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Understanding the use of 2015–2016 El Niño forecasts in shaping early humanitarian action in Eastern and Southern Africa

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ABSTRACT

Humanitarian organizations are increasingly interested in using seasonal forecasts to prepare for and mitigate the impacts of potential disasters before they begin. El Niño teleconnections increase the predictability of flooding and drought events in Southern and Eastern Africa, providing humanitarian stakeholders with advanced warning of potential weather events. This study draws on evidence from key-informant interviews with humanitarian organizations and government officials in five African countries (Zambia, Somalia, Kenya, Ethiopia, and Malawi) to better understand how national, regional, and international humanitarian organizations respond to climate and weather warnings. We find that organizations looked to data from past El Niño events to develop contingency plans and gradually implement response activities but that few organizations attempt to monitor and evaluate their activities or use forecasts to help people capture additional benefits. Although they would like greater specificity and higher forecast skill, humanitarians largely trust international forecasts. Access to intermediaries, contextualized data, and flexible funding, and well-established social protection mechanisms facilitate action. Based on these results we recommend that future efforts focus on developing capacities and complementary, localized, information that will help actors translate the forecasts into action. Future research is also needed to understand whether action leads to desired impacts.

1. Introduction

As forecasting capacity has improved in recent decades and concern about climate change has grown, donors and organizations working in the fields of humanitarian aid and development have expressed increasing interest in the use of forecasts to inform their operations. This is part of a broader shift toward investing in disaster preparedness and mitigation [53,87,89] and efforts to connect humanitarian response to longer-term development, such as the Sustainable Development Goals [86], the Sendai Framework for Disaster Risk Reduction [88], the Grand Bargain [52]. There is also widespread belief among practitioners, and mounting evidence, that shifts to mitigation, preparedness, and early action can help reduce the costs of humanitarian response [14,15,46,26]. Likewise, advocates of forecast use believe that monitoring seasonal (3–6 months) and short-term (10 days) forecasts can help humanitarians and disaster managers prepare for and respond to climate-related shocks such as floods as droughts [10,24,45,50] and reduce overall expenditures [46].

The disaster management cycle consists of four phases: mitigation, preparedness, response, and recovery. Mitigation and preparedness occur before disasters, whereas response and recovery take place afterward. Mitigation seeks to increase capacity or reduce vulnerability and exposure in order to reduce impacts once an extreme event hits. Preparedness includes developing plans or early warning systems and refreshing training so that responders are prepared to act when an event hits. Response refers to humanitarian efforts once people are suffering from a disaster. Recovery consists of short- and long-term reconstruction and restoring “normalcy.”

The use of forecasts has the potential to influence actions during mitigation and preparedness phases. Long-term climate projections, combined with seasonal and short-term forecasts can be used to identify and execute more targeted, effective mitigation and preparedness measures and to help target early action measures in areas that are most likely to be affected by an extreme event. The Red Cross Red Crescent Movement, African Risk Capacity Facility, START Network, Global

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Parametrics, the United Nations Food and Agriculture Organization (FAO) and other organizations, for example, have been testing trigger-based, index-based (see for example [26]) and forecast-based financing (FbF) as a means of anticipating and initiating early action with an aim to minimize disaster impacts (for further information on FbF see [24]).

In response to growing interest in forecasts from the humanitarian community and beyond, scholars have examined opportunities and constraints to the use of forecasts at the household and individual level (see for example [47,67,77,69,79]). However, at the organizational level, comparatively little is known about how humanitarian organizations respond to seasonal forecasts or about the factors that enable and constrain institutional humanitarian action.

This study begins to fill that gap by examining forecast-based early action in five countries in response to seasonal forecasts issued during the 2015–2016 El Niño. While we do not attempt to assess the skill of forecasts and whether they merited a response, we shed light on the enabling factors for taking early action. Based on interviews with national, regional, and international humanitarian organizations involved in prediction of and response to the 2015–2016 El Niño, this research addresses four primary research questions:

1) How do international humanitarian organizations currently respond to seasonal forecasts?
2) What factors constrain forecast-based early humanitarian action by national, regional, international organizations?
3) What factors facilitate forecast-based early humanitarian action by national, regional, international organizations?
4) What policy implications or lessons for future practice can we draw from these responses, opportunities, and constraints?

1.1. Relevance of the 2015–2016 El Niño

There are two primary reasons that the 2015–2016 El Niño provides an excellent opportunity to understand whether humanitarian organizations are able to take early action based on forecasts and what factors facilitate or hinder action. Firstly, global teleconnections associated with El Niño and La Niña episodes provide intrinsic predictability that increases the skill of seasonal predictions of rainfall and temperature over large regions of the tropics and subtropics during El Niño and La Niña years [4,42,81,94]. The frequency of climate-related disasters does not increase during an El Niño or La Niña years relative to neutral years, meaning ENSO represents a best-case scenario in terms of the ability to forecast seasonal precipitation and estimate likely impacts [42]. As an El Niño or La Niña event becomes stronger, forecast skill also increases because the likelihood of seeing the historically expected impact increases [42]. Better predictive skill and accumulating experience acting on El Niño forecasts has the potential to increase the capacity of humanitarian actors to anticipate—and hence take early action—based on seasonal weather patterns and their likely impacts. As the 2015–2016 El Niño was considered the strongest El Niño event in nearly two decades [58] examining early humanitarian action based on these forecasts sheds light on how organizations respond when skilful forecasts are available.

Secondly, leading up to the 2015–2016 El Niño, forecasters and intermediary organizations made concerted efforts to disseminate El Niño forecasts and impact advisories to governments, and international development and humanitarian organizations around the world with the express purpose of influencing appropriate action. Understanding whether such efforts were fruitful can help to improve forecast production, dissemination, and use during future El Niño or La Niña events.

1.2. Structure of this study

The paper is structured as follows. In order to inform our analysis of responses to the 2015–2016 El Niño forecasts, we begin by reviewing the literature on potential humanitarian responses to forecasts and the relationship between forecasts and decision-making. The literature review demonstrates that there is a wealth of existing lessons regarding the opportunities and constraints of forecast-based decision-making across contexts and sectors. After summarizing our methods for data collection and analysis, we present our results as common themes in how organizations respond to forecasts and the factors that enable and constrain their action. The discussion then highlights the lessons learned from these common themes and their implications for future practice. We conclude with a summary of our results and lessons and considerations for future research.

2. Literature review

The broader literature on science and decision-making has shown that science is only one of many factors that influence decision-making [57,66,70,74,80]. Values, issue framing, and social identity are among the other factors that influence the assimilation of science, and hence people's propensity to act on it [71,97,99,100]. Previous studies demonstrate the multitude of factors that may prevent or discourage organizations, individuals, and households from acting on seasonal forecasting information. This section reviews existing literature on forecast use to provide background for our analysis of humanitarian response to 2015–2016 El Niño forecasts.

2.1. The early action space

According to the existing literature, potential organizational responses to forecasts include updating contingency plans, prepositioning relief items, conducting disaster preparedness trainings, requesting pre-emergency funding, or reallocating development funds to meet emerging needs [9,45]. In addition to these actions, there has also been increasing interest in integrating forecasts with adaptive social protection programs. Adaptive social protection seeks to link various social protection mechanisms with disaster risk reduction and climate change adaptation [1,28,29,32,62,73]. In theory, forecasts can provide such a link by allowing governments and humanitarian donors to expand social protection benefits to additional households or provide additional payments to households in areas that are likely to be affected by future floods or droughts, helping households to prepare or cope with the shock [23,28]. Advocates argue that triggering action based on specific data or indices would lead to faster responses and hence less harm [5,23,28]. Preliminary evidence suggests that indices can be used to trigger early action [5], but no studies have demonstrated that forecasts can be used effectively to trigger social protection benefits before shocks occur.

2.2. Factors influencing individual and organizational early action

Much of the academic literature on the use of seasonal forecasts focuses on individual actions and adjustments to livelihood practices based on forecasts. In contrast, information on humanitarian early action comes largely from grey literature and organizational reports (many of which describe responses to 2015–2016 El Niño forecasts). Although there may be significant differences between individual and organizational responses to forecasts, here we provide an overview of what is currently known about both user groups in order to draw parallels, identify gaps in existing knowledge, and reinforce past lessons.

2.2.1. Access

Although access to forecasts was once an obstacle to early action by governments and humanitarian organizations [8], dissemination and access have greatly increased over the last twenty years [96]. While household users still have varying access to forecast information [3,49], organizations, especially those operating at the global scale with regional presence have access to global level forecasts and support regional and national coordination efforts led by government designated entities.

2.2.2. Characteristics of the information

Studies of household and organizational response to forecasts have repeatedly shown that mismatch between user needs and the timing, scale, and format of seasonal forecast can be a significant obstacle to their use. Numerous studies have shown that seasonal forecasts in particular often do not provide adequate information regarding the timing, quantity, or distribution (in time or place) of precipitation that decision-makers need to be able to act on forecasts [6,48,65,76].

Other studies have shown that individual decision-makers have difficulties understanding the probabilistic or technical nature of the forecasts, and therefore need assistance to be able to interpret and act upon forecast information [6,54,64,76,84]. These complications with the use of probabilistic seasonal forecasts have led some scholars to call for a move beyond probabilistic tercile formats [25,75] that still predominate.

Studies have also shown that trust in forecast information or the organizations providing the information influences decision-makers' propensity to act [3,21,31]. Misunderstanding or misrepresentation of probabilities can lead to overconfidence in predictions, leading to poor decisions and threatening to undermine confidence in forecasts in the long-term [40].

2.2.3. Co-production

Limited communication or interaction between forecast producers and users has been found to affect the utility of information across a range of contexts [40,6]. Scientific information is most useful to decision-makers when producers and users interact on sustained, iterative basis and determine jointly what information should be produced and how it should be disseminated [11,20,33,37].

For co-production to occur, capacity for two-way communication and increased interpretation needs to be built. A number of scholars have suggested boundary organizations or intermediaries can play an important role in facilitating communication between producers and users [22,31,59,60,76,101]. Among other benefits, such organizations have been found to help build trust, facilitate two-way, long-term dialogue between producers and users, and contribute to the development of more user-friendly products (all of which have been found to improve the utility of information). Alternatively, building capacity for forecast interpretation and two-way dialog within existing organizations or networks—such as among farmer and religious organizations, national hydro-meteorological services providers, and extension officers—is gaining increasing attention as a potentially effective and sustainable means of fostering connections between producers and users [44,56].

2.2.4. Barriers to action

For those who are willing and able to respond to forecasts at the individual level, forecast timing, access to resources with which to act, and other factors may prevent effective forecast-based decision-making. Seasonal forecasts often do not necessarily provide household decision-makers sufficient lead time to modify their activities [20,54,78]. Farmers may not be able to act on forecasts because they are unable to access credit, transportation, markets, seeds or other necessary resources [9,31,54,65,72,92]. Humanitarians may not be able to reach affected populations because of insecurity and violence [12]. Humanitarian action may also be slowed by limited inter-sectoral or ministerial coordination and unclear roles and responsibilities for action [7,40,45]. Therefore, although forecasts are often presented as a means of helping the most vulnerable (see for example [98]), unequal access to information or unequal ability to act on forecast information can therefore exacerbate inequalities rather than reaching those most in need [19,38,64,67,93].

Organizations are likely to face similar financial constraints to action [40]. In most developing countries, government early action is heavily reliant on donor support that is often unpredictable, and marred with other competing demands [45]. Studies show mixed results about the willingness of humanitarian donors to commit resources on the basis of probabilistic forecasts [75]. Previous studies of humanitarian action have found that agricultural monitoring systems–which provide a seasonal outlook but wait for the results of agricultural monitoring and post-harvest assessments to trigger action–have mixed results which depend in part upon political will and the availability of funding for humanitarian response [45].

Governments may also face a number of political and social pressures to delay action [39]. These include fear of "wasting" money on events that never materialize [3,13] or concern that changing established sources of information and decision-making procedures could yield suboptimal results [27]. Similarly, decision-makers in the water, health, and agriculture sectors (not necessarily related to international disasters risk reduction or humanitarian response) may fear changing existing decision-making protocols for fear of reputational and political repercussions should the impacts be negative [101].

3. Methods

This study aims to better understand how, if at all, forecast information influenced national, regional, and international humanitarian decision-making and lead to early action. We focused at these higher levels of action, because we wished to understand if and how organizations responded to forecasts, and we knew that international forecasters at made concerted efforts to disseminate forecasts at this level. We do not evaluate whether their actions were successful, focusing instead on the determinants of action.

In order to answer these questions, we combined document review with qualitative, semi-structured interviews with disaster planners and managers within organizations receiving forecasts. The research team conducted a total of 60 interviews humanitarian practitioners from 53 United Nations Agencies, donor organizations, and government ministries in Zambia, Malawi, Kenya, Somalia and Ethiopia.[1] Table 1 details the organizations interviewed in each country.[2] We used our networks to identify organizations in each country that received forecast information and to identify informants within each organization who were responsible for disaster planning and response. We then asked these informants to suggest additional organizations or informants. Whenever possible, we supplemented and triangulated the information provided by reviewing secondary data and reports regarding each organization's responses. This combination of sources allowed us to reconstruct whether, how, and why forecasts were used and to identify common opportunities and constraints to forecasts use. To protect the identities of the respondents, we attribute quotations to categories of actors as outlined in the footnotes.[3]

The team selected these countries with input from the United Kingdom's Department for International Development (DFID) because they experience different weather patterns and impacts in El Niño years (some countries are more prone to increased rainfall and others to reduced rainfall, see Table 2), they exhibited different levels of forecast-based action (overall, organizations in some nations were more

[1] The organization totals treat informants from different levels within the same organization as separate organizations. For example, because they received information at different times and responded at different scales, WFP headquarters, WFP Regional headquarters, and WFP Malawi would be counted as separate organizations in this tally. In addition to humanitarian practitioners, we interviewed international forecasters from NOAA (n = 2), ICPAC (n = 2), the United Kingdom Met Office (n = 2) and the International Research Institute on Climate and Society (n = 3), bringing the total number of informants to 73 individuals from 57 organizations.

[2] Five informants responded to our questions via email, for a total of 65 humanitarian practitioners as reflected in Table 1.

[3] Quotation numbers correspond to the following categories of actors:

1. Government officials
2. Humanitarian (NGO, UN agency, consultant, or academic)
3. Scientists, forecaster, or information providers (as in SWALIM or FEWS NET).
4. Donors

Table 1
Breakdown of key informants by country and organization.

Informant country	BRCiS	CARE international	Concern worldwide	DFID	FAO	FEWS NET	Government safety net program	Government agricultural ministry	Government disaster ministry	International committee of the Red Cross Red Crescent	National meteorological service	Save the Children
Zambia	0	1	1	1	1	2	0	0	0	0	1	1
Somalia	2	1	1	1	2	0	0	0	0	2	0	0
Kenya	0	0	0	1	0	0	1	0	0	0	1	1
Ethiopia	0	1	0	1	0	0	0	0	2	0	1	0
Malawi	0	0	0	1	1	0	0	1	1	0	1	0
International -level informants	0	1	0	0	0	0	0	0	0	0	0	0
Totals	2	4	2	5	4	4	1	1	3	2	4	2

Informant country	Oxfam	Red Cross Red Crescent National Society	Red Cross Partner National Societies	UNDP	UNICEF	University Researchers	UNOCHA	USAID	WFP	World Vision	Total Organizations	Total Informants
Zambia	1	2	0	0	2	0	0	0	1	1	13	15
Somalia	0	1	0	0	1				2	0	9	13
Kenya	0	3	1	0	1	0	1	0	1	0	9	11
Ethiopia	0	1	0	0	0	1	1	1	1	0	10	10
Malawi	0	3	0	0	1	0	0	0	3	0	8	12
International -level informants	0	0	0	1	0	0	1		1	0	4	4
Totals	1	10	1	1	5	1	3	1	9	1	53	65

responsive than others), and they receive support from DFID, which is seeking to mitigate disaster impacts through forecast-based early action.

A team of four interviewers (including the third and fourth authors) conducted semi-structured interviews asking respondents to reconstruct when, how, and from whom they received El Niño warnings. Informants were also asked to explain which information they found most useful and how they were able to act on the forecast information. The semi-structured interview guide is provided in Appendix A. When possible, the team conducted interviews in-person, but they also used Skype depending on informants' availability. Interviewers recorded the interviews (with permission from the informants), which were transcribed and qualitatively coded and analyzed by the lead author in order to reconstruct early action and response timelines. We identified common themes through grounded, qualitative coding of responses [41]. We chose to focus on the themes below because we believe they hold relevant lessons for future practice for the reasons outlined in Table 3 and because we had the most robust and consistent evidence to support these conclusions as common themes.[4]

3.1. Study limitations

Responses to forecasts occur at various levels. This study focused on humanitarian response by large, international humanitarian organizations working at the national, regional, and international levels, such as United Nations Agencies and the Red Cross (see Table 1) (referred to as humanitarian organizations from here forward, despite the subset of organizations interviewed) and their government partners Although it was clear from interviewees' responses that government officials and ministries play a central role in determining the extent of early action, only 9 of the 69 informants were government officials (one in Zambia, two in Kenya, three in Ethiopia, three in Malawi, and none in Somalia). Consequently, our results may overstate the humanitarian community's willingness and ability to respond to forecasts while overstating political obstacles. Nevertheless, they provide valuable insight into how humanitarian organizations at these levels perceive their ability to respond to forecasts.

4. Results: common themes in forecast-based early humanitarian action

Because we focused on national, regional, and international responses, all of the informants we spoke to had received warning of the impending El Niño through their networks, but the precise timing of first warnings varied. Most informants reported first learning of El Niño between March and August 2015, approximately one to six months before first impacts were likely to be felt.[5] This represents a significant improvement over dissemination during the last very strong El Niño event (1997–1998), when many actors in Southern Africa did not have access to early warning information [8]. These first warnings came from a number of international organizations and forecasting centers, including the Famine Early Warning System Network (FEWSNET) and the Regional Climate Outlook Forums (RCOFS) coordinated by international and regional forecasting centers such as the International Research Institute for Climate and Society (IRI), Intergovernmental Authority on Development Climate Prediction and Application Centre (ICPAC) and the Southern African Development Community Climate

[4] The full report Tozier de la Poterie et al. [85] provides a full write up of the results for each country as well as more tentative conclusions that merit more in-depth exploration in future studies.

[5] El Niño impacts vary depending on season and livelihood patterns in each regions. For example, lead time in Ethiopia is shorter because El Niño typically commences in June, the same period when forecasts improve following the Spring Predictability Barrier, and impacts in Ethiopia begin during the Kiremt (June–September) rainy season, whereas in Somalia heavy rains are not likely until October or November.

Table 2
Influence of El Niño on climate conditions in study countries.

Country	Influence of El Niño on climate	Forecast during the 2015–2016 El Niño	Impacts felt in 2015–2016
Zambia	El Niño is often associated with drier conditions during the rainy season (from December to January).	National seasonal forecasts provided by Zambia Meteorological Department in September 2015 indicated increased chance of normal to below-normal rainfall in the Western, Southern, and Eastern Provinces from October-December and a return to normal rainfall December-February.	According to our informants, rainfall was lower than usual in the beginning of the rainy season, though heavy rains in the second half of the rainy season allowed many farmers to recover their crops.
Somalia	Northern areas often see below-normal rainfall, while southern regions often experience increased rainfall and flooding.	Information conveyed from The Somalia Water and Land Information Management (SWALIM) and Food Security and Nutrition Analysis Unit (FSNAU) focused on increased likelihood of severe flooding.	Flooding was not as severe as anticipated [95]. According to our informants, because of the emphasis on potential flooding (and the comparative ease of preparing for floods as opposed to droughts) there was little preparation for droughts which materialized in the north and eventually required substantial response.
Kenya	El Niño is associated with increased rainfall during Kenya's short rains, which occur from October to December.	Forecasts indicated a likelihood of drier than normal conditions in the northeast and along the coast and wetter than normal conditions in the rest of the country during the short rains.	Our respondents focused their responses on flood mitigation. Though the short rains were longer and stronger than usual, they were not as bad as anticipated (based in part on experience from 1997 to 1998 [95].
Ethiopia	Ethiopia is climatically diverse. El Niño is associated with below average rainfall in areas that receive Kiremt rains from June–September.	Forecasts indicated increased probability of below-normal rainfall and the possibility of failing Kiremt harvest.	The 2015–2016 El Niño followed a failed Belg rainy season (February-March). As a result of two consecutive seasons of drought, there was a shortage of pasture and higher than usual crop failures [95].
Malawi	According to our informants, el Niño is associated with increased rainfall in the north and reduced rainfall in the south.	The Malawi Department of Climate Change and Meteorological Services's (DCCMS) September 2015 seasonal forecast indicates an increased probability of below-average rainfall and advises farmers to plant early maturing varieties (DCCMS 2015).	The 2015–2016 El Niño exacerbated impacts from flooding and drought that occurred in 2014 and early 2015 [95]. According to our informants, preparation for the El Nino was overshadowed by response to previous events.

Table 3
Relevance of common themes summarized in this study.

Common Themes Question 1: How Organizations Respond	Rationale for Inclusion in this Article
Look to analogue years	Nearly every actor mentioned the use of analogue years and found such comparisons useful for planning and identifying actions.
Contingency plans	Every organization used forecasts to update their contingency plans.
Gradual Action	The patterns of response in each country as reconstructed by our informants point to increasing action as the forecasts become more certain.
Not measuring impacts	Donors (including the funder of this study) are particularly interested in understanding whether and how forecast-based early action contributes to better outcomes. We were tasked with identifying and aggregating impact studies, but found that only two of 53 organizations attempt to measure impacts.
Focus on mitigating impact rather than producing benefit	Donors (including the funder of this study) are interested in how forecasts might be used to capture additional benefits rather than simply avoid losses. That only two of 53 organizations attempted to help people capture benefits suggest the potential for new responses to forecasts.
Common Themes Questions 2 and 3: Enabling and Constraining Factors	Rationale for Inclusion in this Article
Trust	Contrary to findings at other levels of action, our findings show that trust is not the most significant barrier to action among international humanitarian organizations.
Specificity of forecasts	This finding confirms the results of previous studies suggesting that tercile format forecasts may not be particularly useful for humanitarian action.
Boundary organizations	Those organizations that were best able to plan and act upon forecasts were supported by intermediaries.
Funding	Every organization mentioned funding (or lack thereof) as a key component of their ability or inability to act.
Social Protection	As discussed in the literature review, donors (including the funder of this study) and practitioners are increasingly interested in how forecasts might be integrated social protection. As four of the five countries included in this study have social protection programs, this study was a good opportunity to gather lessons on attempts to integrate forecasts.
Political Considerations	Studies have repeatedly shown that forecasts or other kinds of scientific information are not the only factors that influence where, when, why, and how decisions are made. Our findings reinforce that political considerations need to be accounted for if forecast-based action is to succeed.
Flood vs. Droughts	Our findings suggest that forecasts may be more useful in planning for localized events. This has implications for where to focus future efforts.

Service Centre (SADC-CSC), more localized forecasting efforts (SWALIM and FSNAU), and regional or national headquarters of global organizations. More detailed confirmation came later, usually from National Met Services.[6]

In this section, we review eleven common themes that emerged from across the five case studies. We present the results below according to the first three research questions above: humanitarian early action in response to forecasts, factors facilitating early humanitarian action to forecasts, and factors constraining early humanitarian action. We summarize these results and their policy implications in Table 4.

4.1. Common early actions

Humanitarian organizations in all five countries described similar patterns of response to forecasts. Organizational actors expressed confidence in the forecasts and a concomitant willingness to act on the information. Responses to the forecasts included looking to analogue years to understand impacts, developing scenarios and contingency

[6] A full description of the type of information received and the channels of dissemination is beyond the scope and space constraints of this article. For more detailed information on how forecasts were produced and disseminated in each country see [85].

Table 4
Summary of results.

Question	Answer	Conclusions/implications for practice
How do organizations respond to forecasts?	Look to analogue years	Some of the preparation for El Niño events could take place before forecasts are issued. Countries can compile and update information on the impacts of past El Niños to facilitate planning for future events.
	Develop contingency plans	Although the most common action, value of contingency planning for early action is limited without funding for those early actions. More research is needed to assess the value of forecasts for contingency planning.
	Gradual action	Seasonal forecasts are often used, and perceived to be most useful, when combined with other kinds of information. Supplementing seasonal forecasts with shorter-term forecasts and information from real-time impact assessments helps contextualize forecast information, allowing organizations to gradually plan and increase their response efforts as conditions evolve.
	Not measuring Impacts	In order to demonstrate the value of forecast-based early action, organizations need to more rigorously track their early actions and estimate benefits.
	Not capturing benefits	Most organizations remain focused on mitigating harms. The potential to use forecasts to boost production or livelihoods of the most vulnerable remains relatively unexplored.
What Factors enable or constrain action?	Trust the forecasts	Trust does not appear to be a limiting factor for humanitarian action, though confidence in the reliability of downscaled forecasts varies across countries.
	Specificity and presentation of forecasts	Lack of forecast specificity and overly technical language hinder early action even for comparatively large, well-resourced organizations. Forecasts that are tailored to provide information on the hazard or impacts of interest are most likely to be used.
	Availability of boundary organizations or intermediaries	Organizations who had access to intermediaries who could help interpret the forecasts as delivered (the Red Cross Red Crescent Climate Centre in Kenya), or who received information tailored to their specific context and needs (as in the case of SWALIM and FSNAU) were most able to take forecast-based early action. This reinforces the existing literature, which has repeatedly demonstrated that in order for forecasts to be useful, there needs to be additional support for interpretation and defining actions and increased focus on developing forecast products that are tailored to specific user needs and decisions. Boundary organizations and investments in increasing such capacities within existing networks are two promising means of increasing such connections.
	Funding	Funding was cited as the most common obstacle to early action. If donors consider early action a priority, they will need to develop new funding mechanisms to distribute funds on the basis of forecasts. The ability to reprogram funds through crisis modifiers or other flexible funding mechanisms facilitates early action, but these options are often unavailable.
	Integration with social protection	Experience in Kenya suggests that social protection mechanisms can be used for forecast-based early action. However, experience in other countries shows that such systems must be fully operational and designed to adapt to forecasts in order to be successful.
	Political context	Humanitarian organizations are often dependent on government authorization to begin new programs. The political context can significantly influence whether governments are willing to acknowledge potential disasters before the impacts are felt. Flexible projects and funding allow organizations to take preliminary action without needing authorizations for new initiatives. Pre-approved trigger-mechanisms may also help to bypass some of these political delays.
	Flood vs. Drought	Organizations find it easier to take early action to mitigate localized impacts. Forecasts that can combine hazard information with local vulnerability information might be able to provide indications of such localized hotspots for preparedness. Resources would be well allocated to help identify these hotspots (e.g. as SWALIM does by providing flood data that complements seasonal forecasts).

plans based upon anticipated impacts, identifying and taking no regrets actions, and gradually responding to new forecast and monitoring information. Interestingly, most organizations did not attempt to measure the benefits of early action or to assist households in capturing the benefits of increased rainfall. We elaborate on each of these themes below.

4.1.1. Analogue years: looking to the past to understand likely impacts

In many instances, actors appeared to be responding to an El Niño alert based on knowledge of past impacts. In such cases, the forecast information was not what necessarily prompted action. Looking to analogue years was one means by which government and humanitarian stakeholders transformed often vague or technical forecasts into actionable information. Many respondents—especially at the regional or global level—responded to forecasts by researching previous El Niño events in their countries or regions to better understand the implications of the forecasts.

Informants in Somalia, Kenya, Malawi, and Ethiopia explicitly mentioned the value of searching for "analogue" years that could help to predict the impacts for which they should prepare. In Somalia, FAO instructed SWALIM to look at data from the past six El Niño events in the country to understand where flooding was likely to occur. A combination of historical information, regular experience with flood response, and knowledge from local contacts enabled local non-governmental organizations (NGOs) to determine where to reinforce weak riverbanks and preposition supplies for likely flooding. Likewise, government and humanitarian organizations in Ethiopia examined impact reports from El Niño events in 1997–1998, 2002–2003, and 2010–2011 to develop impact scenarios and plan how the humanitarian community could work together to reduce impacts. In Kenya, vivid memories of the 1997–1998 event and its impacts prompted action. Based upon the severe flooding of the 1997–1998 El Niño, government and NGO stakeholders, as well as citizens and the media, prepared for severe flooding by reinforcing dykes, desilting rivers, establishing early warning systems, and improving drainage systems.

Despite the potential limitations of relying on analogue years (see the discussion), humanitarian stakeholders turned to historical impact data to interpret the forecasts and translate them into planning and action. Some informants understood the potential problems of looking to a single analogue year, but looking to the past nevertheless provided them with a means of concretizing impacts and understanding how they should prepare. As one informant noted, the past is "not going be identical, but at least [it] starts to give you a sense. Is this something that should be on my radar? Is this something we need to actually invest

our resources into to understand what are the potential impacts?"(2). In the absence of other sources of interpretation, looking to analogue years helped humanitarian organizations begin their planning.

4.1.2. Contingency plans

By far the most common action stakeholders took in response to El Niño forecasts was developing or revising disaster contingency plans. Contingency plans outline different disaster scenarios and determine which actors will prepare for and respond to sector-specific impacts. If funding is available, preparedness elements can also be incorporated into the plans and can be implemented before impacts are felt. Every organization interviewed mentioned using forecasts to revise contingency plans based on the likelihood of specific events in El Niño years. This finding is consistent with the actions of decision-makers in other contexts, who have also used forecasts to inform contingency planning [9,101].

Contingency planning processes took place at the organizational, regional, and national level, with varying degrees of coordination among the various organizations. In Somalia, Malawi, and Kenya, individual humanitarian organizations devised their own contingency plans based on anticipated impacts in the regions and sectors in which they work. In Kenya and Malawi, the government then brought stakeholders together, to develop national-level plans outlining which organizations would take specific actions to raise funds, mitigate risk, and respond to emergencies. In Somalia, the National Government and Somalia's Humanitarian Country Team played a similar coordination role.

Government and NGO stakeholders often used estimated impacts from past El Niño events or analogue years (discussed above) to update scenarios in the contingency plans. For example, government officials in Kenya worked with humanitarian organizations to develop a National, El Niño-specific contingency plan that focused on mitigating the impacts of floods, because flooding is common in Kenya in El Niño years. By pointing planners toward previous El Niño events, El Niño forecasts "helped [stakeholders] in coming up with the best national contingency plan with different scenarios" (1).

The widespread use of contingency planning is unsurprising, as it is a common tool in disaster preparation and management. According to our informants, developing contingency plans is a low-cost action, and most humanitarian and government organizations develop or update contingency plans every few years independently of specific forecasts. Officials in Malawi, for example, update contingency plans annually. However, by definition, contingency planning does not ensure early action to prevent or mitigate disasters. While some contingency plans may specify early actions or potential preparations, their primary purpose is often to make response more efficient once events occur. As discussed below, where early actions were included in contingency plans, lack of funding was often an obstacle to following through with such actions.

4.1.3. No regrets

Those actors that were most successful in taking early action often attempted to identify "no-regrets" actions they could take on the basis on forecast and El Niño information. Official definitions of no-regrets action vary [30], but our informants used the term to refer to activities that build resilience or benefit target populations whether or not an extreme event occurs in the short-term. From the perspective of humanitarian donors and responders, no-regrets actions help to alleviate concerns regarding wasted resources or having "acted in vain."

Actors in Kenya and Somalia explicitly mentioned prioritizing actions that were likely to have medium- to longer-term benefits regardless of the weather in a particular season. Such actions include purchasing and pre-positioning non-perishable supplies, reinforcing riverbanks or infrastructure in areas prone to regular flooding, training staff and communities to respond to specific hazards, desilting rivers, and cleaning drainage systems. These actions permit organizations to "prepare and then, if the event does not happen, [the effort] is not wasted" (2). Many of these actions bridge humanitarian preparedness and longer-term development, using forecasts to prioritize actions or projects that may provide an immediate buffer but will be beneficial regardless.

Our respondents indicated that identifying no-regrets actions is particularly applicable in areas that regularly experience similarly extremes or receive regular humanitarian assistance. In such cases, organizations "will either use [supplies] in another region because you can move them around, or you can use them in the same place in the next season. It is very unlikely that you will regret it" (2). In areas of Kenya, Somalia, and Malawi, for example, there are areas that flood regularly; therefore efforts to mitigate or prevent flooding will eventually beneficial. Similarly, certain areas of Malawi and Somalia receive regular aid, therefore prepositioned supplies will be used eventually, if not for the precise event for which they are forecast.

4.1.4. Gradual action

Previous studies indicate that humanitarian action is often informed by impact assessments rather than forecasts [45]. In keeping with these findings, many of our informants stated that impact assessments were essential to securing political support for action. However, many of our informants also described combining information from long-term forecasts with short-term forecasts and the results of on-the-ground monitoring and assessment. Long-term forecasts are less certain and have a lower spatial resolution than shorter-term forecasts. Organizations often responded to more vague, long-term predictions by identifying likely impacts, developing contingency plans, and attempting to raise funds, while "continually com[ing] back to these forecasts and reassess[ing] what new information in the season might tell us about how the rest of the season is going to go" (3). By monitoring shorter-term forecasts and local conditions (often through community assessments), organizations decided when, where, and how to increase their level of preparedness. As the forecasts become more localized and detailed, organizations invested additional resources, procuring and prepositioning supplies and "adjust[ing] to what the reality is" (2). This gradual action underscores the need for clear communication channels and providing assistance so that decision-makers can integrate information from different sources and on different timescales.

4.1.5. Missing elements: measuring impacts and capturing benefits

Our conversations with humanitarian responders also highlighted two neglected facets of forecast-based early humanitarian action. In addition to the primary research questions outlined above, our research team also originally sought to 1) understand or measure the value of early action (benefits in terms of impacts avoided) and, 2) understand whether organizations used forecasts to help households take advantage of favorable climate conditions (for example, by helping farmers or pastoralists benefit from higher than normal rainfall). Our team found that little is being done in either area.

Those promoting investments in forecasts for development and humanitarian decision-making face pressures to demonstrate the value of forecast-based early action. Our team asked informants whether and how they attempted to measure benefits. Although most organizations took some kind of action, only two of the 53 humanitarian organizations we spoke with (Kenya Red Cross Society and BRCiS) attempted to measure or quantify the benefits of early action (for details of these studies see [16,61]). This can be explained by difficulty in knowing what would have occurred without early action (for a discussion of these challenges see [85]). Because of the dearth of impact information, we were unable to evaluate whether the actions that were taken were indeed beneficial to the at-risk populations. Further research on the impacts of early action can help with forecast-based decisions in the future.

Although the possibility of helping households benefit from favorable climate conditions exists, we found that most organizations focus

on mitigating risks and damages rather than capitalizing on foreseeable benefits. Again only two organizations, Kenya Red Cross and Building Resilient Communities in Somalia (BRCiS) attempted programs to help farmers benefit from the potential above normal rainfall. Our informants explained that humanitarian stakeholders "are used to investing in response and are used to investing in preparedness, but donors are not necessarily used to investing in [the upside] of forecasts" (2). These results indicate that, at present, most organizations focus on disaster mitigation and prevention rather than more anticipatory programs based on forecasts. This confirms the results of previous studies finding that while the climate scientists providing forecasts see them as opportunities, most humanitarian agencies do not [42].

This focus on disaster mitigation may also reflect incentive and accountability structures in the humanitarian system; the potential rewards for preventing a crisis or capitalizing on benefits are not defined, but the repercussions for acting in vain are clear and sizable, contributing to a lack of action [2].

4.2. Factors that enable and constrain action

Although most organizations used forecasts to update their contingency plans, their ability to move beyond planning was contingent on other factors. Contrary to other sectors where trust in forecasts may be lacking, humanitarian organizations largely expressed trust in the forecast information provided. Instead, we identified five factors that influenced whether and how organizations were able to take early action: the specificity of the information provided; the availability of assistance or interpretation from boundary organizations or other intermediaries; the availability and flexibility of funding; integration with existing social protection programs; and the political context. These factors enable or constrain action depending upon the dynamics of the particular situation. For example, funding inhibits early action when donors are reluctant to distribute funds based on forecasts; but funding can also enable early action when organizations have access to early, flexible funding. Consequently, we present the enabling and constraining factors together.

4.2.1. Trust

Previous studies have found that lack of trust in forecasts can be a significant obstacle to action. In contrast to evidence from studies at the individual or household level [3,21,31], people working within humanitarian organizations appear to trust international El Niño forecasts and associated warnings from international and regional forecasting centers. None of the informants we spoke to expressed skepticism about the quality of international forecast information. The high level of trust is particularly interesting given the potential for false alarms, as occurred in 2014, and the potential opportunity and reputational costs of "acting in vain."

On the other hand, confidence in national-level forecasts varied across countries. Humanitarian actors in Kenya, for example, were quite confident in Kenya Meteorological Department predictions. Actors in Zambia and Malawi felt that the National Met Services have more limited capacity and expertise in downscaling. Studies have likewise shown that downscaling seasonal forecasts does not always improve forecast skill [43,63]. These perceptions of forecast reliability—the tendency for the observed frequency to match the forecasted probability of season—are consistent with studies that demonstrate that international forecasts are more reliable than those produced in Regional Climate Outlook Forums [4,68]. Many National Meteorological Services base their national seasonal forecasts on the results from the RCOFs. Despite the desire for more reliable information, most humanitarian actors were willing and motivated to act on forecasts provided they had the resources and understanding to do so.

4.2.2. Forecast scale and the ability to understand information

Our results confirm the results from studies of other kinds of actors showing that a lack of specificity in forecasts and uncertainty in how to act were major constraints to early action [48,65,76]. At least half of our national-level humanitarian informants explicitly mentioned problems with forecast scale, timeliness, or specificity. Informants in Zambia and Malawi complained that the "the information is too generic, and the country is vast" (2) or that forecast are not area or sector specific (1). With regard to timing, one informant lamented, "I hate to be down on the forecasting stuff, but for 98 per cent of [possible early action measures] the short-term [forecasts] are too short-term, and the long-term forecasts are not even close to specific enough" (2).

Because of the way the information was presented, many humanitarians were unclear how to act upon the information. Humanitarians struggle to know where or how to act upon probabilistic forecasts of above-normal, below-normal, and normal precipitation. Forecasters themselves also acknowledged that scientists "are prone to using the words 'there is likely to be above normal,' 'normal to above normal'" without providing necessary context about what 'normal' means (3). As a result, decision-makers and the organizational level are left asking "what is above normal?" (3) and, "How do I translate that into my preparedness?" (2). Without greater context and assistance interpreting forecast maps, humanitarians are left with forecast maps depicting "a big blob of blue or a big blob of green" (2) and little ability to translate the information into action. These results suggest that tercile forecasts may not be useful to humanitarians in some contexts, and point to the need for investment in forecasting system development to enable enough skill for the provision of more tailored information, such as forecasts of the extremes of the distribution (e.g. top 10th percentile of seasonal rainfall) or forecasts of flooding for specific river basins [25]. Nevertheless, in some instances, boundary organizations or actors can help humanitarian practitioners interpret the forecasts and translate them into action, as discussed in the next section.

4.2.3. Boundary organizations or intermediaries

Just as vague or overly technical information hinders humanitarian action, the ability to interpret scientific information and connect it to appropriate actions facilitates it. Our interviews confirmed findings from previous studies that highlight the important role of boundary organizations or intermediaries in translating scientific information into action [22,31,59,60,76,101].

In Kenya and Somalia, the availability of intermediaries with expertise in forecasting and humanitarian planning helped humanitarians understand the implications of the seasonal forecasts and translate them into action. Every humanitarian organization in Somalia credited detailed, context-specific impact information provided by SWALIM, FSNAU and FEWS NET with their ability to identify areas that were likely to flood and take necessary actions to prevent or mitigate impacts. These organizations were able to provide valuable information because they have years of experience producing forecasts in the region and an intimate knowledge of the climatic, hydrological, and social context.

In Kenya, intermediaries also facilitated planning and action. Representatives from the Kenya Meteorological Department and Red Cross Red Crescent Climate Centre joined humanitarian planning meetings to explain the implications of forecasts, interpret uncertainties, and devise "simple, practical" actions (2). Kenyan informants believed it was "incredibly helpful having a climate practitioner — not just a climate scientist, but a climate practitioner — who was able to do the translation job that is so often missing" in forecast distribution (2).[7] In areas where such support was lacking, our informants called for greater "emphasis on interpretation and advisories…because just having information is not enough" (2). Stakeholders desire assistance in identifying how that information "translates

[7] Translation here refers to translation of technical information into likely impacts and potential actions, not translation from one language to another.

into action" or can "assist the organization to program and give appropriate support" (2). The greater the specificity, both in terms of scale and suggested actions, the easier it is for humanitarians to incorporate the information into their decision-making.

4.2.4. Funding

Just as access to resources is a common limitation to individual action based on forecasts [9,31,54,65,72,92], humanitarian organizations face significant funding constraints. Humanitarian actors across all five countries confirmed that timely, flexible funding is essential to forecast-based early action. Conversely, insufficient funding often limits when and how humanitarian organizations can prepare based on forecasts. The inability to secure funding for preparatory actions outlined in contingency plans in Kenya, Malawi, and Somalia limited the degree to which early action could take place. An informant in Malawi noted "if [organizations] end up having these plans but then no resources, [they] will not be able to implement" (1). Incorporating early actions into contingency plans is only useful if countries have the resources to operationalize them.

Informants attributed funding challenges to the fact that humanitarian funding is designed to respond to existing crises, not to prevent them before they happen. Because "donors sometimes do not release funds until [a disaster] happens," organizations are unable to take early action (2). An informant in Malawi noted, "I can say, 'I want money to pre-position these materials.' They will not give it to me. But when I say, "I want money to rescue these people," they will give it to me" (2). As a result of existing funding structures, many organizations lacked the funds necessary to take action.

No-regrets and flexible funding, on the other hand, make it easier for organizations to take early action. One informant described such sources of flexible funding as "the difference between what [they are] able to do and what most other NGOs…are able to do" (2). Donors that embrace a no-regrets approach to funding and do not penalize organizations for taking precautions based on forecasts enabled early action. For example, organizations in both Somalia and Kenya anticipated severe flooding and prepositioned supplies to help with flood relief. While some of it was used for El Niño-related events, the flooding in both countries was not as severe as anticipated. Because the donors were flexible, organizations were able to shift remaining materials and funds to new areas of need when El Niño had passed.

Crisis modifiers also facilitate early action by facilitating the quick reallocation of funds. In Ethiopia, for example, bilateral donors reprogrammed funds from development to emergency response to provide humanitarian organizations with funds to procure emergency food supplies. Respondents in Malawi likewise reported shifting funds from existing programs to program to mitigate the anticipated effect of El Niño. Crisis modifiers and flexible programs can also help organizations circumvent political obstacles to early action (described below), as they allow organizations to repurpose existing funds or modify existing projects based upon emerging needs rather than having to get approval for entirely new programs or wait for a formal emergency declaration.

4.2.5. Social protection and early action

Evidence from these five countries suggests that, given appropriate preparation, forecasts can be used to scale up existing social protection programs. Of the four countries with some kind of social protection program—Kenya, Malawi, Zambia, and Ethiopia—only Kenya was able to scale its social protection based on forecasts. This was because mechanisms for channelling additional funding and scaling the program to new beneficiaries were in place before the forecasts were issued.

The Kenyan government successfully scaled up its Hunger Safety Net Program 2 (HSNP) in response to the 2015–16 El Niño forecasts. The HSNP typically provides cash payments to orphans and vulnerable children, the elderly, the disabled, and the otherwise poor and vulnerable who are affected by drought. The program recently established a scalability mechanism to expand to additional beneficiaries when action is triggered based on observed vegetation conditions. In 2015, humanitarian donors reallocated funding to provide anticipatory emergency payments to approximately 190,000 households that were not receiving regular payments, but were registered in the system and likely to be impacted by flooding [51]. These payments were dispersed in late October 2015 [51]. Although not all recipients were ultimately impacted by the floods, our informants who were involved in the program believed it had been a success.

In contrast, experiences in Malawi, Zambia, and Ethiopia, illustrate the potential challenges of taking forecast-based action through social protection mechanisms. Existing social protection programs in these countries were not ready to accommodate additional, emergency beneficiaries and were therefore unable to respond to forecasts. In Malawi, DFID attempted to take early action using social protection channels, but the system was not equipped to handle multiple funding sources and new beneficiaries. In Ethiopia, the Productive Safety Net Programme (PSNP) has been able to use establish systems to expand coverage in response to shocks in the past, but it was not able to take effective early action before the 2015–2016 El Niño [82,90]. A new phase of the PSNP was not fully operational at the time and was not equipped to facilitate early action based on El Niño forecasts. In Zambia, donors, NGOs and government officials began conversations about how to integrate forecast into the Social Cash Transfer programs in late 2015; but as developing such a program takes time, the program did not begin testing until late 2016, after the 2015–2016 El Niño had ended. In light of these complications, donors, governments, and NGOs in each country have begun initiatives to improve integration of forecasts into social protection systems to facilitate early action in the future.

When contrasted with the Kenyan experience, efforts in Malawi, Zambia, and Ethiopia show that social protection programs need to be prepared to adapt based on forecast information to facilitate early action. It takes time for governments to identify potential beneficiaries, establish or expand distribution channels and update operational procedures for the delivery of benefits.

4.2.6. Political considerations

Our results affirm that political context and the government's willingness to declare a disaster can have significant influence over when and how humanitarian organizations respond to forecasts [55]. Ten informants in two countries indicated that, in their view, government officials weighed the potential benefits of early action against the potential political repercussions of anticipating or declaring emergencies. As one informant noted "declaring emergencies puts the government in a position they don't like because they feel the opposition will use it against them" (2). Informants in both countries felt governments were reluctant to act on forecasts for fear of raising unnecessary alarms. As humanitarian organizations often need government approval to begin humanitarian responses, these political considerations can slow early action, a finding consistent with previous studies [8].

Evidence from other case studies confirms the role of politics in shaping action, though in the other direction. Our informants in Kenya cited collective memory of the catastrophic 1997–1998 El Niño as a motivation for government and NGO action. Likewise, a study from Peru, where the impacts of El Niño are well understood, forecasts prompted government officials to invest in early action out of the belief that a disaster would threaten their chances of re-election [34].

Whether political incentives increase or decrease the propensity for early action likely depends on the context, but these cases highlight the role of political consideration is shaping humanitarian action. Efforts to improve forecast-based early action will therefore need to account for political incentives to respond to forecasts. As discussed below, establishing forecast triggers upon which humanitarian organizations are allowed to act may be one potential way to circumvent the need for official emergency declarations.

4.2.7. Flood vs. drought and the availability of concrete actions

Our respondents also pointed to important differences in the ease and ability of preparing for acute, localized hazards, rather than slow onset hazards covering larger areas. Flooding is relatively localized. As noted by our informants, this facilitates action in two ways. Firstly, "if you say there's a probability there's going to be flooding in Uganda, there are specific spots that there is going to be flooding, not the whole part of Uganda" (2). Secondly, humanitarians have some "pretty tangible things (they) can do to mitigate flooding: preparing banks, prepositioning sandbags" (2).

Because floods are more localized, it was relatively common for organizations in Malawi, Kenya, and Somalia to take forecast-based early action to prevent flooding or the impacts of flooding. Practitioners used historical and hydrological data (such as that provided by SWALIM and FSNAU in Somalia) to narrow the scope of potential response and select suitable actions. In areas where floods occur frequently, humanitarians mentioned that they "knew what engineering was required" to mitigate the impacts (2). For example in Somalia, practitioners felt they knew where to stabilize riverbanks, and in all three countries flood maps and hydrological patterns allowed practitioners to preposition transport and other supplies to mitigate damages and expedite response.

In contrast, our informants indicated that response to drought forecasts is slower and more challenging. Drought affects larger areas and materializes more slowly. It is therefore "a lot more complicated, and [the humanitarian community] hasn't really articulated clearly what the preparedness actions are" (2). As noted by another informant, "It just wasn't so possible to trigger early action" in response to drought forecasts, because the information available was more general and the connection between the data and the actions to be taken was less straightforward (2). As a result, drought responses occurred after impacts were being felt and traditional assessments could articulate the needs.

5. Discussion: lessons and policy implications

In addition to the finding-specific implications of each common theme provided in Table 4, in this section, we focus on the broader implications of these findings.

5.1. Under the right conditions, forecasts can lead to early action

Although more precise forecasts will always be desirable, our results show that when funding, interpretation, and political constraints are addressed, international humanitarian organizations are able to take forecast-based early action. Unlike in several other sectors or levels of society, humanitarians trust the information provided and are willing to plan and act on forecast information, but additional financial, technical, and institutional support is often needed to move from contingency planning to action. It is important that the forecasting community ensure that the information provided is skilful and useful, to maintain this trust.

5.2. The potential for longer-term ENSO preparedness

Humanitarian organizations may be able to begin preparing for El Niño before a forecast is issued. For example, research into analogue years, development of likely scenarios, and identification of no regrets actions for the most likely or highest risk scenarios can be done before a specific forecast is issued. Such planning might free organizations to search for funding for their plans once an El Niño forecast is issued. Such preparations, however, may not be an appropriate response for seasonal forecasts more generally, as there may be greater variation in potential scenarios, and therefore unrealistic to guess which are most likely or to prepare of all of them. These strategies also have potential drawbacks, as discussed in the following sections.

5.3. Current strategies have their risks

Given that most actors looked to analogue years to develop their plans, it is important to caution and publicize that focusing on single analogues, such the 1997–1998 El Niño event, can lead decision-makers to focus too narrowly. A single El Niño event does not represent the full range of possible El Niño related impacts which may vary from year to year [17,36] at least in part because 3-month precipitation totals (the probability of which is provided in seasonal forecasts) are not the only factor influencing flooding [36]. Our study shows that even looking at several historical events can be misleading. Our informants in Somalia, for example, focused on preparing for flooding based on experience with El Niño. As a result, they later found themselves unprepared for an unexpected drought "in a totally different location that was not part of the plan."

Specific impacts are also highly dependent on the vulnerability and exposure of a population to changes in rainfall, factors that can change significantly in the time between El Niño events [18]. The use of analogue years and historical disaster information introduces the risk that early action planning focus on past risk, without adequate attention to updated risk profiles. For example, past events may not account for new migrant populations. So, while analogue years may be useful, forecast providers may also want to caution against deterministic understandings of El Niño impacts.

As with the focus on analogue years, a focus on no-regrets actions may also have its drawbacks. While no-regrets funding and action facilitate early action, funding is often not made available for these actions outside the context of forecasts because it is being used for other priorities; there is an opportunity cost of investing in early action. Further research into the benefits of specific "no-regrets" actions could help make the case for investment in those early actions that are indeed worth prioritizing over competing "normal" programming requests.

5.4. Focus on hazards and information that have proven useful

Rather than trying to use existing forecasts to support decision-making for all climate-related hazards, it may be better to invest in decision-support and complementary information related to specific hazards and specific actions, such as identifying the probability of extreme river flooding in a season and overlaying that with information on the sections of the river that are most likely to burst. The provision of complementary information should draw on experiences for which actions have been proven to reduce impacts.

5.5. Invest in learning 'lessons'

Many of the challenges identified in this study have been identified in previous studies of responses to forecasts at other levels of decision-making. The organizations that were unable to act were often hindered by poorly tailored information, a lack of funding for early action, a lack of expertise in managing forecast uncertainty or developing predictions of localized impacts, and unfavorable political climates. These findings will not surprise scholars and practitioners familiar with the broader literature on forecasts.

Indeed, the organizations that were able to move beyond planning to early action were those who had addressed these constraints and apparently operationalized lessons from previous forecasting efforts. They had access to boundary organizations or technical supports that could help them to identify localized, context-specific actions. They had political support, and they had access to funding that permitted them to take early action. While funding and finding solutions to the social and political constraints to forecast use may not be as straightforward (or for some appealing) as funding technical capacity, it is essential to enabling forecasts to fulfil their promise.

5.6. Future research

Finally, our research points to several areas for future research. Our team did not evaluate whether the forecast information merited specific actions, focusing only on whether people chose to act based on climate information. We also did not attempt to assess the impact of any of the actions taken, such as the revision of contingency plans, the most commonly cited response. As noted above, few of the actors we interviewed has assessed the benefits of their efforts either. Further research is therefore needed to understand whether forecasts-based updates and revisions to contingency planning improve disaster preparedness and response outcomes.

Although our evidence shows that it is possible to integrate forecasts and social protection programs, further research is needed to understand the actual benefits of forecast-based social protection programs. In Kenya, flooding did not materialize in many areas where payments were distributed. Our informants (both donors and practitioners) described the program as a successful no-regrets action, but there is no guarantee donors or government will continue to provide similar funds in the future, especially given the potential to distribute funds to unaffected areas or households. Given the interest in integrating forecasts and social protection programs, additional research is needed to analyze the potential benefits and drawbacks of forecast-based social protection.

Finally, there are several climate information products currently under development that could support the information needs articulated by many humanitarian actors. Impact-based forecasting methodologies are being tested in several countries. These methodologies attempt to overlay current risk information with current forecast information, providing up-to-date context that can inform action planning. “Flexible forecasts” already available provide seasonal probabilities of extremes, rather than only terciles, and several seasonal forecast agencies are currently developing seasonal hydrological forecasts that will provide information about flood risk in specific basins [35,83]. For drought, methods to combine historical rainfall information with forecasted future information are also under development in several regions [91]. These products have the potential to improve the usability of forecast information, but more research is needed to understand whether humanitarians can make use of these new kinds of information.

6. Conclusion

Our study finds that humanitarians’ trust in forecast information is quite high, that organizations already take steps to act upon forecasts, and that—given the right context and resources—they can act. The most common of these actions, however, like contingency planning and identifying no-regrets solutions could be done independently of forecasts. Others, like looking to analogue years and no-regrets planning, carry risks of their own.

Our study also confirms that known constraints from other contexts are relevant to whether and how humanitarian organizations are able to act on forecasts; for forecasts to lead to improved outcomes, humanitarian organizations need more tailored information and/or increased capacity to interpret forecasts, whether internally or through intermediaries. They also need adequate funding mechanisms and strategies for overcoming political obstacles to early action. If forecasts are to improve humanitarian decision-making, well-established barriers to forecast-based decision-making will need to be addressed.

We conclude that rather than emphasizing forecast quality and broad-based efforts at dissemination, proponents of forecast-based action need to invest additional time and resources in addressing established, cross-cutting lessons from past studies of forecast use. In contexts where skill is weak, data is lacking, and risk is widespread, practitioners should also consider whether forecasters can provide information with sufficient lead-time and resolution to assist decision-makers. In some cases, investments in forecast-based action might be more useful if redirected to locations with more favorable conditions for early action.

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Appendix A. Semi-structured interview guide

Our team used the following guide to ensure that all relevant topics were covered.

A. Background

1. Please tell me more about your role in your organization (and in receiving and responding to forecasts).
2. In your understanding, briefly, what is El Niño? How/when did you first learn about El Niño as a phenomenon?
3. What are the anticipated impacts of El Niño in your country?

B. Forecasts and action

4. Did you or anyone in your organization receive information, forecasts or warnings of the 2015–16 Niño?
5. Would you be willing/able to share the forecasts with us (especially if via email)? If yes, I will get these documents from you at the end of the interview or via email.
6. When was the earliest you remember hearing of El Nino? From what source?
7. Did your organization undertake any new programs or activities in response to the 2015/16 El Niño forecasts?
8. **If yes**, please describe your organization's process of planning for and preparing for potential El Niño impacts
   a. What sources did you get information from? (Prompt: Media, forecast from Met Service, international forecasts, other organizations etc.)
   b. What was the course of events that led from information to action?
   c. What were the key decision points?
   d. What role did climate information play?
   e. Were there multiple source of forecast information?
   f. How did this information reach you (email, telephone, word of mouth, you requested it etc.).? (If multiple methods, which one was most preferred/effective?

g. Were the forecasts accompanied by any advice, suggested actions, sector-specific warnings?
   i. If yes, what were they? Were they useful?
h. Did the warning include information on potential impacts of El Niño in your area?
   i. If yes, what are the anticipated impacts of El Niño in your country?

C. Usefulness of information (if not covered in the discussion above)

1. Which information did you use in preparing for and responding to the impacts of the 2015/16 El Nino (Prompt: media, online sources, internal communications, national communications, international organizations, met services forecasts)?
   a. Which information was most useful? Why?
   b. Which information prompted action?
   c. Which information was least useful? Why?
   d. What other information would you have liked to have had?
   e. How might the information have been improved?
   f. Did uncertainty in forecasts influence action/in-action? (*Prompt: was uncertainty a barrier to action? did the actors wait for a level of certainty to be reached before acting, or did activity ramp up gradually as certainty improved?*)

D. Successes and challenges (if not covered in the discussion above)

9. In your opinion, what were the primary successes, achievements or benefits of your early response to El Niño forecasts? (*Prompt: Institutional Readiness to Respond? Reducing losses or damages? scale of impacts* avoided?)
10. What were the primary challenges of responding to the El Niño forecasts?
    a. What other factors influenced your organization's ability to prepare and respond to the El Niño forecasts?
    b. Were there any barriers to the use of the information for early action? (*Prompts: logistical considerations, approvals of funding, requests for support from government, agreements by coordinating bodies*)
    c. Did you encounter any problems in trying to interpret the forecast and associated warnings? (*Prompt: Were you able to understand the format of the El Niño forecast without outside help/expertise?)*
    d. In your opinion, how accurate or credible are the El Niño forecasts produced for your region/country?
11. Based on your experience, what suggestions would you make to improve El Niño forecasts or their dissemination in the future?
    a. What other information would you have liked to have had?
    b. How might the information you received have been improved?

E. Previous El Niño events, social protection and lessons

12. Were you involved in any El Niño preparedness in 2011/2012 or during earlier El Niños? If yes, was the 2015/2016 response different in anyway? How?
13. Did you receive any information regarding an El Nino in 2014? If yes, did this impact the response in 2015/16?

F. Closing

14. Anything else related to preparedness and the use of El Niño forecasts we did not cover that you think is important for us to understand?
15. Anyone else in your organization or other organizations working in your country that you recommend I speak to?
16. Do you know of any studies of El Niño impacts, or impacts avoided, from your country?

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