WEATHER AND CLIMATE INFORMATION SERVICES (WCIS) INTO USE FOR HEALTH

The role of County Meteorological Directors in Kenya

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INTRODUCTION

In Kenya, droughts are considered one of the biggest threats to achieving development outcomes. Their adverse impacts on people's health and well-being are compounded by limited healthcare provision in areas most exposed to droughts, as well as temperature increases and heat waves due to climate change.[1] In turn, populations who suffer from chronic malnutrition and other episodes of ill-health are less able to withstand climate shocks and other risks.[2]

Weather and Climate Information Services (WCIS) provide information on rainfall patterns, shifts and trends in temperatures, air quality and warning of extreme weather events that can help people to protect themselves, their health and their livelihoods.[3] WCIS have the potential to help populations and authorities to anticipate risks, such as drought, and implement response measures. However, the effectiveness depends on when and how well the information is communicated and whether it is useful, relevant, accessible and understood by people to inform decisions.

Healthcare providers are not typically targeted as end-users of WCIS.[4] Yet, they not only have an interest in weather and climate information since weather events pose risks to population health; they can also provide opportunities to communicate this information to communities and are sometimes better placed to reach all members of society, including women.[5] In the Kenyan context of devolved health governance and meteorological services, it is interesting to understand how WCIS can better support people's well-being, by providing information that serves the needs of the health sector. This paper particularly focuses on the role of the County Directors of Meteorology (CDMs) in the delivery of WCIS and how information is shared at sub-national level with the health sector.

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1 *GERICS– Climate Service Center Germany (2016)*
2 *Government of Kenya – GoK, (2015)*
3 *Based on the definition of the World Meteorological Organisation, "Weather and Climate Information Services prepare users for the weather they will actually experience. Climate services provide climate information in a way that assists decision making by individuals and organizations. Such services require appropriate engagement along with an effective access mechanism and must respond to user needs." https://gfcs.wmo.int/what_are_climate_weather_services*
4 *Vogel et al., 2019*
5 *Poulsen et al., 2015; Huyer et al., 2017*

WISER Weather and Climate Information Services for Africa
NIRAS ODI SOUTH SOUTH NORTH
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This paper aims to provide an introduction to WCIS in relation to the health sector by addressing three main questions:

I. How is Kenya's burden of disease impacted by the environmental determinants of health, such as safe water and clean air, weather conditions and climate change?
II. What are the main WCIS in Kenya and how are they provided at the County level to the health sector?
III. What benefits could WCIS tailored to healthcare providers needs bring?

Key messages

- Meteorological services in Kenya provide WCIS that are largely geared towards addressing drought risks. Short-term forecasts such as alerts and daily forecasts are reported to be more accurate, timely and easier to understand by end users.
- The Health sector tends not to be targeted by WCIS provision and feedback mechanisms are not established consistently.
- County level can offer a suitable context for local governments to raise awareness of WCIS provision and create demand from different sectors. Feedback mechanisms between WCIS users and producers need to be formalised so that WCIS producers understand what the needs of health actors are and can tailor information accordingly.
- The Kenyan Meteorological Department (KMD) must coordinate and strengthen observation stations across the country, equip observation stations, including mobile ones, to systematically collect data on air quality and make it publicly accessible.
- Funding schemes must be designed in a way that supports the co-production of WCIS across sectors and create accountability to address the needs of end-users from the health sector.
- The main factors limiting targeted forecasts for different sectors and specific locations are limited resources – human, financial and equipment.
- WCIS providers can draw lessons from the Maintains programme[6] for building the climate shock-responsiveness of Kenya's health system.

METHODOLOGY

To examine the delivery and relevance of WCIS for health in Kenya, particularly at sub-national level, the analysis draws on a combination of data sources. First, a review of the scientific literature provides a summary of the impacts of environmental shock and stresses on human health and the extent to which public health issues are exacerbated by the environmental determinants of health.

Second, seven interviews were conducted with key informants involved in the production of WCIS in Kenya. This includes County Directors of Meteorology (CDMs) from Kwale, Kilifi and Kitui Counties, and representatives from KMD, the National Drought Management Authority (NDMA) and the Kenya Medical Research Institute (KEMRI). The COVID-19 pandemic halted the initial plan to conduct fieldwork in the targeted Counties, namely Kitui and Kilifi, and interviews with healthcare providers. Instead, the enquiry was desk-based and focused on examining the roles of WCIS providers to support the health sector with attention to the major health issues in Kenya, as well as gender equality and social inclusion. Interviews were conducted remotely by phone.

6 *Fortnam et al. 2020*

Third, the paper draws on findings from the evaluation of the WISER CRISPP (Coastal Resilience and Improving Services for Potato Production in Kenya) project's coastal component implemented in Kenya. Grey literature from different programmes that aim to strengthen the health sector in the context of climate change were also gathered. This includes lessons from a recent study conducted by the Maintains programme on the levels of preparedness and response of health systems to climate shocks. Insights were also drawn from panel discussions with experts in the field of health, climate and WASH (Water, Sanitation and Hygiene) which took place on the 14th–15th April 2021 in Nairobi and online. The event sought to explore how knowledge on climate and health can contribute to anticipate climate-driven disease outbreaks and anticipate responses in WASH and health.[7]

A focus on the health sector brings attention to gender inequalities

Gender inequality is considered among the top causes of vulnerability to climate change in Kenya's National Climate Change Action Plan (NCCAP).[8] Individuals and communities who are socially, economically and politically marginalised are more likely to be vulnerable to the impacts of hazards and disaster events.[9] They might not have access to requisite services (due to transportation or cost issues) nor the capacity to deal with the sources of risks (i.e. air pollution) or the impacts of disasters (i.e. malnutrition), particularly in the absence of social support from the state, such as universal health coverage.[10] In Kenya (as in many other countries), women are more likely than men to experience a denial of their rights. This includes rights over their bodies and reproductive health, as well as property and inheritance rights. Women are disproportionately expected to take on unpaid care roles, they face ongoing underrepresentation in politics, and are the primary victims of gender-based violence.[11]

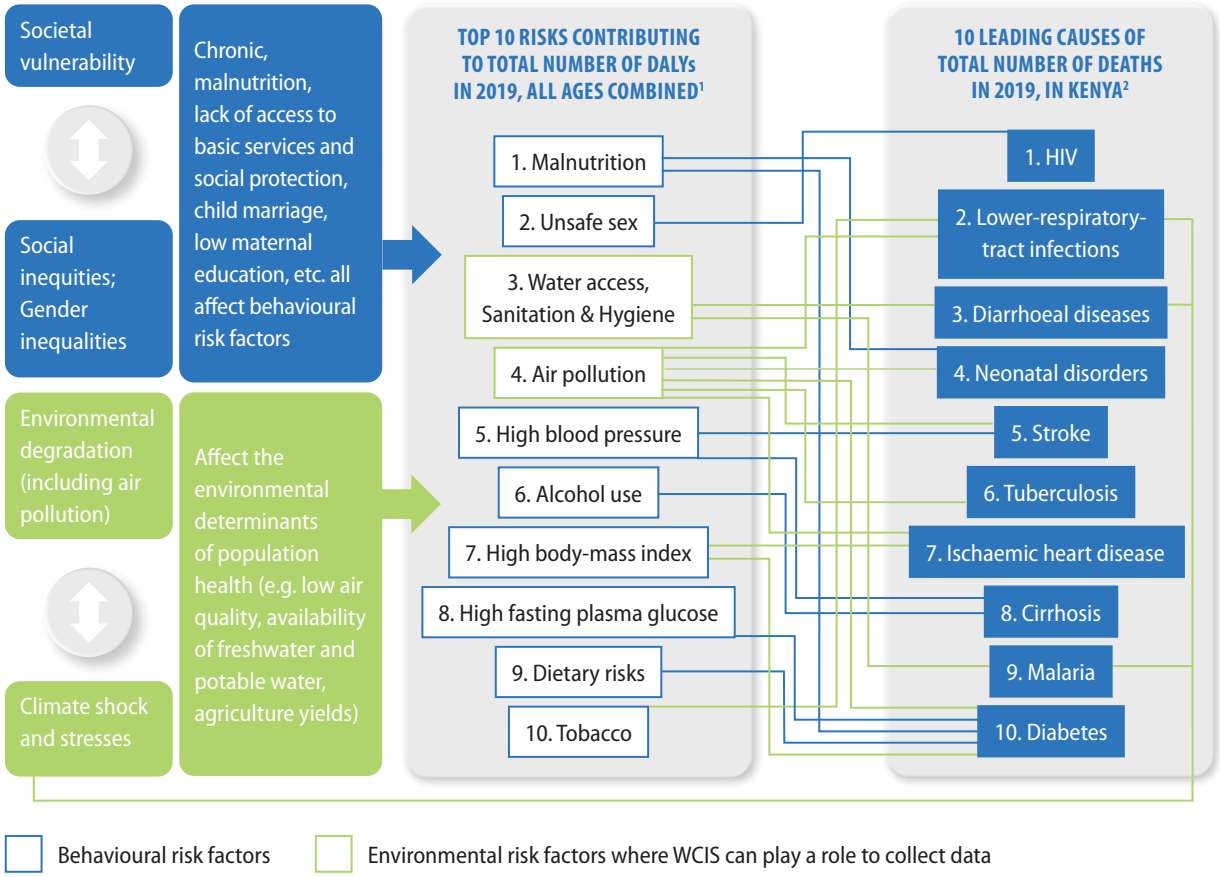
These inequalities restrict opportunities for women and impact their ability to access resources or services that could help them cope better with climate shocks and stresses.[12] National policies, such as Kenya's NCCAP, rely on gender analyses and stress the importance of inclusive climate-related action – for instance, gender-aware agricultural extension services to ensure that women receive, use and benefit from vital information such as WCIS. Social and gender-related inequalities also constitute a strong social determinant of (i) people's health status, (ii) people's access and use of healthcare, and (iii) how well health systems address the different needs that people of diverse genders, identities and sex characteristics have with respect to health care. A thorough understanding of the social determinants of health and how they interact with gender inequalities in both health needs and healthcare provision can help co-produce and deliver relevant WCIS.

7 *https://whatworks.co.ke/climate-workshop/index.php*
8 *GoK, 2018*
9 *Wisner et al., 2012*
10 *Clarke & Le Masson, 2017*
11 *GoK, 2019*
12 *Shale, M. 2020. They can also impact other social groups who are discriminated against on the basis of their age, ethnicity, religion and other social identities. "GENDER EQUALITY IN CLIMATE CHANGE Analysis report on Gender in Climate Change Policies, Programs and NDC Processes." https://www.uneca.org/sites/default/files/ACPC/Gender-Climate-Change/gender_analysis_of_climate_change_in_africa.pdf*

1 HOW IS KENYA'S BURDEN OF DISEASE IMPACTED BY ENVIRONMENTAL DETERMINANTS OF HEALTH?

In 2019, the top three leading causes of mortality in Kenya were HIV/AIDS, respiratory infections and diarrhoeal diseases[13] (Figure 1). A number of risk factors lead to these diseases and to premature mortality and disability (captured in Disability-adjusted life years – DALYs). The first of these risks is malnutrition, followed by unprotected sex, issues related to water access, sanitation and hygiene, and air pollution. These risk factors and their consequences on people's health are influenced not only by a person's individual characteristics and behaviours, but also by the socio-economic and the physical environment, referred to as the determinants of health.[14]

FIGURE 1 **Linkages between the environmental and social determinants of health, risk factors of disability-adjusted life years and leading causes of mortality in Kenya (Authors)**



1 Disability-adjusted life years (DALYs) encompass premature mortality (YLLs) and disability (YLDs) within a population. Source: IHME, 2020 based on The Lancet *study: https://doi.org/10.1016/S0140-6736(20)30752-2*

2 Source: IHME, 2020 based on The Lancet *study: https://doi.org/10.1016/S0140-6736(20)30925-9*

13 IHME, 2020 based on The Lancet *study: https://doi.org/10.1016/S0140-6736(20)30925-9*

14 WHO, 2021. https://www.who.int/news-room/q-a-detail/determinants-of-health

Climate change affects health in direct ways (by leading to mortality and morbidity) and indirect ways, as outlined in the Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment Report.[15] By also impacting negatively on water access, agriculture and other sectors of the economy, the manifestations of climate change affect the environmental determinants of health and intersect with societal vulnerabilities, which generate adverse consequences on malnutrition, sanitation and water-borne diseases, vector-borne diseases and respiratory illnesses.

First, the observed increase of temperature across all seasons, increase of heatwaves and decline of long rains in recent decades in Kenya is leading to longer and more intense droughts.[16] These generate crop failure, shrinking of productive crop areas and loss of livestock. All of these negatively impact food security.[17] According to the Global Hunger Index (2019), 29.4% of the population in Kenya is undernourished, with the highest proportions of stunted children[18] found in Kilifi (46%) and Kitui counties (39%).[19] The adverse impacts of drought are particularly acute for pastoralists in the Arid and Semi-Arid Land (ASAL) areas where 70% of livestock mortality is caused by drought.[20] Livestock production is also sensitive to heavy rainfall periods which trigger disease outbreaks that kill livestock, contributing indirectly to malnutrition due to loss of milk production and related income.[21] Chronic food insecurity and water scarcity are recurring issues for public health, particularly for pregnant women, lactating mothers, children and the elderly.[22] Nearly 1.17 million children and women require treatment for acute malnutrition, with around 135,500 of them experiencing severe acute malnutrition.[23] Projected changes in annual mean temperature range from +1.3 to +3.9 °C by 2085 (high confidence)[24] and the impacts of warming temperatures are likely to lead to further yield declines for the most important crops of maize and beans.[25] Loss of assets and disruptions in income streams can exacerbate episodes of ill-health, particularly in settings characterised by limited provision of basic services that worsen people's vulnerabilities.[26] Without adequate healthcare provision, climate change impacts will increase the proportion of stunted children who are dependent on rain-fed agriculture.[27]

Second, extreme weather events such as floods can cause direct impacts on mortality and morbidity. For instance, above average rainfall throughout May 2020 triggered flooding in more than three quarters of Kenya's Counties (36 out of 47), which displaced over 116,000 people[28] and killed 237 according to local news outlets. While climate projections of increases in mean precipitation across East Africa remain uncertain,[29] extreme rainfall and flood magnitudes are predicted to worsen in Kenya in the coming decades.[30] Riverine floods account for almost half of all disasters associated with hazards recorded in Kenya since 1964 and generate 27.5% of disaster-related fatalities.[31] Floods and heavy rainfall events negatively affect people's access to clean water and sanitation, particularly in ASAL Counties where basic services are limited.[32] This creates suitable conditions for outbreaks of water-borne diseases, such as typhoid, cholera, and diarrhoeal diseases.

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15 *Smith et al., 2014: Chapter 11*
16 *GoK, 2018*
17 *GoK, 2018; Oluoko–Odingo, 2011*
18 *Stunting is the impaired growth and development that children experience from poor nutrition, recurrent infections or chronic diseases which cause poor nutrient intake, absorption or utilisation. Childhood stunting is assessed based on height-for-age compared to the WHO Child Growth Standards median. (WHO, 2021)*
19 *GoK, 2018: 29*
20 *Ibid; Kabubo–Mariara, 2009*
21 *Fortnam et al., 2020*
22 *GoK, 2018*
23 *Kenya Food Security Steering Group, 2020; OCHA, 2020a*
24 *GERICS, 2016*
25 *MetOffice, 2011*
26 *GoK, 2015*
27 *Grace et al., 2012*
28 *OCHA, 2020*
29 *Burgin et al., 2020*
30 *UK Met Office, 2011; WRI, 2015*
31 *EM–DAT / CRED, 2020*
32 *GoK, 2015*

The higher exposure of women to indoor air pollution due to their assigned roles in the house is well researched globally, and is also found in Kenya where low-income households rely heavily on biomass fuel for cooking and heating.

Third, vector-borne diseases, such as malaria, dengue, yellow fever and Neglected Tropical Diseases (NTDs), are highly sensitive to rainfall and temperature patterns, as well as flood events.[33] Until 2017, malaria was ranked as the fourth leading cause of death in Kenya's Health Sector strategy.[34] Although the malaria burden is decreasing in Kenya's endemic areas, malaria is expanding in the low-transmission zones, and the size of outbreaks is increasing. Antimalarial drug resistance and migration of vectors from lowland regions to the highlands due to increased human mobility have been suggested as causes.[35] In the highlands, the number of people at risk is projected to increase between 36% and 89% by the 2050s, meaning an additional 2.8 to 7.0 million people could be affected.[36] In endemic areas, pregnant women and children under five are the most affected by malaria.[37]

Fourth, air quality is a major determinant of the occurrence of respiratory diseases, the second leading cause of mortality in the country[38] and the first cause of both morbidity and mortality in Nairobi among people over 5 years of age.[39] They are caused by indoor air pollution[40] but also increasing exposure to particulate matter ($PM_{2.5}$). The higher exposure of women to indoor air pollution due to their assigned roles in the house is well researched globally, and is also found in Kenya where low-income households rely heavily on biomass fuel for cooking and heating.[41] Moreover, studies that measure air quality in Nairobi consistently show a dangerous excess of $PM_{2.5}$ concentration vis a vis the World Health Organization (WHO) guidelines, due mainly to vehicle traffic.[42] Other risk factors, including the presence of mineral dust in air (aggravated by droughts),[43] the combustion of solid fuels for cooking, poorly ventilated households, burning of waste, open dumpsites and industrial emissions, also contribute to low air quality in poor urban residential areas in Nairobi.[44] Reducing local air pollution is considered an essential building block to promote urban environmental sustainability and improve healthy lives in the IPCC's special report on the impacts of global warming of 1.5 °C above pre-industrial levels.[45]

WCIS have a role to play in documenting some of the environmental determinants of health risks. Through forecasting temperatures and rainfall patterns, measuring air quality as well as warning against extreme weather phenomena, WCIS can help different sectors and local authorities to anticipate environmental conditions that aggravate some of the leading causes of mortality, including respiratory infections, diarrhoeal diseases and malaria.

33 *Bryson et al., 2020*
34 *GoK, 2018a*
35 *Githeko, 2010*
36 *Wandiga et al., 2010 cited in Parry et al., 2012*
37 *UNDP /BCPR, 2013*
38 *GoK, 2018a*
39 *Nairobi City County, 2017*
40 *Ezzati et al., 2001*
41 *Dida et al., 2021*
42 *deSouza, 2020*
43 *Gaita et al., 2016*
44 *Egondi et al., 2016*
45 *Roy et al., 2018*

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2 WHAT ARE THE WEATHER AND CLIMATE INFORMATION SERVICES PROVIDED TO THE HEALTH SECTOR AT THE COUNTY LEVEL?

The main provider of WCIS in Kenya is the Kenya Meteorological Department (KMD), who produce several types of forecasts, including daily, seven day, monthly and seasonal forecasts and warnings and alerts. Users of WCIS provided by KMD include intermediaries such as projects, County government ministries and departments, beach management units (BMUs), non-government organisations (NGOs), community-based organisations (CBOs), private sector bodies, research institutions and community members (Table 1).

TABLE 1 **Weather and climate information and services provided and used in Kenya**

Authority/ Institution/ Project	Weather and Climate Information Services	Description	Utilisation
Kenya Meteorological Department (KMD)	Weather forecasts	Daily, five day, weekly (seven days), marine forecast; monthly, seasonal forecasts (March–April–May (MAM) and October–November–December (OND) which also show the likelihood of total precipitation being above normal, normal or below normal June–July– August (JJA) for cold/dry season	The KMD weather forecast is broadcast on radio and TV and also accessible online: https://www.meteo.go.ke/ KMD Social media accounts @MeteoKenya and https://www.facebook.com/KenyaMeteorologicalDepartment Downscaled to County Directors of Meteorology Temperature, rainfall and wind data used by NDMA to produce the DEWS, and the Kenya Food and Nutrition Security Assessments (FNSA)
	Air quality monitoring	KMD's station on Mount Kenya (only monitored surface ozone as of 2019) and a mobile van that operates when contracted by the National Environment Management Authority (NEMA) to monitor pollution in specific locations. Only provide analyses on demand (not dataset) (deSouza, 2018)	Data not publicly available except for data on surface ozone through the NASA/GSFC SHADOZ (Southern Hemisphere ADditional OZonesondes) portal: https://tropo.gsfc.nasa.gov/shadoz/Nairobi.html

Authority/ institution/ Project	Weather and Climate Information Services	Description	Utilisation
National Drought Management Authority (NDMA)	Drought Early Warning System (DEWS)	• Monthly early warning bulletin generated with data from sentinel sites (up to nine in each county) and remote sensing collected during the previous month. • Drought early warning bulletins prepared every year before March–April–May (MAM) and October–November–December (OND) rainfall seasons. • Both monitor biophysical, production, access and utilisation indicators for food security, including livestock production (including milk) markets, terms of trade, water availability and nutrition (MUAC) and climate-related indicators.	Downscaled to sub-county levels to inform planning; Used by the Kenya Food Security Steering Group (KFSSG) to produce the Kenya Food and Nutrition Security Assessments (FNSA)
Inter-Governmental Authority on Development (IGAD) Climate Prediction and Application Centre (ICPAC)[46]	GHACOF (Greater Horn of Africa Climate Outlook Forums)	Participants discuss the impacts of the past season, present the consolidated regional climate outlook for the next season and discuss the implications of the climate forecast and response strategies.	A summary for policy makers is available online: https://www.icpac.net/publications/summary-for-decision-makers-march-to-may-2021/
IRI-Columbia University and KMD	Maproom ENACTS	Maps and charts can aid in forecasting malaria epidemics by comparing current climatic conditions to climatic conditions during a past outbreak.	Information products available online; Researchers use them for analysing health impacts (e.g. Kipruto et al., 2017) but slow uptake by NHMs
Met Office (UK)-WISER, IRI, the IGAD Climate Prediction and Applications Centre (ICPAC)	SCIPEA (Strengthening Climate Information Partnerships)	Repository of seasonal and sub-seasonal Forecast Model Datasets and Observation Datasets at regional level	The project has stopped but the Climate Data portal is still available online: http://scipea.iri.columbia.edu/maproom/index.html
FAO Desert Locust Information Service (DLIS) / World Climate Service (WCS)	FAO Desert Locust Bulletin	Issues bulletin every month and posted online. Based on survey and control results from affected countries combined with remote sensing, historical data and models. Supplemented by alerts and updates during outbreaks and seasonal precipitation predictions.	Kenya's Ministry of Agriculture uses information to roll-out mitigation measures (deploying surveillance and spray aircrafts and ground teams). The locust watch and Hub websites compile all the information: http://www.fao.org/ag/locusts/en/info/info/index.html https://locust-hub-hqfao.hub.arcgis.com/

Source: Adapted from Fortnam et al., 2020 and populated based on document analysis and KIIs.

46 *Kenya and the region*

County Directors of Meteorology and their role in providing WCIS

Following the promulgation of the Constitution in Kenya in 2010, meteorological services were decentralised with the offices of County Directors of Meteorology (CDMs) instituted in each of the 47 Counties.[47] The purpose of CDMs are to develop and disseminate decentralised forecasts (downscaled forecasts) to ward level, implement national policies at County level and deliver WCIS to inform decision making at County level (Box 2).

BOX 1 **Roles and Responsibilities of CDMs in Kenya**

- **Monitoring weather, climate and related environmental information within the County;**
- **Expansion and management of the meteorological observational network within the County;**
- **Interpreting and implementing national policies on meteorology and climate change adaptation at the County level;**
- **Downscaling of national weather forecasts and climate outlooks to the County level;**
- **Issuing public warnings on hazards and extremes related to weather, climate and air pollution;**
- **Generating essential weather and climate information to support climate sensitive sectors such as livestock, agriculture and food security, water resources, energy, transport, public health and sanitation, environmental conservation, disaster risk reduction, insurance, mining and tourism;**
- **Building public awareness of the use of meteorological data;**
- **Producing weather and climate information which can support the County's social and economic development;**
- **Mainstreaming meteorological services in the development agenda of the County;**
- **Promoting the use of local knowledge to build the resilience of communities in dealing with climate change extremes within the County; and Mainstreaming gender in weather, climate and environmental governance in line with the Constitution.**

The main channels of dissemination of WCI include radio, internet, social media (Facebook, WhatsApp, Twitter), intermediaries (Non-Government Organisations and Community Based Organisations, County Steering Group (CSG)[48], County Development Coordination Committees (CDCC)[49], Participatory Scenario Planning (PSP) and chiefs' "barazas".[50]

The CDMs interviewed for this study stated that they do not develop tailored products for the health sector in their Counties. Figure 2 shows how information flows from KMD to communities through the CDMs. They instead provide the health sector and other relevant sectors with a seven day, monthly and seasonal forecast. The forecasts cover three weather parameters – wind, temperature and rainfall – which are relevant to the health sector and are also used in the Drought Early Warning Bulletins and Food and Nutrition Security Assessment reports. The health sector can use wind, temperature and rainfall information to assess prevailing diseases, including airborne and water-borne diseases. Temperature is further used to determine conditions conducive for bacteria to survive. One CDM shared that another relevant parameter for the health sector could be radiation (to inform about risks related to sun exposure including skin cancers), although it is currently not provided in their forecasts.

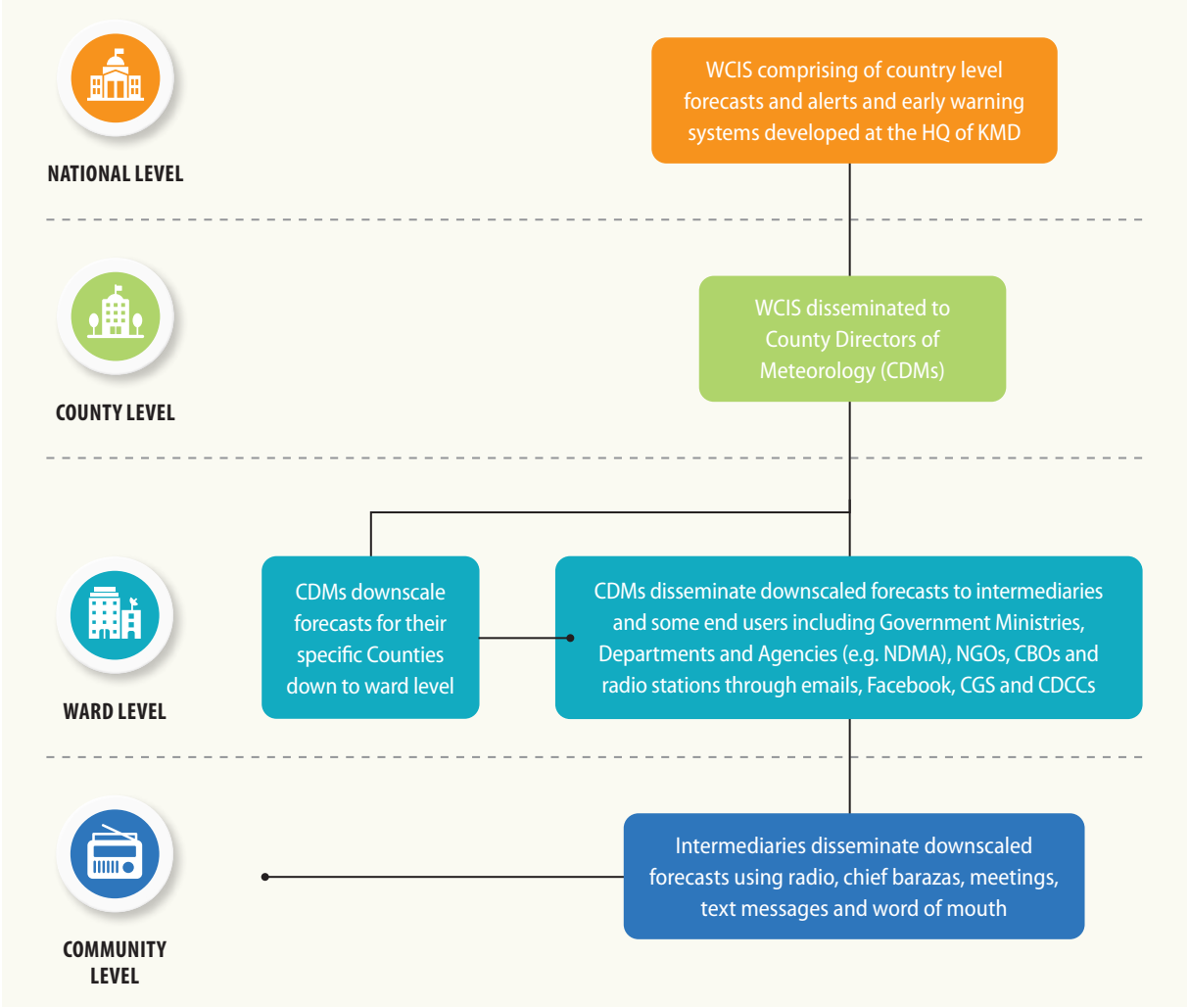
47 *Hindawi Publishing Corporation International Journal of Atmospheric Sciences Volume 2015, Article ID 02076, 8 pages http://dx.doi.org/10.1155/2015/302076*

48 *The CSG is convened by NDMA monthly. It comprises of relevant Ministry and Departments at the County, NGOs and WCIS actors. In the CSG meetings NDMA's bulletins are discussed and the CDMs are given an opportunity to address any questions from the stakeholders regarding the forecasts.*

49 *County Development Coordination Committee is chaired by the County Commissioner. It comprises of all departments in the County government and is responsible for implementing national policies at County level.*

50 *Meetings convened at the village level by the local chief for purposes of addressing local issues and facilitating the percolation of state agenda and policy at the grassroots.*

FIGURE 2 **Information flow from KMD to communities in Kwale, Kilifi and Kitui Counties of Kenya**



All CDMs interviewed confirmed that they provide WCI to the health sector in their specific Counties primarily through email. Health sector representatives are listed as part of intermediaries in their mailing lists who consistently receive the three forecasts listed above, in spite of the additional information they receive through other sources such as radio, television and internet. The CDMs also interact with representatives from the health sector at the CSG, CDCC and PSP meetings and when conducting the Food and Nutrition Security assessments (see next section).

There are cases where CDMs provide WCIS to specific sectors based on requests, but all three CDMs indicated that they have never received such requests from the health sector. Two CDMs mentioned that there is a lot of focus on the linkages between meteorological services and the agricultural sector in their Counties because numerous projects funded by external donors and Government initiatives focus on agriculture. One of the CDMs also shared that the main concerns affecting the health sector in his County are waterborne diseases that may break out during flooding episodes and malnutrition as a result of drought. According to the CDMs, the health sector mainly uses seasonal forecasts to create awareness amongst residents about the types of crops to grow during the long and short rains based on their nutritional value and benefits to ensure residents have sufficient food that can boost their immunity. From the perspective of the CDMs, this may be the reason health officers engaged in the NDMA processes to focus more on food security.

Baseline and endline assessments conducted for the Coastal Resilience and Improving Services for Potato Production in Kenya (CRISPP) (Box 2) show that the health sector is not singled out as a focus of CDMs interventions in the four target Counties of Kilifi, Kwale, Mombasa and Taita Taveta. As previously described in Box 2, the CDMs' main role is to disseminate WCIS to intermediaries at the Counties, who are then responsible for using the information to address challenges and issues in different sectors and sharing it with end users. This is different to the past, where CDMs did not interact with intermediaries and end users beyond sharing WCI. This can be attributed to limited resources, including workforce, funding and equipment (observation and prediction systems). It is only in recent years through donor funding, such as FCDO's WISER programme, that KMD has been able to increase their interaction with intermediaries and end users. For example, in the CRISPP project, the CDMs regularly attend CSG meetings, chief's barazas and radio shows in local stations, during which they interact directly with intermediaries and end users. Such platforms have provided opportunities for users of WCIS to ask questions, seek clarification and provide feedback. The CDMs have also reported that through these interactions they have come to appreciate that the uptake of WCIS by both intermediaries and end users is directly linked to their ease of understanding of forecasts. The endline assessment conducted for CRISPP shows that the main factors influencing uptake of WCIS by end users were accuracy of the information, timeliness, ease of understanding and relevance to livelihood groups, which requires service providers to issue advisories with relevant information.[51] Lastly, while health care providers should be part of the CSG, this is not necessarily the case in most Counties.

BOX 2 **CRISPP project**

Funding was allocated under the WISER programme, to support a national project for Kenya, called 'Coastal Resilience and Improved Services for Potato Production' (CRISPP). The project was split into two sub-projects, 'Increasing the Resilience of Kenya's Potato Sector' and 'Enhancing access to weather and climate information for Kenya's coastal region'. In this paper, we are focusing on the coastal component. The project sought to deliver accessible and decision-relevant weather and climate information for 80,000 households in Kenya's coastal region in four Counties: Kwale, Kilifi, Mombasa and Taita Taveta. Its scope covered three main areas:

- **the development and delivery of demand-led and decentralised Kenya Meteorological Department (KMD) services in coastal Kenya;**
- **the development of proposals for the streamlining of KMD's forecasting to improve existing services and facilitate delivery of new products and services in response to demand from users in the coastal Counties, and**
- **investment in improved marine forecasting techniques to provide better downscaled information, early warnings and associated advisories.**

The project aimed to develop a distinct set of co-produced products and tools on climate information services that could deliver transformational change through the improved uptake and use of weather and climate information (WCI) across multiple Counties and livelihoods. The project brought together producers, users and intermediaries to identify needs, design WCI services for user needs and test their effectiveness in helping to improve decision making on livelihood and sector strategies. The intermediaries included County administrations of the four target Counties, non-governmental organisations (NGOs), as well as media and local organisations. Users ranged from vulnerable households to agricultural smallholders, fishermen, the shipping sector and County Government.

51 *Monitoring and Evaluation report for the CRISPP– Coastal Resilience and Improving Services for Potato Production in Kenya (CRISPP). NIRAS, 2020*

Use of WCIS by National Drought Management Authority and the Health Sector

The National Drought Management Authority (NDMA) is a primary user of WCI in Kenya (see Table 1). NDMA monitors drought through a Drought Early Warning System (DEWS) in 23 ASAL Counties. The DEWS aggregates data and information monthly from sentinel sites and key sectors like education, agriculture, livestock and health. For each early warning indicator, thresholds are set to define three drought stages: alert, alarm and emergency.

After the rainfall seasons, NDMA conducts Food and Nutrition Security Assessments to analyse the food and nutrition security situation following the cumulative effect of the previous rainfall season and provides recommendations for possible response options based on the situation analysis. The assessments also cover Vegetation Condition Index (VCI) and are conducted in conjunction with relevant County level sector actors, including met services, departments of health, water and agriculture and the Famine Early Warning Systems Network (FEWSNET).

For these assessments, health officers provide data on rates of malnutrition – providing advice on types of crops that should be grown based on the forecasts in order to boost nutrition, consumption patterns and public health. NDMA uses this data, together with WCI received from the CDMs, KMD HQ and satellite data from FEWSNET and WFP, to provide recommendations in the Drought Early Warning Bulletins and Food and Nutrition Security Assessment reports. Assessments are based on the status of food security and milk consumption at household levels during the months under review, and nutrition interventions at health facilities in the County, and provide recommendations for the health sector for the coming season. According to an NDMA officer, there is a strong focus on food security because it is a major determinant of human health. When households are food secure, their financial resources can help them access healthcare instead of purchasing food.

In a separate study conducted in 2019 in Kilifi County as part of the CRISPP project,[52] the survey team interviewed an NDMA officer who shared that NDMA develops and disseminates Drought Early Warning Bulletins to stakeholders and communities in the County. The bulletins are developed using WCI data from three different sources: Normalised Difference Vegetation Index (NDMI) from Boku University in Austria; information collected by community observers in weather stations that are set up at chief's offices and schools around the County, and WCI (daily, seven day, monthly and seasonal forecasts) from KMD. The bulletins are designed to assist the County to allocate resources and coordinate assistance and response to shocks and hazards. The County is however still very reactive to emergencies, and lacks adequate systems and resources to plan for such events in advance.

The reactive approach to climate-related shocks was also pointed out in the Maintains study.[53] While highlighting that the early warning system for droughts is functioning, the dissemination of NDMA's bulletins enabled a more timely delivery of nutrition services and quicker resource mobilisation to respond to the drought in 2019 compared to previous events. The study also emphasises that institutional response to shocks remains primarily reactive and that there is strong focus on food security rather than on wider health issues.

52 *LTS, 2019*
53 *Fortnam et al., 2020*

3 WHAT BENEFITS COULD WCIS TAILORED TO HEALTHCARE PROVIDERS' NEEDS BRING?

Health risks result from a combination of environmental hazards and the social determinants of health.[54] WCI can help address some of these risks by strengthening the anticipatory capacity[55] of institutions concerned with protecting people and their livelihoods. Even if meteorological services can forecast the exact location of the next flood in advance and warn local authorities, this might not prevent a cholera outbreak if affected people still lack access to clean water and sanitation.

Kenya's health system is improving, but infrastructure for health is unequally distributed where twenty-three Counties are below the national average of 2.3 health facilities per 10,000 people.[56] Health facilities also face shortages of health workers, supplies and equipment. On average, Counties have only 50% of the required communication equipment (31% for computers with internet access).[57] These are examples of challenges that affect everyday health services delivery and influence the effective use of WCIS in the health sector.

In a workshop on tools for drought monitoring and forecasting in Eastern Africa in 2017,[58] participants discussed the relevance of Maprooms[59] to adequately respond to the constraints and needs of the health sector. Some of the recommendations arising from the workshop stressed the importance of extending the use of Maprooms to other priority climate sensitive diseases and health conditions (e.g. vector-borne diseases such as Dengue fever, Yellow fever, Lymphatic Filariasis), water-borne diseases (cholera) and malnutrition. Digital tools such as Maprooms were also highlighted as useful if they could be accessed offline by users, especially during training sessions that can be affected by network challenges. Emphasis was also placed on the need to upload non-climate data, e.g. epidemiological data, and/or link the tools to national health management information systems such as District Health Information Software 2 (DHIS2) to better combine climate and health information.

Overall, there is a gap between technology reliant WCIS tools such as Maprooms or connected databases and the lack of basic communication infrastructure at County level. Similarly, County health officers might benefit from capacity building to make use of WCIS, but effective uptake will remain limited if the means to share information is not adequate. Furthermore, while WCIS can support anticipatory decision making in important domains of development (e.g. agriculture, livestock production, warning against floods), their actual contribution to mitigate risks and limit negative impacts is minimal if populations' access to basic services, such as healthcare or water, sanitation and hygiene remains limited.[60] This is partly why collaboration with the humanitarian sector is important and why context-specific feedback mechanisms are crucial for WCIS providers to adapt their activities and maximise their usefulness.

54 *WHO, 2017*
55 *Anticipatory action encompasses a set of planned and pre-financed measures to strengthen people's capacity to manage risks effectively and adapt to climate change (Wilkinson et al., 2020)*
56 *GoK, 2018a*
57 *bid*
58 *Owusu et al., 2017*
59 *Maprooms compile maps and other figures that monitor climate and societal conditions both in the present and in the recent past. E.g. http://digilib.icpac.net/maproom/index.html*
60 *See also the Whatworks initiative to predict climate-driven disease outbreaks to better respond in WaSH https://whatworks.co.ke/climate-workshop/index.php*

WCI for food security

Support from WCIS providers to the health sector is predominantly framed around food security and how droughts can be best anticipated to help farmers and pastoralists protect or adapt their livelihoods. In the context of Kitui County, the NDMA officer works with technical officers from the health sector (including nutrition and public health experts and volunteer community health workers) in conducting Food and Nutrition Security Assessment Reports each year for the County after the long rains (March–April–May (MAM)) and short rains (October–November–December (OND)). The assessments determine the impacts of the long rains related to crop performance as well as the cumulative effects of previous seasons on food and nutrition security in ASAL Counties. The main weather parameter used for the analysis is rainfall – amount, distribution, onset and cessation. The assessments also draw on non-meteorological data, including: nutritional status and dietary diversity; measuring the mid-upper arm circumference (MUAC) for children under five years; food consumption patterns including consumption of milk by children under the age of five years; common diseases such as typhoid, malaria and cholera; morbidity and mortality rates for both children under five years and the general population in the County; and hygiene and sanitation, assessing toilet and latrine coverage, handwashing practices and access to clean and safe water. Food security indicators used in the assessment include percentage of maize stocks held by households, livestock body condition, water consumption, price of maize, distance to grazing, and food consumption score.

Technical officers collect and analyse this information and then share with the NDMA officer. Based on this information, the assessments provide the food security outcomes for the periods after the long and short rains, and recommendations of interventions can be used to address the challenges identified in each of the sectors: agriculture, livestock, water, health and nutrition, education, peace and security, and markets and trade.[61] The NDMA's consistent early warning bulletins and Long and Short Rains Assessments are used by County governments and development agencies to raise awareness of, and plan for drought shocks across sectors. However, these bulletins do not necessarily help in anticipating how long a drought will last, the exact location of impacts and therefore where surges in demand for and utilization of health services might occur.[62]

Advisories developed in co-production processes with producers and users of WCIS as in the CRISPP project, assist end-users to plan for the long and short rains. Co-production is facilitated through the PSPs, funded by project and donor activities and normally conducted twice a year before the short and long rains. However, availability and consistency of funding and project timeframes can make this challenging. Intermediaries and end users interviewed in the endline study of the CRISPP project stated that the PSPs are not often conducted at the right time, i.e. before the season to support planning and preparations.

The NDMA's consistent early warning bulletins and Long and Short Rains Assessments are used by County governments and development agencies to raise awareness of and plan for drought shocks across sectors.

61 *Kitui County – long rains food and nutrition security assessment report, 2020.*
62 *Fortnam et al., 2020*

To support the translation of technical early warning information on droughts into tangible advice for end users, particularly at household level in response to alert phases, more use of community-level knowledge and data is needed. In particular, data collected by Community Health Volunteer and Community Health Extension Workers, who are often women, could support decision making to tackle malnutrition.[63]

WCIS and the mitigation of vector-borne diseases

According to a meteorological officer from KMD HQ, the health sector uses WCI for surveillance, control and treatment of weather and climate sensitive diseases such as malaria. The main weather elements that they look at include temperature, rainfall, relative humidity, wind patterns (magnitude and strength), solar radiation and air pollution and quality. One such agency is the National Malaria Control Programme based at the Ministry of Health. Representatives from the programme are actively engaged in the Greater Horn of Africa Climate Outlook Forum (GHACOF) where they receive seasonal forecasts and together with representatives from other sectors, evaluate potential impacts and co-produce mitigation measures and advisories which are disseminated to relevant stakeholders and actors regionally. Additionally, the programme also uses WCI for vector control – selecting appropriate insecticides and treated materials and making estimations for annual national requirements; surveillance – by monitoring elements such as El Niño, Southern Oscillation (ENSO) and unusual climatic conditions, especially rainfall and temperatures that favour breeding and longer survival of the malaria vectors; and developing effective epidemic preparedness and response.

A recent study observed time lags between peak malaria cases and climatic variables such as rainfall.[64] Other research findings also established a spike of "malaria cases two months after the onset of the rains and a month after experiencing minimum temperatures ranging from 18.6 °C–21 °C (which are suitable for vector and parasite development) and an increase in vegetation cover (which provide ample resting places for the mosquitoes)".[65] In the case of the highland Baringo County, researchers determined that the monitoring of rainfall and temperature trends using local weather data can provide an accurate forecast of transmission risk, and hence inform timely action to mitigate malaria outbreaks. This reinforces the importance for CDMs to compile climatic and environmental data from KMD, but also from local weather forecasts to provide locally appropriate information for Early Warning Systems (EWS) for malaria.[66] For instance, to best forecast malaria epidemics in highland areas where mosquito breeding sites are numerous, temperature is the most important parameter. In lowlands areas and ASAL counties where temperature is always high, rainfall is the most important factor.[67]

The Kenyan Malaria Early Warning System (KMEWS), supported by the Green Environment Fund until 2014, provided early warning information three months in advance to County health officers and malaria prevention managers.[68] More recently, the climate-based malaria epidemic EWS for the western Kenya highlands has been developed to provide predictions to the malaria control division in the Ministry of Health.[69]

A CDM interviewed for this study shared that he works closely with the veterinary sector, who are interested in rainfall distribution and use their forecasts and alerts for disease surveillance. Their collaboration has helped provide tailored information to vet services, who use it effectively. For instance, in periods where high levels of rainfall are predicted, vet services organise vaccination campaigns for Rift Valley Fever and other diseases.

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63 *Fortnam et al., 2020: 32*
64 *Kipruto et al., 2017. This study was part of a research project in Baringo County on Improving Human Health and Resilience to Climate Sensitive Vector-Borne Diseases in Kenya (2014–2017).*
65 *Estambale, 2017:6*
66 *See also the Ministry of Health's Guidelines for Malaria Epidemic Preparedness and Response*
67 *Ministry of Health, 2020*
68 *WHO–UNDP, 2015*
69 *Githeko, et al., 2018*

A woman checks a rain gauge in her village of Nanighi, located in North Eastern Kenya, near the Somalia border. Kenya relies on thousands of volunteers to help record how much it rains. © Francesco Fiondella / Alamy Stock Photo

WCI for better air quality management

The objective of mitigating air pollution to address the second cause of mortality in Kenya has not received as much attention from WCIS providers and funding schemes as malnutrition or malaria. Although the country's Health Sector Strategic Plan for 2018–2023 mentions the importance to reduce environmental pollution, it only sets out containment efforts to limit indoor air pollution. The management of air quality has also been devolved to Counties, a task to be coordinated by the Council of Governors Committee on Environment.[70] The Nairobi City County for instance, produced an Air Quality Action Plan (2019–2023) to develop better air quality management strategies. Its first objective aims to undertake an inventory of the air pollutants and emission sources that most contribute to poor air quality in Nairobi City.

However, these are nascent initiatives. Challenges include the lack of clarity of institutional responsibilities to monitor air quality (between NEMA and Counties), establishing air quality action plans and enforcing these plans to mitigate pollution, particularly when collected data are not made easily accessible to the public (i.e. free of charge). Additional to these institutional obstacles is the lack of trained staff and funding to manage reference stations, interpret data, liaise with urban planners and issue public health warnings.[71]

Yet, information on air quality is already produced in Kenya based on satellite data to estimate outdoor pollution or using citizen science. The latter involves measuring personal exposure, using GPS and mobile monitoring, and engaging community members in interpreting data and potential sources of pollution that are hard to detect based on aerial photographs.[72] Other collaborative initiatives exist, such as the Kenya Air Quality Network[73], to collect data from low-cost air quality monitors. Moreover, the evidence base already stresses the high exposure of urban dwellers to particulate matter in certain parts of Nairobi.[74] Two studies also found gaps in perceptions of air quality, with more people being concerned about external sources of air pollution even though monitoring data show high levels of indoor air pollution.[75] Awareness raising of health risks linked to the environments could provide information related to maternal health, for instance the risk that women who are chronically exposed to particulate air pollution are more likely to have babies born too small or too early.[76] This concerns both families and healthcare providers who operate in polluted urban centres.

70 *DeSouza, 2018*
71 *DeSouza, 2018*
72 *West et al., 2020*
73 *Set up by UNEP, SEI and the African Population and Health Research Center (APHRC)*
74 *See deSouza, 2020 for a review*
75 *Egondi et al., 2016; West et al., 2020*
76 *Health Effects Institute, 2020*

4 LESSONS FOR DELIVERY OF WCIS IN KENYA TO SUPPORT HEALTH OUTCOMES

Meteorological services in Kenya provide WCIS that are largely geared towards addressing drought risks in line with government strategy to end drought emergencies. Health services that make use of this information include Drought Early Warning Systems and Food and Nutrition Security Assessments that can support development efforts to tackle malnutrition, the leading risk factors for premature mortality and disability in the country.

Uptake of WCIS by end users is mainly determined by ease of understanding, timeliness and accuracy of the forecasts. Based on the results of the endline study undertaken across four targeted Counties in the CRISPP project, end users stated that forecasts have significantly improved in the past two years. They are easier to understand – the format has pictures and simple language; they are more accurate – especially the short-term forecasts such as the daily, five day and seven-day forecasts and alerts; and unlike the past they are more timely – especially the seven day and monthly forecasts. Additionally, the forecasts are downscaled and cover more specific areas at ward level. Key informants confirmed that the short-term forecasts (i.e. alerts, daily and seven day) are more accurate than long-term forecasts (i.e. monthly and seasonal) as a result of initiatives such as the CRISPP project. A large proportion of end users are starting to understand that forecasts are predictions and may not always be 100% accurate. However, the producers of WCI perceive there is still need to create more awareness about their services and provide more analysis alongside forecasts. The main challenge is time and resources. For example, the PSPs are a good platform for conducting needed analyses and developing advisories for different sectors. Yet they are hosted externally by producers and are not within the control of National Meteorological Services themselves. Respondents from the endline survey of the CRISPP project shared that the PSPs are often conducted late after the dissemination of seasonal forecasts, which largely reduces the rate of uptake and usefulness of the information amongst end users. Moreover, effective uptake of WCIS by health practitioners remains unclear as they are usually not the targeted end users or intermediaries. The gap between technology-reliant WCIS, the lack of equipment at county level and the lack of communication equipment at and for health facilities is also an obstacle to effective uptake.

Overall, it was difficult to understand from CDMs where their responsibilities end and where the roles of other service providers working across different sectors begins. Limited formal mechanisms for receiving feedback from users, combined with the lack of clarity of actual usage of meteorological data and services provision, call for a clarification of the roles of CDM and the resources at their disposal to fulfil them. Moreover, a good understanding of social determinants of health and how they interact with gender inequalities in both health needs and healthcare provision can help co-produce and deliver relevant WCIS. This is particularly relevant for CDMs who are responsible for not only generating weather and climate information for supporting public health but also for mainstreaming gender considerations into weather, climate and environmental governance.

RECOMMENDATIONS

Feedback mechanisms must be formalised between WCIS users and producers: Feedback provided to CDMs tends to be informal and does not create accountability for acting on it. Context-specific feedback mechanisms are also crucial for WCIS providers to adapt their advisories and maximize their usefulness.

WCIS producers must liaise with county-health officers to understand their needs and tailor information accordingly: CDMs rarely receive specific requests for WCIS from the health sector. Raising awareness on the information they provide, and addressing feedback from health actors, could help the co-production of context-specific WCIS for health.

Healthcare workers should be more targeted and supported as intermediaries in the co-production of climate services: This would help ascertain information needs and priorities and identify appropriate communication channels with different end users to increase the value of WCI services.[77]

Observation stations across the country must be coordinated: KMD acknowledges that their observation systems – particularly for rainfall data – have limited coverage, despite various organisations having observation stations countrywide. With proper support and guidance, KMD can help such organisations collect correct observations that can be used in a forecast. To achieve this, KMD will need to lead and coordinate standardization processes.

Observation stations must be equipped to systematically collect data on air quality and make it publicly accessible: The burden of diseases attributable to air pollution presents a major health challenge for the country. KMD already has the legal mandate to monitor and issue public warnings on air pollution and related hazards. Establishing an observational network to gather air pollution data and develop research and pilot services could be a first step.

Funding schemes must support the co-production of WCIS across sectors: CDMs themselves recommend more collaboration with sectors beyond agriculture, starting with health. This would help provide more tailored information that health actors can use and training to ensure health practitioners can interpret forecasts and use them appropriately.

WCIS providers can draw lessons from the Maintains programme for building the climate shock-responsiveness of Kenya's health system: The predictability of current early warning systems for droughts could be strengthened by using IMAM (Integrated Management of Acute Malnutrition) surge data, whereby frontline health staff who monitor malnutrition admissions could pass on information on the capacities of health facilities to absorb surges.[78]

WCIS could support building the evidence base on the environmental determinants of health risks: Demographic Health Surveys and the 2015 Kenya Malaria Indicator Survey (KMIS) can be used as additional sources of data to complement risk and vulnerability assessments. These surveys provide free quantitative data relating to health, disaggregated by sex, age, counties and other useful variables which can be layered with other vulnerability indicators (e.g. access to water, sanitation and health facilities) to anticipate populations at risk.

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77 See also: Huyer, et al., 2017
78 Fortnam et al., 2021

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