Integrating climate forecast in humanitarian decision making: How to get from early warning to early action?

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Abstract

Disaster risk management efforts currently focus on long-term preventive measures and post-disaster response. Outside of these, there are many short term actions, such as evacuation or distribution of water purifications tablets, medical supplies or flood response drills, which can be implemented in the period of time between the warning and a potential disaster to reduce the risk of impacts. However, this precious window of time is often overlooked in the case of climate and weather forecasts, which can indicate a heightened risk of disaster but are rarely used to initiate preventive action. The aim of this thesis is to enhance knowledge about, and how to facilitate, the choices facing humanitarian actors whether to undertake preventive actions in response to climate forecasts to prevent potential impacts of disaster. In order to meet the thesis aim, three different objectives were set. A scoping study of scientific literature was then conducted in order to meet the objectives. The search strategy under the scoping study identified 1375 papers, of which 20 were identified as primary papers relevant to the research. Data were extracted from these 20 papers to identify challenges and opportunities when implementing early actions. Five categories of challenges and three categories of opportunities were identified upon analysis. Further, papers were assessed to understand the availability and reliability of forecast at different timescales. Likewise, different aspects characterizing decision situation to undertake early action and methods to link early warning with early action were identified. The findings from this paper are expected to help researchers and practitioners in humanitarian sector to understand the challenges and opportunities involved in implementing the early action based on forecast and also benefit from the synthesized knowledge about strategies that are being undertaken to link early warning with early action.

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LIST OF ACRONYMS

ACMAD	: African Centre of Meteorological Applications for Development
DREF	: Disaster Relief Emergency Fund
ENSO	: El Niño Southern Oscillation
EWEA	: Early Warning Early Action
FAO	: Food and Agriculture Organization
FbF	: Forecast based Financing
FEWS NET	: Famine Early Warning Systems Network
IFRC	: International Federation of Red Cross and Red Crescent Societies
IRI	: International Research Institute for Climate and Society
NFI	: Non Food Item
NMHS	: National Meteorological and Hydrological Services
RCOF	: Regional Climate Outlook Forums
SOP	: Standard Operating Procedure
WCAZ	: West and Central Africa Zone
WMO	: World Meteorological Organization

1. INTRODUCTION

1.1. Rationale

Climate related disasters like floods, droughts, cyclones and storms are entirely predictable. But despite the anticipation of their potential occurrence and their early warning, a number of people dying and suffering because of such disasters are increasing (Suarez &Tall, 2010). Hazards like floods, for instance, often come with the months of warning. Different preventive actions can be implemented in the timeframe between a forecast and a potential disaster to prepare for and mitigate the impacts of disaster. But the windows of time between forecast and a potential disaster, where different preventive actions become worthwhile to implement, are not often utilized (Braman et al., 2013; De Perez et al., 2015; Tall et al., 2012). Yet the humanitarian system remains largely focused on response after the disaster (Hellmuth et al., 2011; Tall et al., 2012).

When adequately informed, humanitarian actors can take action to prevent hazards from becoming disasters. One of the many ways such hazards can be addressed is by using climate forecast to better predict for disasters before they occur and take appropriate preventive actions that can mitigate the impacts of such disasters before they happen (IFRC, 2010). Acting early before a disaster has actually happened or reached its peak is critical: it can save lives and protect livelihoods from the immediate shocks as well as protect longer term development gains by increasing the resilience of communities over time (FAO, 2018). Likewise, early actions guided by early warnings have shown to be extremely cost-effective. The majority of evaluations of preventive actions demonstrated that avoided disaster losses can at least double or quadruple the investment in risk reduction (De Perez et al., 2015). In a similar manner, a preliminary quantitative analysis of International Federation of Red Cross and Red Crescent Societies (IFRC) flood response operation in West and Central Africa Zone (WCAZ) showed that the cost per beneficiary in 2008 was lowered with early actions. As reported by Braman et al., (2013), IFRC WCAZ responded early warnings of floods with a number of early actions including development of floods contingency plans, preposition of relief supplies, improving disaster response capacity through training as well as preparing flood prone households with sandbags and drainage systems. With the early actions followed by flood response, cost per beneficiary was roughly 33 percent lower in 2008 than in 2006 and 2007 where flood response was carried out alone with no early action ahead (Braman et al., 2013).

Though the use of climate forecasts are largely recognized by the humanitarian communities, the humanitarian actors often find difficultly to translate warning into action (Braman et al., 2013). Often they find themselves immobilized of receiving a forecast of likely extreme events, due to the less clarity on how to make a decision and what action to be taken (Perez et al., 2016). Often they are unsure of when it would be worthwhile to take action based on a forecast (Perez et al., 2016).

1.2. Research aim

In light to this, the thesis aim to enhance knowledge about, and how to facilitate, the choices facing humanitarian actors whether to undertake preventive actions in response to climate forecast to prevent potential impacts of disaster.

1.3. Research questions

The thesis addresses three research questions which are presented below:

- RQ1: What is known about early warning early action approach in scientific literature?

  More specifically this research question focuses on two questions,

  - RQ1a: What are the constraints in implementing early warning early action approach?
  - RQ1b: What are the opportunities in implementing early warning early action approach?
- RQ2: What is known about the availability and reliability of climate forecasts useful to support humanitarian decision making?
- RQ3: What characterize the decision situations humanitarian organizations face when choosing whether to undertake early action, and how can they use climate forecasts to select appropriate preventive actions?

1.4. Research Objectives

In order to answer above mentioned research questions, three specific research objectives were met:

- Conduct scoping study into scientific literature to identify the constraints and opportunities in implementing early warning early action approach
- Document the availability and reliability of climate forecasts to support humanitarian decision making
- Identify ways to help humanitarian actors to integrate climate forecast information into their decision making

First, using scoping study, the constraints and opportunities in implementing the early warning early action approach was identified. Second, information on the availability and reliability of climate forecast to support humanitarian decision making was documented using the same approach. Finally, the findings of above two objectives was analyzed and further scoping of the literature was done to identify the ways to help humanitarian actors to integrate climate forecast information into their decision making.

2. BACKGROUND

With the remarkable advances in science and technology, not only climate forecast has become increasingly reliable (Suarez, 2009) but it has also become possible to access forecast at different timescale (Tall, 2010). The temporal and spatial scales of improved forecasts ranges from highly localized tornado alerts and short-term tropical cyclone tracks to seasonal rainfall predictions based on El Niño and long-term sea level rise caused by global warming (Suarez, 2009). Hence, this provides significant opportunity for humanitarian actors in better anticipating disasters and in better preparing for them.

Humanitarian actors on the other hand are already facing bigger challenges due to the rising risk and increasing disaster (Hellmuth at al., 2011; Suarez, 2009). Disaster statistics shows that there is a rise in climate and weather related natural disaster such as floods, droughts, cyclones etc. The number of such disasters has increased from between 200 and 250 in the period 1987-1997 to about double that in the first seven years of the 21st century (Suarez, 2009). Not just the number of occurrence has increased but hazards like floods are damaging greater areas than they did two decades ago (Braman et al., 2010; Braman et al., 2013). Moreover, these rises are accompanied by a rapid increase in socio-economic losses and in the number of people affected (Hellmuth at al., 2011; Suarez, 2009). In addition, climate change is further exacerbating these rising risks and expected to worsen more by bringing more extreme and unusual events (Braman et al., 2013). This all increases the excessive workload for humanitarian actor when they are already struggling to manage the existing risks.

In order to keep pace with this increasing climate risks, there is a growing recognition in utilizing Early Warning Early Action (EWEA) strategies. EWEA is defined as "routinely taking humanitarian action before a disaster or health emergency happens, making full use of scientific information on all timescales (IFRC, 2008). In such strategies, climate forecast is used before any humanitarian emergency occurs, with the goal of systematically triggering action in order to improve preparedness and response. Based on the available lead time of forecasts, a variety of early actions are implemented. All those actions that are implemented in the time frame between an early warning trigger and the actual occurrence of a disaster are early actions (FAO, 2018). At the shortest timescales, early action could be evacuation. On the longer timescales, early action could be working closely with local communities to understand the changing risks they face. Likewise, cholera awareness and prevention campaigns, clearance of drainage canals and many other risk reduction measures could be taken. Early action could also includes updated contingency planning and volunteer mobilization ahead of the disaster to reduce the potential impacts. So basically on the longer timescales, early action could be identifying at risk communities, investing in disaster risk reduction, and enhancing preparedness to respond so that more lives and livelihoods are saved at the shortest timeframes when a flood does arrive (IFRC, 2008). All these actions are likely to avoid risks thus preventing any disaster from causing large amount of damage.

The IFRC in West Africa conducted several actions based on longer timescales forecasts such as disaster relief supplies were pre-positioned at strategic locations ahead of time based on a 2008 seasonal forecast of above-normal rainfall, which improved relief supply availability in most countries in Africa from about 40 days to two days when flooding did occur in the region (Braman et al., 2013). In other locations, volunteers have used information about heightened risk at seasonal time scales to fortify vulnerable structures, such as reinforcing latrines to reduce the risk of diarrheal disease outbreaks when above-normal rainfall is likely to occur (Red Cross/ Red Crescent Climate Centre, 2013). This shows that not only does climate forecast helps in better predicting for disasters before they occur but based on the forecast, different early actions can be taken that can minimize the impacts of such disasters. Such preventive action taken before any potential events not just reduces critical response times but early action taken ahead of any disaster saves both lives as well as livelihoods (Hellmuth et al., 2011) and according to the evaluation report of IFRC (2009) it also reduces emergency response cost which otherwise can double or quadruple the investment in risk reduction if disaster is avoided (De Perez et al., 2015).

While the humanitarian organization clearly benefits from integrating weather and climate related information into their decision making, but often they fail to translate early warning into early action (Braman et al., 2013). The majority of forecasts however, does not routinely trigger early action in the humanitarian sector to reduce disaster risk. For example, the devastation from extreme flooding in Pakistan in 2010 affected 20 million people (De Perez et al., 2015). Heavy rainfall had been predicted several days in advance (De Perez et al., 2015), and if forecasts had been used to trigger early action, the humanitarian sector could have averted many of the impacts. In the case of drought, the 2011 famine in southern Somalia was preceded by 11 months of early warning, including a specific famine warning three months before the event (De Perez et al., 2015). Major disasters such as cyclone Nargis in Myanmar, the 2005 famine in Niger, and hurricane Katrina in United States illustrate the extent to which entirely predictable extreme events became deadly disasters (Suarez, 2009).

In all of the above situations, a warning was followed by disaster situation, the distinction was if action had been taken to prevent impacts of disaster. However, this is not always the case. Many studies concluded that the issue related to nature of forecasts often challenges humanitarian actors in implementing early action based on forecasts (Braman et al., 2013; Tall et al., 2012; De Perez et al.,2016). Forecasts are highly uncertain and probabilistic in nature (Braman et al., 2013; Tall et al., 2012; De Perez et al., 2016). This creates difficultly for disaster managers to commit resources to prepare for a particular outcome when still there is a good chance that unanticipated events will occur. De Perez et al.,(2016) added that the uncertainties open the possibility of action "in vain" i.e., action that is taken after forecast, but is not followed by extremes events. In such a case of action "in vain", the humanitarian actor would have chosen an alternative use of resources if they had known that the extreme event would not materialize.

3. METHODOLOGY

The study focus on enhancing knowledge on how humanitarian organizations can use climate forecast in their decision making to undertake preventive action before a hazard materialize. In order to provide an overview of the scientific literature on the given study, evidence was collected using a scoping method. The study was conducted in Feb 2018 using an adapted version of the framework outlined by Arksey & O'Malley (2005) as a guideline. This section describes the framework and its application.

3.1. Scoping study

Scoping study is amongst many techniques for mapping relevant literature in the field of interest (Arksey & O'Malley, 2005). The aim of this thesis is to provide an overview of the available scientific literature and to suggest methods of improvements. Thus the aim of scoping studies, "*to map the literature on a particular topic or research area and to provide an opportunity to identify key concepts; gaps in the research; and types and sources of evidence to inform practice, policymaking, and research* (Beerens & Tehler, 2016)", corresponds the aim of thesis. Furthermore, as scoping studies do not seek to assess the quality of research in a study area (Arksey & O'Malley, 2005), this further support the use of the scoping study method, given the thesis scope and constraints. Specifically, the study follows the 'six step framework' presented by Arksey and O'Malley (2005). The first four steps are described below, and the remaining steps in the results and discussion section.

Step 1: Identifying the research question

The first step is to identify the scoping study research question. Arksey and O'Malley (2005) recommended that a broad and open approach is taken in order to generate breadth of coverage, arguing that decisions on how to set parameters can be made once some sense of the volume and general scope of the field has been gained. As such, the study addressed the following research questions:

"*What is known about early warning early action approach in scientific literature?"*

Before starting the systematic search for material, quick-scan searches were conducted in academic journals in the field of weather and climate science, disaster and decision making. Beerens & Tehler (2016) stated that such approach helps researchers to develop a broad understanding of the material, where it might be found and the terminology used to address the topic. This information provided input for the subsequent steps.

Step 2: Identifying relevant studies/papers

The second step is to identify relevant articles. Arksey & O'Malley (2005) recommended conducting a broad search that is consistent with the overall research question. An electronic database was chosen as the source for the scoping study and the search strategy was developed from the research question and definitions of key concepts (Arksey & O'Malley, 2005). A distinction was made between 'database selection' (i.e. where to search) and 'search query identification' (i.e. how to search) (Beerens & Tehler, 2016).

i. Database Selection

The electronic database Scopus (https://www.scopus.com) owned by Elsevier was selected as the sole database as it is the largest database of peer-reviewed literature, multi-disciplinary and covers a wide range of research fields (Beerens & Tehler, 2016). Access to articles was possible through the subscription to the academic journals provided by Lund University. As the focus was limited to peer-reviewed scientific articles published in academic journals, no grey literature was searched.

ii. Search Query Identification

Search strings were formulated using key words derived from the research questions. Boolean "OR" and "AND" operators was used to concatenate the keywords into search strings.

The four distinctive keywords in the research questions were: (1) warning (2) action (3) climate and (4) decision making. However, these key words have synonyms so searching these words alone would be insufficient (Beerens & Tehler, 2016). Therefore, a list of synonyms was compiled by searching thesauruses and reflecting upon the results of the quick scan searches of Step 1. The synonyms were systematically combined and the various combinations of search queries were used to search in the Scopus database and the number of results was noted for each query. Synonyms that generated irrelevant results were removed from the list. Apart from synonyms, the terminology that complements key words were identified and combined in the database. For instance, whilst climate is neither synonymous with weather nor season, and in a similar manner, neither warning nor uncertain is a synonym of forecast, but these words were paired given their pragmatic usage in the field particularly related to climate science and early warning system. Likewise, whilst "decision-making" is neither synonymous with "disaster risk management" nor "humanitarian", these key words were paired as separating them significantly reduced the number of results in Scopus (indicating perhaps limited literature spanning the fields).

This reduced the number of synonyms and merged the four keywords to the following:

- Warning OR Forecast OR Prediction OR Uncertain
- Action OR Response OR Prevent OR Prepare
- Climate OR Weather OR Season
- Decision making OR Disaster Risk Management OR Humanitarian

This resulted in total 1375 individual papers. Figure 1 shows the search string, initial number of results and the selection process of core literature.

Step 3: Study Selection

The total of 1375 papers was filtered by language (English) that reduced the number of results to 1331. Only the papers from 2005 onwards were included as the study focus on disaster risk reduction efforts and it was not until when Hyogo Framework for Action was signed in 2005, disaster risks were acknowledged (Manyena 2012). Otherwise, originally humanitarian institutions were created with a mandate to respond to disasters only after they had occurred (De Perez et al., 2015). This reduced the number of papers to 1174. The 1174 articles were then exported to Excel, where 11 duplicates were removed using the function 'Remove Duplicates'. This left a total of 1163 articles to be analyzed.

Many of the final samples of the 1163 papers did not address climate forecast and its use in humanitarian decision making for early action and had to be removed by assessing the title. Articles that were clearly irrelevant for instance, "*Consequences of an uncertain mass mortality regime triggered by climate variability on giant clam population management in the Pacific Ocean",* or *"Vaccines for preventing influenza in healthy adults",* as determined through the analysis of their titles were removed and borderline cases were retained for further analysis. This led to the removal of 1016 articles. The abstracts of each of the remaining 147 articles were then read and assessed against the inclusion and exclusion criteria described below.

i. Inclusion Criteria

The selected articles must have full text available. They may be reports from journals, conferences or book articles. The paper should contain all the elements addressed in the research question; it should focus on climate related extreme events especially floods, should address use of climate forecast in humanitarian decision making to take early action, and should talk about forecasts' relaibility and availability to support humanitarian decision making.

ii. Exclusion criteria

Articles that did not explicitly discuss the role of climate forecast in decision making in the context of climate related hazard risk were excluded from this analysis, in addition to those that did not focus on early warning and early action approach or provided insufficient details regarding humanitarian decision making to take forecast based early action. Likewise, articles that documented uptake of climate information for adaptation to climate change were excluded. Further exclusions have been made in those articles that focus on use of climate forecast in, other than humanitarian or disaster management sector such as, agriculture planning and water management. For this review, the predominant focus is on humanitarian decision making bodies; consequently household-level decision making were excluded in this review. Furthermore, the documents that solely focused on use of forecasts on long term preparedness measures or post- disaster response were excluded; however, here in this review, the focus is utilizing short windows of time between forecasts and a potential disasters.

Following the application of the inclusion and exclusion criteria, borderline cases were retained and the whole article was analyzed. This left 27 articles in total.

Step 4: Charting the data

The analysis was performed in two steps: an initial, overall analysis focusing on broad trends and characteristics followed by in-depth analysis involving a more detailed analysis focusing on identifying constraints and opportunities in implementing early action and identifying ways to integrate climate forecast on humanitarian decision making to undertake preventive action.

i. Overall analysis

All 27 articles were read and analyzed to determine if the articles were relevant. The aim was to identify papers that explicitly address humanitarian decision making for early action based on forecasts. The 27 articles were then divided into two groups. Group 1 contained 12 articles that addressed aspects of the research question per se and Group 2 contained 15 articles that addressed relevant aspects but to a lesser degree or closely related fields. In addition, a snowball technique was used to find more relevant documents. The references in the papers in Group 1 were analyzed to see if they contained any other relevant documents. Further, eight papers were selected after analyzing based on inclusion and exclusion criteria. This resulted in total of 20 papers in Group 1. Both Group 1 and 2 were included in overall analysis, however only Group 1 was included in the in-depth analysis.

To identify broad characteristics and trends, articles were examined according to subject area, publication type, year of publication as well as region of publication and geographical focus. These characteristics and trends were identified using information provided by Scopus as well as determined by the researcher’s analysis of the article. Graphs and tables were produced in Microsoft Excel and Word.

ii. In-depth Analysis

The 20 papers in Group 1 were analysed in detail in order to answer the research questions mentioned above. Going through the articles and placing their results, discussions and conclusions into categories, constraints and opportunities of implementing early warning early action approach were identified. Likewise, information on availability and reliability of forecast as well as aspects characterizing decision situation to undertake early actions and ways to link early warning with early action were documented. The articles were then individually assessed in order to identify any explicit or implicit reference to the identified factors and information. An overview of the articles analyzed in the in-depth analysis is presented in the Appendix 1.

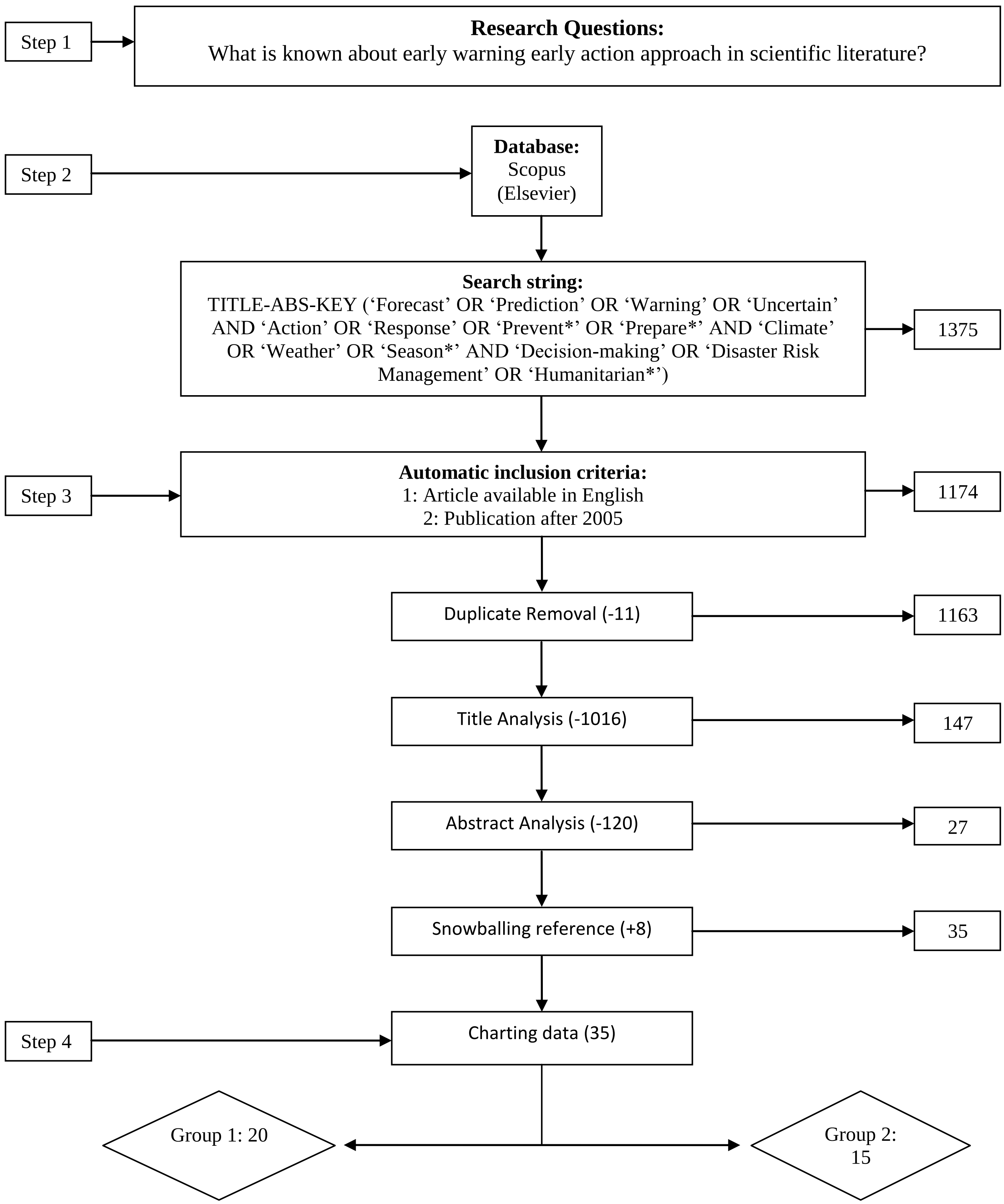

Figure 1: The selection process of core literature

4. RESULT AND ANALYSIS

This chapter provides the results of the scoping study which is divided into two sections: overall analysis and in-depth analysis.

4.1. Overall analysis

In order to examine the broad trends and characteristics, the final selected papers were categorized into general subject areas based on their title and disciplines. Further, it was categorized according to their year of publication, region of publication and study location. Articles from Group 1 and 2 were merged (total, n=35) and included in the overall analysis, however a distinction was made for articles from Group 1 (n=20), given its importance.

4.1.1. Classification based on subject area

Table 1 presents an overview of articles based on their subject area. Articles were categorized as defined by Scopus and by the analysis of their title and abstract. Six subject areas were identified. Most papers (49%) were published in the area of the Earth and Planetary Science followed by the Environmental Sciences (20%). The remaining papers contributed from the subject areas of Social Science (11%), Agricultural and Biological Sciences (11%), Weather and forecasting (2%) and Engineering (1%). In Group 1, the Earth and Planetary Science provided nine articles (45%) while the Environmental Sciences, Social Science and the Agricultural and Biological Sciences each contributed with three (15%) articles. Furthermore, the Weather and Forecasting provided two articles while there was no contribution from Engineering.

Table 1: Documents by subject area

Documents by subject area	**Total n=35**		**Group 1 (n=20)**	
Environmental Science	7	20%	3	15%
Earth and Planetary Science	17	49%	9	45%
Social Science	4	11%	3	15%
Agricultural and Biological Science	4	11%	3	15%
Weather and Forecasting	2	6%	2	10%
Engineering	1	3%	0	0
Total	**35**	**100%**	**20**	**100%**

Table 2 shows that the most papers were journal articles (74%) followed by conference paper (6%), book chapter (6%) and book (3%). Similar to the overall analysis, the significant contribution was from journal article in Group 1 with 70% while the least contribution came from book (5%).

Table 2: Publication type overview

Publication type	Total n=35		Group 1 (n=20)	
Journal article	26	74%	14	70%
Conference paper	6	17%	4	20%
Book	1	3%	1	5%
Book chapter	2	6%	1	5%
Total	**35**	**100**	**20**	**100**

4.1.2. Temporal distribution of the selected papers

Figure 2 shows that the number of papers focusing on forecast based humanitarian decision making for early action is increasing over the last few years. It can be argued that the publication trend may be an indicator of practitioners and researchers growing interest in using climate information for decision making. While no publications were observed in the year of 2008 and 2011 but since 2009 the number of publications has risen, peaking in 2016, with six publications. In Group 1, the increase in publications per year is less pronounced and the number of publications fluctuates between 2009 and 2017.

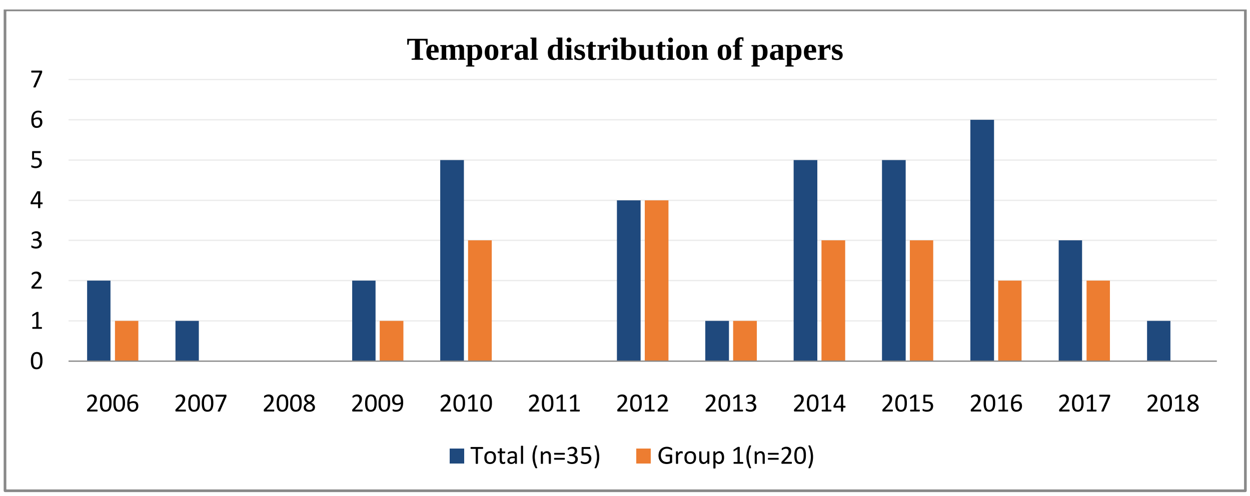

Figure 2: Number of publications by years

4.1.3. Classification based on region of publication

Table 3 shows that the majority of the articles were published from United States based institutions (43%). There were significant contribution from United Kingdom, European and Australian institutions as well with 20%, 17% and 14% of published articles respectively. From Africa, only two articles were published (6%). Similar to overall analysis, in Group 1, United States was the largest contributor with 30% of published articles. The contribution from United Kingdom, Australian and European institution increased to 25%, 20% and 20% respectively. However, there was only one article published from African institution. This finding demonstrates that the majority of the peer reviewed literatures that will be taken forward for the in-depth analysis were published from developed nation.

Table 3: Documents by region of publication

Region of publication	**Total (n=35)**		**Group 1 (n=20)**	
UK	7	20%	5	25%
Australia	5	14%	4	20%
Europe	6	17%	4	20%
Africa	2	6%	1	5%
US	15	43%	6	30%
Total	**35**	**100**	**20**	**100**

4.1.4. Geographical focus of selected papers

Table 4 provides an overview of articles based on the geographical focus. The geographic focus of most papers spans East and West Africa (46%) shortly followed by those concentrating primarily on United States (17%), United Kingdom (14%) and Australia (11%). Europe (9%) received notably fewer mentions, with South America only addressed by a single short-listed paper. In Group 1, the percentage of articles that focused on East and West Africa rose to 55%. The relative contribution from other region included: 20% from UK, 15% from Australia and 5% from US and Europe. This finding indicates that the geographical focus of the articles chosen for the in-depth analysis was strongly African orientated, particularly East and West Africa.

Table 4: Documents by study location

Region of focus	Total (n=35)		Group 1 (n=20)	
Europe	3	9%	1	5%
United Kingdom	5	14%	4	20%
Australia	4	11%	3	15%
East and West Africa	16	46%	11	55%
United States	6	17%	1	5%
South America	1	3%	-	-
Total	**35**	**100**	**20**	**100**

4.2. In-depth analysis

Following the overall analysis, an in-depth analysis of the 20 papers in Group 1 was conducted in order to address the research questions. Here, the paper focuses on climate related hazards especially floods. The results and analysis of the scoping study are discussed in this section.

4.2.1. Constraints in implementing EWEA approach

This part addresses the first part of the first research question (RQ1a), *"What are the constraints in implementing early warning early action approach?"*. Here, a word *"*constraint" refers to *"a factor or something that limits what one can do or prevents one from doing what they want to do"* – taken from Collins dictionary.

Ten constraints to the uptake of climate information in humanitarian decision making for early action were identified in the literature. These constraints were categorized based on the keywords and themes identified from the literature. In order to synthesize the range of different factors, identified constraints were grouped into the five overarching categories as shown in figure 3. To answer the research question, the frequencies and percentages of the identified constraining factors were determined which is shown in Figure 3.

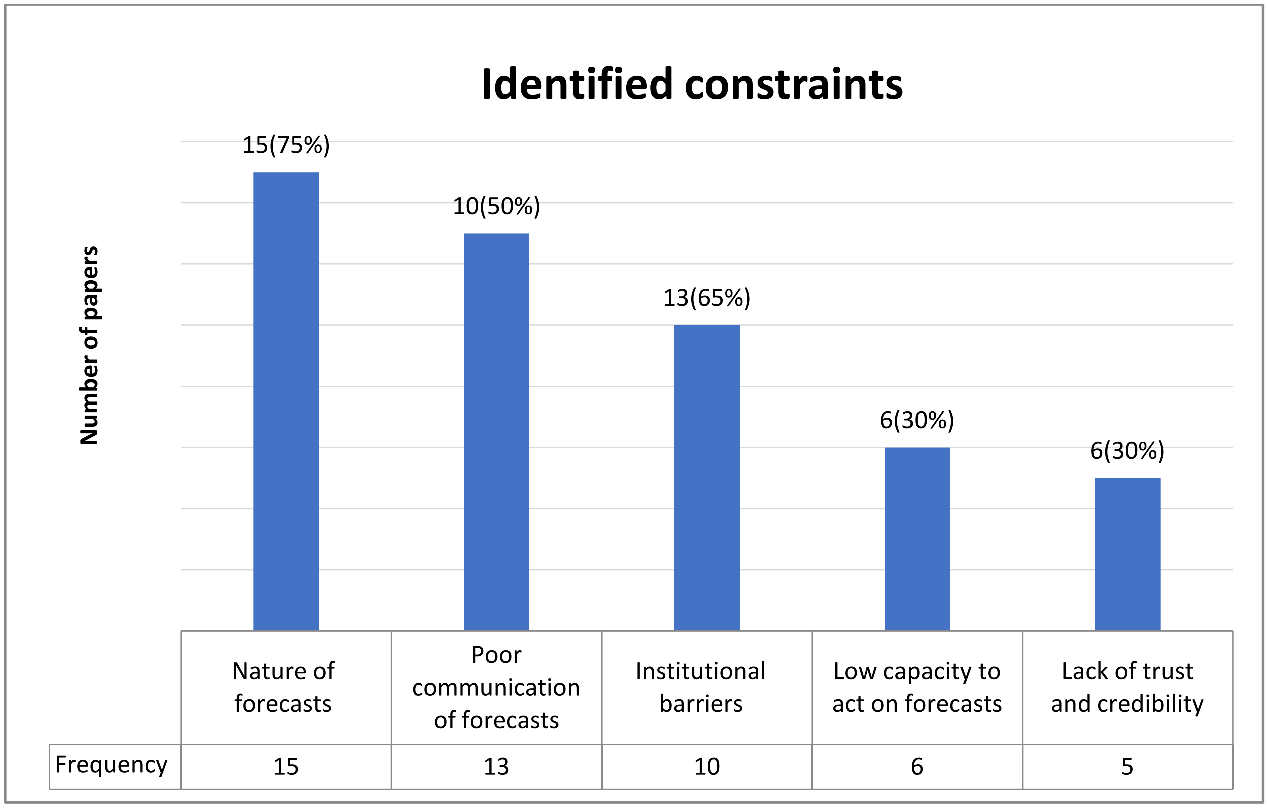

Figure 3: Constraints identified when translating warning into action

i. Nature of forecasts

Issues related to the nature of forecast was found to be the major constraining factor when making decision for early action based on climate forecast (75%). Two constraints were identified including a) probabilistic nature of forecast and b) lack of relevant forecast.

First, the probabilistic nature of forecast and the associated uncertainties is seen as a key impediment. The forecasts are usually expressed in probabilistic terms (De Perez et al., 2015; De Perez et al., 2016; Tall et al., 2012) which ensures that there will be instances in which the most likely category of rainfall does not materialize. In addition, forecast uncertainty is also high especially in data scarce region (De Perez et al., 2016) which ensures that there is no way of knowing ahead of time, whether deciding to act will avoid losses or waste scarce resources. This opens the possibility of action " in vain". In such a case of action in vain, the humanitarian actor often believe that they would have been better spent money, time and resources on other activities. Hence, this makes it difficult for humanitarian actors to commit resources to preemptive events.

Second, lack of relevant forecast is a significant barrier in translating forecast into action. Seasonal forecasts do not predict weather at a specific location or time, instead, it tells about the likelihood of averaged weather, such as rainfall totals, over periods up to a season in length (De Perez & Mason, 2014). Such information related to seasonal rainfall totals is not necessarily relevant to the humanitarian workers (De Perez & Mason, 2014) ; instead, they are interested in the likelihood of exceptionally heavy rainfall and/or where heavy rainfall locally occurs in the coming days, which can be used as a proxy for flood risk to undertake early action. But, seasonal forecasts lack the spatial and temporal specificity indicating where and when within the forecasted area and time period extreme rainfall events might occur (Tall et al., 2012). Tall (2010) considered this as a scientific barriers which is due to climatic data limitations. For instance, in Africa, the density of meteorological stations is about eight times lower than the minimum recommended by the World Meteorological Organization (WMO) and many of these stations are non-functional and governments have failed to invest in equipment and trained personnel (Tall, 2010; Tall et al., 2012). Improving the local specificity of climate information in Africa will therefore require greater investments in infrastructure that supports hydro-meteorological application.

ii. Poor communication of forecasts

The second category of constraint concerns to a poor communication (65%). Three distinct communication challenges were identified: a) low accessibility to climate information b) difficulties in translating climate information into actionable guidance for decision makers, and c) lack of interaction between forecasts providers and humanitarian actors.

Firstly, the climate information transmitted by forecast providers rarely reaches to vulnerable groups and decision makers at community level. This is particularly evident in the developing countries, where there is a lack of operational community level relay of climate information, media outlets, and information sharing systems (Tall et al., 2012) to transfer information from regional/national to district level, on to communities and back. For instance, in West Africa, the duly produced forecast is sent from regional climate forecasting institution to the national relays: National Meteorological and Hydrological Services (NMHSs) but there is no direct outreach to transmit information from national level to communities at risk, available forecast information is thus not targeted to vulnerable groups neither is it tailored to meet their needs or fit their decision-making, and so the information either does not reach the community level at all or fails to reach the more marginalized groups (Tall, 2010).

The second communication challenge pertains to difficulties in translating forecast into actionable information. Meinke et al.,(2006) pointed out that current climate forecasts and the way they are presented and disseminated are at best ineffective, while at worst they can increase risk due to inappropriate action by the decision maker. Firstly because the language, content and format of forecasts are too technical (Tall et al., 2012; Tall, 2010; Suarez, 2009) that it is not understandable by the layperson untrained in climate science. Secondly, because the needs of forecast providers and disaster managers are different (Sene, 2010) where in the former case the interest is in getting the best possible forecast that can be in the form of maps, numeric tables, or technical statements, whereas in the latter case the interest is getting information in a way that will help inform the best possible decision. In addition, Tall et al., (2012) stated that the probabilistic nature of forecast is often prone to misinterpretation and confusion. Also the high uncertainty in forecasts contributes to difficulty in communicating climate forecasts in a way that triggers appropriate and timely action.

Finally, a lack of interaction between forecast producers and humanitarian actors acts as a considerable constraint to effective humanitarian decision making. To ensure the usefulness of climate information, collaboration between forecast producers and humanitarian actors is essential however, the lack of interaction between these two groups is one of the key constraints (Suarez, 2009). Part of a reason for this challenge relates to the absence of effective boundary organization that bridge the gap between forecast producers and users. Boundary organization act as a middleman providing better synthesis, translation and packaging of climate information that could be useful for users, and also increasing scientist's awareness of, and ability to work towards addressing, the needs of users (Kiem et al., 2014). Absence of such organization limits two way communications making difficult for both producers and users of climate forecast to engage with one.

iii. Institutional barriers

More than 50% of the shortlisted articles identified institutional barriers as a key constraint. Two institutional barriers were identified: a) lack of international humanitarian funding for pre-emptive events and b) lack of organizational mandate to conduct forecast based early action.

Firstly, the forecast based preparedness falls in between the two well established disaster management funding channels that currently exist: post-disaster work (response, recovery and reconstruction) and long-term disaster risk reduction. Funding are rarely available to respond to the anticipation of extreme events; about 88% of humanitarian financing is delivered only after disaster effects have already commenced (De Perez et al., 2015). In fact, the international humanitarian organization lack mechanisms to support humanitarian action based on forecasts on different timescales. De Perez et al., (2015) illustrated factors: protracted debate over the best strategy for intervention, inherent uncomfortableness on the part of donors to invest in a situation that will likely arise but is not certain, the high consequences of "acting in vain", and the lack of responsibility or accountability to act on early warnings as attributes for lack of funding based on early warnings.

Secondly, the organizational mandate to implement early actions based on scientific forecast is often not well-defined. Many organizations lack Standard Operating Procedure (SOP) which designates specific duties and responsibilities to specific entities for hypothetical situations (Perez et al., 2015). Often there is no clarity among the humanitarian actors on who would be responsible for making decisions and what decision would be appropriate to take based on the early warning. Humanitarian actors are often unsure of when it would be worthwhile to take action and spend resources based on a probabilistic forecast (Perez et al., 2016) and if the anticipated hazard does not materialize after the early action is taken, the decision makers is considered culpable for his or her poor decision-making. This risk of acting in vain is inherent in probabilistic risk information, hence many decision makers are consequently reluctant to make decisions without 100% certainty that the hazard will happen (Perez et al., 2015).

iv. Low capacity to act on forecasts

Low capacity of humanitarian organization to act on forecast was discussed in 30% of the selected articles. Two issues related to limited capacity were identified a) lack of in-house expertise and b) limited organizational capacity.

First, lack of in-house expertise was pointed out as a factor that can limit effective translation of warning into action (Soares et al., 2017). Tall et al., (2012) supported this point stating that humanitarian actors as having low capacity to understand and use forecasts. He further pointed out that the forecast information becomes unusable by decision makers without the presence of a in-house climate translator. Soares et al., (2017) therefore, suggest that either there needs to be some form of organizational or institutional capacity building or training to address this expertise deficit or alternatively forecast information needs to be tailored and provided in a way that is compatible with existing in-house systems.

Second, limited organizational capacity acts as a significant obstacle that inhibits early action strategies (Braman et al., 2013). For instance, limited financial resources to transport non-food items, less number of vehicles to transport teams to conduct immediate assessments, delays experienced by supply trucks at country borders, and varying degrees of access to technology and communication tools can slow down response in spite of the preparedness measures and strategies. In addition, some communities are too poor to take action based on warnings (Tall, 2010). For instance, impoverished communities settled on hazard prone areas such as in flood plains are continually vulnerable to floods, and yet can make little use of early warnings as they have few options to go elsewhere.

v. Lack of trust and credibility in forecasts

About 25% of the selected articles referred to lack of trust and credibility in forecast as a barrier to translate climate information into action. A perceived lack of credibility among decision makers with regards to climate forecast prevents them from using and acting upon available knowledge (Meinke et al., 2006; Tall et al., 2012). Many decision makers are skeptic about the validity of climate information (Kniveton et al., 2014). Furthermore, perceived lack of accuracy, reliability and credibility were found to drive low levels of trust in climate science amongst decision makers (Soares et al., 2017; Kniveton et al., 2014; Suarez, 2009). This is accompanied by the uncertainties and probabilistic nature of forecast. Due to inherent forecast uncertainties, some preventive actions in response to early warnings will prove unnecessary for specific events if that event does not materialize. Such issue of "crying wolf" potentially leads to loss of trust (Sene, 2010; Braman et al., 2010).

4.2.2. Opportunities of implementing EWEA approach

This part addresses the second part of first research question (RQ1b), *"What are the opportunities in implementing early warning early action approach?"* Several opportunities were highlighted in the scoping study that humanitariann organization can champion or implement. Similar to the constraints, the opportunities were categorized based on the recurring keywords or themes identified in the literature, and then were classified into three overarching themes a) early action funding b) developing partnerships with scientific institution and c) capacity building.

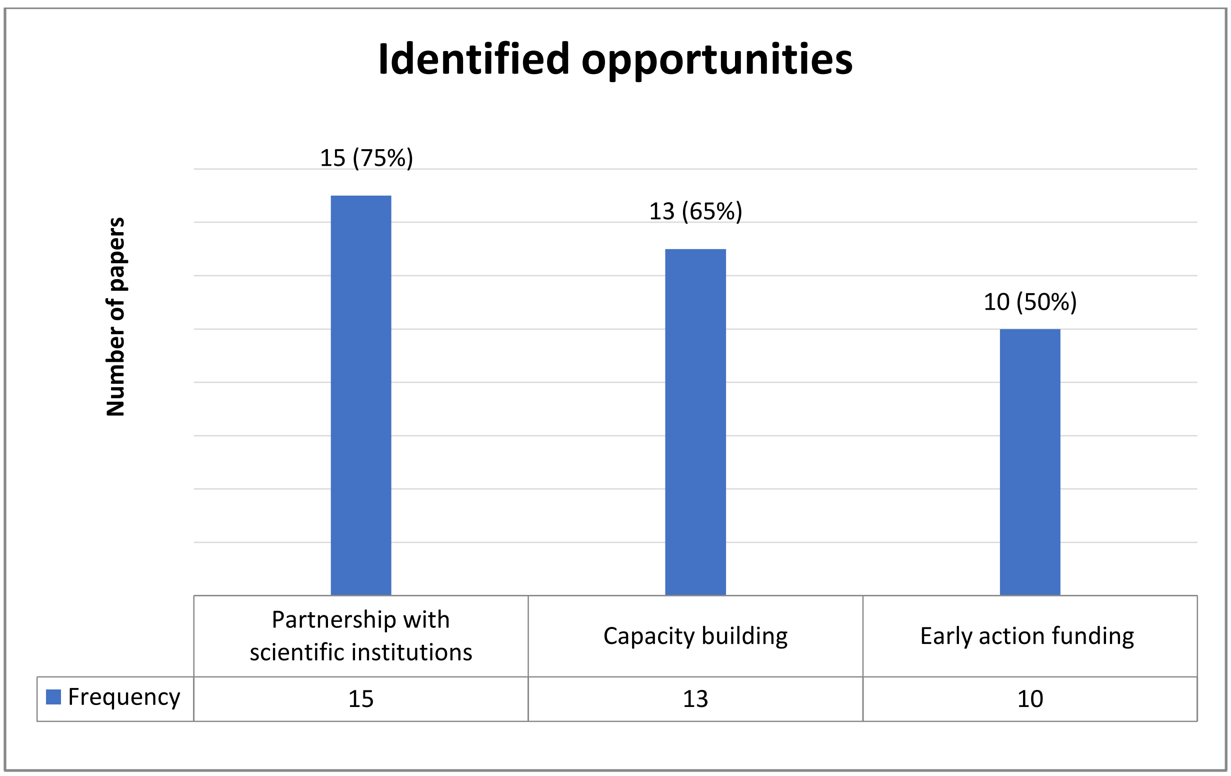

Figure 4: Opportunities in implementing early warning early action approach

i. Partnership with scientific institutions

A majority of papers highlighted the role of partnership between forecast producers and humanitarian actors in order to improve access to weather and climate information to implement early action. With early warning early action approach, there is an opportunity to connect humanitarian actors with forecast producers encouraging the uptake of climate information in the humanitarian sector. Discussions involving both sector experts to note potential impacts are useful to guide action planning, as noted by Tall et al., (2012).

Hillbruner & Moloney (2012) demonstrated in their paper the use of Famine Early Warning Systems Network (FEWS NET) to access credible forecasts. De Perez & Mason (2014) in their paper highlighted how International Federation of Red Cross and Red Crescent Societies (IFRC) partnership with a leading climate research and forecasting institution, International Research Institute for Climate and Society (IRI), allow humanitarian actors to have timely discussions of forecasts and increased probability of risk as well as how collaboration helped humanitarian practitioners to better understand and interpret the forecast and incorporate forecast into disaster planning and make decisions accordingly. Likewise, Braman et al., (2013) demonstrated the need to address climate information on a variety of timescales; including seasonal forecasts for three months, monthly forecast, 10 day forecasts, weekly forecasts, as well as three and one day forecasts, through the National Meteorological Institution in order to obtain more precise information regarding where and when extreme weather events might occur.

Successful uptake of seasonal forecast and implementation of early action is heavily dependent on decision makers being explicitly involved and contributing to the formulation of climate information (De Perez & Mason, 2014). Such participatory process of engagement ensures that the views of both forecast producers and humanitarian actors are represented in the development of forecast information. On one hand, forecast producers understand the decision making context of humanitarian actors thereby increasing their ability to customize the information to meet needs of humanitarian actors while on the other hand, enhances the capacity of humanitarian actors to understand science based forecasts ensuring that the humanitarian actors are interpreting the forecast accurately. Not only partnership allow reliable forecast to reach decision makers timely and accurately but it also provides ready access to climate expertise (Tall et al., 2012) which allow humanitarian actors to discuss the limitations of the forecast in terms of skill, uncertainty so that these aspects are well understood in decision making processes. Hence, increasing levels of collaboration and two way communication between both parties can help to build trust, encourage better understanding of sectoral expertise, and promote co-production of knowledge.

ii. Capacity Building

The capacity to understand climate forecast for making appropriate decision is highlighted as second major oppotunities in the scoping study herein. De Perez & Mason (2014) discusses how El Niño forecast information was presented and shared by the climate institution and used by the IFRC to plan preparedness action in advance of disaster. As noted in most literature, the focus here is to build up systems that enable humanitarian practitioners to identify the changing risks and develop appropriate action plans and to strengthen the organization capabilities to link climate forecast with early action. This can be obtained as identified in most of the literature by bridging the gap between humanitarian actors and climate institutions (De Perez & Mason, 2014; Kiem et al., 2014; Tall, 2010; Tall et al., 2012) that not only supply timely and accurate forecast but also facilitate improve decisions on all timescales making humanitarian actors understand and take advantage of the advanced lead time provided and prepare for increasing extreme events. Tall (2010) reported how training on seasonal forecast as a result of partnership with climate institution developed the capacity of IFRC to interpret seasonal forecasts and short term precipitation predictions and use it to formulate action plans.

The scoping study also found that the use of early warning early action enhances the capacity of humanitarians to become ready to respond when hazard actually strikes. Braman et al., (2013) discussed how early actions based on climate forecast, in this case the prepositioning of relief items, improved IFRC respond to the floods in West and Central Africa zone in 2008 by significantly reducing the response time. As a result of this, most countries in WCAZ received needed relief supplies in a matter of days after flooding which otherwise had been estimated 40 days late in starting of flood response operations (Braman et al., 2013) . Moreover, Tall et al., (2012) in his case study of IFRC West Africa reported how the timely information on the seasonal forecast and training in disaster preparedness helped the Gambia Red Cross to perform a post flood needs assessment and submit a funding request within two days of flooding, a process which generally took them several weeks after the flood event. Likewise, in

Togo, in response to the 2008 seasonal forecast, a newly developed early warning enabled the small community of Atiégou Zogbédji with 2000 populations to evacuate with just an hour and a half notice of flooding (Tall et al., 2012).

iii. Early action funding

Through the scoping study it is clear that early action is supported when there is funding in place and hence, highlighted as a third major opportunities. Funding for anticipated disaster that are just likely but not certain to happen are rarely available (De Perez et al., 2016; Tall, 2010) however, this incentive structure is changing. Tall (2010) in his case study of International Federation of Red Cross and Red Crescent Societies reported that, when enhanced probabilities of above-normal rainfall forecast was issued for July to September over most part of West Africa, flexibility in the use of funding for the operation on the basis of imminent crises was made available through the Disaster Relief Emergency Fund (DREF), an internal Red Cross funding source intended for small-scale or rapid start-up of relief activities, but can also fund operations on the basis of 'imminent crises' (Braman et al., 2010). Funding available from DREF was then used to initiate preparedness activities and to preposition the emergency stocks around the region in advance of disaster.

Another model of funding for pre-emptive disasters as illustrated in the paper of De Perez et al., (2015) and De Perez et al., (2016) is Forecast based Financing (FbF). This mechanism sets up funds and allocates resources prior to a hazard occurring based on a preselected forecast and based on early action plans developed. FbF also allow for the possibility of acting " in vain" if the hazard does not materialize, ensuring that the long-term gains of preventative action will outweigh the costs of false alarms. Making use of this concept, Uganda and Togo is piloting this approach that disburses funds after a forecast is issued but before a disaster occurs, to carry out early actions (De Perez & Mason, 2014).

This shows that early warning early action does create opportunities to invest and incentivize early action despite the risk of acting in vain. Such incentives, when emerges will maximize the potential of forecast information allowing selecting and investing on preparedness actions that are likely to reduce disaster losses in the long run, even though they will periodically be done "in vain".

4.2.3. Availability and reliability of climate forecast

This part addresses the second research question, "What is known about the availability and reliability of climate forecasts useful to support humanitarian decision making?"

i. Availability of climate forecast

The analysis revealed that translating forecasts into early actions require use of multiple forecasts on multiple timescales; forecast range from seasonal forecast to short range weather forecast is most frequent type of climate information used for humanitarian decision making (Tall et al., 2012; De Perez & Mason 2014; Braman et al., 2010). The scoping study confirmed its importance, with 80% of the selected articles (16 articles) indicating the use of seasonal to weather forecasts to inform decisions to take early actions.

Seasonal forecast predicts average weather conditions over three to four month periods (Braman et al., 2010) with the lead time up to one to six months (Kniveton et al., 2014). The lead time is defined as the time between the receipt of a warning, and the onset of hazard (Sene, 2010). This means that, with seasonal forecasting, an alert of a heightened risk of a hazard like flooding can be provided in a month up to six months ahead. On the contrary, short range weather forecast are provided with a lead times up to three days ahead (Sene, 2010). Apart from this, the extended range timescales which bridge the gap between weather forecast and seasonal forecast can be provided with 15 to 30 days forecast lead times (White et al., 2015; White et al., 2017).

Moreover, the scoping study shows that the information on weather and seasonal forecast can be accessed and sourced from multiple organizations. 60% of articles (12 articles) show that translating forecast into action requires humanitarian organization to rely on multiple forecast providers rather than single source including National Meteorological and Hydrological Services (NMHSs), regional climate center such as African Centre of Meteorological Applications for Development (ACMAD), and university research institute like International Research Institute for Climate and Society (IRI). Because the actions are taken before a potential disaster strikes, use of information from multiple sources increases confidence in the predictions (Braman et al., 2013). Seven out of 20 papers highlighted the Regional Climate Outlook Forums (RCOFs) as reliable provider of seasonal forecast on regional scale. The forum provides consensus based forecast by bringing together national, regional and international climate experts to produce regional climate outlooks and is considered as the most authoritative voice on conditions most likely to prevail over the upcoming season (Tall, 2010).

In addition to it, 75% of articles stressed on developing partnership between humanitarian sectors and climate institutions to access forecast on multiple time scales. Partnership with the research institute like International Research Institute for Climate and Society (IRI) was highlighted in majority of articles and the benefits that partnership bring to bridge forecast with action was also discussed in many articles. Not only the partnership promotes uptake of necessary weather and climate informations for early actions, but according to Tall et al., (2012) it also serve as a pathway to secure inflow of reliable and trustworthy climate information.

ii. Reliability of climate forecast

White et al., (2015) stated that the accuracy of forecasts varies with lead time that is, shorter the forecast lead time, more accurate the forecast is and vice versa. Whilst seasonal forecasts are capable of providing a month up to several months lead time of flood forecast, but the information contained in such longer lead time forecasts has a high degree of uncertainty (Braman et al., 2010; Sene, 2010; White et al., 2015). Also the seasonal information is given in more general terms such as of average temperatures or total rainfall, express in terms of below-normal, near-normal, and above-normal seasonal average conditions (Tall et al., 2012). On the other hand, short range forecast holds less uncertainty and are increasingly able to estimate the likelihood of extreme climate or weather related events and also where and when an extreme event is approaching (Braman et al., 2010; Braman et al., 2013). Monitoring forecasts on short timescales, when an alert for a heavy rainfall or storm season is issued, is therefore important (Braman et al., 2010). Monitoring forecasts on multiple time scales helps to reduce uncertainty, geographic area at risk can be specified, and early actions can be accelerated prior to heavy rainfall events (Braman et al., 2013).

Rainfall and temperature forecasts for coming months, weeks, or days, exhibit some skill in many parts of the world (De Perez et al., 2015). These forecasts, where available, can indicate heightened risk of disaster. Foresight expert evaluation of forecasting capacity indicated that current science has “medium to high” ability to produce reliable forecasts for the timing of storms and floods in a 6-day lead time in many locations (De Perez et al., 2015). At the seasonal scale, research has indicated that increased probability of above-normal seasonal rainfall totals in standard forecasts is correlated with increases in the chances of heavy rainfall events within the same region (De Perez et al., 2015; De Perez & Mason, 2014). That is, the actual risk of flooding increases in a region in that year in which the total rainfall is expected to be unusually high. If large enough areas are considered, and forecasters do not attempt to predict the precise location of a disaster event within this area, there is evidence for the predictability of extreme rainfall events on a seasonal scale (De Perez & Mason, 2014). That is, region wide changes in disaster risk can be used to make decisions within the same region, without need for highly localized information.

Over the past decades the skill to predict seasonal rainfall forecast has enhanced significantly (White et al., 2015; Braman et al., 2013) and this stems largely to the improved ability to predict El Niño Southern Oscillation (Braman et al., 2013) phenomena. ENSO is associated with the seasonal forecasts prediction and have also been linked to extreme events like flooding and drought in more than one third of the world's landmass (De Perez et al., 2015). It is also reported that the tropics region like western, eastern and southern Africa, which is strongly influenced by ENSO events, displays higher rainfall forecast skills (White et al., 2015; White et al., 2017).

4.2.4. Linking early warning with actions

This section deals with the third research question (RQ3), "What characterize the decision situations humanitarian organizations face when choosing whether to undertake early action, and how can they use climate forecasts to select appropriate preventive actions?"

This section is divided into two parts; first part discusses the different aspects that characterizes decision situations to undertake early actions and second part explains how humanitarian actors can select appropriate preventive actions based on climate forecast.

i. Aspects characterizing decision situations

Linking climate information to decision is not an easy task. With the constraints identified in the RQ1a, it can be argued that humanitarian actors often finds difficulties in undertaking decisions with any confidence, at least at the present. With the sound but highly technical climate information provided by climate institution, humanitarian actors might need to address the questions like "*Do we evacuate or not?* ", "*Do we preposition relief items or not*? " or "*Do we ask donor support or not?*". Addressing such question often depends on different factors.

a. Forecast at different timescales

The scoping study found that decision to undertake early actions varies with the forecast available at different timescales that is, depending on the forecast at multiple timescales, different actions are implemented. This highlights the need to obtain accurate forecast at all timescales which provide humanitarian practitioners the scientifically informed process to make key planning and decision under uncertainty. From the RQ2, it is found that the accuracy of a forecast also varies with timescales such that short range weather forecast are more accurate than forecast at extended range timescales which in turn is more accurate than seasonal forecast. Thus, with the progression of forecast on shorter timescales, increase level of preparedness action should be implemented (Braman et al., 2013). Seasonal forecast for instance, can be used for planning of early actions; humanitarian actors can plan for procuring supplies needed for risk reduction actions such as pesticides for mosquito fumigation, chlorine tablets for water purification, or sandbags to reinforce river banks based on seasonal forecast. Upon receiving extended range forecast, pre-purchasing and then pre-positioning of those supplies in the at-risk region can be initiated and when receiving short range warning, those risk reduction supplies can be distributed to the at-risk communities.

Figure below shows the accuracy of forecast which varies with the forecast range depicting that short range weather forecast are more accurate than seasonal predictions. Figure also shows the preparedness action corresponding to the forecast. However, it is important to note that actions presented here are only examples found from the literature and are not exclusive to a forecast range.

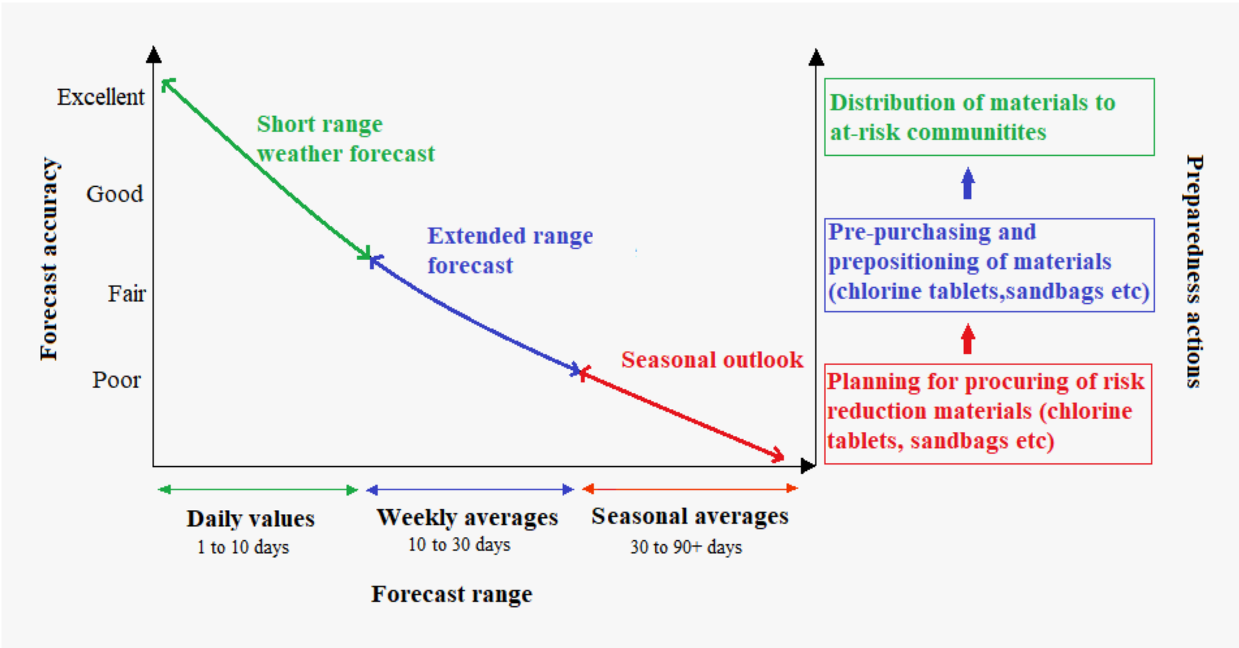

Figure 5: Forecast accuracy based on forecast range from short range weather forecast to seasonal predictions, and corresponding actions. Definitions are based on WMO Meteorological forecasting range: http://www.wmo.int/pages/prog/www/DPS/GDPS-Supplement5-AppI-4.html.

Along with forecasts at different timescales, it is found that decision to undertake early actions depends upon probability of forecasts and lead time available (Perez et al., 2015; Sene, 2010). It is found that actions are taken when probability of hazards occurence are unusually high or low, in case of floods, chances of floods occuring should be high enough in foreseeable future (Braman et al., 2013; Arame Tall et al., 2012). Similarly, actions are undertaken depending on if there is enough time to implement selected actions. This emphasizes the need of timely forecast with sufficient lead time so that there is enough time to implement decisions of taking early actions. Many articles has indicated at least a month lead time of seasonal warning to the humanitarian organization to trigger early preparedness actions (Tall et al., 2012) while at shorter timescales, a lead time of more than two hours is indicated as necessary for most actions (Perez et al., 2015). What different actions can be implemented based on forecast lead times and probabilities are discussed in the next section below.

b. Funding to undertake early action

The range of plausible action that could be taken to reduce potential losses is also determined by the funding mechanism available to use before potential disaster. Implementation of early actions requires that there are enough money to carry out selected actions at different timescales. Perez et al., (2015) stated that funding should be disbursed when a forecast is issued and should supply enough money to carry out the selected actions, with the understanding that occasionally funding will be spent to action "in vain".

Funding mechanisms such as Disaster Relief Emergency Fund (DREF) as mentioned in RQ1a could be a good vehicle for forecast based actions if such mechanism is established to use specifically for action based on probabilistic forecasts rather than at responding to a disaster. Braman et al., (2010) reported that the reliance of Red Cross National Societies in West and Central Africa Zone on international support was lower in 2008 through the DREF, owing to the investments made in advance that enabled National Societies to mobilize local resources and be ready to respond quickly. Another model of funding for implementing early action could be Forecast-based Financing system (Perez et al., 2015) that supports a timely disbursement of funds when climate related variables indicate that a humanitarian crisis is likely to happen.

c. Organizational guidelines/ protocol

Decision to undertake early action also require that there are organizational protocol in place within the humanitarian organization to assign responsibility to act based on warnings. It should be clear who would be responsible for making a decision and what decision is appropriate based on the early warning. It should be clear from the beginning on who takes action when, where and with what funds.

In the light of above, De Perez et al., (2015) proposed the development of an organization specific set of Standard Operating Procedures (SOP) that specify each selected forecast, the designated action, the cost for action, and also the responsible party to undertake action. Whenever the forecast reaches the probability or whenever an alert is issued, such as a forecast of a certain amount of rainfall, the designated action is taken by the responsible party, using funds from the available financing mechanism that should be immediately made available.

ii. Matching forecast with actions

As discussed earlier, early action to implement in the timeframe before the anticipated disaster varies across the timescales. There are number of actions that could be taken in those timeframe but only few actions will be suitable. The actions thus selected at particular timescales must be appropriate given the lead time and the probability of the forecast (De Perez et al., 2015).

Of all the actions that could be taken by the disaster managers, not every actions are possible to complete at the given lead time of a specific forecast. Only those actions should be taken into consideration that can be accomplish at specific lead times (De Perez et al., 2015) corresponding with available early warning information - short term forecast to seasonal forecast. For instance, based on a short range forecast, people are not be able to build drainage canals, but they could create teams to clear existing drainage canals based on a seasonal forecast. In comparison, flood response drills and distribution of medical supplies might be possible within a few hours or days of the forecasted disaster.

Subsequently, actions thus selected at particular timescales also need to correspond to the strength of the specific forecast (De Perez et al., 2015), such that high regret actions are not taken based on low probability forecast. For example, evacuating population based on a low probability of forecast wouldn't make any sense instead, flood response drill would be appropriate as they can withstand action in vain. Therefore, it is needed to set the forecast probability and identify action corresponding to that probability such that each time forecast reaches specific probability, designated action are taken.

Figure below highlight the relationship between known risk of disaster over time and examples of actions that is a function of both lead time (the difference between actions based on seasonal forecast to short term forecast) and the probability of flood risk (the difference between the far right actions in both plots).

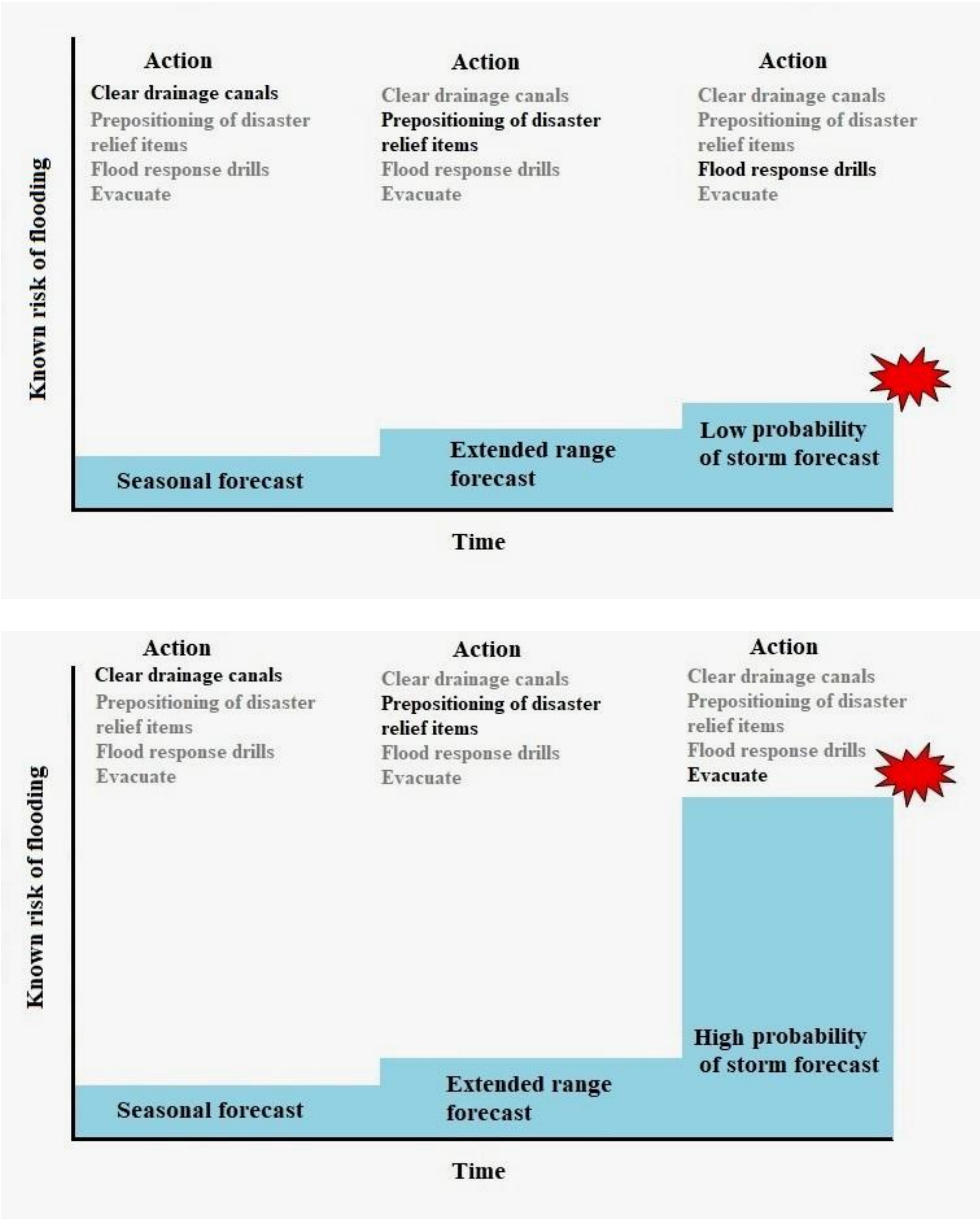

Figure 6: Schematic diagram depicting known risk of disaster impacts over time along with the appropriate actions. Adapted and edited from an original figure by De Perez et al., (2015).

In light to this, many researchers proposed the use of “No-regrets” strategies as a useful approach to act based on probabilistic forecasts (Braman et al., 2013; De Perez et al., 2015; Dale et al., 2016; Dale et al., 2014; Tall et al., 2012). No-regrets strategies are low-cost efforts, consist of actions and intervention that do not go to waste if the forecasted event does not take place (Tall et al., 2012; Braman et al., 2013) in the sense that they will remain useful in future disasters likely to happen sometime in the coming few years. For instance, prepositioning of relief items like non-perishable food items and NFIs that disaster manager could reuse during successive years if forecasted floods do not occur. Likewise, capacity building and training of volunteers and staff on first aid or response does not divert resources from other activities, but these trained volunteers and staff will be useful in any future emergency, whether or not the forecasted season follows a disaster situation.

The implication of no-regrets approach could have potential benefits, but while selecting no-regrets actions it is important that each action is analyzed based on the consequences of worthy action (where action is followed by disaster) and acting in vain (De Perez et al., 2015). For instance, in the case of purchasing water purification tablets, acting in vain might result in an opportunity cost relative to investment in other activities, but worthy action could prevent the loss of life in a cholera epidemic. Based on the assessment of whether consequences and likelihood of acting in vain outweigh the consequences and likelihood of worthy action, decision should be made to carry out particular actions. For a given forecast lead time and probability, action would be selected if the risk of acting in vain is outweighed by the likely benefits of preventing or preparing for disaster (De Perez et al., 2015). For example, decision to evacuate a community would be taken only if there is a high likelihood that not doing this could put lives in danger or have other serious consequences.

Figure below shows different forecast timescales and the list of possible early actions that can be implemented corresponding on the forecast timescales. It is also important to note that the actions presented here are only examples found from the literature and are not exclusive to a forecast range.

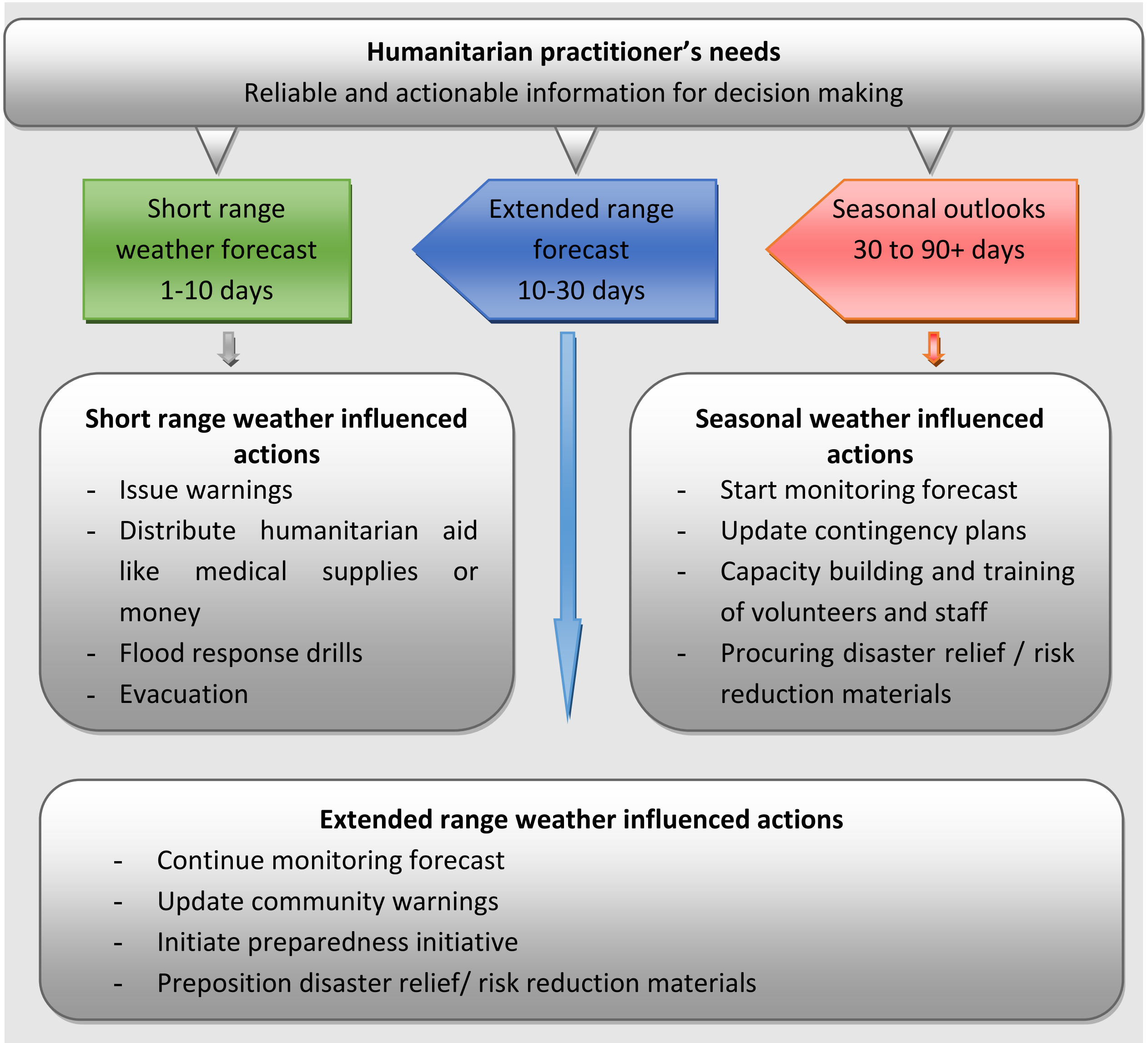

Figure 7: Schematic diagram highlighting different forecast timescales, with examples of actionable information that can enable decision-making across humanitarian sectors. Definitions are based on WMO Meteorological forecasting range: http://www.wmo.int/pages/prog/www/DPS/GDPS-Supplement5-AppI-4.html.

As shown in the Figure 6, preparedness actions should be scaled up when science indicates that the risk is elevated, and should be implemented months, weeks and days before a potential disaster. While a short term forecast allows for a head start in taking action, extended range forecast and seasonal forecast allows time for planning action so that the actions are implemented timely and correctly at a time when warning are actually issued. When preparing to reduce the potential impacts of flood risk, action such as updating contingency plans, training volunteers on response, and sensitizing at-risk communities in the general region of the forecast would be relevant based on seasonal forecast (De Perez & Mason, 2014; White et al., 2017); warning specific regions about impending rainfall anomalies, purchasing and pre-positioning of relief items, intiating a local preparation activities would be relevant based on the extended range forecast (De Perez & Mason, 2014); activating contingency plan, mobilize human resource and supplies, deploy an assessment team, activate volunteers, and conduct locally appropriate action such as evacuation or distribution of aid would be relevant based on short term forecast (De Perez & Mason, 2014; White et al., 2015; White et al., 2017).

5. DISCUSSION

The humanitarian organizations are increasingly aware of the value of climate information and role it can play in risk reduction, early warning and early action (Hellmuth et al., 2011). In fact there is a growing recognition among the humanitarian communities to integrate the climate information into their decision making. But often the use of climate information to date has been limited. Often, the warning issued month ahead of the disaster fails to trigger early action which otherwise can prevent potential impacts of disaster. Evidence from the scoping study showcases the diversity of challenges that disaster managers faced when translating warning into actions. The scoping study also highlights several opportunities that translating warning into action offered. These challenges and opportunities can be related, to some extent, to the way climate forecast and disaster risk reduction is conceived and implemented by humanitarian organization and scientific communities.

While many of the challenges as identified from the scoping study may appear overwhelming, the literature suggests that they are not insurmountable. Several literatures have documented successful applications of seasonal forecast for improved disaster risk management and risk reduction (See Braman et al., 2010; Tall et al., 2012). Clearly more needs to be done to advance understanding of the climate system and the likely impacts of changing climate and weather on people and communities on different timescales. However, promoting the uptake of climate information is not just about improving climate science; while the scientific community is continuing to advance the skill of forecasts across different timescales, many of the biggest constraints relate to issues of institutional factors; lack of funding, lack of organizational mandate and lack of organizational capacity, each act as concrete impediments to the uptake of climate information and have meaningful impact on decision making processes and early actions.

Reflecting on the early warning early action approach, such concept highlights an increased or decreased likelihood of a particular event occurring over the forecast period, empowering disaster managers to adapt and react accordingly to initiate preparedness activities during seasonal to extended range timescales as well as supporting the crucial shift to early actions in the short-range timescale. At seasonal scale, climate information seems to provide more like a steering function rather than directly influencing decisions made in response to, or anticipation of, more immediate risks. It is largely because the information at seasonal timescales is highly uncertain and, particularly in formats, harder to integrate into decision making process. Such climate information however, provides an opportunity to plan for action ahead of time so that the actions are implemented timely and correctly at a time when warnings are issued. Many of the disaster preparedness actions that can be taken based on increased risk of an extreme event require time to activate (White et al., 2017). Procurement of disaster response supplies can take several weeks and is often the reason that actual response time to a disaster can lag well behind the event itself (White et al., 2017). Hence, seasonal forecasts allow for such response materials to be pre-purchased and prepositioned in the at-risk location in advance of the actual event, allowing for more immediate responses during the time of event. Supplies needed for risk reduction actions, such as chlorine tablets for water purification, or sandbags to reinforce river banks, are subject to the same time constraints as the response materials (White et al., 2017).

Based on the observations regarding the findings, it is found that the challenges that emerge from this study overlap with those found in the literature on the uptake of long term climate forecasting predominantly associated with decadal and centennial timescales (see Jones et al., 2017). While this study focus more on seasonal forecast, it is found that these two domains draw on different kinds of climate information and are typically oriented toward different kinds of decisions making, but both appear to involve similar sets of fundamental issues. The issues include high uncertainty, lack of spatial and temporal specificity, lack of collaboration between forecast providers and forecast users and communication challenges. Furthermore, successful uptake of both climate information appears to be associated with the collaboration process that involve iterative communication between climate scientist and humanitarian decision makers, carefully tailored information and the willingness of both scientists and decision makers to move out of their institutional comfort zones (Jones et al., 2016). Most importantly, this suggests that actors seeking to promote more effective use of seasonal climate information may gain ideas substantially from drawing on the lessons learned in overcoming constraints to the uptake of long term information and same goes around.

In reflecting on the typology of the studies found within the review, it is clear that there is a strong skew within the peer-reviewed literature towards documenting early warning early action cases from African region. However, in terms of region of publication, most papers were published from developed country mainly UK and Europe. The paucity of cases being published from African region may reflect different factors; a weaker research capacity and fewer resources could be a barrier, resulting less likelihood for research to be carried out by developing countries.

While the result presented in this study has been developed from the priorities for research focusing on flood disasters, but the components identified in this study can also be relevant to other climate related hazards such as drought (see Bailey, 2013; Feeny, 2017) and can also be used as a guideline for implementing forecast based early action for those disasters. However, different hazards have differing rates of onset and differing impacts, different forecast skills as well as different challenges faced in their forecasting thus, preparedness action options would also vary accordingly. Therefore, depending on hazard, different design approaches should be used when implementing early warning early action strategies (Perez et al., 2015).

Finally, it is important to note that the results presented in this study are restricted to peer-reviewed literature, in English, and therefore, the study may have captured only a subset of available knowledge and literature. This study does not include grey literature however, there could be a body of grey literature that offers insights into the subject at hand. Including non-peer reviewed literature or grey literature into study, as well as comparison of the main findings of different types of publications, would be an interesting area for additional research.

6. LIMITATIONS

The study excludes grey literature representing a significant limitation as many substantial contributions could have come in the form of informal documents such as reports and articles. The study also excludes articles published in languages other than English and also those that are published before 2005. Likewise, exclusions have been made in those articles that focus on the uptake of climate information in, other than humanitarians or disaster management sector such as, agriculture planning and water management. While including this type of research could potentially be very useful, however, this was done to expedite the review process and to provide a more thorough and in-depth analysis of research that explicitly focuses on early warning early action approach in humanitarian sector.

The review may have missed some papers that address the use of climate forecast in humanitarian decision making, but it is unlikely to have resulted in the loss of important and relevant papers. The papers included in this paper have undergone a thorough selection process adopting a framework provided by Arksey & O'Malley (2005) and has used rigorous and transparent methods throughout the entire process. To ensure a broad search of the literature, the search strategy included electronic bibliographic databases called Scopus, and the snowball technique. Scopus is the largest database of peer-reviewed literature, multi-disciplinary and covers a wide range of research fields. The relevance screening and data characterization were revised as needed prior to implementation. Each article was reviewed thoroughly in order to ensure that the relevant articles are accounted for during the process. So, I am confident that most of the relevant articles have been included and challenges of missing literature have been addressed in a systematic way.

During the data extraction and analysis process, several papers have lacked sufficient details on the constraining factor in utilizing climate forecast in decision making process as well as on the strategies used in implementing early warning and early action process. Some papers also lacked information on the availability and reliability of data on climate forecast. Data was synthesized by identifying and categorizing the themes from the papers included in this review. Since some of the short-listed papers do not provide detailed information, there is a possibility that the extraction and analysis process may have resulted in some inaccuracies.

7. CONCLUSION

Drawing from the overall analysis of the literature, it can be concluded that there is a growing interest on using climate forecast to take early action and make utilization of short window of time between forecast and before a potential disaster. Likewise, scoping study showed a strong skew within the peer-reviewed literature towards documenting the early warning early action strategies in African region. This demonstrates the increasing recognition on the importance of utilizing short window of time to prevent potential impacts of disaster in the African region. This also indicates that the approach could be helpful in developing countries that lack enough resources to maintain a high level of preparedness for climate related disasters at all times.

The first research question: *What is known about the constraints and oppurtunities in implementing early warning early action approach in scientific literature* was answered through the in-depth analysis of articles from Group 1. As highlighted by the scoping study, nature of forecasts, poor communication, institutional barriers, low capacity to act on forecast, and lack of trust and credibility in forecast were identified as a constraining factors. Each of this constraining factor shows some degree of interconnectedness with one another. For instance, inherent uncertainty and probabilistic nature of forecast is often difficult to communicate with humanitarian actor whose on one wrong decision can make a huge difference. It is also one of the reason why humanitarian donors are reluctant towards funding for hazard that are likely but not certain. Likewise, "false alarm" in which the most likely forecasted scenario does not materialize can undermine trust of humanitarian actors on climate information. Considering the interconnectedness, it would be appropriate if the enabling factor to enhance the use of early warning early action approach, can address each constraining factor. For instance, collaboration between forecast producers and humanitarian actors can bring significant benefits and hence, can prove as an effective enabling factor. Two-way communication between the stakeholders helps to build trust, enhances humanitarian capacity to better understanding and use forecasts for decision making at different timescales and also promote co-production of knowledge (Jones et al., 2016).

The second research question: *What is known about the availability and reliability of climate forecasts useful to support humanitarian decision making* was also answered using in-depth analysis of articles from Group 1. Humanitarian decision making to undertake early action uses forecast ranging from seasonal timescales to short range timescales. Because actions must be taken before a potential disaster strikes, it is important that available forecast are confident, for which it is necessary that information are sourced from multiple forecast providers rather than a single one. In terms of forecast accuracy, study revealed that short range weather forecasts are more accurate and holds less uncertainty than seasonal forecast.

The third research question: *What characterize the decision situations humanitarian organizations face when choosing whether to undertake early action, and how can they use climate forecasts to select appropriate preventive actions* was answered by analyzing findings of above mentioned two research quesions and further in-depth analysis of the literature. Humanitarian decision that is taken could cover wide range of possible actions. These actions are "no regrets" actions; impact of implementing these actions might be negligible but potential benefits could be great (Dale et al., 2014; Dale et al., 2016). The review revealed that the decision to undertake these actions depend on several aspects; forecast at different timescales, the funding available to incentivize early action despite the risk of acting in vain, and the organizational protocol or guidelines specifying the action and responsible party to carry out action.

Overall, the review provide information that can be useful for humanitarian practitioners to understand the various constraints that may impact the use of early warning early action strategies, and restrict the use of climate forecast in humanitarian decision making. Moreover, the disaster managers can also benefit from the synthesized knowledge about strategies that are being undertaken to link early warning into early action. However, the strength of evidence found in the literature about the identified strategies is low. That is why it is difficult to offer any specific advice to practitioners solely based on this review. However, this review has identified several research challenges that need to be addressed in the future research efforts.

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9. APPENDIX

Appendix 1: Overview of articles in Group 1

Overview of the 20 articles from Group 1 analyzed in the in-depth analysis of the scoping study. '3': explicit reference and '2':implicit reference to the identified factors/information and 'N/A": not available or referenced in the articles

Title	Year	What paper says about EWEA approach?								Availability and reliability of forecast		Linking early warning with early action			
		Challenges					Opportunities								
		Nature of forecast	Institutional barriers	Poor communication of forecast	Low capacity of act on forecast	Trust and credibility	Early action funding	Partnership	Capacity building	Availability	Reliability	Timely and confident forecast	Appropriate early actions	Flexible funding mechanism	Organizational guidelines
Sectoral use of climate information in Europe: A synoptic overview	2017	3	N/A	2	2	3	N/A	2	N/A	3	2	N/A	N/A	N/A	N/A
Potential applications of subseasonal-to-seasonal (S2S) predictions	2017	3	N/A	3	N/A	N/A	N/A	3	N/A	3	2	3	3	N/A	N/A
New Approaches in Flood Forecasting and Warning - Risk-Based Decision Support with Probabilistic Forecasts	2016	3	N/A	N/A	N/A	N/A	N//A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A
Action-based flood forecasting for triggering humanitarian action	2016	3	3	N/A	N/A	N/A	3	3	2	3	2	3	3	3	3

Forecast-based financing: An approach for catalyzing humanitarian action based on extreme weather and climate forecasts	2015	3	3	N/A	3	N/A	3	3	3	3	3	3	3	3	3
Dealing with uncertainty: Integrating local and scientific knowledge of the climate and weather	2015	2	2	2	N/A	2	2	3	2	2	2	N/A	N/A	N/A	N/A
Using subseasonal-to-seasonal (S2S) extreme rainfall forecasts for extended-range flood prediction in Australia	2015	3	N/A	N/A	N/A	N/A	N/A	3	3	3	2	3	2	2	N/A
Climate forecasts in disaster management: Red Cross flood operations in West Africa, 2008	2013	3	3	3	3	N/A	3	3	3	3	3	3	3	3	2
Using seasonal climate forecasts to guide disaster management: The Red Cross experience during the 2008 West Africa floods	2012	3	3	3	3	3	3	3	3	3	3	3	3	3	2
Bridging the gap between end user needs and science capability: decision making under uncertainty	2012	3	N/A	3	N/A	N/A	N/A	3	2	2	2	2	N/A	2	N/A
Climate change adaptation: Integrating climate science into humanitarian work	2010	3	3	N/A	3	N/A	2	3	2	2	2	2	3	2	N/A

Hydrometeorology: Forecasting and applications	2010	2	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A
Probabilistic flood forecasting and decision-making: An innovative risk-based approach	2014	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	2	N/A	2	N/A	N/A
Actionable climate knowledge: From analysis to synthesis	2006	N/A	N/A	2	N/A	N/A	N/A	3	2	2	2	N/A	N/A	N/A	N/A
Climate forecasting to serve communities in West Africa	2010	N/A	3	3	N/A	N/A	3	3	3	3	2	3	3	3	N/A
Early warning, late response (again): The 2011 famine in Somalia	2012	N/A	2	3	N/A	N/A	2	N/A	N/A	3	3	3	N/A	2	2
When early warning is not enough-Lessons learned from the 2011 Somalia Famine	2012	N/A	2	3	N/A	N/A	2	N/A	N/A	3	3	3	N/A	2	2
International research institute for climate and society: Why, What, How	2014	N/A	N/A	N/A	N/A	N/A	N/A	3	2	N/A	N/A	N/A	2	N/A	N/A
Linking climate knowledge and decision: Humanitarian challenges	2009	3	3	3	3	3	2	3	2	2	2	2	3	2	2
Climate information for humanitarian agencies: some basic principles	2014	3	N/A	3	N/A	3	N/A	3	3	3	3	3	2	N/A	3