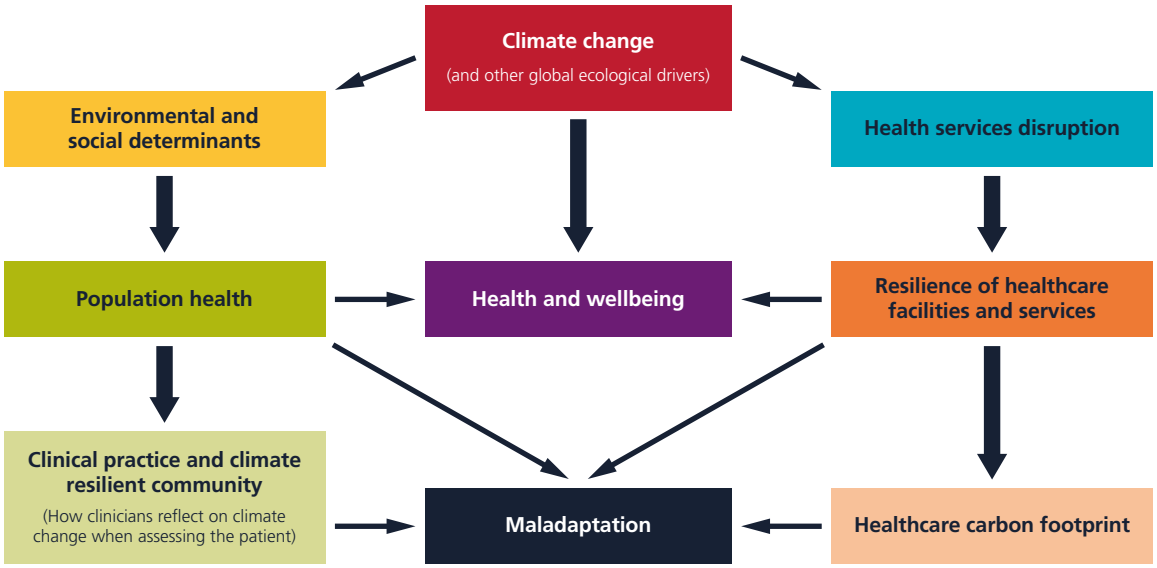
5. https://wmo.int/publication-series/2023-state-of-climate-services-health
6. Harhay MO et al. (2009). *Health care waste management: a neglected and growing public health problem worldwide.* Trop Med Int Health **14**(11), 1414–7. doi: 10.1111/j.1365-3156.2009.02386.x. Epub 2009 Sep 4. PMID: 19735368
7. https://noharm-global.org/sites/default/files/documentsfiles/5961/HealthCaresClimateFootprint_092319.pdf

Public health research communities, like Climate-Health Africa Network for Collaboration and Engagement (CHANCE) and African Risk Capacity (ARC) are spearheading efforts to mitigate the carbon footprint of healthcare facilities, as well as institutions, such as South Africa's George Hospital and Aga Khan Hospital, which are at the forefront of environmentally sustainable healthcare research. One notable focus of such research is optimising the use of anaesthetic gases, with studies exploring innovative methods to minimise waste and emissions. These institutions are committed to knowledge-sharing initiatives, with the aim of disseminating best practices to other hospitals. He also described other climate-related efforts within the health sector in South Africa, like tree-planting initiatives at facilities like Heidelberg Hospital, which reflect a commitment to fostering climate-resilient healthcare infrastructure that prioritises both patient well-being and environmental stewardship. Dr Lokotola argued that these collaborative research and practical interventions symbolise a promising shift towards greener and more sustainable healthcare practices.

Focusing in more detail on how healthcare facilities can reduce their carbon footprint, Dr Lokotola discussed the challenges here, and the need for a multifaceted approach. Firstly, the lack of evaluation mechanisms (indicators/metrics) hinders the ability to assess the effectiveness of sustainability initiatives. In response to this problem, he suggested establishing robust data and indicators at the district or community level, to enable tracking of the impacts of climate change on health, better informed decision-making and more targeted interventions. Secondly, Dr Lokotola indicated that there is a pressing need to bolster capacity within healthcare systems to implement and monitor environmentally friendly practices.

Thirdly, there is a lack of accountability in regard to local community health, with a need to foster a culture of responsibility and engagement among healthcare providers. Decentralising decision-making power to district and community levels could enhance community participation and community ownership of climate-resilient strategies. On a related point, Dr Lokotola argued that healthcare professionals should advocate for sustainability and raise awareness of the issue within their communities. Fourthly, financial constraints, which are particularly prevalent in low- and middle-income countries, pose considerable barriers to undertaking climate change activities in the health sector. He suggested that addressing these financial barriers is crucial for scaling up the implementation of climate and environmental strategies in the health sector.

Dr Lokotola ended by stating that overcoming all these challenges and implementing sustainable healthcare practices that ensure the well-being of both the population and the planet will demand collaborative action, innovative solutions, sustained investment and a holistic approach to healthcare. He suggested that collaborative learning platforms like the Community of Practice in Ecosystem Approaches to Health can be helpful in enabling this transformative change. In these ways, health facilities can enhance their resilience, better serve the needs of both the population and the environment and avoid maladaptation (see figure below).



Dr Edeh: Determinants shaping African policies relating to climate change and health

In her presentation, Dr Edeh described the targets of The Paris Agreement, which set ambitious targets to curb global warming, and by limiting the temperature rise at below 2°C above pre-industrial levels, with a further aspiration to limit it to 1.5°C to mitigate the most severe impacts of climate change. Unfortunately, temperatures are already nearing the 1.5°C limit; nonetheless, achieving these goals would prevent substantial morbidity and mortality. Mitigating climate change has direct and indirect health co-benefits, especially in developing countries where vulnerable populations are disproportionately at risk. The important co-benefits of reduced air pollution will ultimately lead to better health outcomes for communities worldwide and contribute to greater global health equity.

To bolster Africa's resilience to climate change and its impacts on health, Dr Edeh noted a coordinated regional climate intervention as imperative. Such an intervention would also strengthen collaboration among the African Union and regional partners, thereby enhancing Africa's collective stance in global climate negotiations and ensuring its interests are effectively represented.

Moreover, Dr Edeh argued that the infrastructure support for healthcare facilities is paramount to ensure adequate response capacity in the face of climate-induced health challenges. She stated that combining climate change policy with governance measures is essential. This includes strengthening institutional structures and fostering good governance practices, which are crucial for effective implementation and enforcement of climate change policies. Dr Edeh suggested that by integrating climate policy and governance into the framework of interventions, Africa can enhance its resilience to climate change while simultaneously advancing health outcomes and sustainable development.

To conclude, Dr Edeh advocated for a comprehensive adaptation policy framework in Africa, focusing on health system recovery, equity and multisectoral collaboration. She emphasised the importance of building capacity among healthcare workers, especially in countries with weaker systems, and called for global cooperation in pandemic response and disaster management to bolster resilience against future health crises.

Breakout sessions: Empowering African health systems – innovations and interventions for climate

Policy

During the breakout session on the policy track there was collective agreement amongst the participants that there is a need for urgent and coordinated action, strengthened policies, improved health systems and enhanced collaboration between African countries to address the complex intersection of climate change and health. According to the participants, addressing these challenges requires a holistic, multisectoral approach that prioritises resilience, adaptation and sustainable development.

The following are some of the points raised by participants regarding the policy track:

The approach to policy planning in Africa is disjointed
African countries lack a unified voice at the level of international policy planning, such as at the Conference of the Parties (COP), due to diverse regional contexts and perspectives. The absence of a coordinated approach hinders Africa's ability to effectively advocate for its own interests, leads to substandard outcomes, and undermines Africa's influence in shaping global climate policies and agreements. Coordination among ministries at the national level is crucial for effective climate change and health action. However, many African countries struggle to achieve this coordination, leading to fragmented responses and inefficient use of resources. Health vulnerabilities that are of particular significance in Africa include infectious diseases, vector-borne diseases, cardiovascular diseases, respiratory ailments and meningitis, and these are affected by issues such as migration and food and water security.

There is a need for robust policy frameworks and legislative support
Inadequate policy frameworks compound the challenges faced by Africa in addressing climate change and health. Policies lack strength, efficiency and integration into national development plans, hindering effective adaptation efforts. There is an urgent need for committed officials to enact and enforce laws effectively by identifying appropriate interventions and determining the relevant actors responsible for implementation. For instance, South Africa's climate change bill, though not yet enacted into law, includes adaptation measures.

There are limited publications on climate change and health, and collaboration in – and funding for – research is lacking
Africa's limited scientific publications on climate change and health mirror broader challenges of insufficient research and insufficient funding for, and collaboration in, research in the region. This creates a knowledge gap that hampers progress in addressing climate-related health issues. To address this gap, of particular importance is conducting transdisciplinary modelling to forecast future trends and challenges over the next few years and to inform policy decisions. This will require extensive data collection at both global and local levels. In this regard, it is important to note that while global perspectives provide valuable insights, localised data – including community perspectives and subnational-level information – are equally vital; however, there is still a lack of robust evidence at the local level. To address this lack, there is a need to invest in case studies, implementation research and a balanced mix of qualitative and quantitative methods.

Public awareness and access to information should be enhanced
A significant challenge is ensuring policy transparency and accessibility. Policies often remain inaccessible to the public, with a need for additional processes to disseminate them. For example, in South Africa, access to information is hindered by the lack of explicit provisions in Bills, with relevant provisions

contained in multiple regulations. Although access to information is formally protected under the Freedom of Information Act, the process of obtaining information can be cumbersome, even when the assistance of NGOs is provided. Ensuring the formal right to access information requires the translation of national policies into language and provisions that are applicable to, and can be understood by, local communities. However, rural communities often lack awareness of policies, highlighting the need for effective delivery strategies that consider the complex interaction of factors involved.

The role of NGOs and civil society

Civil society plays a pivotal role as a primary interface in policymaking and policy dissemination, representing the voices and concerns of communities. NGOs serve as advocates for marginalised groups and facilitate communication between citizens and policymakers, ensuring that policies are responsive to the needs of the people. Donors also increasingly provide funding directly to NGOs, recognising their grassroots connections and ability to implement projects efficiently. For instance, in Malawi, NGOs have conducted climate vulnerability assessments, which are crucial for understanding and addressing the impacts of climate change on local communities. These assessments provide valuable data that policymakers and aid organisations can use to formulate targeted interventions and adaptation strategies.

Sectoral planning and cross-sector collaboration relating to climate change are lacking, from regional to community level

Few African countries possess health sector-specific adaptation plans, with fewer than 20% having national health climate adaptation plans, and climate-smart sector implementation plans and investments also remain lacking. Furthermore, the integration of climate considerations into sectoral planning, including in the health sector, remains weak. There is a need for a multisectoral approach as health sector components intersect with various aspects of society and governance. Regional and national multisectoral meetings should be held, involving politicians at all levels, to facilitate dialogue in this area. National climate change committees can play a coordinating role, while the establishment of climate change health ambassadors, both nationally and at grassroots levels, can further enhance advocacy and action. In regard to the community level, establishing community climate health response agencies can enhance local capacity to mitigate and respond to climate impacts. It is crucial to expand and strengthen community health response programmes – and also to support women to act as first responders in climate-related disasters.

Bridging the gap between science and policy remains essential

In Nigeria, template laws covering health and climate change have been taken to parliamentarians in the hope of passing laws that mandate action. There is a need to promote the World Health Organization's (WHO's) Health in All Policies (HIAP) tool during the development of Nationally Determined Contributions (NDC) and National Health Adaptation Plans (NHAPs).

Research

During the breakout session on Research, participants raised wide-ranging issues from the fragmentation of climate change research in Africa, to the lack of longitudinal cohort data needed to understand the long-term impacts of climate change on health and society.

Climate change research is taking place in parts of Africa, but it is fragmented

While research on climate change has been initiated in East Africa, Southern Africa and parts of West Africa, there are regions where awareness of climate change is still lacking. At the same time, learning from initiatives such as the early warning systems in Tanzania and the climate-smart villages approach in Ghana, Senegal and Mali is promising, but implementation by governments is slow, and not transferred between countries and regions. Research programmes often operate in fragmented silos, hampering collaboration and knowledge exchange. Although there are many African publications on infectious and vector-borne diseases, translating research findings into policies remains challenging. Limited in-country funding for climate research exacerbates shortages of data and of modelling scientists. At the same time, community-level engagement initiatives, like Planetary Health Day discussions between healthcare providers and communities, provide opportunities for grassroots participation.

There is a need for collaborative efforts in climate change research and action

Many research institutions are adopting a multidisciplinary approach and partnering with humanitarian organisations, such as the Red Cross, to address climate change challenges comprehensively. For example, in South Africa, the implementation of a National Climate Change Adaptation Strategy has transformed a previously siloed approach to research into a centralised approach, ensuring greater coordination and efficiency. Under the strategy, an integrated climate change information system directs all research into one centralised platform, streamlining access to research and facilitating prioritisation of leading research projects as funding becomes available. Under this strategy the prioritisation of funding for Master's and PhD students ensures the cultivation of a new generation of researchers who are equipped to tackle climate change issues effectively. Behavioural interventions aimed at mitigating carbon footprints, such as those implemented in the Faculty of Medical and Health Sciences at Stellenbosch University, likewise highlight the importance of interdisciplinary approaches in addressing climate change. Similarly, initiatives like the multidisciplinary team at the University of Ghana, consisting of behavioural scientists, social scientists, nurses and NGOs, exemplify collaborative efforts to address climate change from various angles and perspectives.

Funding mechanisms for scaling up evidence-based interventions

Scaling up successful pilot interventions implemented in a research context remains a persistent challenge in addressing climate change due to a lack of funding. Researchers are investigating industry financing models and advocating for the 'polluter pays' principle, implemented through government channels, such as levies and taxes, which hold companies accountable for their effects on the climate as alternative funding mechanisms. Furthermore, in response to the limitations of traditional funding bodies, researchers are also increasingly approaching companies directly to seek funding.

Addressing data gaps is essential in order to strengthen the evidence base

There is a notable lack of longitudinal cohort data in Africa, which is crucial for understanding the long-term impacts of climate change on health and society. Additionally, population-based data are necessary to assess the broader trends and impacts of climate change on communities, while both longitudinal data and population-based data are necessary to understand the effectiveness and impact of interventions over time. At the same time, data to operationalise early warning systems are particularly critical for effective disaster preparedness and response. In this regard, local and community knowledge systems can provide valuable insights and complement scientific data collection efforts. Thus, incorporating local knowledge systems into research projects and prioritising community engagement are essential for fostering ownership and sustainability. Moreover, the evaluation and monitoring of intervention studies are often overlooked, which can result in a failure to scale up useful interventions. Finally, establishing a formal platform to share experiences and findings can help avoid duplication of research efforts and foster collaboration in addressing evidence gaps.

Tools/mechanisms/strategies that can help to overcome barriers

To enhance climate change research and action there is a need for greater interaction among research departments at national and regional levels, which can be facilitated by greater government engagement with researchers. At the same time, utilising app technology for data collection on smartphones can improve data accessibility in resource-limited areas. A clear description of the impacts of research studies helps to communicate the role of transdisciplinary teams and overcome barriers from ethics committees. Reporting on climate change workshops with actionable outputs can support effective strategies in the African context.

The value of multidisciplinary collaboration for research

Facilitating multisectoral collaboration in addressing climate change requires a fundamental shift in the mindset of climate change researchers to embrace multidisciplinary teams and disciplines that include not only scientists but also behavioural scientists, social scientists and property developers. By fostering collaboration among diverse fields, it is possible to harness a broader range of expertise and perspectives, which can help in developing more inclusive and effective solutions. Additionally, establishing robust partnerships with funders and government agencies further strengthens collaborative efforts, ensuring that resources and support are aligned with the shared goal of mitigating climate change impacts.

Data

During the breakout session on the data track, participants discussed how meteorological and health-related data are essential in order to quantify the adaptation and resilience needs on the ground. In addition, they suggested that ensuring data on climate change and health that are both accurate and integrated is essential for evidence-based decision-making and policy formulation. Participants suggested that across Africa there are abundant sources of health-related data, robust infrastructure for data processing and storage, and a network of ground-based meteorological stations, although this availability differs per country. The gaps and opportunities that are common amongst the different regions were also discussed.

The following themes emerged from the data track:

There is a need for investment in more accurate data repositories
Verifying the accuracy of re-analysis data (datasets that are crucial for climate monitoring and research) and downscaled climate models presents a challenge. Even though there are large databanks, there are still large data gaps. There is a need to prioritise investment in high-quality meteorological data that is unaffected by challenges such as load shedding.[8,9] High-quality data repositories can facilitate international collaboration and data-sharing agreements between countries and organisations, and so are a major building block in the collective effort to address climate and health challenges.

Data management and utilisation need to be improved
Proficiency in database management and seamless integration of data sources are indispensable. The appropriate documentation of metadata and the development of standardised data collection, reporting and storage are essential to this endeavour. Digitisation of hard-copy records and the enhancement of personnel skills and storage infrastructure are likewise essential. Furthermore, when integrating data, it is imperative to consider privacy, responsible use and data sharing. Additionally, addressing cultural, religious, political and language barriers is essential for fostering collaboration.

There is a need for standardised metrics
To date, a notable gap in the African context is the absence of standard metrics to adequately capture and compare the efficacy of resilience and adaptation projects. Furthermore, very little research exists on indicators of the effectiveness of adaptation activities, particularly in the health sector in Africa.

Making climate and health data more accessible can enhance disaster preparedness
Participatory geographic information system (GIS) initiatives can provide mapping and data collection to enhance early warning systems and response mechanisms. Additionally, the downscaling of global climate models, as exemplified by CORDEX AFRICA, helps to provide localised climate impact assessments, which is particularly crucial for localised data in Africa. Moreover, the digitisation of historical climate and health data, alongside networks like Trans-African Hydro-Meteorological Observatory (TAHMO), enhances data accessibility and analysis, which are crucial for understanding the correlation between climate and health outcomes.

Strategies for overcoming data availability barriers
There is a need for data warehouses and the careful use of open access platforms (without compromising privacy constraints). In addition, promoting interactive GIS and citizen science initiatives can facilitate community engagement. Other important initiatives include employing remote-sensing technologies, providing multidisciplinary training, raising awareness of data sharing benefits and establishing feedback loops for continuous improvement. Acknowledging data providers in academic publications is also important. These strategies can collectively enhance accessibility, reliability, transferability and utilisation of crucial data for addressing climate and health challenges in Africa.

Empowering action across global, national, regional and local levels
To effectively address the intersection of health and climate change challenges, a cohesive approach to

8. Load shedding refers to the temporary disruption of electricity to prevent severe power outages and electricity grid failures
9. https://www.entergynewsroom.com/storm-center/restoration/loadshed/

data is vital. This involves leveraging the expertise and resources of global organisations, such as the WHO and WMO, alongside regional players like the African Union, Southern African Development Community (SADC) and Economic Community of West African States (ECOWAS). Various initiatives are required: putting in place multinational data sharing agreements to facilitate the exchange of crucial information across borders; investing in multinational training programmes to enhance skills development and capacity-building efforts; leveraging existing infrastructure and human capital to maximise efficiency and resource utilisation; and implementing national-level policy directives to promote collaboration and standardise data collection methods, which can foster transboundary cooperation. Finally, expert group collaborations can provide valuable insights by reporting on the state of health and climate at a regional level, which can guide strategic decision-making processes.

Community engagement

During the breakout session on the community engagement track, participants highlighted the importance of community engagement in developing and implementing health system climate adaptation strategies. Participants defined communities as the backbone of society, comprising groups of individuals who are bound by shared interests and aspirations. These can include local neighbourhoods, academic institutions or professional circles ranging from medical practitioners to farmers. However, effective community engagement and involvement is often elusive or is sidelined and can be complicated by power dynamics and varying interests.

The following themes emerged from the community engagement track:

Collaboration on engaging communities

While programmes exist across Africa that engage communities in health and climate change issues, siloed approaches sometimes lead to inefficient allocation of already limited resources. Thus, it is necessary that initiatives do not duplicate existing institutions but rather complement them. To promote collaboration, living labs should be established, to overcome the obstacles to understanding the needs of communities and to capturing local knowledge systems. Living labs are 'real-world environments where research and experimentation take place in an open and collaborative manner'; they test interventions to ensure they are effective.[10] Moreover, in light of the widespread absence of frameworks for assessing community knowledge, it is important to set up Community Boards and to encourage coordination among stakeholders. Furthermore, developing communities of practice can foster knowledge-sharing and innovation, ensuring that community engagement efforts are inclusive, effective and sustainable.

The pivotal role of government leadership

While NGOs often fill the void left by limited government leadership, truly sustainable development requires a concerted effort involving all sectors of society. Inclusive and coordinated community engagement can help unlock the full potential of collective wisdom and drive meaningful change. By contrast, inadequate government involvement, either from the outset or due to the appointment of ill-suited representatives, can lead to a lack of continuity and can undermine the legitimacy of engagement efforts.

Navigating gaps and overcoming barriers in community engagement

The limited participation of communities often results in the absence of authentic community voices in decision-making processes. Compounding this issue is the lack of capacity and knowledge within communities to actively engage in these discussions. Moreover, a pervasive lack of trust, stemming from historical disenfranchisement and broken promises, can further complicate matters. Building trust takes time and concerted effort.

Innovative approaches to community engagement in disaster management

There is a need to envision a more resilient and community-centric approach to disaster preparedness. Two examples of such an approach are communal water management and timely disaster communication. By equipping communities with timely disaster communication, as happens in Japan's National Tsunami Alert system, proactive and timely communication enables swift response mechanisms, helping to safeguard lives and livelihoods against impending threats.

10. https://ec.europa.eu/newsroom/rtd/items/810822/en#:~:text=Living%20labs%20are%20real%2Dworld,and%20address%20real%2Dworld%20needs

Resilience and climate adaptation initiatives in the health sector

During the workshop, contributors gave presentations on different studies and initiatives on enhancing climate resilience and adaptation in African health systems. Summaries of these presentations are given below.

Dr Zakari Ali: Sustainable diets in sub-Saharan Africa – implications for health and food systems' adaptation to climate change

Dr Ali described the challenges that climate change is placing on the food system in The Gambia. He analysed the dietary habits among the population, and the impacts of climate variables on agricultural production. He outlined strategic measures to foster agricultural self-sufficiency, thereby strengthening resilience, bolstering food security and mitigating risks posed by climate-related disasters at the global level.

The Gambia's population of over 2 million people is heavily reliant on imported fruit and vegetables, rice and cereals, with local cash crops like cassava being cultivated but not widely consumed within the country. This underscores the need for strategic interventions to align specific food production with local dietary needs and climate resilience. The climate impact of diets may be lower in Africa compared with other settings due to the lower level of meat consumption compared with high-income countries. However, diets in The Gambia have a high sugar content with lower levels of fruits, vegetables and whole grains. Dr Ali argued that the promotion of healthier diets alongside diversification of agriculture to meet the population's nutritional needs is imperative, without escalating the carbon footprint. He said that initiatives led by the Ministry of Environment, Climate Change & Natural Resources, focusing on evidence-based evaluations of adaptation strategies, are pivotal in this regard. He emphasised the importance of addressing agricultural practices and the population's dietary intake to enhance food security and mitigate environmental impacts.

Professor Matthew Baylis: Exploring the need to develop models to forecast the future impact of climate change on vector-borne diseases for adaptation and resilience

Professor Baylis shared his knowledge and expertise in modelling the transmission risk of vector-borne diseases and discussed the impact of climate change on vector-borne disease transmission using the examples of the Zika virus, which is transmitted by mosquitoes, and a viral disease called bluetongue, which affects sheep and is transmitted by midges. Professor Baylis explained that to develop models of vector transmission for use in early warning systems and to predict epidemics, investigators use four factors: vector competence, vector distribution, vector abundance of the vector relative to hosts, and the vectorial capacity or ability to transmit pathogens. All these factors are dependent on the climate.

Professor Baylis described the concept of vectorial capacity, which is the expected number of feeds taken by infectious individuals in a vector population, such as mosquitoes, per susceptible host. Once infected, the vector remains infectious throughout its life cycle. Warmer temperatures sustain vector and host ecology. However, as Professor Baylis pointed out, the mortality rate of vectors tends to rise with increasing temperatures. Thus, the transmission of vector-borne diseases may not necessarily increase with increasing temperature. In fact, in some cases transmission rates may decrease due to the complex interplay between climate and vector biology.

Vector-borne diseases are considered 'climate sensitive' because the climate influences both the vectors themselves and their ability to transmit pathogens. Modelling provides evidence that climate change, and climate variability, are contributing to the emergence and spread of vector-borne diseases. Modelling also enables us to predict whether adaptation measures are needed and whether we have the necessary tools to achieve this.

Zika virus is a fascinating example of the dynamics of vector-borne diseases. Originating in Uganda and Nigeria, the virus remained relatively obscure for over six decades, with only sporadic human cases reported. However, its impact dramatically escalated when it reached Yap Island in the southwestern Pacific Ocean in 2007, resulting in thousands of cases.[11] Subsequent outbreaks in French Polynesia saw tens of thousands affected,[12] and when it spread to South America the number of cases soared into the millions.[13] This prompted intensive research efforts, leading to the development of a model that elucidated the risk factors for Zika transmission.[14] Africa and South America emerged as regions of heightened risk in 2015, as quantified by annual transmission rates dating back to the 1950s, and a link between increased Zika transmission in 2015 and El Niño events was uncovered, demonstrating the influence of large-scale climatic phenomena on disease spread. Specifically, the movement of warm water across the Pacific Ocean during El Niño events alters air pressure differentials, sea surface temperatures and atmospheric conditions, collectively known as the El Niño Southern Oscillation. Professor Baylis suggested that this research underscores the complex interplay between environmental factors and infectious disease dynamics, providing valuable insights for disease control and prevention efforts.

Professor Baylis presented another fascinating example of the impact of climate on vector-borne disease transmission: the occurrence of bluetongue in sheep. He explained that the prevalence of *Culicoides* biting midges, commonly known as 'midges', is not confined to Africa (being notably more prevalent in the UK). Due to their diminutive size, midges possess the ability to feed on the blood of mosquitoes. Professor Baylis discussed how the vector-borne disease bluetongue has emerged in Europe over the past two decades, and is now effectively endemic in the region. He explained that the basic reproduction number (R0) of bluetongue has surged since the mid-1990s, and that models suggest that midge populations are becoming increasingly adept at spreading the virus, likely in response to climate change. These models not only predict the risk and scale of future epidemics but also give researchers the ability to predict whether we can adapt to these evolving diseases. As Professor Baylis explained, models demonstrate that even under high emissions scenarios, current control measures can effectively mitigate the spread of bluetongue.[15] Professor Baylis argued that this research underscores the importance of proactive measures in managing and controlling emerging vector-borne diseases in the face of changing climatic conditions.

11. Hayes EB (2009). *Zika virus outside Africa.* Emerg Infect Dis **15**(9), 1347–50. doi: 10.3201/eid1509.090442. PMID: 19788800; PMCID: PMC2819875
12. https://www.npr.org/sections/goatsandsoda/2016/02/09/466152313/zika-in-french-polynesia-it-struck-hard-in-2013-then-disappeared
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14. Caminade, C *et al.* (2016). *Global risk model for vector-borne transmission of Zika virus reveals the role of El Niño 2015.* PNAS, doi:10.1073/pnas.1614303114
15. Jones, AE *et al.* (2019). *Bluetongue risk under future climates.* Nature Clim Change **9**, 153–7. https://doi.org/10.1038/s41558-018-0376-6

Dr Gloria Maimela: Evaluating the effectiveness of heat adaptation interventions for pregnant women, infants and healthcare workers

Dr Maimela showcased her work at the Wits Reproductive Health and HIV Institute to demonstrate the significance of evidence-based heat adaptation measures. Firstly, she highlighted the scarcity of data in this field from low- and middle-income countries, with most data originating from high-income countries,[16] suggesting a need for more studies in low- to middle-income countries. Dr Maimela then introduced her work with the HIGH Horizons project, aimed at implementing heat indicators for global health surveillance, and early warning systems to mitigate heat impacts on pregnant women, infants and healthcare workers in the EU and Africa. This project focuses on identifying cost-effective interventions to alleviate heat impacts on healthcare workers and to reduce associated carbon emissions. According to Dr Maimela, preliminary findings from ethnographic observations underscore the need for interventions such as optimising indoor thermal environments, protecting newborns from heat exposure, and addressing workload-related challenges faced by healthcare workers. Dr Maimela explained that through empirical evidence and continuous monitoring, the HIGH Horizons project aims to inform the co-design of climate change adaptation interventions for health facilities in South Africa and Zimbabwe, while exploring the feasibility of, and attitudes towards, heat adaptation strategies.

Dr Maimela went on to showcase innovative approaches to early warning systems for communities, such as the ClimApp, which delivers personalised thermal climate warnings. Emphasising the vital role of community engagement, she discussed a workshop conducted during a heatwave in Gauteng, during which pregnant and postpartum women were encouraged to capture photos illustrating the severity of the heat, advocating for investment in heat adaptation measures in their respective areas. A total of 303 photographs were submitted by these women. Additionally, Dr Maimela introduced the Heat Adaptation for Pregnant women and Infants (HAPI) study, which aims to advance heat adaptation policies and practices in low- and middle-income countries, particularly in Southern Africa, through the development and testing of a collaboratively designed intervention that focuses on reducing heat impacts on pregnant women and newborns, with a primary emphasis on community involvement at the household level.

Finally, Dr Maimela highlighted the role the CHANCE Network is playing as a collaborative platform that unites policymakers, researchers, climate scientists and various stakeholders dedicated to addressing climate change and health challenges in Africa. With the core aim of fostering synergies across East, West and Southern Africa, the network strives to advance regional policymaking, facilitate knowledge exchanges and promote cooperation among diverse stakeholders. Additionally, it aims to support national and regional initiatives by aiding in securing funding for climate change and health-related programming and research endeavours. Dr Maimela explained that the CHANCE Network is supported by Enhancing Belmont Research Action to support EU policymaking on climate change and health (ENBEL) and funded by the EU Horizons programme, and plays a pivotal role in facilitating coordination and networking efforts to tackle climate change and health issues effectively across the African continent.

16. Chersich MF *et al.* (2020). *Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: systematic review and meta-analysis.* BMJ **371**, m3811. doi: 10.1136/bmj.m3811. PMID: 33148618; PMCID: PMC7610201.

Dr Christopher Green: Developing the next generation of vaccine cold chain systems for future resilience and vaccine security for African communities

Dr Green discussed his groundbreaking work in Rwanda, which showcases innovative approaches to the storage and deployment of mRNA vaccines, particularly in times of emergency. He explained how existing vaccine storage facilities at both fridge and freezer levels were initially mapped out, using audit data from the Rwanda Biomedical Centre (RBC). It became evident that these freezer storage units were often located far from areas requiring vaccine rollouts to patients, posing significant challenges in transportation via conventional road systems and potentially compromising vaccine integrity. Consequently, the concept of leveraging unmanned aerial vehicles or drones emerged as a promising solution for efficient vaccine distribution, marking a significant advancement in the field. This innovative approach aligns closely with the research interests of Africa Centre of Excellence for Sustainable Cooling and Cold Chain Systems (ACES), which focuses on designing the next-generation cold chains for African settings (both food from 'farm to fork', and in reverse, vaccines from freezer to the patient). Their research programmes encompass real-world vaccine cold chain models, digital twins for understanding threats such as climate change and disease outbreaks, and the integration of biomedical data to enhance vaccine deployment efficiency. Additionally, ACES Healthcare conducts clinical trials, develops novel technologies for real-time vaccine decision-making, and utilises bioinformatics for climate change threat planning, reflecting a holistic approach to addressing healthcare challenges in Africa.

Anne Gudere: Climate resilience and environmentally sustainable interventions in developing countries

Anne Gudere from Kenyatta University discussed that in the face of escalating climate change impacts there is an urgent need to implement adaptation and mitigation measures across various sectors, including health and agriculture. She explained that building resilience within communities necessitates facilitating access to climate-smart interventions aimed at both adaptation and mitigation. She argued that central to this effort is the promotion of livelihood diversification among communities, to increase their ability to withstand and respond effectively to the challenges posed by climate change. Considering this, Ms Gudere described how she set out to explore the efficacy of adaptation and mitigation interventions in reducing vulnerability, with a particular focus on promoting access to climate-smart solutions and encouraging livelihood diversification within communities. Through this research, she and her colleagues aimed to contribute to the discourse on building resilience in the face of climate change and enhancing community preparedness to confront its impacts.

Ms Gudere's study, which was conducted in Marsabit County in Kenya, employed a survey research design, focusing specifically on Saku Sub-County, which falls within agro-ecological zones IV and V, and which was purposively chosen for its representativeness of the region. Ms Gudere explained that the study utilised stratified sampling to select three wards within the sub-county, and that the sampling frame consisted of households that were primarily engaged in crop cultivation and livestock-rearing as their main economic activities. According to Ms Gudere, agro-pastoralists from Karare, Sagante/Jaldesa and Dakabaricha/Marsabit

Central wards were randomly selected for participation. The study population comprised 373 households, determined by applying the Yamane formula.

Ms Gudere explained that the study investigated the impacts of adopting climate-smart technologies, and that it found significantly higher incomes among agro-pastoralists who embraced these innovations. Moreover, she explained that the study found that households relying on both crops and livestock for income recorded more positive coefficients, compared with those solely dependent on either crops or livestock. According to Ms Gudere, the integration of climate-smart interventions enabled community members to diversify their diets, consequently reducing malnutrition rates. Notably, efficient water management practices, a key component of climate-smart agriculture, were identified as vital for enhancing food security, particularly in arid and semi-arid areas. Ms Gudere suggested that the increase in income resulting from climate-smart technologies and practices also contributed to improved health outcomes, as it enhanced access to healthcare and other necessities.

Annexes

Annexe one: Steering committee

Co-chairs

Professor Ashley Woodcock FMedSci, Professor of Respiratory Medicine, University of Manchester

Professor Loretta Feris, Professor of Environmental Law, University of Pretoria

Members

Dr Peninah Murage, Assistant Professor, London School of Hygiene & Tropical Medicine

Dr Robert Zougmore, West Africa Lead, Accelerating Impact of CGIAR Climate Research for Africa (AICCRA), Alliance of Bioversity International and CIAT

Sinah Kgosietsile, Associate Researcher at Botswana Institute for Technology Research and Innovation (BITRI)

Dr Thandi Kapwata, Specialist Scientist, Environment & Health Research Unit, South African Medical Research Council

Dr Youba Sokona, Former Vice-Chair of the Intergovernmental Panel on Climate Change (IPCC); Honorary Professor at University College London

Annexe two: Attendees

Abraham Motau, University of Botswana
Professor Adamson Muula, Academy of Sciences of Malawi; Kamuzu University of Health Sciences, Malawi
Dr Ama Essel, Community Health Physician Specialist, Consultant for LFA for Global Fund
Amudi Chioma Felistas Edeh, National Council on Climate Change
Dr Annah Mabidi, National University of Science and Technology, Bulawayo
Anne Timbor Gudere, Kenya Agricultural Research & Livestock Organization
Christian Lueme Lokotola, Stellenbosch University
Dr Christopher Green, University of Birmingham
Professor Coleen Vogel, University of the Witwatersrand
Professor David Denning FMedSci, University of Manchester
Delani Mathevula, Department of Forestry, Fisheries and the Environment, South Africa
Delme Cupido, Natural Justice
Dr Deoraj Caussy, Integrated Epidemiology Solutions
Professor Dorothy Yeboah-Manu, Noguchi Memorial Institute for Medical Research, University of Ghana
Faith Nkohla, Department of Forestry, Fisheries and the Environment, South Africa
Dr Gloria Maimela, The Wits Reproductive Health and HIV Institute
Hanna Andrea Rother, University of Cape Town
Dr Henry Roman, International Water Management Institute
Jackie Kado, Network of African Science Academies
Professor Jennifer Fitchett, University of the Witwatersrand; South African Young Academy of Science
Jerome Singh, University of Toronto
Professor Josephine Ngaira, Masinde Muliro University of Science and Technology
Professor Judicaël Obame-Nkoghe, University of Science and Technology of Masuku; Interdisciplinary Centre for Medical Research
Lukoye Atwoli, Aga Khan University Medical College, East Africa

Lydia Adeleke Mosunmola, University of Technology, Nigeria
Professor Marizvikuru Manjoro, University of Venda; South African Young Academy of Science alumna
Martin Muchangi, Amref Health Africa
Martina Dhliwayo, Seed Global Health
Dr Matlhogonolo Kelepile, University of Botswana
Professor Matthew Baylis, Oxenhale Chair of Veterinary Epidemiology Livestock & One Health, University of Liverpool
Professor Michael Kidd, University of Kwazulu-Natal
Mikateko Sithole, Department of Environmental Affairs, South Africa
Modathir Zaroug, Nile Basin Initiative
Mohau Mateyisi, Council for Scientific and Industrial Research
Moses John Chimbari, Great Zimbabwe University; University of KwaZulu-Natal
Mwila Musumali, African Development Bank Group
Ntombi Maphosa, Centre for Environmental Rights
Ntokozo Mnyandu, University of KwaZulu-Natal
Dr Oliver Moses, University of Botswana
Dr Pauline Scheelbeek, London School of Hygiene & Tropical Medicine
Professor Refilwe Nancy Phaswana-Mafuya, University of Johannesburg
Reitumetse Molotsoane, National Business Initiative
Professor Robert Kibugi, University of Nairobi
Dr Samwel M Limbu, University of Dar es Salaam
Dr Sokhna Thiam, African Population and Health Research Center
Dr Temitope Samuel Egbebiyi, University of Cape Town
Victor Ongoma, Mohammed VI Polytechnic University
Dr Zakari Ali, London School of Hygiene & Tropical Medicine

Annexe three: List of acronyms

WMO World Meteorological Organization
AU African Union
SADC Southern African Development Community
ECOWAS Economic Community of West African States
MECCNAR Ministry of Environment, Climate Change, and Natural Resources
HAPI Heat Adaptation for Pregnant women and Infants
AMS Academy of Medical Sciences
ASSAf Academy of Science of South Africa
CoP Communities of Practice
COP Conference of the Parties
EU European Union
WHO World Health Organization
HIAP Health in All Policies
NDC Nationally Determined Contributions
NHAP National Health Adaptation Plans
TAHMO Trans-African Hydro-Meteorological Observatory
MECCNAR Ministry of Environment, Climate Change, and Natural Resources

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