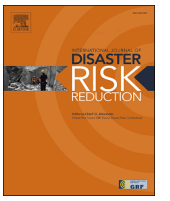
International Journal of Disaster Risk Reduction 81 (2022) 103242

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr



# How do information problems constrain anticipating, mitigating, and responding to crises?

Erin C. Lentz [a, *], Daniel Maxwell [b]

[a] Lyndon B. Johnson School of Public Affairs, University of Texas at Austin, 2315 Red River St., Austin, TX 78723, USA
[b] Feinstein International Center, Friedman School of Nutrition Science and Policy, Tufts University, 75 Kneeland St., Boston, MA 02111, USA

ARTICLE INFO

*Keywords:*
Early warning
Anticipatory action
Humanitarian action
Crisis

ABSTRACT

The explosion in data availability and new analytical tools combined with increasing humanitarian need and the imperative of anticipatory action compel us to rethink humanitarian information systems and humanitarian action for the future. Synthesizing interviews with humanitarian practitioners, donors, analysts, and researchers and analyses of early warning (EW) information systems and their linkages to Anticipatory Action (AA), we describe six information challenges within the current system: abundant but confusing information, the difficulty of predicting conflict, politicized information, limitations of new analytical tools, varying information needs, and limited data sharing. We then propose an approach to improve the timeliness and appropriateness of action for humanitarian crises and disasters. Rather than ask, "What can we do with the information (early warning and otherwise) that we have to inform action?" we propose asking, "What information do we need for anticipatory (and other) action?" In other words, we propose planning from known and likely hazards and actions back to information needs. Such an approach should help to mitigate shocks before they cause major humanitarian crises. While not all crises can be prevented, this approach could also support responsive action, which is equally important for protecting human life and dignity.

## 1. Introduction

The disconnect between information and early warning on one hand, and actions to prevent, mitigate, or at least provide a timely response to crisis on the other hand, has long been acknowledged [1,2]. At face value, the problem is straightforward and simple: Information about the combination of current conditions and the impact of likely hazards *should* initiate prompt action to protect life and livelihoods in the face of a crisis or shock.[1] Research has shown that prompt action not only reduces human suffering, it also costs less to prevent or mitigate a shock than to respond later to the human suffering caused by it [3,4], but research also shows that despite this knowledge, crises are frequently *not* acted upon until *long after* the humanitarian consequences have struck [5]. In 2018, a new

* Corresponding author.
*E-mail address:* erinclentz@utexas.edu (E.C. Lentz).

[1] There is some confusion over the terminology of crisis. In common parlance, the terms "crisis," "disaster," and "emergency" might be taken to mean very similar things. Some analysts use the term "disaster" to refer specifically to events triggered only by natural hazards (storms, drought, earthquakes, etc.). Some use the term "emergency" only to refer to a very short-term, acute event. In the very specific language of the Integrated Food Security Phase Classification (IPC) analysis, "crisis" refers to one specific category of severity, and "emergency" refers to a more severe classification. To minimize confusion, we use the term "crisis" in this paper in a general sense to refer to any event that results in unacceptable humanitarian outcomes, without specific reference to causal factors, time frame, or relative severity. If any of those factors require incorporation into the analysis, additional terminology is used to clarify.

https://doi.org/10.1016/j.ijdrr.2022.103242
Received 17 February 2022; Received in revised form 2 August 2022; Accepted 8 August 2022
Available online 21 August 2022

coalition, led by the World Bank and the UN Office for the Coordination of Humanitarian Affairs (OCHA), piloted a more comprehensive approach to "anticipatory action," following a major address by UN Under Secretary General for Humanitarian Affairs, Mark Lowcock [6]. Anticipatory action (AA) includes actions taken to reduce the impact of specific disaster events [7] and builds on decades of experience with disaster risk reduction. The new approach would combine machine learning and artificial intelligence (to improve prediction) with novel forms of financing (to improve the speed and scale of action) along with better contingency planning and preparation. Given its wealth of information collected by the Somalia Food Security and Nutrition Analysis Unit (FSNAU), Somalia was the first trial case. And yet …

During the autumn of 2021, it became clear that a renewed crisis was brewing in the Greater Horn of Africa. The two previous rainy seasons, while not complete failures, had registered total rainfall amounts in the lowest tercile of recorded totals in history, and the 2021 autumn (*deyr*) rains were also a near total failure in much of northeastern Kenya, southern Ethiopia, and, most worryingly, much of Somalia [8]. Data from the Armed Conflict Location and Event Database (ACLED, n.d.) showed that the intensity of conflict in Somalia rivaled that of conflict happening concurrently in northern Ethiopia—although the latter had substantial international media coverage whereas the conflict in Somalia garnered little coverage. And much of the conflict in Somalia was between factions that were at least nominally aligned with the government, not between government-aligned forces and Al-Shabaab. Late in 2021, global prices for basic food stuffs had reached a ten-year high [7]—and Somalia is a food importing country even in non-drought years. By late November, the seasonal weather forecast was warning of continued La Niña conditions into the first half of 2022—indicating likely below average rainfall for the upcoming season as well. And yet …

By early December 2021, with *both* the updated early warning information on Somalia *and* the planning and information gathered in the process of making Somalia one of the countries earmarked for rapid anticipatory action, decision makers from across the humanitarian sector still confessed to confusion about whether this was the time for anticipatory action (or even just "rapid response"). Over the course of 2021 as conditions worsened, only about $40 million, or 4% of the $1 billion Humanitarian Response Plan (HRP) had been allocated to anticipatory action [9]. In a region that included political turmoil in Sudan, civil wars in Ethiopia and Yemen, and on-going large-scale violence in South Sudan, Somalia was not front-page news on a global scale, but conditions in the country were evident to anyone working there. And yet …

The "and yet …" part of these observations indicates an enduring confusion about the role of information—especially probabilistic forecasts—in humanitarian operations and preparedness. This paper builds on a decade of research on early warning and information systems and synthesizes the results of six studies on the link between information and action and some of the problems arising to try to address one of the most confounding and persistent problems in humanitarian action.

## 2. Background

The number of people globally requiring urgent humanitarian assistance has ballooned over the past dozen years—by some estimates increasing by a factor of ten. While budgets have increased, they have failed to keep up, excluding an ever-increasing number of people from the formal humanitarian response mechanisms [10]. Fig. 1 presents the number of consolidated appeals met in billions of dollars on the left axis and the people in need in millions on the right axis. Whereas the needs of 26 million people were almost three-fourths funded in 2007, by 2020 less than half the needs of an estimated 235 million people were covered.[2] The data from Fig. 1 is presented in Table A1, found in Annex 2.

While several means have been suggested for addressing the problem of rapidly growing humanitarian needs, one of the most appealing is "early" or "anticipatory" action—action taken before a shock puts people into a crisis situation, either by preventing or mitigating the hazard itself or by mitigating the impact of the resulting shock [6].[3] Evidence confirms the hypothesis that early or anticipatory action can reduce the humanitarian impact of shock—fewer people in acute food insecurity or malnutrition, for example—and therefore lower humanitarian budget demands, putting the savings towards addressing other kinds of need not as amenable to anticipatory action (e.g., Refs. [2,11–16]).[4]

Anticipatory action to mitigate the impact of a shock is frequently significantly less expensive than intervening once a crisis is fully manifested, and a primary rationale for AA is that it can stretch limited budgets to reach more people in need [6,18]. As a result, AA to prevent or mitigate humanitarian crises is now formally an objective of nearly all UN agencies, the Red Cross, the World Bank, most formal donor agencies, and alliances such as the START Network, which is comprised of 55 international and national NGOs [19]. UN OCHA's Anticipatory Action Toolkit[5] is one tool used to help determine appropriate early interventions. While there are enough success stories to make the case for greater investment, to date many are relatively small-scale responses to single-hazard shocks—mostly climatic hazards, such as the above example in Somalia where about 4% of the total needs were allocated for anticipatory action [20].

[2] People are not entirely dependent on the formal, international humanitarian response system—there are other mechanisms, including people's own social networks and connections. But the formal sector figures underscore the problem.

[3] To most actors involved in the field, "early" and "anticipatory" action are broadly understood as the same thing, but "anticipatory" action is increasingly used to avoid misunderstandings ("early action" can be confused for "rapid response," which is also important, but is in a more life-protecting mode rather than shock-mitigating mode).

[4] Note that the primary rationale for anticipatory action is humanitarian, not financial, and given the rapidly rising levels of humanitarian need, even substantial investments in AA are not likely to diminish *overall* humanitarian budgets any time soon.

[5] See United Nations Office for Coordination of Humanitarian Affairs at https://anticipatory-action-toolkit.unocha.org/.

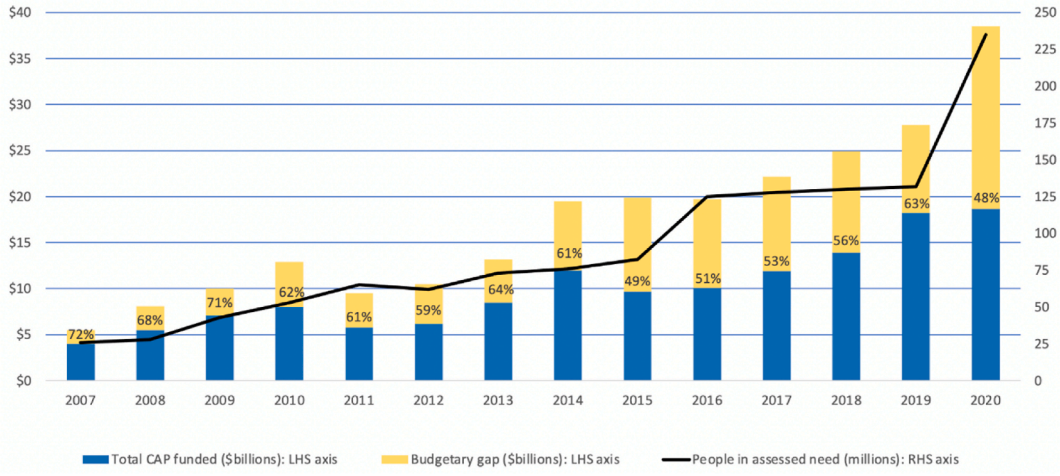



**Fig. 1.** UN Consolidated Appeals Process (CAP) appeals: People in need, funding requests, and gaps. Note: In 2015 CAP was renamed the UN Humanitarian Needs Overview (HNO) or Global Humanitarian Overview. Source: UNOCHA (various years) Development Initiatives [10,17].

### *2.1. Six challenges to linking information and action*

One clear conclusion is that greater efforts are needed to explicitly link information and analysis to interventions if we are to begin to address the problem highlighted by Fig. 1. But it should also be clear that AA is not the answer to every problem manifest in Fig. 1. Many protracted crises today are maintained by a series of small shocks and stressors that do not lend themselves to AA, and of course AA is—at least to date—not as applicable to some kinds of shocks.

Synthesizing across six recent studies [20–25], we identify six confounding challenges that inhibit linking information to analysis action. After introducing these challenges and our objectives for this paper, we then describe our methods. In our findings section, we discuss the six challenges and propose ways forward for each; we draw on relevant literature in that section to indicate where our findings converge or diverge with other studies. In our conclusion, we then propose a more holistic approach that considers how hazards and anticipatory (and other) actions could inform information systems to improve linkages.

The six challenges:

1. **Information is abundant, but can be confusing and may not meet needs.** In many ways, the humanitarian world has never been more awash in information. However, most contemporary information is either sectoral in nature if related to humanitarian outcomes (food security, nutrition, health, shelter, etc.) or hazard-specific if related to predicting the likelihood of shocks [20]. There are multiple demands for information that is simultaneously inter-sectoral in which people with overlapping needs (e.g., WASH and food security) are identified [26]—and also demand for information that is disaggregated by gender, age, and other categories of social vulnerability [27]. At the same time, users seek synthetic analyses that assess the cumulative impact of multiple hazards on specific outcomes [21]. Across the six studies, respondents report considerable confusion in sorting out the different types of information and how these information types could inform action. It is not always clear what the difference between current status and early warning is—for example in some cases, current status information is the basis on which humanitarian action is planned for the upcoming year (as if current status alone were predictive). And situations can change quickly, rendering good early warning information out of date in a short period of time—the rapid onset of a global pandemic irrevocably reminded us of that, if we had forgotten the lesson from earlier crises. This in turn has raised the demand for "real-time" information and "nowcasting" [24].
2. **Conflict is difficult to predict … and more difficult to prevent or mitigate.** Despite plentiful information in general, information about and predictive analysis of conflict—in addition to the lack of viable mitigation plans and the capacity to implement them—is a serious constraint to AA in conflict-related crises. But violent conflict is the main or a major driver of crisis—including in 13 out of the 15 "worst" humanitarian crises of 2021—in terms of the severity of the crisis and the number of people affected [25,28,29]. And the crucial issue of *access* to affected areas and populations is a major constraint—even for life-protecting humanitarian response, let alone AA. Information is crucial here, but information alone doesn't solve the problem.
3. **Information is power … and analysis is frequently politicized.** Information and analysis are frequently politicized, manipulated, or obfuscated to serve non-humanitarian objectives [25]. See also [30]. This includes delaying and undermining data collection processes, limiting or restricting access for information collection, intimidating or threatening analysts, and quashing or delaying reports. This is most frequently the case with regard to the analysis of famine—particularly famine driven by violent conflict in which a government is one party to the conflict and also oversees data collection and analysis processes [25].
4. **New analytical tools are being developed, but how much will they help?** Researchers and analysts are increasingly using new tools, including machine learning and predictive analytics for early warning, for situational analysis and to estimate

and identify needs [23]. See also [15,31,32]. Predicting the likelihood of a shock or a series of shocks and the likely outcome is a complex business that is highly variable across different hazards [23]. Yet, many observers expect that artificial intelligence and machine learning will address some of the above challenges [20].

5. **Analytical tools often do not account for uncertainty and severity.** The strength of the EW-AA link is highly variable depending on the severity, certainty, and complexity of a shock [20]. Some hazards are highly predictable and the impacts can be forecasted; other crises are the result of multiple hazards that are rare or hard to predict [33]. These different hazards and crises may need different early warning information and different analyses, which include processes of scenario development or semi-automated "triggers." Yet, there is a temptation to search for a one-size-fits-all approach to assessing the likelihood and impact of, and response to, crises [20,23].
6. **Limited data sharing and transparency contribute to competition across information systems, and accountability for data and analysis is sometimes lacking.** While there is an abundance of information, some regularly collected data are often unavailable to those who need it for decision-making. Further, data collection processes are often not transparent, making it difficult for outsiders to assess data quality. These delays or outright stalling in sharing data and quality concerns have contributed to the establishment of parallel information systems, with competition for resources across information systems rather than collaboration. Such competition underscores a lack of accountability to people in need [20,25].

Two further points put these challenges in perspective. First, several components beyond information and analysis influence anticipatory action. We focus our analysis in this paper on the information and early warning that AA requires. However, AA also requires the ability to plan what actions will be taken in what time frame and with regard to what hazards or potential shocks to prevent or mitigate a humanitarian crisis—that is, good contingency planning. AA also requires the capability to act on that information, implement that plan, and act quickly—that is, capacity on the ground and access [20].

And finally, it can hardly be stressed enough that not all information demands are linked to AA. Less anticipatory or more responsive forms of humanitarian action also critically require information—that for the most part has to come from the same systems. Crucially, all humanitarian action—whether anticipatory or responsive—requires access to the *area* and the *population* at risk.

### 2.2. Objectives

The goal of this research is to improve humanitarian information systems' abilities to inform action of all kinds—whether it be decisions to prevent or mitigate humanitarian crises, or respond to them in a timely manner. Over the past two or more decades, researchers [1,34,35] have made similar points about the disconnect between information and action. What is different now is that several factors have added new challenges to the humanitarian information space: (1) the abundance of information and confusion about its usage, (2) the emergence of conflict as a main driver, (3) the politicization of information, (4) the development of new analytical tools, (5) more nuanced categorization of crises and hazards, and (6) competition between information providers and calls for transparency and accountability.

We use the case of AA to propose that responses to these information challenges ought to be incorporated into a broader humanitarian systems perspective. While AA is the main focus of this paper, when the window for AA is missed, the need to link information to analysis and interventions remains.

### 2.3. Methods and data

We synthesize findings from six studies [20–25]. This research was conducted between 2018 and 2021 and included desk reviews and interviews with over 400 researchers, decision-makers, analysts, donors, and field workers. The respondents were humanitarian professionals involved either in early warning and humanitarian information systems or in decision-making positions related to anticipatory action and response, or they were researchers (see Refs. [20,25] for details). All interviews discussed here occurred between June 2017 and November 2020, with interviews conducted after March 2020 limited to electronic means (e.g., Zoom) due to COVID-19. We initially interviewed actors involved in early warning and information systems and humanitarian action, relying on snowball sampling until reaching information saturation. Annex 1 includes key informant interview guides, and Annex 2 presents three tables of key informant characteristics (Tables A2-A4). Table A2 includes characteristics for individuals interviewed for the Maxwell et al. [20,24] study. Lentz et al. [21]; Lentz et al. [23]; and Maxwell et al. [24] used the same interviews for their analyses. Table A3 includes characteristics for individuals interviewed for the Maxwell and Hailey [25] study. Maxwell and Hailey [22] drew from interviews listed in Table A4. Interviews were recorded and transcribed. Coding was done both using NVivo and manually, with the authors analyzing the interviews using both deductive and emergent coding trees.

The six key findings discussed in this paper include those that were either most commonly reported by respondents or were identified as most urgently needed. Further, they reflect how humanitarian action and information needs have evolved in the past few decades. Conflict is a more common driver of crises than previously [29]. With the emergence of the cluster system, calls for evidence-based programming, the development of the Integrated Food Security Phase Classification (IPC) system, and professionalization of humanitarianism, much more data is being collected [17,31,36]. Finally, new machine learning techniques are being applied to humanitarian problems [32].

We partnered with FAO to vet these findings in a series of on-line workshops held in May 2021 with more than 100 stakeholders, including analysts, modelers, and decisionmakers. Stakeholders were provided a poll to rank their concerns, and during breakout sessions we discussed various information challenges in detail. This workshop confirmed that our analysis of the interviews was in line with the concerns held by the stakeholders.

These studies were approved by the Internal Review Board of Tufts University, the University of Texas, or both. All interviewees' names and identifying information were anonymized in the analysis. We report the appropriate reference and interview numbers for direct citations.

## 3. Findings and implications

We describe each of the six challenges and relate our findings to existing literature. After describing each challenge, we discuss implications and suggest possible ways forward for each.

### *3.1. Information is abundant, but can be confusing and may not meet needs*

#### *3.1.1. The challenge*

The humanitarian sector is awash in information. Researchers have described the contemporary moment as a "data revolution" [37]. Earth observation and other remotely sensed data and social media data can provide new and or more nuanced information for early warning [13,38]. Better predictions of climatic events—such as cyclones and hurricanes, flooding, and drought—have enabled the development of new prediction and anticipatory action tools, such as forecast-based financing and insurance [12,14,15,39,40]. Confirming this abundance of data, one respondent explained the humanitarian community is "lagging in early action, not in early warning."[6] In fact, this "disconnect" was abundantly clear to the same respondent in 2010–11, when governments and donors had been warned of Somalia's famine with a six-month lead time, yet timely action was inadequate—almost none of a preventive nature and too little in response mode [5]. In the decade since that famine, early action is still too rare.

An unintended consequence of this super-abundance of information is that key informants perceive the variety of information available and the large number of information sources to be overwhelming. Many key informants acting in decision-making roles across these studies were staff from donor and government agencies and voiced a concern that so much information could be counter-productive to good decision-making on early action. They reported that while triangulating across data sources can be valuable, they also spent a significant amount of time tracking down and gaining access to these different sources and then seeking information on underlying assumptions about sampling and specific indicators. They noted that trying to reconcile different data sources and findings frequently led to delays in early action. Faced with seemingly contradictory or inconsistent findings, many described experiencing "data confusion."

Analysts, researchers, and donors also observed that information was abundant but not suited for their needs, encouraging them to collect different types of information. Data on conflict, specifically, was perceived to be limited (see below). Analysts and decision-makers argued for higher frequency or more spatially disaggregated data to support targeting and modeling.[7] Other (non-conflict) contemporary information is often sectoral in nature if related to humanitarian outcomes (food security, nutrition, health, shelter, etc.) or hazard-specific if related to predicting the likelihood of particular shocks. How to make sense of sectoral data to get a holistic picture of the magnitude of the threat or how to move from the likelihood of a shock to its impacts was often unclear to our respondents. This lack of clarity contributed to an increasing demand for information that is both inter-sectoral and joined up with regard to outcomes, but also disaggregated by gender, age, and other categories of social vulnerability. Changing donor demands for greater flexibility and increasing contextualization contributes to the demand for additional, specialized data collection, as has been documented elsewhere [41].

Finally, many key informants identified (non-conflict) gaps in humanitarian information. Key informants with research interests reported a desire for more spatially and temporally granular data, particularly indicators currently not well-measured by remote sensing, such as prices, mortality, nutrition, accurate population estimates, and measures of displacement and displaced populations.

Analysts, decision-makers, and researchers who experience "data confusion" are often faced with data that seem contradictory at first glance but are often collected at different temporal and spatial scales and for different hazards. Making sense of a mix of current-status and predicted information (including indicators predicted for different periods) is not straightforward; confusion about how to synthesize different data sources with different timescales into a coherent narrative impedes both early warning and action [20].

In sum, a commonly held belief among respondents is that there is an abundance of information, but that they need better ways to synthesize types of data in order to identify actions. A major barrier, discussed in detail below, is the access to and sharing of data, resulting in duplication of effort.

#### *3.1.2. Implications*

To address data confusion requires thinking about what the data are being used for and how they do or do not help with identifying responses. A first step to addressing this data confusion is to clarify terms and to be clear about what kind of information is intended for what purpose. Understanding the purpose of information, and where gaps exist can narrow down which data are truly needed. The basic components of a diagnostic humanitarian information system can be described as follows.[8]

***Early warning*** (EW) identifies hazards and their risk of causing damage to people and their livelihoods—i.e., *causal factors*. While early warning can produce a specific signal or trigger a pre-determined response, usually early warning information is pre-

[6] [20] (Interview 007).

[7] See also former UN Secretary General Kofi Annan [61]; who wrote, "if you can't see it, you can't solve it." Taken to the extreme, this would call for more and more disaggregated and higher frequency data; in practice, many respondents who were practitioners reported feeling overwhelmed and unsure how to build scenarios when using a variety of indicators collected at different spatial levels and timeframes.

[8] This section draws from Ref. [24]. For more information, see also [21].

sented as a series of scenarios. The Famine Early Warning System Network (FEWS NET) produces scenarios, as do many national and localized EW systems.

The "most likely" scenario typically acts as a basis for planning both anticipatory action and response. However, EW forecasts also include "less likely" scenarios that have a reasonable chance of occurring. Any very severe outcome with at least a small likelihood of actually occurring has to be taken seriously alongside more likely scenarios.[9]

***Current-status assessments*** report figures on the current condition of populations. The Integrated Food Security Phase Classification (IPC)—or Cadre Harmonisé in West Africa— is one type of current status assessment. It classifies populations into phases of severity and estimates both the populations in each phase and the total population in need (PIN). IPC analyses occur one to two times per year and draw on data from the World Food Program surveys and, for nutrition, on SMART surveys.

***Projections*** are predicted figures for the population in need and at specific intervals in the future before the next current-status update. The projected PIN is likely the single most important piece of actionable information in humanitarian information systems. However, PIN numbers are estimates and subject to errors, and actual numbers can be quite different from projected PIN numbers, especially in rapidly changing situations.

The potential for sizable differences between projected and actual PIN figures contributes to the need for ***real-time monitoring (RTM)***. RTM information overlaps with information for other components of a diagnostic system, including causal factors (similar to EW) and outcomes (similar to CSA) as well as "hotspot" identification and the verification of assumptions that drive projections.

Fig. 2 depicts these relationships, with example dates for different data collection. For example, the first projection lies about halfway between current status assessments and the second projection overlaps with the next assessment to enable comparison between projection and actual. Few countries have all components listed in the figure. For example, Yemen has regular current status assessments and projections produced through the IPC process but limited real time monitoring of the assumptions underlying the projection. This makes course correction difficult. A recent proposal aims to monitor the assumptions [24]. In places where these systems are operating, mapping these information sources onto the diagnostic figure below can help to clarify the temporality of a given analysis and mitigate confusion arising from seemingly contradictory information. That is, a current status assessment may indicate a relatively normal situation at present but early warning scenarios, published at the same time, indicate deteriorating future conditions. An example is information on East Africa in late 2019, as analysts sought to make sense of current and future information, including future droughts and current floods, locusts, and other factors [20].

### *3.2. Conflict is difficult to predict … and more difficult to prevent or mitigate*

#### *3.2.1. The challenge*

Conflict is a major driver of crisis and humanitarian need globally, but information and analysis of conflict is frequently missing or inadequate [28,42], and the links to AA are not nearly as well developed. When asked about information-related barriers to AA, respondents cited lack of conflict information and analysis *more often than other single issue*. While the role of conflict in causing humanitarian crises is clear, how to best measure and analyze conflict—let alone predict its course—lags far behind EW system information for other hazards (e.g., climatic hazards) [22]. Recent literature finds a range of relationships between conflict and food insecurity (e.g., Refs. [18,43]). Reflecting the variation in the literature, several key informants warned that we don't yet have the rules of thumb on how conflict can impact humanitarian crises more broadly (i.e., causal theories). While there is little doubt that conflict is a major driver of humanitarian crises, observed relationships between conflict and humanitarian outcomes may be skewed by mismeasurement, driven by context-specific temporal relationships, and result in widely differing relationships—both temporal and spatial.

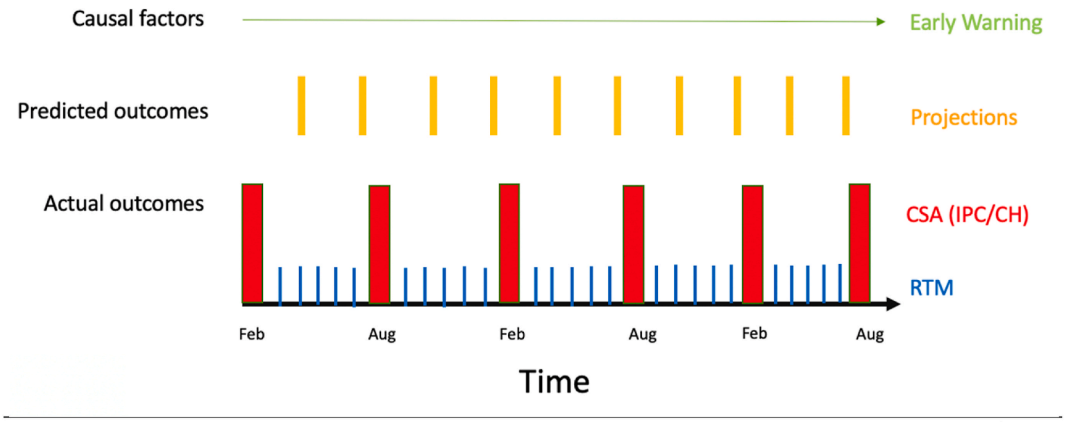
Beyond the lack of information on conflict, key informants across these studies raised concerns that including conflict in early warning analyses would render the analyses too sensitive or "political," potentially undermining the ability of actors to engage. As a result, analyses tend to use vague language, describing conflict as a "contributing factor" but not providing in-depth analysis about the humanitarian consequences of conflict [20,25]. This lack of direct focus on conflict was perhaps best expressed by one respondent, who said, "Conflict is still there and still the major driver, but we're not focusing there right now."[10]

Vague language is part of the problem; the presumption that only certain types of violence actually drive humanitarian crises is another. For instance, one set of concerns is around the difference between "political" violence and "localized" or "intra-communal" violence—with the latter often dismissed as not a major concern [44]. Several interview respondents reported that the lack of data on conflict leads to delayed responses (see also [22,25]). Many key informants indicated that missing or incomplete information or missing analyses of conflict made triggering action difficult (see also [22]). Informants reported wanting more spatially disaggregated information (e.g., casualties or attacks by village rather than aggregated to higher levels), which sometimes resulted in calls for more data collection.

And whereas a reasonable toolbox of AA interventions is available with regard to other hazards, AA for conflict-related emergencies has a very limited set of interventions. Conflict sensitivity and a "do no harm" approach to working in conflicts—both of which rely on good conflict analysis—are gradually becoming a more standard practice, but both refer mostly to humanitarian response and not to actions that might prevent or mitigate conflict. UN Security Council Resolution 2417 of 2018 is often cited as an example of the

[9] For the purpose of this paper, terms are defined as follows: A **prediction** is a definitive and specific statement about when and where an event will occur: "*Famine will occur in this location in June 2020.*" A **forecast** is a probabilistic statement regarding the likelihood of future events: "*There is a 65% chance of famine in this location in the period June-August 2020.*" A **scenario** is a possible future situation described in a hypothetical narrative in consideration of how key variables of interest may evolve over a given period, often taken as a set of several possible situations of varying likelihood of occurring: "*The most likely scenario for this location in the period June-August, is famine.*"

[10] [20] (Interview 054).




Source: Lentz et al., 2020

| | |
|---|---|
| CSA | Current-Status Assessment |
| IPC | Integrated Food Security Phase Classification (standard for current-status assessment) |
| CH | Cadre Harmonisé (same protocol as IPC, used in West Africa) |
| JIAF | Joint Intersectoral Analysis Framework |
| RTM | Real-Time Monitoring |

**Fig. 2.** Diagnostics: Relationships between EW, projections, CSA, and real-time monitoring.

kind of international action that can be invoked to restrain conflict actors but, to date, its impact on preventing conflict or mitigating its impact on humanitarian outcomes has been limited by a hamstrung Security Council and a variety of other factors [45].[11]

#### 3.2.2. Implications

In situations with protracted conflict or a history of sporadic conflict, foregrounding the types of information that need to be collected and monitored, and then identifying how to integrate this information into analysis, are essential steps to resolving uncertainty about how to use or interpret conflict data. Various improvements have been made in conflict analysis, including automated analysis of ACLED or similar data in relation to humanitarian outcomes (see Refs. [18,43]). But much of the best conflict analysis remains in the realm of qualitative analysis, based on more classical forms of intelligence gathering rather than automated or remotely sensed data [22,44]. As a result, the information is often highly sensitive and almost always confidential. Information from ACLED and the Uppsala Conflict Data Program (UCDP) are among the few publicly available sources of conflict information, but they are about events and outcomes, not necessarily about drivers or predictive factors—except for the extent to which conflict events are themselves predictive of negative humanitarian outcomes. The sensitive, political nature of conflict information means that it is frequently kept confidential and is not or cannot be shared for fear of compromising confidential sources. While a specific case, this is symptomatic of the politics of information more broadly.

### 3.3. Information is power … and analysis is frequently politicized

#### 3.3.1. The challenge

Information is power, and the exercise of power is, by definition, political. As a result, it is impossible to entirely separate information and analysis from politics. But not all information is equal in this regard. Information about natural hazards—drought, flooding, earthquakes, disease, or pests—is usually considered beyond the realm of human causation and thus subject to considerably less political pressure than conflict, displacement, famine, and mortality. And yet, the latter are all (increasingly) part of the analysis of any humanitarian crisis—whether predictive analysis or ex-post needs assessment [25]. While states party to conflict crises might be the main suspects with regard to the politicization of information, information is politicized or manipulated by nearly all actors in humanitarian crises [25]. But the extent to which information or analysis is politicized contributes to the "recurrent failing" of humanitarian action—both anticipatory and responsive [30].

Echoing other research (e.g., Ref. [30]), our respondents reported examples of politicized data collection and analysis. Examples related to data included restrictions on access or delays in permissions, which frequently result in low quality or missing data—particularly with regard to conflict as a driver and mortality and malnutrition as outcomes. Respondents noted that even basic information on population is frequently missing, making it difficult to estimate prevalence or population-in-need figures. Several respondents also described how analyses have been politicized through directly intervening to stop analysis exercises, quashing reports, or sometimes threatening analysts—when powerful parties do not like the outcomes of an analysis or what those outcomes tend to imply [25]. This results in the misspecification of needs, but in some cases can also lead to significant errors in early warning or predic-

[11] This is the topic of current research.

tion [28,44], which results in lost opportunities for mitigation or at least for timely humanitarian response—and which therefore contributes to loss of human life.

More chillingly, analysts in highly politicized information environments, such as South Sudan, reported a good deal of self-censorship—by either toning down the results or tuning some of them out altogether. The most stunning example of this is the decision of a few key informant analysts to simply leave the population in famine out of an analysis, whether it be a current status assessment or a projection of future status—a so called "left-skewed but truncated" distribution of an affected population across different categories of severity[12] [25]. That study also noted many instances in which it had been made clear to analysts that powerful actors (states and armed groups) simply did not want any mention of "famine" made in the analysis.

#### 3.3.2. Implications

One of the studies in our synthesis dealt specifically with the politicization of humanitarian information and analysis—in this case, the analysis of famine [25]. While "famine" itself is a highly sensitive term, a main conclusion was that the risk of politicizing or manipulating information and analysis was the highest where the technical data collection and analysis capacity were the weakest. But strengthening technical capacity is no panacea. Other needed improvements include clarifying the role of national governments in humanitarian information gathering and analysis processes—processes that national governments lead (at least nominally) in most cases. Improving data sharing is another (see below). Broadening the participation in information collection and analysis to include local (non-governmental) actors is a third. The challenges of dealing with any of these will require the active engagement of donors.

### 3.4. New analytical tools are being developed, but how much will they help?

#### 3.4.1. The challenge

Data does not speak for itself. New and improved modeling, including machine learning and artificial intelligence, has improved forecasts of potential hazards [13,14]. However, our respondents noted that identifying what a hazard's impact would be or what to do in response is less clear. As one respondent asked, "What do you *do* with a forecast?"[13]

We found that what "counts" as analysis varies across institutions and institutional objectives. A minority of interview respondents advocated for analysts to build qualitative scenarios. Scenarios incorporate multiple hazards into the analysis but also consider multiple outcomes and may use a combination of qualitative and quantitative data and often rely on expert judgment. For some respondents, a series of indicators in a dashboard format is considered adequate analysis. The expectation is that human analysts can synthesize dashboard information to generate an overall understanding or a forecast of people in need. Other respondents look toward predictive models that synthesize information from a variety of sources to generate an estimate of people in need or to identify when a pre-determined threshold has been reached, triggering a response. Triggers are thresholds that result in a pre-set action (e.g., pay-outs for drought insurance are triggered when rainfall is below a certain amount) and are increasingly commonly used in forecast-based financing and insurance [12,14,15,39,40]. Given the difficulties in accessing and quantifying certain types of data (e.g., on conflict), much of the effort towards trigger-based analysis to date has focused on single (and mostly, climatic) hazards and shocks.

Leveraging the abundance of earth observation and other remotely sensed data, researchers are increasingly turning toward machine learning and predictive analytics to nowcast and forecast outcomes as well as develop trigger-based analysis [18,22,32,46]. The abundance of meteorological data has supported a great deal of innovation in modeling and predicting climatic crise [13]. Some key informants hope that machine-learning tools combined with triggers could "automate" the analysis portion of early warning, which in turn could remove human dithering and politics from the response, and in turn speed up early action (see also [11,14,15,39]).

Yet, this remains contested terrain. Respondents warned that the abundance of data in one area can lead to neglect of other important drivers in data-scarce contexts. In other words, focusing on modeling outcomes with adequate data may result in other, less data-rich crises being overlooked or being dismissed as infeasible for early action. In addition to the lack of data on and analytics for conflict, key informants described concerns that abundant data (e.g., climatic information) is often presumed to be a useful proxy for less abundant data, such as prices, which are influenced by weather and numerous other factors, such as domestic and international policies [23,46]. At the same time, weather-related variables cannot fully capture the heterogenous impacts of hazards, which can vary by livelihood, and access to institutional support, for example [47].

This highlights a limitation of machine-learning models: like all analytical tools, they are only as good as the underlying data. Several respondents active in the modeling community warned that machine-learning models may be particularly poorly suited to rare, complex, or rapidly evolving crises, for which there may not be adequate historical data. These respondents argued that machine learning may be more suitable for monitoring and in places with "predictable" crises and adequate information. At the same time, emergent critiques about machine learning approaches include concerns that digital data, big data, and machine learning can reproduce or exacerbate inequalities [31,48], produce dependencies via "techno-colonialism" [49], and bury assumptions [31,50], among other concerns [21,51].

#### 3.4.2. Implications

New analytical tools, such as predictive modeling, hold promise as a way to routinize the forecasting of highly frequent, predictable crises. Currently, the impacts of complex crises with multiple hazards are more challenging to predict with these new tools,

[12] In the case discussed, the "left-skewed but truncated" description results from ever increasing numbers across the lower phases of IPC analysis—i.e., more in Phase 2 than Phase 1, more in Phase 3 than 2, and more in Phase 4 than 3—but then zero population in Phase 5, or famine. This was seen across a dozen or more analyses in South Sudan and in nearly half the areas assessed in one analysis in Yemen—for both current status and projected future status. See Ref. [25].

[13] [20] (Interview 007).

suggesting an important role for human analysts and qualitative analysis of rapidly changing or highly complex crises. As new analytical tools emerge, how can human analysts assimilate findings from models with their other analyses? Identifying how to support analysts to make sense of different streams of information has not received much attention thus far by the modeling community. One important avenue for future research is understanding whether findings from predictive analytics models combined with findings from existing EW systems (e.g., combining the current IPC process with a predictive analytical approach) improve the overall accuracy of predictions. But this also underlines the need for greater investment in real-time monitoring for rare or less predictable crises.

### *3.5. Analytical tools often do not account for uncertainty and severity*

#### *3.5.1. The challenge*

EW systems can be thought of as having two different, but related challenges: (1) predicting the impacts of high-frequency and known hazards (e.g., flooding, drought, price fluctuations) and (2) identifying the impacts of acute, unexpected, rare, and hard-to-predict hazards (e.g., pandemics, conflict, locusts). While opinions vary on where the balance is between what a model can do well and what an analyst should monitor, several key informants proposed that newer tools, including various forms of predictive modeling, are well suited to monitoring and predicting events with rich historical data, such as droughts and floods. Respondents active in this space pointed out that designing triggers and identifying responses will be more straightforward for "more predictable" or "more reliable" hazards.

Some respondents argued that without rich historical quantitative data sets, human analysts will be better suited to identifying hard-to-predict, rare hazards or severe crises resulting from multiple hazards than machine-learning based models. This perspective means most of the predictive modelers we interviewed (implicitly) expect human analysts to read model results against whatever else is happening and be able to triangulate findings from several different information-generating processes. In fact, few of the modelers we interviewed expect EW predictive models to "stand alone," fully replacing current food security EW systems. This is consistent with Hernandez and Roberts [52]; who found that most humanitarian predictive analytics projects aimed to complement existing systems rather than replace them.

In situations without robust data to enable predictive modeling using machine learning, qualitative scenario building can offer important insights that will be difficult to produce with quantitative models. Some key informants argued that qualitative data and qualitative analyses, in particular, will remain important for hard-to-predict crises. Interest in local, contextual knowledge and qualitative approaches in data scarce areas has recently increased [53,54]. However, as noted above, relying on qualitative analysis can delay AA because it is often quite difficult to assign triggers or strict cut-offs when intervening early would make sense. For example, when is a conflict "bad enough" that it is likely to cause widespread displacement or hunger? Further, expert judgement is not infallible [55]; unlike with quantitative models, it can be difficult to identify what went wrong when an expert group comes to an inaccurate conclusion: Was it lack of information? Was it incorrect analysis? Was it political pressure?

The challenge of making judgement calls in cases with low certainty has encouraged some respondents to think of EA in terms of "no regrets" programming, where interventions are chosen so that they can be potentially useful to the community or household, regardless of whether the hazard is as bad as predicted (see also [56]). Interviews with government actors and NGO staff indicated that budgetary constraints, however, continue to limit the widespread adoption of no-regrets programming. One respondent warned against a "no-regrets" approach, but advocated for "good financial management," where analysts and decisionmakers would weigh the lower but more frequent costs of intervening early (and sometimes) unnecessarily against the higher and less frequent costs of intervening later, once the crisis is confirmed.[14]

#### *3.5.2. Implications*

Identifying the likelihood and severity of various hazards can help analysts determine how tightly linked the EW-EA chain can be. Predicting the impact of multifactor, new, or rare crises might not be possible [33]. Contingency planning—rather than expecting to be able to intervene early—may be more realistic. In contrast, in more predictable crises, instituting a clear set of triggers for intervention could be relatively straightforward. These examples underline the point that each hazard and its impacts will need different analytical tools, data frequency, and geographic spread. Analysts, however, will continue to need to read across these findings to get a holistic sense of the situation, for example, through scenario planning.

### *3.6. Limited data sharing and transparency contribute to competition across information systems, and accountability for data and analysis is sometimes lacking*

#### *3.6.1. The challenge*

Limited mechanisms for data sharing and lack of transparency about data quality and collection significantly constrain joint analysis and lead to the development of parallel systems [22]. Across our studies, respondents indicated that competition between, rather than cooperation among, various information and analysis actors is not unusual, and it not infrequently results in very different predictions or outcomes—adding to already existing confusion.

There was near universal agreement among respondents that data sharing among donors, state organizations, and humanitarian agencies needs to improve. Some respondents reported it was simpler and faster to start parallel systems than to invest in the institutional relationships necessary to support the timely sharing of information. Others recognize that such an approach impedes local ownership of information and analysis processes. The unwillingness (perceived or otherwise) of managers or owners of data to share

[14] [20] (Interview 019).

it—as well as the incompatibility of data platforms, which limits easy data sharing—constrain good analysis (see also [22]). Barriers to data sharing can be legal, logistical, technical, economic (see also [57]), or simply perceived to involve reputational risk [25]. Engaging in data collection without first resolving these challenges ultimately limit data share-ability and usefulness. Respondents noted that data sharing is particularly fraught in conflict-driven crisis where the state is party to the conflict [22,25]. But it is not only the fear of repercussions from state or non-state armed groups that make data sharing difficult. Information is, to some degree, power—and particularly where funding is concerned. And many key informants in the roles of information managers and analysts expressed concerns about the quality of their own data—frequently collected in difficult circumstances under severe time constraints—and the reputational risk to agencies of putting data out to the public that they know to be flawed or incomplete [25]. For all these reasons, respondents in charge of data reported often deeming it best to simply share findings but keep the original data private.

More careful documentation of data collection approaches would improve the shareability of data as well as bring greater transparency to the data itself. In cases where similar kinds of information are collected using different indicators, timeframes, or scales, organizations need to ask whether the different approaches are warranted. Research has shown more agile, analyst-driven coordination has been found to be more successful than top-down coordination in the humanitarian space [36]. Similarly, including explicit mechanisms to share both tacit and explicit knowledge can help humanitarian organizations with data and knowledge management [58].

More concerted efforts to share data and be transparent about how data are collected would limit the perceived need for competing information systems. Several respondents highlighted the need for improving information sharing as a way to avoid duplication of effort and, thereby, improve accountability. A few respondents argued that accountability regarding information should be framed as accountability to affected populations or engagement with local communities rather than (primarily) to donors. Being accountable to at-risk communities could include both (1) working with communities to identify indicators to monitor and track and (2) prioritizing the dissemination of hazard information to at-risk populations. Several respondents indicated that indigenous early warning systems often draw on community information that differ from other data and can be valuable for triangulation. There is more debate among respondents on the feasibility of communicating hazards back to at-risk communities. One respondent warned of "too much legwork" to relay information back to remote communities.[15] Others argued that information should be disseminated directly to people rather than via governments, which can be slow to release information.

#### *3.6.2. Implications*

To support information sharing and avoid duplication, data platforms and data governance need to improve. This includes increasing their transparency. These challenges should not be underestimated. Collecting new, bespoke data is, in the short run, an often simpler solution and can be an important means to triangulate information. However, the benefits of parallel systems need to be assessed against risk of confusion, increased costs, and potential hampering of longer-term efforts to achieve coordinated responses to anticipating and responding to crises. Governments and especially donors could transform this challenge into a new way of humanitarian engagement through investment in data platforms and mandating data sharing across humanitarian partners.

A complement to better data sharing is measuring accountability not just in terms of funding oversight but also in terms of timeliness and reach to affected populations. Tailoring information to meet stakeholder needs could improve accountability [20,48]. This is especially the case for affected populations, who face barriers to accessing information [59]. While many codes of conduct or other voluntary compliance mechanisms stress the importance of early or rapid action, respondents opined that few mechanisms exist that require hard accountability. In fact, accountability to funders or taxpayers is used as a reason to not intervene early in situations when a crisis is unfolding but the degree of its severity is not yet known. A key informant explained, "It is easier to ask relatives for contributions to funeral costs than to ask for money for someone in a hospital."[16] Yet, at-risk communities should be central to the collection and dissemination of EW information and involved in any early action planning, with attention paid to mitigating or solving barriers to accessing information [59]. This is too frequently forgotten.

## 4. Conclusion: a proposal to link information to action more effectively

The purpose of humanitarian information and analysis is to inform decision-making—both anticipatory and responsive. Yet evidence-based early action remains severely constrained. Our findings have shown that part of the challenge is that information frequently has no clear link to early or anticipatory action and so action is frequently late, misdirected, or non-existent. Further, linking early warning to early action requires rapid or pre-emptive response analysis—determining the most appropriate response or set of responses to a rapidly changing situation [35]—as well as financing, good contingency planning, and the capacity to implement those plans [20].

The challenges highlighted here are not unique to linking early warning to anticipatory action. Rather, the challenges of using information for AA—or more broadly linking information to action—typify the challenges faced by the entire humanitarian information system. Decisionmakers face tension between (1) intervening early while using less accurate data and risk being wrong sometimes and (2) intervening later, when it is clear a crisis has emerged but when intervening is more expensive, and people have already experienced harm. Yet, waiting to respond is often a costly decision in terms of lives, livelihoods, and financial requirements [60].

We propose that to address these challenges any assessment of collected information should seek to identify how data relate to analysis. How different pieces of information "talk" to each other and inform possible responses should be foregrounded in all discus-

[15] [20] (Interview 019).
[16] [20] (Interview 013).

sions of data collection and analysis. Based on the six studies reviewed here, we argue that one approach is to identify possible sets of hazards and interventions and work backwards to identify information needs. For example, if an anticipatory action fodder project to protect the livestock of pastoralists requires six months advance notice to get up and running, but the EW system only provides two or three months information ahead of time, fodder projects aren't feasible. Yet, if they are the most cost effective or most adept at addressing crises for a specific context, it may be better to gather and analyze early warning information with a six month window, even if it has lower precision.

Much of the "system" as it now exists begins with early warning and information and then tracks to the possible options for mitigation and response. The evidence from our interview data strongly suggests that decision-makers are overwhelmed—and sometimes paralyzed—by the amount of information that they need to take in, and yet still don't believe they have the information they need to make good choices regarding anticipatory action or even real time response because the information available doesn't address the policy questions they face. This suggests that a more rational process would "reverse engineer" this whole system and its linkages: rather than ask what we can do with the information (EW and otherwise) to inform action, the question should be what information do we need for anticipatory (and other) action? In other words, we need to plan from known and likely hazards and actions back to information needs. Rather than informing action (usually too late) with existing information, this process would address questions in reverse order. Synthesizing results across these studies, a series of questions can be suggested for improving information systems *and the link to action* (both anticipatory or responsive):

1. What are known or expected hazards (including rare ones)?[17]
2. What early actions *could* be taken to mitigate known or expected hazards? (And what responses will have to be considered if hazards cannot be mitigated or if novel, unexpected hazards arise)?[18]
3. What capacity would be needed to implement the action? Does that capacity exist?
4. What financing would be required? Is it available and sufficiently flexible?
5. What information would be needed to inform action?
6. How would it trigger action?
7. How far in advance would it be needed?

This approach would enable a much more streamlined information system and one that would be driven by the demands of anticipatory action and responses, not a system constantly in search of linkages to action. Too often, known hazards are overlooked or considered to be too remote a possibility to be considered. And too often even if finance is available and contingency plans made, the capacity to implement those plans may not be in place or may not have been adequately assessed.

And finally, we should recall that while interest in AA is burgeoning, the most wicked humanitarian crises may be difficult to address with AA. For needs that AA cannot address, other aspects of the humanitarian information system still need to be improved. These include current status assessment or needs assessments, real time monitoring, equitable or impartial resource allocation, and the use of RTM for program modification or course correction.

In the face of calls for more data and adoption of innovative modeling techniques, we argue that it is essential for decisionmakers to assess exactly how these will directly inform anticipatory actions and humanitarian responses. Doing so will decrease the confusion many humanitarian practitioners currently experience and will potentially improve the timeliness of responses to people in need.

## Funding

This study includes findings from several reports. FAO and SIDA supported research project "Early Warning and Early Action for Increased Resilience of Livelihoods in the IGAD Region" ([20,21,23] stemmed from this research as well). FCDO supported the research project "Seeing in the Dark: Real Time Monitoring in Humanitarian Crises" [24]. FAO, REACH, and FCDO supported the research behind "Towards Anticipatory Information Systems and Action: Notes on Early Warning and Early Action in East Africa" [22]. USAID, FCDO, the Office of Swiss Development Cooperation (SDC), and Action Against Hunger supported the research for "Analyzing Famine: The Politics of Information and Analysis in Food Security Crises" [25].

## Declaration of competing interest

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

## Data availability

The data that has been used is confidential.

## Acknowledgements

We gratefully acknowledge the valuable, frank conversations we had with our respondents and attendees at the Early Warning-Early Action in the IGAD Region meeting series in 2021. We also benefited from feedback and conversations with Anna Colom, Erin

[17] For instance, desert locusts are a well-known, but relatively rare occurrence in the Arabian Peninsula and the Greater Horn of Africa. But even though recognized, for the most part they were left out of contingency planning until massive swarms emerged in 2020 [20,24].

[18] If the COVID-19 pandemic taught the humanitarian sector anything, it was that not all hazards can be specifically predicted and anticipated!

Coughlan de Perez, Matthew Day, Dunja Dujanovic, Cyril Ferrand, Gregory Gottlieb, Peter Hailey, Sergio Innocente, Brenda Lazarus, Daniel Molla, Christopher Newton, Mary Njenga, Chris Porter, Cori Simmons, and Kamau Wanjohi. Feedback from two anonymous reviewers also strengthened the paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2022.103242.

## References

[1] M. Buchanan-Smith, S. Davies, Famine Early Warning Systems and Response: the Missing Link, IT Publications, London, 1995.
[2] R. Bailey, Famine Early Warning and Early Action: the Cost of Delay, Chatham House, London, 2012.
[3] E. Wilkinson, L. Weingartner, R. Choularton, M. Bailey, M. Todd, D. Kniveton, C. Cabot Venton, Forecasting Hazards, Averting Disasters: Implementing Forecast-Based Early Action at Scale, Overseas Development Institute, London, 2018. http://lib.riskreductionafrica.org/bitstream/handle/123456789/1501/Forecastinghazards,advertingdisastersImplementingforecast-basedearlyactionatscale.pdf?sequence=1. (Accessed 16 February 2022).
[4] C. Cabot Venton, C. Fitzgibbon, T. Shitarek, L. Coulter, O. Dooley, The Economics of Early Response and Resilience: Lessons from Kenya and Ethiopia, ALNAP, 2012. https://sohs.alnap.org/system/files/content/resource/files/main/econ-ear-rec-res-full-report-.pdf. (Accessed 2 August 2022).
[5] D. Maxwell, N. Majid, Famine in Somalia: Competing Imperatives, Collective Failures. 2010–2012, Oxford University Press, New York, 2016.
[6] M. Lowcock, A Casement Lecture: toward a Better System for Humanitarian Financing, 2018 Accessed 2/3/21. https://reliefweb.int/report/world/under-secretary-general-humanitarian-affairs-and-emergency-relief-coordinator-mark-0.
[7] FAO, Early warning early action: FAO in emergencies [par]=YToxOntzOjE6IkwiO3M6MToiMCI7fQ==. https://www.fao.org/emergencies/fao-in-action/ewea/en/?page=5&ipp=10&no_cache=1&tx_dynalist_pi1, 2021. (Accessed 16 February 2022).
[8] N.E.T. FEWS, Horn of Africa Food Security Outlook: October 2021 to May 2022, FEWS NET, Washington DC, 2021.
[9] OCHA Somalia, Financial Tracking Service, 2021. https://fts.unocha.org/countries/206/flows/2021?order=flow_property_directional_2. (Accessed 6 February 2022).
[10] Development Initiatives, Global Humanitarian Assistance Report 2020, Development Initiatives, Bristol, 2020.
[11] M. Drechsler, W. Soer, Early Warning, Early Action: the Use of Predictive Tools in Drought Response through Ethiopia's Productive Safety Net Programme." (Policy Research Working Paper), The World Bank, 2016, https://doi.org/10.1596/1813-9450-7716.
[12] N. Jensen, C. Barrett, A. Mude, Cash transfers and index insurance: a comparative impact analysis from northern Kenya, J. Dev. Econ. 136 (2017) 14–28.
[13] C. Funk, S. Shukla, W.M. Thiaw, J. Rowland, A. Hoell, et al., Recognizing the Famine Early Warning Systems Network, American Meteorological Society, 2019 June.
[14] C. Gros, M. Bailey, S. Schwager, A. Hassan, R. Zingg, M.M. Uddin, M. Shahjahan, H. Islam, S. Lux, C. Jaime, E. Coughlan de Perez, Household-level effects of providing forecast-based cash in anticipation of extreme weather events: quasi-experimental evidence from humanitarian interventions in the 2017 floods in Bangladesh, Int. J. Disaster Risk Reduc. 41 (December) (2019) 101275, https://doi.org/10.1016/j.ijdrr.2019.101275.
[15] M. van den Homberg, C. Gevaert, Y. Georgiadou, The changing face of accountability in humanitarianism: using artificial intelligence for anticipatory action, Polit. Govern. 8 (4) (2020), https://doi.org/10.17645/pag.v8i4.3158.
[16] T. Masupha, M. Moelestic, M. Tsubo, Prospects of an agricultural drought early warning system in South Africa, Int. J. Disaster Risk Reduc. 66 (102615) (2021), https://doi.org/10.1016/j.ijdrr.2021.102615.
[17] Development Initiatives, Global Humanitarian Assistance Report 2021, Development Initiatives, Bristol, 2021.
[18] B.P.J. Andree, A. Chamorro, A. Kraay, P. Spencer, D. Wang, Predicting Food Crises (Policy Research Working Paper No. 9412), The World Bank, 2020, https://doi.org/10.1596/1813-9450-9412.
[19] START Network, About us: a new era of humanitarian action (n.d.). https://startnetwork.org/about-us. (Accessed 25 May 2022).
[20] D. Maxwell, E. Lentz, C. Simmons, G. Gottlieb, Early Warning and Early Action for Increased Resilience of Livelihoods in IGAD Region, Feinstein International Center, Boston MA, 2021. https://fic.tufts.edu/wp-content/uploads/EW-EA-1-Main-Report-2021-6-21.pdf.
[21] E.C. Lentz, G. Gottlieb, C. Simmons, D. Maxwell, 2020 Hindsight? the Ecosystem of Humanitarian Diagnostics and its Application to Anticipatory Action, Feinstein International Center, Boston MA, 2020. https://fic.tufts.edu/wp-content/uploads/Hindsight-2020_Dec-14.pdf.
[22] D. Maxwell, P. Hailey, Towards Anticipatory Information Systems and Action: Notes on Early Warning and Early Action in East Africa, Centre for Humanitarian Change and Feinstein International Center, 2020.
[23] E.C. Lentz, C. Simmons, D. Maxwell, Early Warning Early Action Systems in the IGAD Region: Report 3: Predictive Analytics and Machine Learning Approaches to Support EW-EA, Feinstein International Center, Boston MA, 2021. https://fic.tufts.edu/wp-content/uploads/EW-EA-3-Predictive-Analytics-and-Machine-Learning-2021-6-21.pdf.
[24] D. Maxwell, E. Lentz, K. Wanjohi, D. Molla, M. Day, P. Hailey, C. Newton, A. Colom, Seeing in the Dark: Real-time Monitoring in Humanitarian Crises, Feinstein International Center, Boston MA, 2021. https://fic.tufts.edu/publication-item/seeing-in-the-dark-real-time-monitoring-in-humanitarian-crises/.
[25] D. Maxwell, P. Hailey, Analyzing famine: the politics of information and analysis in food security crises, J. Humanit. Aff. 3 (1) (2021) 16–27, https://doi.org/10.7227/JHA.055.
[26] OCHA, Humanitarian Programme Cycle, 2021, Office for the Coordination of Humanitarian Affairs, New York, 2021.
[27] D. Mazurana, P. Benelli, H. Gupta, P. Walker, Sex and Age Matter, Feinstein International Center, Boston MA, 2011.
[28] D. Maxwell, Famine Early Warning and Information Systems in Conflict Settings: Challenges for Humanitarian Metrics and Response, Feinstein International Center, Boston MA, 2019. https://fic.tufts.edu/publication-item/famine-early-warning-and-information-systems-in-conflict-settings/.
[29] ACAPS, Global Risk Analysis, ACAPS, Geneva, 2021.
[30] S. Colombo, F. Checchi, Decision-making in humanitarian crises: politics, and not only evidence, is the problem, Epidemiol. Prev. 42 (3–4) (2018) 214–225 https://doi.org/10.19191/EP18.3-4.P214.069, ISSN 1120-9763.
[31] R. Burns, Rethinking big data in digital humanitarianism: practices, epistemologies, and social relations, Geojournal 80 (4) (2015) 477–490.
[32] Y. Zhou, E. Lentz, H. Michelson, C. Kim, K. Baylis, Machine learning for food security: principles for transparency and usability, Appl. Econ. Perspect. Pol. (2021) https://doi.org/10.1002/aepp.13214, Online first:
[33] M. Caravani, J. Lind, R. Sabates-Wheeler, I. Scoones, Providing Social Assistance and Humanitarian Relief: the Case for Embracing Uncertainty, Development Policy Review, 2021 https://doi.org/10.1111/dpr.12613, Online first.
[34] D. Maxwell, B. Watkins, Humanitarian information systems and emergencies in the greater Horn of Africa: logical components and logical linkages, Disasters 27 (1) (2003) 72–90, https://doi.org/10.1111/1467-7717.00220.
[35] C. Barrett, R. Bell, E. Lentz, D. Maxwell, Market information and food insecurity response analysis, Food Secur. 1 (June) (2009) 151–168, https://doi.org/10.1007/s12571-009-0021-3.
[36] A. Tapia, E. Maldonado, L.-M. Ngamassi Tchouakeu, C. Maitland, Coordinating humanitarian information: the problem of organizational and technical trajectories, Inf. Technol. People 25 (3) (2012) 240–258.
[37] R. Read, B. Taithe, R. MacGinty, Data Hubris? Humanitarian information systems and the mirage of technology, Third World Q. 37 (2016) 1314–1331, https://doi.org/10.1080/01436597.2015.1136208.
[38] B.T. Haworth, E. Bruce, J. Whittaker, R. Read, The good, the bad, and the uncertain: contributions of volunteered geographic information to community disaster resilience, Front. Earth Sci. 6 (2018) 183, https://doi.org/10.3389/feart.2018.00183.
[39] E. Coughlan de Perez, M. van Aalst, R. Choularton, B. van den Hurk, S. Mason, H. Nissan, S. Schwager, From rain to famine: assessing the utility of rainfall

observations and seasonal forecasts to anticipate food insecurity in East Africa, Food Secur. 11 (1) (2019) 57–68, https://doi.org/10.1007/s12571-018-00885-9.
[40] A. Getirana, H.C. Jung, K. Arsenault, S. Shukla, S. Kumar, C. Peters-Lidard, I. Maigari, B. Mamane, Satellite gravimetry improves seasonal streamflow forecast initialization in Africa, Water Resour. Res. 56 (2) (2020) 1–15, https://doi.org/10.1029/2019WR026259.
[41] D. Honig, N. Gulrajani, Making good on donors' desire to do development differently, Third World Q. 39 (1) (2018) 68–84, https://doi.org/10.1080/01436597.2017.1369030.
[42] W. Anderson, C. Taylor, S. McDermid, E. Ilboudo-Nébié, R. Seager, W. Schlenker, F. Cottier, A. de Sherbinin, D. Mendeloff, K. Markey, Violent conflict exacerbated drought-related food insecurity between 2009 and 2019 in Sub-Saharan Africa, Nature Food 2021 (2021), https://doi.org/10.1038/s43016-021-00327-4.
[43] S. Tandon, T. Vishwanath, The evolution of poor food access over the course of the conflict in Yemen, World Dev. 130 (2020) 1–16 https://doi.org/10.1016/j.worlddev.2020.104922, 2020.
[44] C. Newton, Pandemic of Hunger Symposium: Famine in a NIAC's Shadow–Other Situations of Violence and a Challenge for UNSCR 2417, 2021 OpinioJuris May 20. http://opiniojuris.org/2021/05/20/pandemic-of-hunger-symposium-famine-in-a-niacs-shadow-other-situations-of-violence-and-a-challenge-for-unscr-2417/.
[45] A. de Waal, New Pandemic, Old Politics: Two Hundred Years of War on Disease and its Alternatives, Polity Press, Medford, MA, 2021.
[46] E.C. Lentz, H. Michelson, Y. Zhou, K. Baylis, A data-driven approach improves food insecurity crisis prediction, World Dev. 122 (2019) 399–409.
[47] T. Gumucio, H. Greatrex, E. Lentz, Causal chains linking weather hazards to disasters in Somalia, Weather Clim. Soc. 14 (3) (2022) 849–860, https://doi.org/10.1175/WCAS-D-21-0165.1.
[48] C. D'Ignazio, L. Klein, Data Feminism, MIT Press, 2020. https://mitpress.mit.edu/books/data-feminism.
[49] M. Madianou, Technocolonialism: digital innovation and data practices in the humanitarian response to refugee crises, Soc. Media Soc. 2019 (2019) 1–13.
[50] D. Coyle, A. Weller, "Explaining" machine learning reveals policy challenges, Science 368 (6498) (2020) 1433–1434, https://doi.org/10.1126/science.aba9647.
[51] C. O'Neil, Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy, first ed., Crown Publishing, New York, NY, 2016.
[52] K. Hernandez, T. Roberts, Predictive Analytics in Humanitarian Action: A Preliminary Mapping and Analysis, Institute of Development Studies, 2020 June. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/15455.
[53] C. Newton, B. Mawien, E. Gray, N. Pendle, Chiefs' Courts, Hunger, and Improving Humanitarian Programming in South Sudan, Conflict Research Program, London, 2021 LSE (draft).
[54] J. Upton, K. Yoshimura, Rapid feedback monitoring system: preliminary findings, in: February 11. Presentation to Government of Malawi and RFMS Stakeholders, 2021.
[55] D. Kahneman, O. Sibony, C. Sunstein, Noise: A Flaw in Human Judgment, Little, Brown, and Spark, New York, 2021.
[56] D. Maxwell, H. Stobaugh, J. Parker, M. McGlinchy, Response Analysis and Response Choice in Food Security Crises: A "Roadmap." HPN Network Paper 73, Humanitarian Practice Network, Overseas Development Institute, London, 2013.
[57] N. Clark, F. Guiffault, Seeing through the clouds: processes and challenges for sharing geospatial data for disaster management in Haiti, Int. J. Disaster Risk Reduc. 28 (2018) 258–270.
[58] M. Caballero-Anthony, A. Cook, C. Chen, Knowledge management and humanitarian organisations in the Asia-Pacific: practices, challenges, and future pathways, Int. J. Disaster Risk Reduc. 53 (2021) 1 (102007).
[59] S. Anson, H. Watson, K. Wadha, K. Metz, Analysing social media data for disaster preparedness: understanding the barriers and opportunities faced by humanitarian actors, Int. J. Disaster Risk Reduc. 21 (2017) 131–139.
[60] M. Ruel, P. Menon, J.P. Habicht, C. Loechl, G. Bergeron, G. Pelto, M. Arimond, J. Maluccio, L. Michaud, B. Hankebo, Age-based preventive targeting of food assistance and behaviour change and communication for reduction of childhood undernutrition in Haiti: a cluster randomised trial, Lancet 371 (9612) (2008) 588–595, https://doi.org/10.1016/S0140-6736(08)60271-8.
[61] K. Annan, Data can help to end malnutrition across Africa, Nature 55 (7) (2018) https://doi.org/10.1038/d41586-018-02386-3, February 28.