



Systems approach to climate services for health

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ABSTRACT

Climate change and variability remain a pressing global challenge directly and indirectly affecting human health. This has increased the demand for usable climate information for adaptation to climate related health challenges and for building effective response strategies. Climate services for health can help to enhance human well-being and in extreme cases can save human lives by reducing morbidity and mortality. Very little has been done and understood about how we can enhance climate services for health. The main aim of this perspective article is to bring empirical evidence, conceptual clarity and interdisciplinary approaches to policy makers and practitioners dealing with this crucial issue. The article explores the application of a holistic, broadly termed 'systems' approach to climate services for health in the context of adaptation and resilience. It uses illustrative examples from Ethiopia, Bhutan and Germany to demonstrate and elaborate the application and merits of the systems approach to emerging climate services for health. The systems approach improves conceptual thinking about climate services for health. In addition, it is a valuable analytical framework that unifies the diverse stakeholders involved in health adaptation and resilience planning, interventions and policy making. This perspective article fills in the existing gaps in scientific literature on the subject and enhances conceptualisation of climate services for health. It makes suggestions to improve understanding of climate services for health.

1. Introduction

There is growing and incontrovertible evidence that climate change and variability can directly and indirectly act as an amplifier of threats to human health globally (Costello et al., 2009). The World Health Organization (WHO) estimated that 12.6 million or 23 per cent of all deaths worldwide in 2012 were attributable to environmental factors mainly related to climate variability (Neira and Prüss-Ustün, 2016). Human health outcomes are largely impacted by both extreme weather events (EWEs) and gradual changes in weather and climatic conditions. EWEs, on the one hand, can affect physical and psychosocial wellbeing, influence access to healthcare and cause vulnerability (Aadil Gulzar et al., 2021). Gradual climatic changes, on the other, can trigger exposure to harmful or beneficial health conditions (Whitmee et al., 2015).

Recent scientific models and predictions show that the global effects of climate change are more pressing than ever (IPCC, 2021). The evidence demonstrates increasing health effects of variations in climatic

conditions. It also shows that non-integrated (climate information alone or health information only) is inadequate for decision making on diseases and illnesses related to climate variability. Rather than only focusing on 'climate change' as the central issue the overall system in which climate change is occurring and playing itself out is needed for informed climate action. Transdisciplinary approaches that integrate actionable climate information, observations and models we argue are required for actionable knowledge about the health impacts of climate exposure (Hewitt et al., 2021).

Integrating climate and health information and making it actionable is, however, a very difficult task. Nevertheless, increased mortality and morbidity has intensified the urgency for responding decisively to health impacts of climate change. A holistic, robust and sustained health-climate response requires effective deployment of accurate and tailored climate information and dedicated climate services (Watts et al., 2015).

One arena for action is what has been termed 'climate services'

Abbreviations: EWEs, Extreme Weather Events; NMS, National Meteorological Services; HHWS, Heat Health Warning System; HHAP, Heat Health Action Plan.

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defined as the “transformation of climate-related data—together with other relevant information—into customized products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices development and evaluation of solutions and any other services in relation to climate that may be used for the society at large” (European Commission 2015,10, in Street 2016). They encompass timely provision of tailored climate information and knowledge working *with and for* decision makers (Vaughan and Dessai 2014).

Dedicated climate services, that is, climate services for health are vital for enhancing human health adaptation and resilience to the health impacts of climate change. Climate services for health are defined as “the entire iterative process of joint collaboration between relevant multidisciplinary partners to identify, generate and build capacity to access, develop, deliver and use relevant and reliable climate knowledge to enhance health decisions” (WHO/WMO, 2016:15). They encompass use of climate and environmental information in healthcare decision making. Underpinning them is a realization that climate is a key variable in managing the overall burden of disease, excess mortality and to increase life expectancy (Tadese et al., 2008).

This perspective article examines the application of systems approach to climate services for health. The systems approach to climate services for health can be defined as a holistic and transdisciplinary framework for understanding the dynamic and complex interconnectedness and non-linear feedback loops that exist between health and climate information as well as other social, economic and environmental dimensions that affect health outcomes. It also elaborates the merits of the systems approach to climate services for health. It aims to provide conceptual clarity on climate services for health as well as fill in existing gaps in literature on the subject. Conceptual clarity is important for a diverse range of stakeholders making policies and planning for health adaptation and resilience. The insights presented are derived from selected examples and case studies. With this background, we firstly explore why the systems approach is necessary for climate services for health.

2. Reasons for the systems approach to climate services for health

The systems approach articulates the importance of viewing health adaptation and resilience responses holistically. This is in line with the WHO definition of health “as a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity” (Sartorius, 2006, p.662). Climate services for health symbolize a ‘messy’ set of interactions that if explored and understood can begin to facilitate use of actionable climate information in concrete health decision making. The application of the systems approach to climate services for health, we argue, can help to facilitate integration of climate and health information in climate-health responses.

2.1. Health systems adaptation through climate services for health

Climate services for health can inform health adaptation interventions, planning and policy processes and outcomes. The Intergovernmental Panel on Climate Change (IPCC) (2014, p.118) report defined adaptation as “the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities”. While public health practitioners and policy makers need climate information to effectively plan for health adaptation, the uptake of climate information has been underwhelming (Goosen et al., 2014; Boon et al., 2021). Policy makers and practitioners assess the salience, credibility, legitimacy, ‘actionability’ and usability of the information (Prokopy et al., 2017). They often consider and use co-produced and co-delivered, adaptable, targeted and context-relevant climate services for health (Vollstedt et al., 2021). Therefore, we suggest that health adaptation interventions

require climate services that understand and can demonstrate risks and impacts at various spatial and time scales.

The variety of adaptation responses require further clarity and are not a ‘once-size-fits all approach’. As indicated above, climate services for health are essential for reactive adaptation or coping, that is, diminishing the deleterious impacts on health during and after extreme climate events. *Reactive adaptation* is a ‘wait and see’ approach whereby decision makers postpone actions on climate change effects until the negative effects have materialized (Yousefpour, Augustynczyk and Hanewinkel, 2017). Reactive adaptation may be a result of a deliberate policy position based on cost-benefit analysis of acting or not acting. Where the benefits of not acting outweigh acting and the climate change impacts are reversible, policy makers can apply reactive adaptation. Similarly, practitioners may implement interventions after the low impact adverse climate change event has occurred. Decision makers operating within resource constrained settings may take a reactive adaptation position because of lack of resources to deploy before or during the occurrence of negative health impacting climate events.

Incremental health adaptation can also be enhanced through climate services for health. Incremental health adaptation encompasses proactive health interventions aimed at preventing the negative effects on physical and social systems. The incremental health adaptation approach is preventative. Interventions that fall under this approach include raising awareness on climate change-health impacts among health and allied workers, integrated climate-health risk monitoring systems, and early warning systems anchored on integrated climate-health information. Climate services for health, using such approaches, can promote Health in All Policies which acknowledge that health outcomes are affected by all explicit and implicit public health policies. The systems approach emphasizes effective production and delivery of climate services for health by promoting strategic coordination of health and other sectors that affect health. Furthermore, it includes influencing non-health sectors to promote policies and interventions that produce positive health outcomes.

Climate services for health can also try and facilitate a more radical and ‘transformational health’ form of adaptation, that is, proactive approaches that aim to address the main reason for vulnerability to climate risks, promote sustainable development and resilience. To be transformational the institutional context needs to be ‘shaken’ and changed and the uptake of information seriously addressed (Lotz-Sisitka et al., 2016). The application of the systems approach can assist in identifying populations most vulnerable to health impacts of climate change. In most settings, persons most vulnerable to the impacts of climate change and variability include children, women, the elderly and persons living with disabilities. The delivery and mechanisms for uptake of information of climate services for health can transform the lives of these vulnerable groups for the better and guarantee better health outcomes for them. The WHO guidelines for climate-resilient health systems do not articulate climate services explicitly. However, the guidelines highlight important activities that are dependent on and related to climate services for health (WHO, 2015). These include vulnerability assessments, comprehensive monitoring of threats and early warning systems and developing climate informed health programs, among others (Ebi, 2016).

It is worth pointing out that our presentation of three distinct adaptation categories simplifies the complex reality that include overlaps among categories. Health adaptation actions and policies can thus encompass reactive, incremental, and transformational aspects together therefore being a messy approach rather than a simple set of actions that bridge science to policy and action. While the WHO published some guidelines on how health systems can be protected through adaptation planning and how countries can transition to climate-sensitive policies and programs, the importance of climate services for health in guidelines is not very explicit. Given this, innovations that “make climate services [for health] far more useful and valuable to users, and to allow the services to address specific, complex adaptations” are necessary

(Hewitt et al., 2021, p. E584). Applying the systems approach to climate information for health displaces “the dominant tradition on adaptation ...[which] primarily takes an actor-centered view, focusing on the agency of social actors to respond to specific environmental change stimuli and emphasizing reduction of vulnerabilities” (Nelson et al., 2007, p.395).

2.2. Health systems resilience through climate services for health

Climate services for enhanced health and well-being can provide valuable information for enhancing resilience against health risks. “Health systems resilience” can be defined as the capacity of health actors, institutions, and populations to prepare for and effectively respond to crises; maintain core functions when a crisis hits; and, informed by lessons learned during the crisis, reorganize if conditions require it” (Kruk et al., 2015, p.1910). Resilient health systems can protect and save human lives and guarantee quality health outcomes in the immediate, short term and long term. They comprise of five elements, namely they need to be integrated, are aware, diverse, self-regulating and adaptive (Kruk et al., 2015). Within the systems approach, health systems resilience is also usually examined and interrogated at the micro, meso and macro scale (Lyng et al., 2021).

Resilience of health systems through climate services for health is premised also on two propositions. First, climate services for health can help maintain the health system in a more desirable and functional state during and after being affected by climate extremes. Climate services for health enable delivery of comprehensive, beneficial, and positive health outcomes as well as facilitate the development of a more responsive health system. Overall, climate services for health enhance the capacity of health systems to withstand climate change impacts.

Second, climate services for health can facilitate the identification and ‘crossing’ (transgressing) of broad thresholds by stretching the boundaries at which health systems reach a tipping point. The generally acknowledged effects of climate variations on health systems are mostly disruptive; and hence, health systems with greater threshold withstand climatic threats, risks and actual shocks (Lotz-Sistika et al., 2016). The role of climate services for health is to fortify health systems and make them more complex systems that include nonlinear changes and nonlinear feedback loops, self-organization and learning (Ziervogel et al., 2021). The complex systems, inclusive of and strengthened by climate services for health do not easily reach tipping points.

The systems approach allows for more integrated approach to climate-health responses. The main advantage of the systems approach is that it guides decision makers to move beyond only adopting linear approaches of management and helps them to begin to think through what a more adaptive, complex and transdisciplinary management of climate-health impacts may entail. Despite these merits, has the systems approach to climate services for health been applied or implemented in practice and with what outcomes?

3. Application of the systems approach to climate services for health

3.1. Status of application of the systems approach

Our assessment of the available and existing literature shows that publications on climate services for health emerged less than three decades ago and have increased rapidly over the last decade. The application of the systems approach to climate services for health is very limited even though the approach has been widely used in public health. For example, the WHO developed a health systems framework with six building blocks that encompass service delivery, health workforce, health information systems, access to essential medicines, financing and leadership or governance (WHO, 2007). The key outcomes of the systems framework are improved health, responsiveness, social and financial protection and improved efficiency (World Health

Organization, 2010). Although the WHO systems framework is informative, it has not been widely adapted in conceptualizing health-climate issues.

Currently, health and climate systems are not integrated. Ebi (2016, p. 4) observes that “current policies and programs for managing climate-sensitive health outcomes were established without considering climate variability and change, resulting in a significant gap for achieving resilience” and adaptation. Health and climate systems currently generate data and information for their own independent use and purposes. In practice, National Meteorological Services (NMS) independently generate climate information, while health systems separately generate health information with little to no interactions taking place between the two systems.

Despite this, climate services for health require blending a “range of techniques to integrate spatial and time-scaled weather and climate information in combination with clinical, epidemiological and other health data to understand and apply knowledge about how climate in the past, present, and future influences health outcomes, health risks and health service delivery” (WHO/WMO 2016, p. 15). Co-production and co-delivery of the services are imperative to effective and robust climate services for health. In addition, transdisciplinary approaches that help health professionals understand the impacts of climate variability and change on health and mobilize them to take appropriate action are essential. The following section provides some emerging examples of application of the systems approach to climate services for health.

3.2. Illustrative examples of systems approach to climate services for health

Three illustrative examples are provided below, that demonstrate some emerging use of systems approach to climate services for health using some illustrative cases are from Ethiopia, Bhutan and Germany. These examples are purposely chosen to demonstrate different facets of the application and merits of using the systems approach to climate services for health. Noteworthy, the examples are not perfect prototypes of the application of the systems approach to climate services. They provide some important information that can inform the content of the systems approach to climate services for health.

The first example is from Ethiopia, a country located at the horn of Africa. The collaboration between the Ethiopian Ministry of Health (EMoH) and the National Meteorological Services of Ethiopia (NMSoE) shows an attempt towards applying a systems approach to climate services for health. Ethiopia is among the early adopters of the WHO health systems framework in Africa (Manyazewal, 2017). The country made serious attempts to operationalize the six building blocks of the WHO health systems framework. However, the initial use of the WHO health systems framework excluded environmental metrics, especially climate change information (Teklegiorgis et al., 2016). Yet, Ethiopia has been adversely affected by climate change. Some disease outbreaks in Ethiopia may be associated with EWEs and climate variations (Ermert et al., 2012). The use of the WHO health systems framework alone meant that the country could not effectively respond to diseases associated with climate variations such as malaria.

In a typical non-integrated fashion, the NMSoE independently generated and delivered weather and climate information, while the EMoH generated and delivered health information separately (del Corral et al., 2012). Through international partnerships and support, the NMSoE and EMoH were introduced to how they could use climate information in health decision making (Dinku et al., 2014). The NMSoE and EMoH created a Climate-Health Working Group to provide leadership and coordinate the efforts of synergizing climate information and health information for health decision making (Dinku et al., 2016).

Ethiopia’s Climate-Health Working Group has influenced the evolution of climate services for health in general through facilitating exchange of information, analyzing and interpreting the information,

training and capacity building health workers and enabling decision makers to focus on diseases generally affecting the populace (Tadese et al., 2008). An example where Ethiopia Health-Climate Working Group has been effective is in coordinating the country's malaria response using climate services for health.

In terms of malaria response, Ethiopia's Health-Climate Working Group ensures that the NMSoE timely provides national climate information (Dinku and Sharoff, 2011). The climate information provided shows the climatic conditions and areas favorable for mosquitos that cause malaria to proliferate. The climate information also forecasts how seasonal weather changes will affect the spread of malaria. The EMOH also provides routine malaria surveillance data from the different areas in Ethiopia. Iterations and interactions coordinated by the Health-Climate Working Group facilitate integration of climate and health information.

The Health-Climate Working Group helps in interpreting the integrated climate-health information and ensures evidence-based decision ensues. The climate services for health specifically focusing on malaria response enables decision makers to plan for malaria prevention activities, including awareness campaigns. It also enables treatment actions to take place, including distributing mosquito nets, spraying some parasite breeding areas as well as providing malaria medication in areas affected or predicted to be affected by malaria.

Overall, the Ethiopia's Health-Climate Working Group has somewhat promoted the systems approach in the delivery of climate services for health in the country. It has helped integrate the previously independent climate and health information systems. It provides a national level platform for information exchanges and shared decision making (Dinku et al., 2016). It involves transdisciplinary teams working on data analysis, interpretation and translation. In the area of malaria intervention, it has helped translate empirical evidence into concrete responses with beneficial lifesaving health outcomes (Dinku et al., 2011). The processes and outcomes of Ethiopia's Health-Climate Working Group demonstrate how climate services for health that are fit for purpose can be co-produced (Thomson and Woyessa, 2011).

Despite these merits, Ethiopia's Health-Climate Working Group still has some areas to improve to make its attempt towards a systems approach to climate services more impactful. It must involve more local communities in co-generating and co-delivering the climate services for health. Obtaining more support for its activities must come from domestic actors, especially the government or the users of the climate services for sustainability, which is not the case at the moment. Capacity building of the diverse actors so that they can actively and meaningfully contribute to the discussions are important (Simane et al., 2016). There are reported climate data gaps because of inadequate weather stations that need investments to make data more complete and coverage of the data less spatial which is imperative for context-specific or more localized decision making (Bhopal et al., 2021). And finally, since the health impacts of climate change are not limited to Ethiopia, promoting a regional systems approach to climate services for health may result in the country realizing more benefits.

The second example is from Bhutan, a landlocked country in Asia (Ebi and Otmani del Barrio, 2017). Climate change is variously affecting human health in Bhutan. Climate Change has been associated with increasing heatwaves, EWEs, heat and extreme variations in precipitation. The health effects of these changes in climate include temperature related illnesses and deaths, extreme weather related health impacts, air pollution related health effects, water and food borne diseases, mental, nutritional, infectious and other health effects (Tshering and Sithey, 2008). Increased incidence and spread of vector-borne diseases, especially malaria and dengue as well as waterborne diseases, including diarrhoea have been attributed to climate change in Bhutan (WHO/UNDP, 2014). Heat and heat events are projected to reduce labor productivity and cause increased mortality by 2080 (WHO/UNDP, 2016).

The WHO/UNDP funded the "Climate change adaptation to protect human health" project in Bhutan that promoted delivery of climate

services for health. The project's specific objective was to strengthen Bhutan's capacities to identify and prevent deleterious effects of climate change on health outcomes in the country (WHO/UNDP, 2014). The project was executed by the Department of Public Health of the Ministry of Health (MoH), while Environmental Health Program (EHP) was mandated to implement and coordinate other agencies (WHO/UNDP, 2014). To ensure involvement of transdisciplinary teams a Project Steering Committee with representatives from relevant agencies was set up to provide advisory and management oversight to the project (WHO/UNDP, 2014).

To deliver climate services for health, Bhutan created national-level committees for cross sector integration of climate-health work. These committees ensured that climate change interventions are aligned with development goals (Ebi and Otmani del Barrio, 2017). The national coordination was also cascaded to lower tiers of government, especially those working directly with communities. Local health committees were established to coordinate climate-health responses at local levels. Nevertheless, the country's efforts aimed at building institutional and technical capacities on climate change and health have not been satisfactory and proportionate to the prevailing challenge (WHO/UNDP, 2016). This means more institutional building work still needs to be done.

To facilitate access to climate services for health at local level, the country developed educational materials on health adaptation to climate change impacts used by all health personnel (Ebi and Otmani del Barrio, 2017). Through capacity building activities, village health workers were trained to understand climate-health risks as well as carry out disease surveillance work. This enabled climate services for health to reach the most vulnerable and most at risk populations in the country (Ebi, 2016).

The application of the systems approach to climate services for health in Bhutan is evolving. Climate services for health are informing health adaptation interventions. Climate services for health have been applied in activities aimed to increase climate resilience of infrastructure in the country. And finally, the country has "climate information included in the Integrated Disease Surveillance and Response system, including development of early warning and response systems for climate-sensitive health risks" (WHO, 2015, p.7).

Bhutan's emerging capabilities to deploy the systems approach to climate services for health through integrating data and information from the MoH and NMS to develop early warning systems at national and local levels is impressive and informative (Ebi, 2016). However, the current activities are mainly funded by international partners. There is need to ensure increased local funding and ownership of the services for them to be sustainable.

The last example is from Germany, a European country with advanced climate services that comprise of producers, brokering institutions and users (Rösner, 2012). However, Germany's climate services are normally conceptualized using a value chain approach which emphasizes a linear delivery of the services and mapping actors involved in the services (Frisch, 2012). The ethos of co-production of climate services have been applied in some cases in Germany (Vollstedt et al., 2021).

The Deutscher Wetterdienst (DWD) whose activities are nationally legislated and include providing meteorological services to different users, including those in public health, for a fee is at the center of driving climate services in Germany (DWD, 2016). However, in this article, we elaborate climate services for health particularly the German Heat-Health Warning System (HHWS) that has been conceptualized using a systems approach (Matzarakis, Laschewski and Muthers, 2020).

Scientific projections show that Germany is experiencing a warming trend (WHO, 2018). The intense and frequent summer heat extremes occurring in Germany are mainly affecting the population health of persons living in urban areas (Mücke and Litvinovitch, 2020). The main health risks in the country are morbidity and mortality caused by inter alia EWEs such as heat waves and cold spells.

In 2003, Germany recorded 7,000 heat-related excess deaths and these are projected to increase to 8,500 per year by 2100 (Mücke and Litvinovitch, 2020). Germany may experience increased incidence of cardiovascular diseases associated with heat and skin cancer due to increased exposure to ultraviolet radiation (Wetterdienst, 2003). Economically, “the estimated monetized losses range from €6m to €43 m per hot day for an entire nation with a GDP of €2.5 trillion and 82 million population” (Karlsson and Ziebarth, 2018, p.115).

The specific negative health effects on health in Berlin including increase in summer morbidity and mortality as well as respiratory diseases have been reported in existing literature (Mahlkow and Donner, 2017). Among other reasons, the urban heat island effect exacerbate increase heat related diseases and deaths in Germany’s cities, especially Berlin (Gabriel and Endlicher, 2011). Given the health effects of heat on the Germany population, the country operationalized the HHWS in 2005 (Matzarakis, Laschewski and Muthers, 2020).

Germany has developed several explicit policy and institutional mechanisms to respond to heat under its National Adaptation Strategy on Climate Change (DAS). Operationalization of DAS has happened since 2011, with government providing 9 million Euros for community adaptation projects for the period 2011 to 2017 of which 10% was specifically allocated to the public health sector (Mücke and Litvinovitch, 2020). As part of the climate change adaptation institutional framework, Germany created a Working Group under the auspices of German Conference of Environment Ministers that comprised of ministries of health and environment as well as state authorities with a mandate to study and provide empirical evidence on the climate-health risks (Baeker and Stutzinger-schwarz, 2017). The Germany Ministry of Health is the heat coordination agency but it collaborates with other ministries (Baeker and Stutzinger-schwarz, 2017).

The DWD plays a pivotal role in the delivery of climate services for health, especially the HHWS. It takes into account all relevant meteorological and non-meteorological, physical (infrastructure and location), socio-economic and demographic parameters influencing the thermal state of the human body to inform the HHWS. (Matzarakis, Laschewski and Muthers, 2020). The DWD issues heat-health warnings to authorities and the public using the radio and television, internet, newsletter, smartphone application or email. Federal governments oftentimes set up telephone hotlines and information campaigns (Baeker and Stutzinger-schwarz, 2017). While the information shared normally includes a map with textual explanations, specific information for the elderly and cities is has been emphasized as well.

In 2016, several stakeholders working under a Working Group on Adaptation to the Impacts of Climate Change in the Health Sector reviewed, analyzed and communicated information on the health effects of heat in the country. The Working Group helped in the creation of the Heat Health Action Plan (HHAP) published in 2017. The HHAP are a masterplan for the country and are used to guide further development of regional plans.

Overall, the main aim of the HHWS is to reduce morbidity associated with heat waves by issuing heat and health warnings, facilitate heat-planning in other non-health but relevant sectors, integrate health into all policies, mobilize resources to respond to heat and raise public awareness on heat (WHO, 2018). The HHWS emphasizes on the most vulnerable groups such as the elderly, chronically ill or obese people, infants, outdoor workers, the poor and persons vulnerable to heat due to social factors.

While the implementation of the heat plan happens at municipal level, the DWD is mandated to issue heat warnings that enable authorities and the public to introduce preventative and protection measures. The heat-health services encompass information on how to reduce indoor heat, to care for vulnerable population groups and informs employees in health, education and social care settings what to do during heat waves. In Berlin, for example, the heat response intervention includes providing drinking water and sun protection products (Baeker and Stutzinger-schwarz, 2017).

What is apparent is that heat-health services in Germany are evolving positively with institutional and policy support. Climate services for health are delivered by public and private as well as national, regional and local actors. Specific agencies involved include aid organizations, hospitals, pharmacists, medical professionals, the Red Cross, schools, kindergartens, care homes, among others (Vanderplanken et al., 2021). However, the federal nature of Germany system of government minimizes centralization of the services.

Having detailed these three examples, we turn to discuss some key points arising from these in the next section.

4. Enhancing the systems approach to climate services

There are five important points arising from the examples provided in the previous section and some merits and limitations of the emerging systems approach to climate services elaborated in this section as follows.

4.1. Structural aspects of emerging systems approach to climate services for health

Our three illustrative examples demonstrate different aspects related to the application and merits of the emerging systems approach to climate services for health. The example of Climate-Health Working Group in Ethiopia demonstrates a centralized systems approach to climate services for health. In this centralized system, the Climate-Health Working Group integrates, interprets, and disseminates climate-health information to policy makers and practitioners throughout the country. While the merit of the centralized systems approach is that it ensures that climate services for health are prioritized and have support from higher levels of government, it is a top-down approach which limits feedback and interactive learning. It also limits delivery of climate services for health to public institutions and provides limited space for private actors as well as services brokering institutions to evolve.

In contrast, the Bhutan example shows a decentralized systems approach to climate services for health. While Bhutan has a national system that integrates climate-health information, the country built the capacities of cadres located at various levels to interpret and disseminate climate services for health to local communities. The local cadres contextualize and localize climate services for health so that they are usable to community members, including the most vulnerable members of the community. The main advantage of the decentralized systems approach to climate services demonstrated by the Bhutan example is that it allows for interactive learning, contextualization of the services and continuous development of the service. It also allows for brokering institutions as well as private actors to flourish.

The German example illustrates a devolved systems approach to climate services for health. In this case, the national system vertically interacts with the regional and municipal level service providers and users, while simultaneously allowing horizontal interactions between regional and municipal level users. The system permits municipalities to make decisions on interventions and policies that benefit local communities under their jurisdiction. The system has permitted private actors and brokering institutions to get involved in the delivery of the HHWS.

4.2. Niche areas and systems approach to climate services for health

The three examples presented demonstrate that services tend to focus on certain niche areas rather than being all-encompassing. The main factor determining the niches is the priority given to actual or perceived or projected negative health outcome, especially the illness or disease associated with climate change and variability. Ethiopians are affected by malaria which justifies climate services for health that focus on malaria response. The embryonic and evolving systems approach to

climate services for health in Bhutan has explored responses to dengue, malaria and diarrheal diseases. These are climate sensitive diseases with high negative impact on population health. Heat and heat waves have caused many deaths in European countries including Germany. Hence, the country's focus on a heat-health response system is reasonable and rational.

The evolving niche-focused service provision within the systems approach to climate services for health makes practical sense and has several merits. Firstly, niche-based services direct resources towards responding to the greatest health needs of the community. This is important because resources are always inadequate to respond to all the health needs of communities. Second, it enables capacity building actions to be focused. The Bhutan example demonstrate how high-quality cadres that could understand and respond to climate-health matters emerged from training and capacity building. Third, it allows for learnings, including policy and practice learning. In terms of practice, niche interventions can be scaled up once proven effective and transferable knowledge used to develop other interventions. New policies on other areas can incorporate learning insights from one niche area. All the examples somewhat demonstrated the importance of interactive learning, albeit in different degrees, in production and delivery of climate services for health.

Given this, the application of the systems approach to climate services for health must be viewed as niche-focused rather than all-encompassing. Thus, the systems approach promotes provision of differentiated services.

4.3. Importance of feedback loops in the systems approach

As stated before, the systems approach to climate services for health shuns linear conceptualization of services. It promotes conceptualizations that value backward and forward feedback loops (Pongsiri and Bassi, 2021). The Germany case is illustrative of this. The creation of the HHWS involved public participation processes. There are also evaluation processes that have commenced in several cities, including Berlin in order to get information on the efficacy of the HHWS. The Ethiopia service also has some elements of feedback loops at the top level. This happens through iterations and interactions within the Climate-Health Group. The systems approach to climate services, therefore, must be conceptualized as non-linear and comprised of feedback loops (Stern, 2016). A system with strong feedback loops enhances sustainability and robustness of climate services for health (Whitmee et al., 2015).

4.4. Furthering the systems approach to climate services for health

This perspective article mainly explored the application and merits as well as demerits of the application of the systems approach to climate services for health at national level. The illustrative examples show that the systems approach is applicable at national and lower tiers of the country, including provincial, municipal and community levels. An analysis at regional level was not done. This is a limitation because climate change effects on health are not limited to national boundaries. Therefore, we encourage further analysis of the application and merits of the systems approach to climate services for health at regional and international levels.

The examples also demonstrate that the systems approach to climate services for health demand integration of different systems, especially the health and climate systems. Through that integration, Health in All policies can be promoted. Despite this, the examples presented should not be interpreted as the best examples of what type of a system must exist. They should be considered as providing existing options on applicable systems that can be adopted and adapted by countries assessing way to deliver climate services for health. The examples shows that there is no one-size-fits-all to the application of the systems approach to climate services for health.

An explicit key point demonstrated by all the examples is that the

involvement of high echelons of government in coordinating some processes and policies facilitate the creation of a conducive environment for delivery of climate services for health. In all cases, the government is involved at ministerial level, which ensures coordination of the service. Given this, government involvement in policy making and coordination is recommended as an essential aspect for effective delivery of climate services for health through a systems approach.

The Germany and Bhutan examples show that the systems approach to climate services for health promotes prioritization of interventions focusing on the most vulnerable populations. The Germany example showed a focus on the elderly who are the most vulnerable to heat, while the Bhutan case focused on persons vulnerable to dengue and malaria. Given this, it can be said that the application of the systems approach can lead to greater inclusion of the marginalized populations. It enables focused interventions that promote resilience amongst populations whose health will be disproportionately affected by climate change effects. Since the systems approach allows for a focused intervention for the vulnerable populations, it may be an approach most suitable to many countries, especially those with many vulnerable persons such as African countries.

4.5. Reconsidering policy and practice

Another key point that implicitly arises from the examples presented is that the application of systems approach to climate services for health somewhat calls for regular reconsideration of policy and practice. Two forms of policy and practice reconsiderations can be drawn from the examples. First, a review of existing policies and institutions so that they are realigned to the demands of delivering climate services for health. Second, continuous assessment and adaptation of policies and institutions so that they can respond to the most pressing health needs of the population. The Germany example showed institutional and policy changes made to deliver effective HHWS. Similarly, the Ethiopia Climate-Health Working group changed the operations of some agencies so that they could deliver climate services for health.

Overall, rigid, and inflexible policies and institutions will not be amenable to the application of the systems approach to climate services. Similarly, failure to regularly assess and review policy and institutional frameworks and adjust them accordingly would not promote the application of the systems approach to climate services for health. As such, an adaptive, interactive learning approach enhances the effective application of the systems approach to climate services for health (Vogel, Steynor and Manyuchi, 2019).

5. Conclusions

The human health effects of climate change and variability are well established in existing literature. Therefore, climate services for health that facilitate decision making and effective responses to the health impacts of climate change are urgently required. In this perspective article, we used examples from Ethiopia, Bhutan and Germany to examine the application of the systems approach to climate services. We drew some insights from the examples and highlighted the merits of applying the systems approach.

Overall, the application of the systems approach to climate services for health can promote integration of climate- health information, effective institutional and policy coordination, capacity building activities, adaptive and interactive learning as well as evolution of contextually relevant climate services for health focused on the most vulnerable populations. The approach can ensure timely review of policies and adaptive adjustment of institutions, necessary for an effective response system. It can help inform policy and practice decisions. It also furthers transdisciplinary ethos in policy and practice and can help bring together information from diverse sources towards a robust service. The application of the systems approach is necessary to enhance health adaptation and resilience.

The empirical evidence presented showed that the systems approach to climate services for health encompasses various dimensions. Regardless of this, the government has a greater role to play in promoting delivery of effective climate services for health. This article importantly provided new insights on how the systems approach has been applied to climate services for health and filled in gaps in knowledge on this subject. It also proffered some suggestions on how to enhance the application of the approach in future. Future studies that focus on the application of the systems approach to climate services for health at regional and international levels are encouraged. While this article provided a robust conceptual framework and rationale for its use, testing and using the framework in other settings will help refine the framework. As such, we recommend some case studies that further refine the conceptualization and application of the systems approach to climate services for health.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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