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Mainstreaming forecast based action into national disaster risk management systems: experience from drought risk management in Kenya

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ABSTRACT
Drought and food security crises heighten risks to lives and livelihoods in East Africa. In recent years, a shift towards acting in advance of such events has gained momentum, notably among the humanitarian and development community. This shift is premised on tools that link climate forecasts with pre-agreed actions and funding, known as Forecast-based Action (FbA), or anticipatory action more widely. While FbA approaches have been developed by a number of humanitarian agencies, the key to scaling-up is mainstreaming these approaches into national risk management systems. This paper addresses this gap in the context of drought risk management in Kenya. We analyse Kenya's current drought management system to assess the potential usability of climate forecast information within the existing system, and outline steps towards improved usability of climate information. Further, we note the critical importance of enabling institutions and reliable financing to ensure that information can be consistently *used* to trigger early action. We discuss the implications of this for scaling-up FbA into national risk management systems.

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Drought; climate information services; forecast-based action; early warning systems; early warning early action; Kenya

1. Introduction and context

Climate change is expected to increase the frequency and magnitude of droughts, storms and floods in the future (IPCC, 2012; IPCC, 2014). To mitigate the impacts of such hazards, emphasis has been placed on developing early warning systems (EWS), in particular EWS which account for the vulnerability of populations at risk (Basher, 2006; UNISDR, 2006). The Sendai framework for Disaster Risk Reduction sets out the need to increase the coverage of EWS and access to disaster risk information (UNISDR, 2006). However, the effectiveness of EWS, specifically translating warnings into effective action, remains a challenge in many countries at risk of climate extremes. This is particularly the case for drought hazards and resultant food insecurity, as it is difficult to define 'trigger' points for action for slow-onset events (Wilkinson et al., 2018). There are several examples of drought early warnings going unheeded, for example, the 2011 Horn of Africa crisis was preceded by 11 months of early warning of drought, followed by a famine warning 3 months before the UN officially declaring a famine (Bailey, 2012).

Recent efforts to overcome late response to hazards are based on linking forecast information with pre-agreed actions and funding, known as Forecast-based Action (FbA), and more broadly as 'Anticipatory Action' (AA). FbA provides a basis for stakeholders to use early warning information to trigger appropriate risk management actions in the time between a forecast warning and a disaster (Coughlan De Perez et al., 2015), taking advantage of advances in weather and climate forecasting. There is growing evidence that acting early is beneficial in reducing losses, mitigating hazard impacts and costs of disaster response (Cabot Venton, 2017; FAO, 2018). Accordingly, several initiatives have emerged around this concept, such as the International Federation of the Red Cross Cross and Red Crescent Societies' Disaster Response Emergency Fund (DREF) Forecast Based Action fund, the START Network's Crisis Anticipation Window and the Food and Agriculture Organisation's Early Warning-Early Action system. The uptake of FbA/AA approaches is growing and is being scaled up; in total a 2018 review recorded 25 different instruments which use a forecast in combination with delivery and financing mechanisms to take early action (Wilkinson et al., 2018). Moreover, the new Risk-informed Early Action Partnership initiative (REAP) aims to reach 1 billion people across developing countries with improved EWS and early action initiatives by bringing together existing actors and initiatives (REAP Secretariat, 2019).

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While the technical details of FbA methodologies differ, they typically have in common three key pillars (Clarke & Dercon, 2016):

1. planning and protocols for action;
2. triggers: a fast, evidence-based decision-making process typically with a specified forecast trigger before event and/or impacts are felt;
3. pre-agreed finance.

As such, the design of FbA systems must encompass hazard information components, most commonly forecasts, as well as agreed actions formulated into plans such as standard operating procedures, and dedicated finance. Achieving all of these demands significant planning, clarification of responsibilities and strong coordination (Wilkinson et al., 2018).

However, challenges remain which constrain the effectiveness of such advances. Foremost amongst these is the fact that small-scale FbA initiatives are typically not rooted in government risk management systems, nor coordinated with national-scale developments in forecasting, EWS or climate adaptation/resilience (Wilkinson et al., 2020). As a result, they are liable to suffer from a lack of political buy-in and hence long-term sustainability; issues that have long limited the efficacy of early warning systems (Buchanan-Smith et al., 1994). In particular, there is little evidence of the modification of existing responsive national risk management systems towards an anticipatory or FbA inspired approach, and limited experience of mainstreaming FbA/AA within national systems and into the wider disaster risk reduction (DRR) landscape (Wilkinson et al., 2020). For example, while there are a number of other FbA/AA initiatives underway in the Eastern Africa region, these are largely independent humanitarian initiatives, such as the UN Central Emergency Response Fund anticipatory response pilot in Ethiopia and Somalia (UN OCHA, 2021a, 2021b).

In this paper, we address this knowledge gap and explore what would need to change to mainstream FbA/AA into drought management in Kenya, towards an anticipatory risk management system. We focus on the changes required to enable climate information to be used in practice, as well as changes to institutional structures and reliable financing to facilitate actions to be taken based on this. This paper is based on extensive research to understand Kenya's existing drought risk management system, which here we call the DEWS, focusing on one semi-arid county, Kitui county. We explore the usability of climate information within the DEWS at a county level, as well as the challenges to enabling climate information to consistently inform this system. We use the conceptual model proposed by Lemos et al. (2012), which describes how the characteristics of 'fit, interplay and interaction' in climate information can overcome the information 'usability gap'. We then consider the extent to which we can narrow the 'usability gap', enabling climate information to transition from being useful to being used in practice (Boaz & Hayden, 2002). We highlight the importance of the wider policy environment which determines the feasibility of acting on this information. Following recent contributions within climate services research that make the case for examining wider enabling factors which can close the 'climate information usability gap' (Vincent et al., 2020), in this paper we provide a detailed case study of these factors in the context of drought risk management in Kenya. We conclude by emphasizing the critical importance of institutional structures and reliable financing, both of which must be situated within a wider context of an enabling national disaster risk management policy. We fully recognize that drought is a complex, slow-onset cascading hazard where food insecurity relates not only to local food production, but to other drivers of food access. Regional studies have shown conflict and economic downturns have been a major cause of food insecurity across Africa (FAO et al., 2018). Moreover, recent years have demonstrated the significant impact on food security of events such as the Covid-19 pandemic (Ayanlade & Radeny, 2020) and agricultural pests, for example locust outbreaks (Salih et al., 2020). However, in this paper, we focus on climate information as a proxy for the biophysical drivers of food insecurity, as explained in Section 3.1.

2. Methods

2.1. Conceptual Framework

We draw from the literature in climate services and policy evaluation. First, we adopt the conceptualisation of Lemos et al. (2012) of 'fit, interplay and interaction' to understand the processes and mechanisms that may move climate information from what producers *hope* is useful, to what decision makers deem '*usable*'. This framework spans a range of characteristics of climate information – broadly categorized as 'fit' of information such as salience and timeliness, 'interplay', meaning the way in which it is produced, such as the extent to which there is a two-way iterative process between producers and users. Finally, 'interaction' factors encompass institutional incentives, cultures, levels of risk aversion and degrees of co-production. However, 'interaction' does not extend to the wider enabling policy environments which we argue are critical to enabling information to become 'used' (see Figure 1).

The Lemos et al. (2012) framework is a key paper within the climate services literature in advancing a number of themes such as the importance of usability or 'actionable' information (Kirchoff et al., 2013), building on the understanding that 'climate science usability is a function both of the context of potential use and of the process of scientific knowledge production itself' (Dilling & Lemos, 2011, p. 680). This is linked to broader science-policy work including critiques of the 'loading dock' model of science in policy (Cash et al., 2006) in which information is simply delivered to 'users' without sufficient consideration of its useability. The concept of co-production, which requires integrating different knowledge, experiences and working practices from across different disciplines, sectors and actors to jointly develop new and combined knowledge (Visman et al., 2018), is a component of the Lemos et al. framework that is further reflected in our research. A co-production approach is essential to solving problems around climate information relevance and usability (Carter et al., 2019). Second, we draw on additional research about information usability. Here we recognize the process of developing

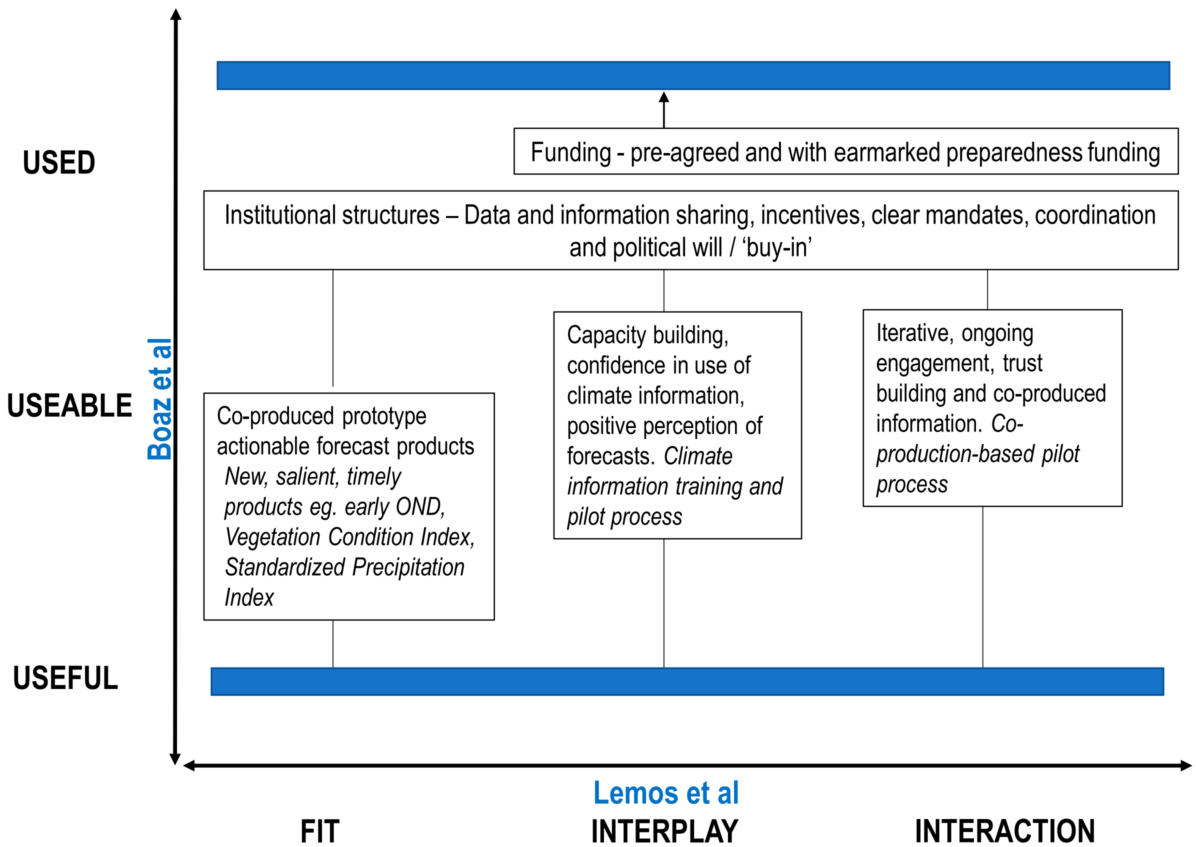


Figure 1. Conceptual framework of climate information moving from useful to usable to use. The bottom bar indicates a baseline at the start of the project, the top blue bars indicate what would need to change in addition to improvements in fit, interplay and interaction to move from useful to use. The italic text in the boxes indicates steps that enabled progress.

information that is both 'useful, usable and *used' (emphasis added)* (Boaz & Hayden, 2002). This is critical because it emphasizes the difference between information being usable in principle, and used in practice, which is a key priority in the FbA community.

In this paper, we combine these two frameworks (Lemos et al., 2012 and Boaz & Hayden, 2002) to outline how climate information becomes used in practice (Figure 1). This shows that while improved climate information and co-production can move information towards being 'usable', there remains a gap between usable in principle and used in practice. Our results suggest that while improving the nature, timing and processes of forecast information (i.e. the fit, interplay and interaction) can move information towards being 'usable', additional attention is needed to move towards information being used. Specifically, the factors that determine this have institutional dimensions including coordination, communication, mandates and financial considerations around timely and reliable finance for taking early action – all of which exist in a wider context of national politics and the DRR landscape.

2.2. Methodology

Our methodology was designed to understand both existing climate information processes and flows in Kenya's drought management system, the wider institutional context this operates in and how this ultimately effects climate information 'usability'. We adopted a mixed-methods approach incorporating desk-based policy review, Key Informant Interviews (KIIs) and a series of participatory workshops, supported by training needs assessment and workshop evaluation questionnaires. Based on findings from this, we developed and piloted new forecast products with research participants.

First, we conducted an initial review of policy literature, selected due to their key role in drought management and early warning processes in Kenya and the wider region. The list of documents reviewed and their relevance to the drought management process is summarized in Table S1. We then conducted a series of KIIs based on a purposive sampling approach to ensure the representation of the principal agencies in drought management at national level, as identified by the policy review. Thus participants were selected to represent key actors involved such as the Kenya Food Security Meeting (KFSM) and the Kenya Food Security Steering Group (KFSSG), representation from national ministries, national and international humanitarian and development agencies, and key members of Kitui's County Steering Group (CSG) for drought, which was our focal case study.[1] KIIs were also undertaken with several County Directors of Meteorological Services (CDMs) to better appreciate their current service provision and engagement with CSG. Designed to collect both quantitative and qualitative data, the KII protocol included open questions and self-assessment scoring on key issues related to drought management and was tailored to the national/regional, county level, and meteorological stakeholders. An exemplar KII protocol for national and regional decisionmakers is included in Table S2.

However, we needed to interact with decision-makers in a more participatory way to triangulate these findings and understand how improved forecast products could be integrated into the existing system to move towards FbA/AA. A series of workshops with stakeholders in the County Steering Group in Kitui were carried out between July 2018 and January 2020 (list of engagements included in Table S3). The assessment of decision makers' confidence in using climate information was undertaken through training needs assessment (see Table S4a), supplemented by the KIIs and participant observation during participatory workshop exercises. Kitui was selected due to it being one of the arid and semi-arid counties where strong relationships had been established through previous projects, which included strengthening climate information services and support in piloting the development of a county climate information services plan (Government of Kenya, 2015).

The workshops employed tools from a Participatory Impact Pathways Analysis approach (PIPA) (Alvarez et al. 2010), which is designed for complex research-for-development contexts and provides a framework for 'action research' on processes of change (ibid: 946) through making explicit assumptions about how the research will lead to change. The essence of a PIPA methodology captures a number of the characteristics of a 'co-production' approach widely emphasized in climate services research, such as building common ground, identifying needs of decision makers and co-developing solutions (Carter et al., 2019). Core elements of PIPA include (i) Causal or problem-tree analysis; (ii) Visioning exercises; (iii) Current and future network maps, indicating interactions and the linkages required to achieve project aims and (iv) an 'Outcome Logic Model' (Audia et al., 2021).

The workshops also drew one exercise from the 'Participatory Integrated Climate Services' (PICSA) approach, which has a particular focus on climate information and climate risk management in research and development (Dorward et al., 2015). PICSA methodologies have been used extensively in relevant research relating to climate information and adaptation in Sub-Saharan Africa (Carr et al., 2020; Clarkson et al., 2019; Dorward et al., 2020). Specifically, we built on PICSA's Options Matrix exercise to develop a 'Forecast Preparedness Options Matrix' which we used during initial workshops to promote discussion on potential preparedness actions, their respective required levels of investment, forecast probabilities and skill to trigger these. An example matrix is included in Table S5.

Finally, based on the training needs assessment, participant observation, KII and informal evaluation feedback from workshops, we developed a climate information training designed to strengthen decision-makers' appreciation of and confidence in appropriately using weather and climate information, establishing the basis for their active engagement in co-production of decision-relevant new and improved weather and climate products that could better support drought risk management.[2]

In summary, these participatory methodologies are important in building understanding and respect for different knowledge sources and the more equitable collaborative partnerships required to support the co-production of decision-relevant climate services (Carter et al., 2019; Vincent et al., 2020). While it was necessary to modify the tools from these methodologies this is not entirely novel – for example, Ely and Oxley show how scaling down the full methodology of PIPA within smaller projects can still provide useful insights and maintain the core participatory essence of these approaches (2014).

3. Climate forecasts and the Kenya drought early warning system

Over 80% of Kenya's land mass and about one-third of the population fall under the classification of Arid and Semi-Arid Lands (ASAL), which are prone to drought and food insecurity. The 2016/2017 drought event affected 23 of 47 counties and the response cost is estimated to have been $96 million (Funk et al., 2018). Kenya has a well-developed drought early warning system. Indeed, stronger and more transparent information systems contributed to a more effective early warning response to the 2016/2017 drought event (Grunewald et al., 2019). However, Kenya's DEWS is still largely responsive, despite the fact that Kenya and the wider Greater Horn of Africa (GHA) is a relative 'sweet spot' of climate predictability over seasonal to subseasonal timescales (Kilavi et al., 2018a, 2018b; MacLeod, 2018; MacLeod et al., 2021). This provides a strong case for more anticipatory systems for drought hazards in Kenya.

3.1. The structure of Kenya's existing drought management systems

The drought management system in Kenya is not well documented in the existing literature. The system evolved from a drought and famine monitoring and early warning project in Turkana county to a nationwide arid lands management project in the early 2000s (Oduor et al., 2014). Today, it is coordinated by the National Drought Management Authority (NDMA), which was established in 2012 through the Ending Drought Emergencies (EDE) framework in response to the drought and food security crisis experienced in Kenya and indeed across the Greater Horn of Africa of 2010–11. NDMA coordinates structures at national and county levels for the 23 ASAL counties. Whilst there is considerable interaction across the national and county levels of governance (see Figure 2), and we outline both structures in this section, our paper focuses primarily on the county level system with the case study of Kitui county.

At a national level, NDMA coordinates the Kenya Food Security Meeting (KFSM) and its advisory technical body, the Kenya Food Security Steering Group (KFSSG). The KFSSG currently provides a multi-agency food security status monitoring, assessment and prognosis for Kenya. This is done through two national assessments undertaken every year, the Short Rains Assessment (SRA) conducted in February and

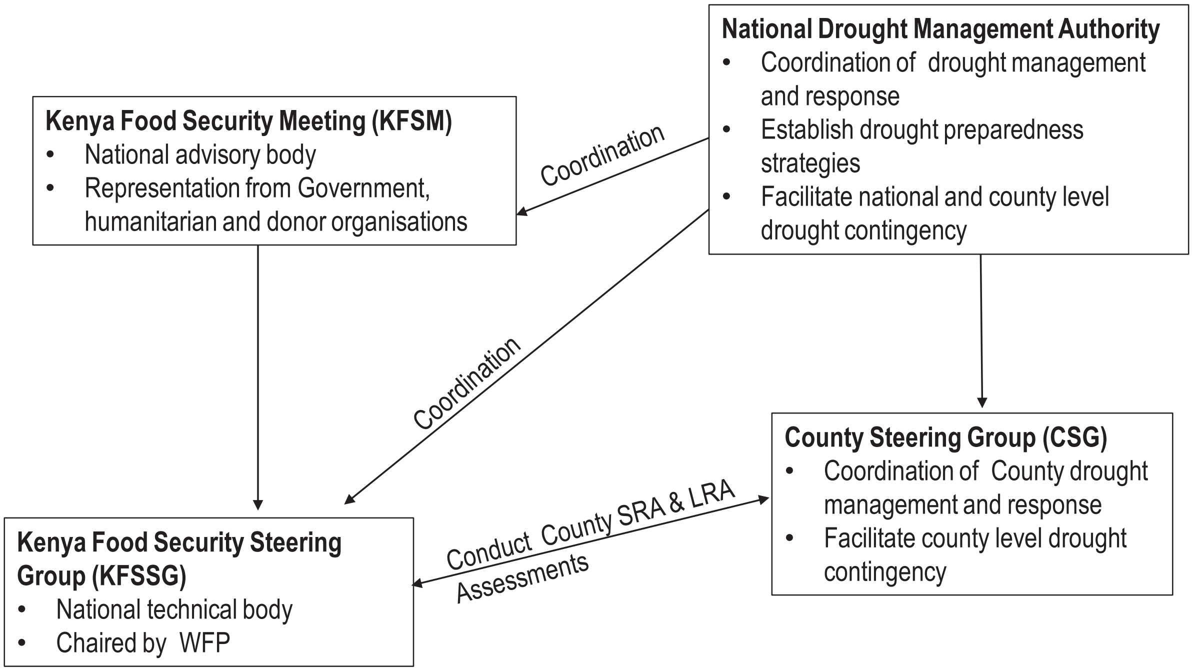


Figure 2. Schematic representing drought management structures in Kenya and the connections between county and national level structures

the Long Rains Assessment (LRA) in July. These analyse the impacts of the two rainy seasons on food security and nutrition and include a food security prognosis for the next 6 months. The national LRA and SRA reports are consolidated from county reports conducted by each ASAL county steering group, combined with secondary datasets from partner institutions. For example, the Famine Early Warning Systems Network (FEWSNet) provides data on markets and climate forecasts from the US National Oceanographic and Atmospheric Administration (NOAA) Climate Prediction Center are also considered. As such, the current county and consolidated national food security status are determined from monitored data while the 6-month prognosis is an expert judgement based on the current status and seasonal climate forecasts. Climate forecasts informing the system are from international rather than nationally mandated institutions – seasonal forecasts from Kenya Meteorological Department are not referenced in the LRA and SRA reports.

The consolidated national report provides recommendations of response activities that key sectors should carry out based on the impact of the past season's rains and the food security prognosis. The report also forms the basis of national drought management planning including the reallocation of development funds to drought response and presidential declarations of drought national disaster. For example, on 10th February 2017, the President declared a drought emergency following the release of the SRA in late January,[3] providing the green light for humanitarian agencies to raise funds for drought response. Thus while the KFSSG does use climate (rainfall) forecast information to inform the food security prognosis (i) the climate information is not used to trigger decisions in a systematic or traceable manner, (ii) the LRA/SRA recommendations propose largely reactive actions to drought conditions informed by the monitoring information in the LRA and SRA, which take precedence in informing national-level policymaking and budget allocation. Further, counties have significant implementation responsibilities through the county steering group process (see below), but they largely require funding allocation from the national government's National Drought Contingency Fund (NDCF) to do so. This two-way dynamic between national and county government, as well as horizontally between ministries at both levels of government is complex, and not necessarily conducive of the clear mandates, decision-making processes and financial arrangements required by FbA/AA to take early action.

At the county level, the key structure for drought management is the County Steering Group (CSG) (Figure 2), co-ordinated by NDMA involving the NDMA County staff, NGOs and key ministries such as agriculture and livestock, as well as a county Kenya Meteorological Department representative. Through the CSGs, NDMA operates a system of drought early warning, based on a two-pronged approach:

(1) Monthly County Early Warning Bulletins.[4] These synthesize and summarize the status of climate and food security in the county. The bulletin headline is the county drought phase classification of normal, alert, alarm, emergency or recovery (Figure 3) defined by the CSG based in part on values of biophysical climate (using the Standardized Precipitation Index, SPI), and vegetation status data (the satellite-derived Vegetation Condition Index, VCI), and socio-economic determinants of food security. The Early Warning Bulletin also indicates recommended drought response activities to be carried out or scaled up. Currently, the Early Warning Bulletins do not include forecast information, although through an ongoing pilot programme this may be set to change – further details are provided in Section 4.3.
(2) CSGs prepare County Drought Contingency Plans (DCPs), which list the sectoral drought response actions, and respective budgets, to be triggered by the various

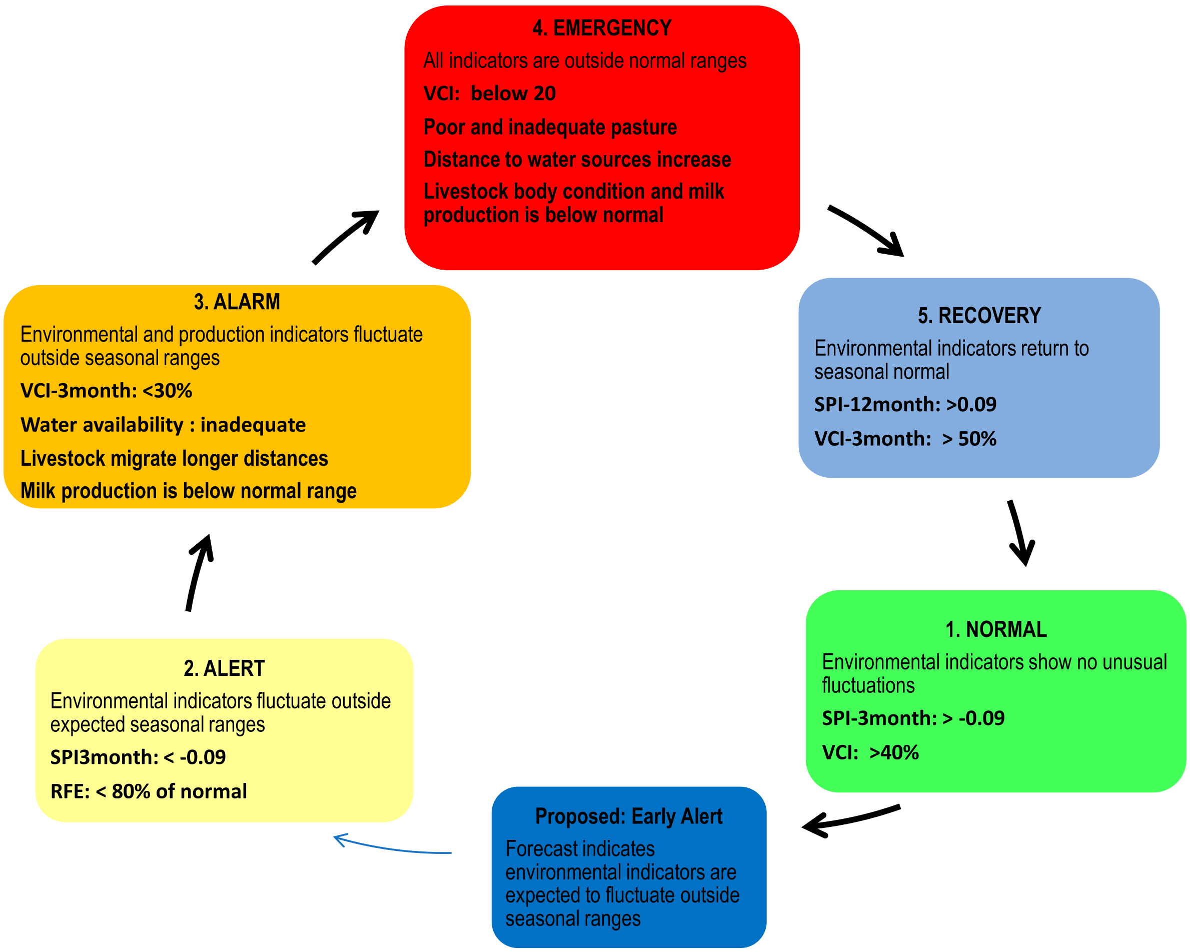


Figure 3. County Drought phase classification cycle, with the defining indicators and trigger threshold values shown, adapted from NDMA County Contingency plans. The proposed 'Early Alert' phase is identified as one way for Kenya's DEWS to become more forecast oriented, triggered by forecasts of the monitoring indicators currently used, discussed in Section 5.1. Note that the phase classifications revert to recovery and normal from the alert, alarm and emergency phases if indicators such as SPI & VCI recover.

county drought phases. A drought phase classification of 'Alarm' status (Figure 3) triggers the activation of funding from the NDCF to support drought response actions. The county phase classification decided by the CSG involves a degree of discretion, which may be influenced by both expert and political judgements, and which can override the biophysical and socio-economic indicators (noted in 1 above). The prioritising of actions to be implemented from the DCP is also discretional to NDMA. The evidence-based county drought classification (Figure 3) and its link to the DCP provides the opportunity for a forecast-based action which we explore in Section 4.1

Thus the DEWS is based on monitoring evolving drought and food security conditions and the actions are reactive in response to established drought conditions. This is the case despite the presentation of the weather and climate forecasts in Kitui's CSG forums by the KMD County Director of Meteorological Services (CDMS), as noted in Section 3.2. We explore the potential for integrating KMD forecasts into the county-level DEWS in Section 4.

3.2. Climate and weather forecast provision by the Kenya Meteorological Department (KMD)

KMD is Kenya's national institution mandated to provide forecasts to government departments and the public. Of KMD's existing national forecast services, those of most relevance to drought management are:

(1) Seasonal forecasts of rainfall, specifically the probability of forthcoming total seasonal rainfall being in one of the three 'tercile' categories of above normal, normal or below normal (Figure 4), as well as the expected onset and cessation of the seasonal rains. These forecasts are released about a month ahead of the main rainy seasons of March–April–May (MAM) and October–November–December (OND).
(2) Month ahead forecasts of the monthly total tercile probability issued at the beginning of each month (i.e. with zero month lead).
(3) Agrometeorological bulletins produced every 10 days analyse the effect of observed and predicted weather on crops depending on the crop growing stage.

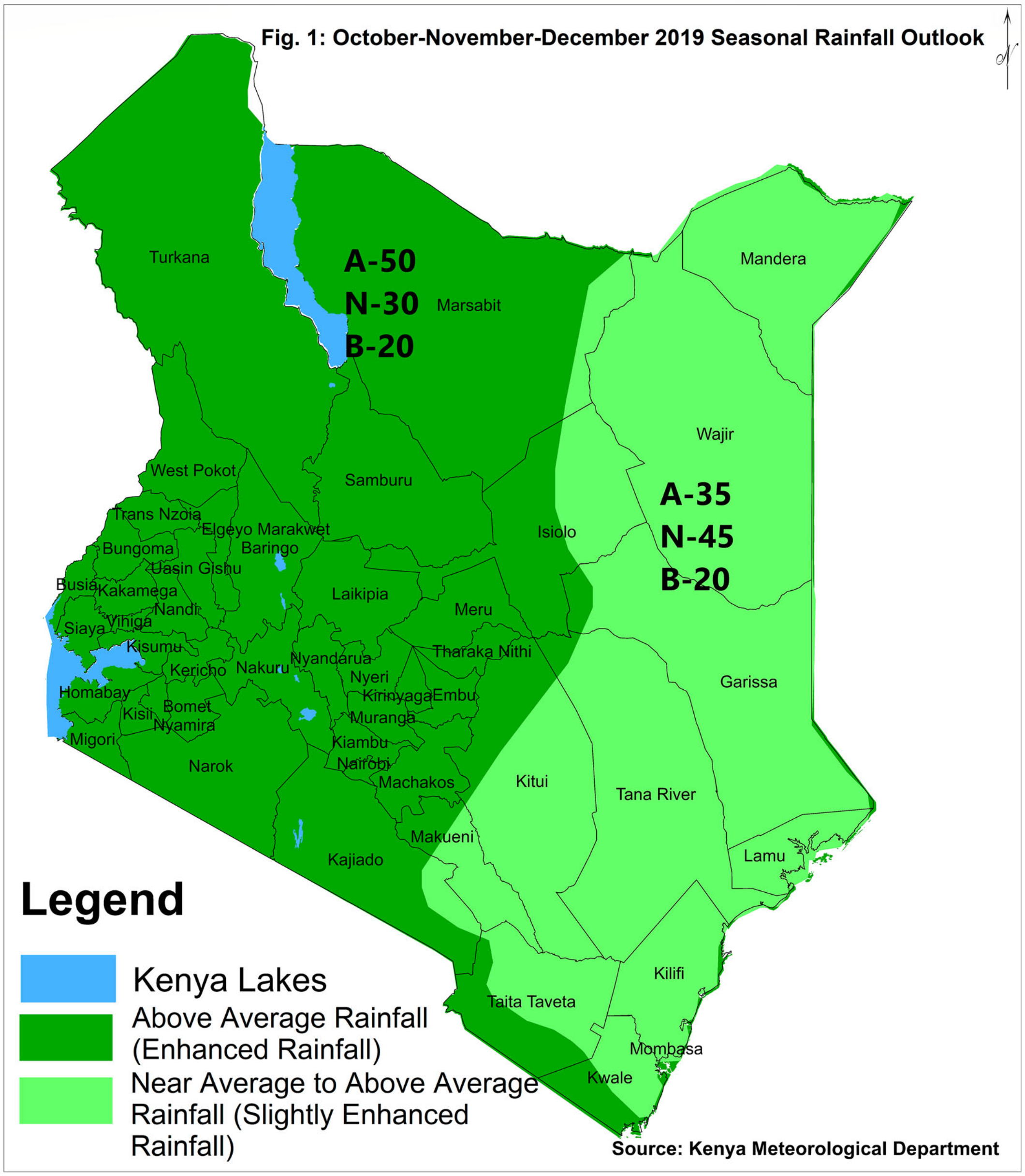


Figure 4. October–November–December 2019 seasonal forecast issued by KMD. 'A', 'N' and 'B', respectively indicates the probability for the three rainfall tercile categories of 'above normal', 'normal' and 'below normal' rainfall.

As noted above, the KMD seasonal forecasts do not contribute to the LRA or SRA assessments or food security prognoses nor, in a systematic way, into the county steering group process. In this paper, we focus on the provision of forecasts by KMD as the national meteorological service, though it is important to note that at a regional scale, ICPAC serves as the regional centre for forecast production and dissemination, and organizes the Greater Horn of Africa Climate Outlook Forum, at which representatives of national meteorological services across the region analyse and discuss various forecasts for the upcoming season.

At county level, KMD operates a decentralized climate service with CDMSs communicating localized meteorological services through accessible channels (Barrett et al., 2020b). In many counties, the CDMS sits on the CSG (see Section 3.1) and presents the national forecasts and a range of 'tailored', downscaled county climate services. In Kitui these services include seasonal forecasts with terciles downscaled and tailored to sub-county level and agro-climate metrics, e.g. probability of receiving rain above a crop-specific threshold. However, the range of KMD climate services is not standardized across all counties and, as stated above, there is no systematic integration of forecasts from KMD within Kenya's DEWS, either at county or national level.

4. Understanding weak forecast usability in the DEWS: fit, interplay and interaction

In this section, we explore reasons for this lack of integration between climate forecasts and the drought phase classification,

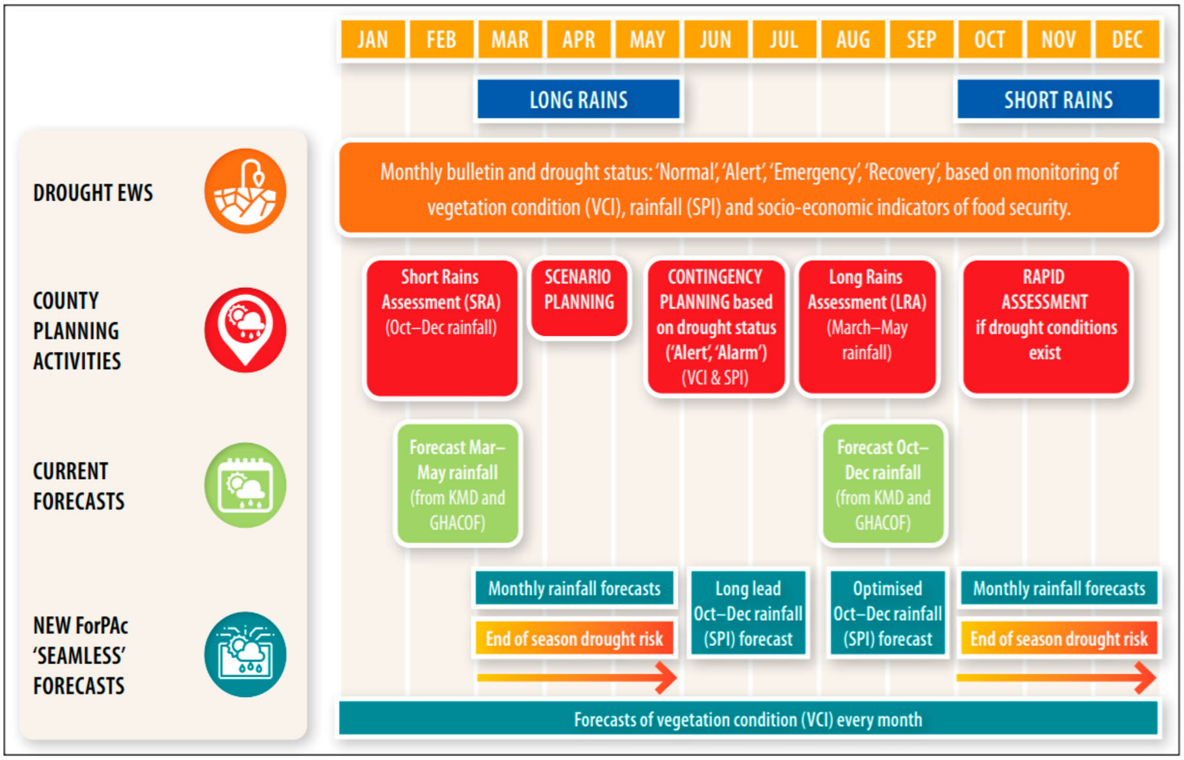


Figure 5. Schematic co-produced with stakeholders during PIPA exercise, mapping seasonal information with drought management and the release of climate information. This schematic helped us to identify entry points where more decision-relevant and timely forecasts could be introduced 'New ForPAc 'Seamless Forecasts'. Reproduced from Taylor et al. (2020).

county drought contingency planning and early warning bulletins, adopting the Lemos et al. (2012) model of 'fit, interplay and interaction'.

4.1. Degree of 'fit': accurate, credible and timely information

Lemos et al. (2012) explain that 'users' are more likely to use climate information that they perceive to be accurate, credible, salient, timely and useful to their decision-making needs. However, it is apparent that KMD forecasts currently do not meet many of these criteria. First, regarding salience as Figure 5 shows rainfall tercile probability forecasts (see Section 3.2, Figure 4) do not match the drought biophysical monitoring metrics used in drought early warning, specifically the SPI3 and VCI3 (Figure 3)

Regarding timeliness, forecast production and communication is not synchronized with drought planning and decision-making processes. KMD issues seasonal lead time forecasts in mid-February for the MAM rains and in September for the OND rains, *after* the NDMA conducts the food security assessments of the SRA and LRA (Figure 5). Were the KMD forecasts to be (i) issued in time for each assessment, (ii) forecast of the drought phase metric indicators, then NDMA could incorporate forecasts into the food security prognosis and link the forecasts directly to drought phases. To achieve this, the timing of forecast production from regional and national meteorological centres would have to change. Indeed, research has shown that the OND season has good predictability as early as July (MacLeod, 2019) potentially allowing much longer lead early action.

In terms of credibility and accuracy, a key constraint is that KMD forecasts do not include skill information and not all forecasts include probabilities and where they do, these probabilities are not calibrated for reliability. Stakeholders, therefore, do not know how often any forecast-based actions might turn out to be unnecessary (in vain) or based on 'false alarms'. Communicating forecast skill information is an essential component of FbA systems because it allows planners to evaluate which forecast-based actions are likely to be worth taking given the likelihood of the hazard occurring, the costs of acting versus avoided losses and the potential of acting in vain. Transparent communication of forecast skill and probabilities is therefore essential to building decision-makers' confidence in acting under inherent forecast uncertainty and underpins the shift towards anticipatory approaches to risk management.

4.2. 'Interplay' of forecasts and existing information flows

The Lemos et al. (2012) concept of 'interplay' describes the flow and uptake of climate information by users and decision makers, including issues of technical capacity, organisational incentives, norms and perceptions of climate information.

In terms of capacity and norms, we find that systematically acting on probabilistic forecast information would be a significant leap from current practices. In principle, actions currently triggered by drought phase classification, e.g. Alert or Alarm could be triggered by forecasts of those defining metrics (the

VCI3 and SPI3), were such forecasts available (Section 4.1). However, shifting from a system based on monitoring data to a forecast-based approach is not a trivial change. Acting on probabilistic forecasts requires agreeing forecast probability thresholds for action as an essential starting point. Following a series of capacity building workshops in our case study county, Kitui, we made progress towards this, but the experience highlighted that scaling this up would require a significant investment of resources and time into such training.

Moreover, we find that the current *modus operandi* of the DEWS is an iterative and somewhat flexible system. For example, within the drought phase classification (Figure 3) moving from the 'normal' to 'alert' levels is premised on indicators of VCI3 and SPI3, but in practice the decision is partly subjective and incorporates expert judgements from the CSG. Second, although there are drought contingency plans with response actions ostensibly triggered by drought monitoring information and phase state (see Section 3.1), the current DEWS allows considerable discretion by county officers (Figure 3). In part, this is a pragmatic result of variable resource allocation across counties and variable priorities on the ground at any time. Therefore, forecast-based contingency plans which would require a fully objective, automated phase classification would then lead to a loss of subjective 'control' by the CSG over county drought phase status, and possibly an undesirable loss of flexibility. Above all, it would require a change in the culture of decision-making towards a more rigid, but rigorous and objective system. The demands such a system would place on finance are considered in Section 5.2.

4.3. 'Interaction': trust, sustainability and co-production

Our research shows some variable evidence of interaction, referring to the process by which climate information is produced and the nature of co-production in this process. KMD operates a decentralized service provision with a CDMS sitting in each county. In many counties, CDMS take part in the CSG and hold interactions with a range of stakeholders at County and sub-County levels. Some have also co-developed 'County Climate Information Services Plans', designed to meet the needs of the County's population, such as Kitui (Government of Kenya, 2015). However, under the current responsive mode of the DEWS, such locally tailored forecasts, like the national forecasts, have no direct entry into decision-making since they do not align with the metrics or decision-making timelines used in the DEWS or County budgeting process (Figure 5).

We also note that path dependency of institutions influences the effectiveness of interactions between climate information producers and users. It is important to remember that Kenya's DEWS is not designed to incorporate forecast information. Indeed, the DEWS was built around a system rooted in food security monitoring and assessment, which has evolved over time with incremental adjustments (Oduor et al., 2014). Similarly, the county-level drought management systems were established prior to KMD's county drought meteorological director roles were established. These path dependencies explain limited formal interaction between KMD & NDMA, both at the county level as well as in opportunities to co-produce decision-relevant climate products. However, interaction between the two agencies is increasing as a result of advocacy for AA and there are now joint initiatives for piloting the introduction of forecast information into NDMA Early Warning Bulletins.[5]

5. Developing usable climate forecasts for anticipatory drought risk management

Our findings identify many challenges in advancing a more forecast-based DEWS in Kenya, consistent with Vincent et al. (2020) on the need for enabling factors that determine the uptake of potentially useful and usable climate information, namely, for supportive institutions and appropriate policy frameworks. In this section, we consider the project's Outcomes Logic Model (OLM) (Figure 6) that was co-developed with stakeholders to identify necessary institutional changes in knowledge, attitudes, skills and practices, to further move towards integrating climate information within the DEWS. In Section 5.2, we turn to the wider policy environment and financial structures that could support climate information to be used within drought risk management.

5.1. Advancing from 'fit', 'interplay' and 'interaction' with co-produced forecasts

Through our research with climate information users (the CSG) and producers (KMD), we co-produced a set of prototype forecast products (that could then be delivered operationally by KMD) that have better 'fit' to the DEWS, including timeliness and salience. These include:

1. Long-lead (from May) seasonal forecasts of OND tercile rainfall available in time for county planning processes (Colman et al., 2020).
2. Seasonal and month ahead forecasts of OND rainfall, issued monthly from July onwards. These forecasts use the optimized method of Kilavi et al., 2018a, 2018b which combines the best performing global models. Forecasted rainfall was transformed into the decision-relevant SPI3 index used in the drought phase classification, and then the forecast probability of exceeding the specific SPI3 thresholds was provided. Such forecasts could be used for example to trigger a new 'early alert' phase (see Figure 3). Examples of the forecast probability of SPI3 being below the critical SPI3 thresholds are shown in Figure 7(a,b).
3. Forecasts of VCI3 at 6-week lead-time based on machine learning methodologies (Barrett et al., 2020).
4. Forecasts of soil moisture, based on a land surface model driven by rainfall forecasts above (Asfaw et al., 2018; Boult et al., 2020).

These products were piloted in 2019 through a series of workshops with the Kitui CSG to support planning for the OND rainy season. Training was provided to stakeholders on the interpretation of the probabilistic prototype forecast products and associated skill information. The skill assessment

FIT	INTERPLAY	INTERACTION
• KMD to strengthen the provision of timely, accurate, reliable and credible climate information • KMD to routinely communicate forecast skill to forecast-users • Systematic inclusion of probabilities in forecasts by KMD • Where feasible, KMD to enhance forecast skill to meet decision makers' requirements • KMD and NDMA to align timing of forecast production and use across drought preparedness processes • If feasible, KMD to increase the forecast period to 6 months to cater for food security prognosis.	• KMD to accept that decision makers need probabilities to enable forecast-based actions • NDMA to strengthen capacity to interpret climate forecasts and effectively integrate them within preparedness decision-making processes • NDMA to systematically integrate climate forecasts across drought preparedness panning processes	• KMD to create a feedback channel and routinely seek users' feedback. • KMD to routinely communicate forecast skill to decision makers • KMD and NDMA to enhance mutual recognition of the need for strengthened collaboration in policies and practice

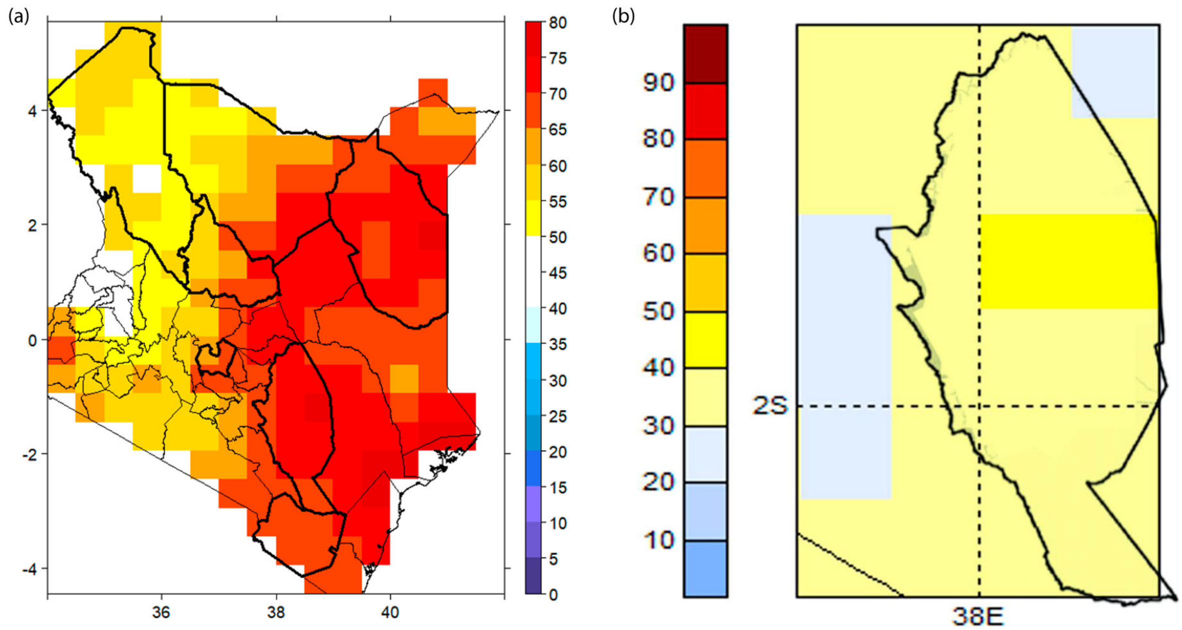
Figure 6. 'Outcome Logic Model' developed through the PIPA methodology identifies changes in knowledge and practices that stakeholders must take to meet project aims – in our case move towards a more forecast-based drought risk management system. Here we present the OLM adapted to the L12 'fit, interplay and interaction' framework.

provides stakeholders with information on the hit rate and false alarm rate of actions taken based on forecasts (exemplified in Figure 7(c)). Such information is critical to build confidence on forecasts and to understand the 'worthiness' of various forecast-based actions.

In July, September and October 2019, forecast updates were released and stakeholders explored the potential for carrying out early drought management actions based on the forecast. With the release of the early long lead OND seasonal forecast in July (Forecast 1 above, documented in Colman et al., 2020), Kitui was already in the drought 'alert' phase of the county phase classification system and reached the 'alarm' phase in September. However, the prototype forecast products (and the principal KMD-issued forecast) strongly suggested enhanced probability of high OND rainfall. Figure 7(b) shows that the probabilities of SPI3 being below the 'Alert' threshold are considerably less than the climatological probability, i.e. a forecast of reduced drought risk. Accordingly, low-cost actions were taken by the CSG to maximize the opportunity provided by forecasts of likely above-average rains including: advisories to plant more maize than normal; vaccinating livestock against diseases related to wet conditions, e.g. Rift Valley Fever; and enhancement of water harvesting initiatives. Figure 7(a) shows the equivalent forecasts for OND 2020 in which there is a clear signal for increased drought risk, with strongly enhanced probabilities of SPI3 being below the critical 'Alert' threshold value. An 'Early Alert' phase warming could have been issued in this case.

To advance 'interplay' of how climate forecasts were understood and perceived within existing systems, we provided training on interpretation of probabilistic SPI, soil moisture and tercile rainfall forecasts. We subsequently introduced the prototype forecast products, with additional training focused on understanding the forecast skill and consideration of the 'worthiness' of actions by quantifying the rate of 'hits, misses and false alarms' of these actions over the hindcast period (see example in Figure 7(c)). Our experience suggests that explicitly linking forecast skill with possible early actions is an effective means to build confidence in forecasts. It effectively shifts forecast perceptions from being based on recent experience towards a perspective in which decisions are based on objective information from long term hindcasts, which is critical to effective FbA/AA. The probabilistic nature of climate information necessarily means that the forecasted most likely outcome may not always occur. However, if the forecast is of sufficient skill and co-production has enabled climate information providers and decision-makers to identify appropriate thresholds for action together, over the long-term, evidence suggests it will be more cost effective to act rather than not act (Cabot Venton, 2017; Carter et al., 2019; FAO, 2018). Our experience shows that sensitising decision-makers to these features of FbA/AA is not trivial but given sufficient time it is certainly possible.

Finally, through the pilot workshops, climate information producers and county decision-makers were able to interact, fostering stronger relationships and communication. Feedback



(c)

		Forecast: Event	Forecast: Non-event
Observed	Event	6 (hits)	3 (misses)
Observed	Non-event	1 (false alarms)	2 (correct rejections)

Figure 7. (a) and (b) Examples of the prototype co-produced seasonal rainfall forecasts (item 2 in Section 5.1). Figures show the forecast probability of SPI3 for OND season being below the critical SPI3 threshold (of − 0.09) used to trigger the drought 'Alert' phase classification (see Figure 3). (a) Kenya-wide for OND 2020 issued July 2020, (b) Kitui county only for OND 2019, issued July 2019. The climatological probability of SPI3 being less than the critical threshold is 46% and is marked by a bold line on the colour bar. (c) Skill assessment of these OND forecasts of SPI3 issued in July over 12 hindcast years. Exemplar forecast verification contingency table showing the 'worthiness' of forecast-based early actions. In this case, an 'event' is indicative of an 'early Alert' drought phase and is defined when 50% of the area of Kitui county has SPI3 values below the critical 'Alert' threshold (−0.09). Verification refers to actions based on a forecast probability of this condition of 50%. The resulting false alarm rate, in this case, is 14%. Forecasts verified against observed rainfall from the CHIRPS dataset (Funk et al., 2015).

from a senior member of the Kitui CSG was that 'forecast products provided through OND 2019 enhanced preparedness and added value to what KMD usually gives. Stakeholder confidence to use the KMD forecast increased: it indicated an increased probability for enhanced rainfall just like the prototype products'. Throughout the season, monthly updates of the prototype forecast products were issued to allow for an interactive process of early warning information and preparedness action. This shows that linking seasonal forecasts with sub-seasonal forecasts has the potential to facilitate progressive actions across lead times, since sub-seasonal predictability is high over Kenya in both seasons (MacLeod et al., 2021). However, currently KMD does not emphasize such monthly updates. Further our prototype within season updates were aligned with the timing and frequency of the monthly county drought management steering group meetings. This frequency is broadly sensible for management of slow-onset drought but higher skill sub-seasonal information could be made available for shorter lead times of 1–2 weeks ahead. Stakeholders indeed identified actions that could be informed by such information, e.g. planting and application of agricultural inputs. A forecast-based DEWS has the potential to invoke a wider set of preparedness actions that could mitigate the impacts of drought than those that are currently taken in response to drought impacts. As such, the current DEWS system is not structured to take full advantage of forecasts to support regular review and revision of planning. Such experience within season helps to build trust and enable decision-making to be supported by the emerging best forecasts as the season progresses; for example, workshop participants reported communicating climate predictions more effectively, a willingness to look at the most recent forecast products and plans to sensitize communities in advance based on the longer lead-time of skillful forecasts for the OND season.

Finally, co-production is increasingly recognized, as noted in the conceptual framework, as a critical component of successful 'interaction', through iterative, two-way learning and trust building by bringing together the producers and users of weather and climate information. In this research, we facilitated co-production of forecasts between NDMA and KMD across multiple levels. At the top level, NDMA leadership identified the potential for the existing drought classification system (Figure 2) to become forecast oriented with a new 'Early Alert' phase that could be triggered by forecasts of the monitoring indicators currently used (see Figure 3). At the county level, by working with the CSG we co-produced new prototype forecast products that match the drought biophysical monitoring metrics used in phase classification, specifically VCI and SPI. As noted above, bulletins which include this forecast information are now being piloted, such as in Taita Taveta county in August 2020. While more systematic forecast uptake across the DEWS has not yet been achieved this pilot shows the potential for improving interaction between forecast users and producers with the objective of moving towards forecast-based drought risk management.

5.2. Beyond climate information: enabling policy environments and incentives for anticipatory drought risk management

Despite the measures described above to improve forecast 'fit, interplay and interaction', we identify very significant 'higher level' barriers to moving towards more anticipatory drought risk management in Kenya.

There is currently no funding available for anticipatory drought management actions, which severely restricts the types of forecast-based early actions that could be considered. While the Kenyan government has established a disaster contingency fund guided by the Contingencies Funds and County Emergency Funds Act, whereby each county is required to make an annual allocation of up to 2% of the total budget for disaster response (Development Initiatives, 2017), this funding was not designed for use in advance of a disaster or for preparedness. However, the government of Kenya does provide funds which could be used for disaster preparedness and prevention including the county emergency fund, which could be used for anticipatory drought actions. This is made available to ministries, state departments and county governments. However, Kitui drought planners did not in practice use available funds for drought response in 2019.

In terms of allocations specifically for drought, these exist through the Ministry of Devolution and Planning. Currently, the primary national finance for drought preparedness is the National Drought Contingency fund, managed by NDMA. County governments can access this fund to support priority response actions from their drought contingency plans once the county has entered the 'Alarm' phase. However, because the contingency planning process is based on monitoring information, the DCF cannot support anticipatory action.

Thus, while there are several funds available, there is a critical gap for anticipatory funds available at a county level for drought management. Without an available fund for early action, the incentives for integrating forecasts into the DEWS and moving towards a more anticipatory approach are limited. However, there are positive developments that have significant potential for the drought risk management system in Kenya. The new National Drought Emergency Fund will be operational by late 2020 to early 2021, as an evolution of the National Drought Contingency and will have 50% of the funds reserved for preparedness and resilience (Government of Kenya, 2017). With projects benefiting from this fund expected to (i) be aligned to national development priorities or be included in the county integrated development plan, (ii) contribute significantly to sustainable development and build community's resilience and (iii) have the evidence of community participation in design, incorporate a sustainability framework and be recommended by the County Drought Committee or the Secretariat of the Fund.

In terms of national frameworks, Kenya's new National Disaster Risk Management policy (Government of Kenya, 2017) is of great importance, having been approved by the Cabinet by March 2018. The policy lays down the strategies for ensuring the Government commits itself to enhancing research in disasters and formulation of risk reduction strategies. Specifically, it proposes a number of key developments which should facilitate improved interaction. This includes the establishment of a single agency to coordinate disaster risk management, a National Disaster Management Authority. The policy also recognizes the importance of risk information and data sharing, for example providing mechanisms to overcome the lack of systematic information provision between agencies such as KMD and NDMA within the DEWS. Thus the key principles of the proposed DRM policy are: (i) the need to improve EWS linked to preparedness activities, consistent with a FbA approach, (ii) the centrality of risk information for effective DRM and the need for a national and centralized disaster risk database and (iii) a comprehensive finance strategy. Given the decentralized governance in Kenya, each county will be required to develop a County Disaster Management Plan, which provides an opportunity to embed these approaches in the county DCP.

However, as a result of the current landscape of drought risk management in many of these counties, we note once again that there is a significant degree of path dependency which may inhibit moving from the current responsive DEWS towards a more anticipatory approach. Political economy analysis has demonstrated the importance of historical embeddedness in determining the shape of decision-making systems in other climate policy domains in Kenya (Naess et al., 2015). The multiple changes necessary for an effective anticipatory DEWS are extensive and would certainly depend on significant political goodwill, buy-in and support from a broader enabling policy environment. It is noted, however, that the proposed DRM policy might provide the incentives and impetus to create this, and that there is already significant support for moving towards a more anticipatory drought management system.

6. Conclusion and recommendations

It is clear that despite the development of FbA/AA in humanitarian organizations the key to scaling-up lies in mainstreaming anticipatory approaches into National risk management systems. This paper provides an assessment of the potential for integrating forecasts into Kenya's drought risk management system to move towards an anticipatory forecast-based approach and outlined what would need to change to that effect.

We find that the current DEWS in Kenya is not conducive to either producing usable information or systematically making use of it, due to weak institutional coordination and a lack of available funding for anticipatory response. Without these structures, there is little incentive to improve forecast 'fit, interplay and interaction' to move towards a more anticipatory approach. It is also critical to note the importance of path dependency and embeddedness in determining the current form of Kenya's DEWS. Having evolved from a famine and drought security monitoring project (Oduor et al., 2014), it should not be surprising that there is little systematic integration of forecast information within the system. The changes that would need to be made to move toward rigorous integration of forecast information within this system should therefore not be underestimated. The operation of both national (KFSSG) and county-level systems and their complex interactions makes such changes all the more challenging.

However, integrating FbA/AA into nationally owned systems is a necessary direction of travel to ensure long-term sustainability of anticipatory risk management approaches. There are emerging examples of forecast-based action projects being integrated within national systems – for example in Zambia, the Red Cross FbA pilot is reviewed by the Zambian government's Early Warning Sub-Committee (IFRC, 2019). Similarly, the Phillipine Red Cross has been lobbying the government to formally adopt their FbA methods with some success.[6] There is the similar political will to replicate this approach in Kenya, which was the host of the first African Dialogue Platform conference on Forecast based Financing/ Action.[7] Our project experience also demonstrates that there is strong will across partner institutions in Kenya to move towards a more anticipatory approach, typified by NDMA introducing prototype forecast information in monthly bulletins, which was piloted for the first time in 2020.

We ultimately find that co-production underpins moving towards systematically used climate information for drought risk management. Specifically, FbA demands a reframing of research away from delivering potentially relevant or useful information, towards research that co-produces forecasts for actionable decision-making, or as others have put it, 'action-based forecasting' (Coughlan de Perez et al., 2016). In this approach, co-production is an essential condition, while wider institutional, policy and financial 'enabling' factors play a significant role in determining if new climate information and research can be actioned. Increasing the potential for climate services to result in tangible benefits for those people most directly impacted by drought requires a sustained focus on the useability of forecasts and the extent to which those forecasts are actionable. This includes through effective institutions and reliable financing, as well as by enabling people to themselves take appropriate forecast-based actions even in advance of awaiting external support.

Notes

1. The full list of KII participants included representatives from the National Drought Management Authority (NDMA), the Ministry of Agriculture, Water and Livestock Development; Kitui County Ministry of Finance and Planning; the World Food Programme (WFP) Famine Early Warning Systems Network (FEWSNET), the Food and Nutrition Working Group (FSNWG) and Kenya Meteorological Department (KMD).
2. Further details on the participatory methodologies developed for workshops are documented within a technical brief (Mwangi & Visman, 2020).
3. http://www.fao.org/kenya/news/detail-events/en/c/470567/
4. Example bulletins: https://www.ndma.go.ke/index.php/resource-center/early-warning-reports
5. For example, see August 2020 bulletin from Taita Taveta county, which gives both VCI, SPI3 and soil moisture forecast information: http://www.ndma.go.ke/index.php/resource-center/early-warning-reports/send/3-taita-taveta/5771-taita-taveta-august-2020
6. https://reliefweb.int/report/philippines/red-cross-lobby-adoption-forecast-based-financing
7. https://www.forecast-based-financing.org/wp-content/uploads/2018/10/Report_DP18Nairobi.pdf

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Data from the interview-based component of this research is not available as respondents were assured that any data used would remain anonymous, de-identified and would not be shared. However, the list of policy documents reviewed is included in the supplementary materials along with a copy of the Key Informant Interview protocol.

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