Forecast-based Financing for Extreme Flooding

Wrtg 316, Literature Review

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ABSTRACT

Forecast-based financing (Fbf) is a humanitarian aid system that seeks to change the paradigm of humanitarian aid from reactive crisis management to active risk management (German Red Cross, 2021). This is done by using scientific climate data from various climatological forecasting models to inform humanitarian and government actors of probabilistic climatological events that may occur. This literature review explores and analyzes the current research on Forecast-based financing as it relates to the use and reliability of global models, the significance of action lifetime in Fbf success, several components and methods of implementing Fbf, and the global challenges facing Fbf.

INTRODUCTION

The most common models in modern history for natural disaster risk reduction and humanitarian aid are long-term infrastructure improvement and post-disaster aid (Coughlan et al 895). This is understandable when one considers the historical lack of reliable forecasts for natural disasters like volcanic eruptions, earthquakes, Typhoons, Tsunamis, and heavy rain induced floods. We are still unable to reliably forecast such events as earthquakes, landslides, and other natural disasters. In recent years though scientific climatological forecasting on a global scale has improved such that we can now probabilistically forecast at several lead times the formation, path, and strength of tropical cyclones, as well as areas that are at increased risk of flooding, with regular skill (Coughlan et al 895). With these advances in forecast skill for tropical cyclones and heavy rain induced flooding, a new model for humanitarian aid has emerged that is known as Forecast-based financing (Fbf). Forecast-based financing is a humanitarian aid system that came about as a result of a 2011 initiative by the German Federal Foreign Office and the International Federation of Red Cross and Red Crescent (IFRC) to change the paradigm of humanitarian aid from reactive crisis management to active risk management. More specifically, Fbf is a system that enables access to humanitarian funding for predefined early actions based on forecast information and risk analysis (German Red Cross, 2021). This is done by using scientific climate data from various climatological forecasting models, such as the Global Flood Awareness System (GloFAS) and the European Centre for Medium-Range Weather Forecasts' (ECMWF) tropical typhoon forecast, to inform humanitarian and government actors of probabilistic climatological events that may occur.

The purpose of this literature review is to evaluate the role of global forecasting in Fbf, the role of action-lifetime in a successful Fbf program, several suggested methods to implement

Fbf programs, and some of the challenges and limitations of Fbf. Based on the literature review conducted, this paper will also suggest future areas of study that may help improve the Fbf approach to natural disasters.

GLOBAL FORECASTING IN FORECAST-BASED FINANCING

The success of a forecast-based financing system is dependent on a reliable forecast at a long enough lead time to implement the predefined actions. Identifying the proper time to act can be difficult because there is an inverse relationship between forecast certainty and lead time. For example, forecast systems like GloFAS' flood forecast and ECMWF's tropical cyclone forecast show the highest certainty of an event occurring at the shortest lead time and the lowest certainty of it occurring at the longest lead time (Bischiniotis et al. 1). However, even when a forecast shows a high certainty of an event occurring, this does not mean that it will occur. Before a forecasting model is used to inform decisions that may be fiscally expensive, or have high man-hour requirements, the model needs to be verified against actual occurrence data to determine the model's fidelity to reality. Currently, GloFAS flood risk forecasts have yet to be verified for most basins across the world (MacLeod et al. 276).

In addition to this, many developing countries that are the most susceptible to tropical cyclones and extreme flooding don't have the infrastructure to collect in situ data to verify GloFAS' flood forecast. For those countries that do have in situ data and that have compared their results against the GloFAS forecast results, GloFAS exhibited varying levels of accuracy. For example, one article that evaluated the effectiveness of emergency flood bulletins that were issued in Mozambique during cyclones Idai and Kenneth concluded that GloFAS successfully identified the districts in Mozambique that were at the greatest risk of flooding (Emerton et al.

8). Another article that sought to verify forecasts of extreme rainfall, tropical cyclones, and flood and storm surge in Myanmar and the Philippines concluded that GloFAS flood forecast was unreliable for simulating floods with a 1 in 2-year return period or higher. According to the authors' analysis, GloFAS correctly forecasted floods that had a 2-year return period or higher at a rate of 35% and had a false alarm rate of 65% (Macleod et al. 1). This same study also concluded that ECMWF's tropical cyclone forecast is highly reliable and only slightly overconfident (Macleod et al. 1). What these studies may indicate is that GloFAS' flood forecast performs better when the source of the rain is a tropical cyclone rather than from a typical rainstorm. This may be the case because as MacLeod et al. concluded in his paper, ECMWF's tropical cyclone forecast is highly reliable. More research in this area is needed to determine if GloFAS flood forecasts are generally reliable in identifying areas that are the most susceptible to floods that result from cyclone induced rains.

Despite the imperfections of global models that forecast flooding, such as GloFAS, several authors agreed that global models could still be used in Fbf programs to inform humanitarian actions (Coughlan et al. 6, Jiemba et al. 241). If, for example, the reliability of a forecast is low then humanitarian and government actors could implement an action plan that is neither labor intensive nor monetarily expensive to reduce the cost of potentially acting in vain. To paraphrase Coughlan et al., humanitarian actors can't afford to wait until flood forecasting models are more reliable before they act to help those vulnerable to such disasters. They have to do so now with the resources available to them, and although they are imperfect global flood forecasting models can still be valuable in informing decision makers of potential risks.

When Actions are triggered due to a probabilistic forecasted flood, there is a chance that the action taken will not be followed by an event. This would be considered an action taken in vain. One of the main reasons for the current lack of preventative action by humanitarian actors and government organizations is their uncomfortableness with possibly acting in vain (Bischiniotis et al. 11). One way to reduce this risk of acting in vain is to implement actions that have long lasting benefits.

Because flood events typically happen in a region during a short season, actions taken that have longer lasting benefits can help reduce the risk of acting in vain (Bischiniotis et al. 11). One study that evaluated early action mechanisms in Peru for El Niño shows the effectiveness of actions with a long lifetime in reducing economic losses from acting in vain. In this pilot Fbf initiative, actions were triggered in 2016 to prepare preselected homes for flood and heavy rainfall that were forecasted as a result of El Niño Southern Oscillation (ENSO). Upon the triggering of these humanitarian actions, the preselected homes were given a protection kit for reinforcing their home's roof and other structural elements of their homes. These protection kits had an estimated action lifetime of about one year. This long action lifetime was necessary in avoiding economic losses from acting in vain because the coastal El Niño event did not occur until almost a year after the initial warning was issued (Aguirre et al. 505). When the ENSO event did occur in 2017 the homes that received protection kits were 63-66% less damaged than similar homes that did not receive the kits. Although this example shows that humanitarian actions that have a long lifetime have a higher probability of providing the desired protection to

the vulnerable, it also is an extreme example of action lifetime and may be subject to criticism. The criticism of this example is that if the success of an Fbf program is dependent on whether its actions were successful in protecting against the disaster, then actions with a long lifetime may mask some of the imperfections of the forecasting model and create a false sense of reliability. Until global forecasts become more reliable though, Fbf programs that have actions with a long lifetime will have a higher probability of adding value than those with shorter action lifetimes.

METHODS TO IMPLEMENT FORECAST-BASED FINANCING

From the reviewed articles in this literature review, there were no competing claims about how to implement forecast-based financing. Most of the sources seemed to explicitly agree on the necessary components of Fbf (Hagen et al. 1, Jiemba et al. 238, Coughlan et al. 3551), and one source seemed to assume the necessity of these components within a two-stage early warning early action system (EWEAS) (Bischiniotis et al. 11).

NECESSARY COMPONENTS OF FORECAST-BASED FINANCING

Several authors used differing descriptive terms but seemed to agree that Forecast-based financing consists of three primary components: 1) flood forecast model triggers that are triggered when a certain probability threshold of an event is reached, 2) financial mechanisms that secure and release pre-allocated funds once a trigger is activated, and 3) standard operating procedures (SOPs) that designate who, how, and when to act when a warning is triggered (Hagen et al. 1, Jiemba et al. 238, Coughlan et al. 3551). In general, these components offer a good description of the requirements for a successful Fbf program. One thing that should be added to this list, but is taken for granted in the current list, is a reliable forecasting model.

1. FLOOD FORECAST MODEL TRIGGERS

In choosing probability thresholds to trigger actions, Coughlan et al. noted that the stakeholders in the Uganda Red Cross had difficulty deciding on an acceptable false alarm ratio (FAR) for the system. They choose an acceptable FAR of 50%. Coughlan et al. observed that there is other research that suggests that when people choose a 50 % probability, it is an expression of their not being sure as to the answer (Coughlan et al. 3557). Coughlan et al. also noted that further research into decision science could improve how actors come to this decision (Coughlan et al. 3557). As much as research into decision science could help actors decide on acceptable thresholds, it seems that the main issue of choosing appropriate threshold triggers could be solved by giving decision makers relevant data for their decision. This data would be things like community survey results that indicate the false alarm ratio that the community would tolerate before losing confidence in the system; an array of potential economic losses at various probability thresholds, as well as the number of man-hours that may be in vain at various probability thresholds. The decision of what probability thresholds should trigger actions seems to be more of a data optimization problem rather than a subjective choice of actors.

2. FINANCIAL MECHANISMS

Having financial mechanisms in place that secure and release pre-allocated funds is a key element in reducing the cost of humanitarian aid. As mentioned earlier, one of the main reasons for lack of preventative humanitarian actions is actor's aversion to spending time and money on actions that may be in vain (Bischiniotis et al. 11). However, in the article *an approach for catalyzing humanitarian action based on extreme weather and climate forecasts* the authors note that the cumulative cost savings or losses will depend on many factors such as the hit rate of the climate forecast at the trigger thresholds and the cost of implementing the actions. Through an

analysis of these and other factors though, humanitarian and government actors should be able to implement a plan that results in significant cost savings over time.

3. STANDARD OPERATING PROCEDURES

Standard operating procedures are also critical for the success of a Fbf program. Currently many disaster warnings go unheeded in developing countries due to a lack of standard action plans (Coughlan et al. 902). Standard operating procedures are necessary so that no individual or group will be blamed for losses when action is taken in vain (*Forecast-based financing: Climate science and timely funding of early actions in an anticipatory humanitarian system).* Standard operating procedures may be the most important component of forecast-based financing because it is "where the rubber meets the road". Forecasts and all other plans are useless in humanitarian aid unless the actions are taken, and SOPs are the mechanism that guide actions.

TWO-STAGE EARLY WARNING EARLY ACTION SYSTEM

The two-stage early warning early action system (EWEAS) is a methodology that can be applied to Forecast-based financing to increase disaster preparedness and reduce economic losses from acting in vain. The concept of two-stage EWEAS is that there are two stages for action: the first stage where preliminary action is triggered by a low-certainty forecast at a long lead time, and a main action that may be triggered later by a high-certainty forecast at a short lead time (Bischiniotis et al. 11). The benefit of this two-stage system is that by taking low-cost preparatory action at a longer lead time, the expensive actions can be postponed until event certainty is higher. This can be seen in the study where the authors ran an eight-year GloFAS simulation on two rivers in Akokoro Uganda and compared the relative economic value of

one-stage and two-stage EWEAS responses to simulated events. The results of the study showed that the two-stage EWEAS is consistently more cost-effective than the one-stage EWEAS (Bischiniotis et al. 10).

This two-stage EWEAS is an effective approach to use in most Forecast-based financing programs. Even if the preliminary action is to warn the at-risk communities of the potential danger, this seems more effective than taking a single action when a threshold is reached. One thing to be aware of though when implementing low-cost preliminary actions is how they will be received by the at-risk communities. If preliminary actions are taken at a frequency that makes false alarms common, the community may start to disregard such actions, therefore causing more harm than good.

CHALLENGES TO FORECAST-BASED FINANCING

Some of the challenges to wide-spread use of Forecast-based Financing are the imperfections of the Global forecast, determining the acceptable threshold triggers, and institutional capacity and mandate.

IMPERFECTIONS OF THE GLOBAL FORECAST

Forecasting is the engine of Forecast-based financing. Without a reliable forecast, humanitarian actors cannot take preventative action for tropical cyclones or extreme flooding. The GloFAS flood forecast is unreliable in forecasting 2-year or greater return period floods in Myanmar and the Philippines, and likely elsewhere too (Macleod et al. 1). Another article noted that GloFAS flood forecast has yet to be verified or calibrated for most basins across the world (MacLeod et al. 276). The challenge then with using global forecasts, like GloFAS, is that before it can be used in Fbf, the model needs to be calibrated for the specific region. Although there are

less accurate methods to calibrate the model in the absence of measured data, typically an effective model calibration requires in situ historical data, which many developing countries don't have.

Further research into the development of methods to verify and calibrate global models, like GloFAS, in the absence of measured in situ data would help make Fbf feasible in more areas across the globe.

DETERMINING THE ACCEPTABLE THRESHOLD TRIGGERS

Determining thresholds to trigger actions is challenging because a system that systematically underestimates the occurrence of an event will be criticized by the community as unreliable when it was needed the most. On the other hand, a system that systematically overestimates the occurrence of an event will lose the trust of the community due to false alarms (Bischiniotis et al. 2). Losing the trust of the community is less likely to occur though when the expectations of the community are less. For example, a community will be much less inconvenienced by a recommendation to store extra water than they would by an evacuation order. If they were evacuated and the event didn't occur, then the community would be less likely the next time to obey the evacuation order. This can be seen in a study in which the Uganda Red Cross Society eliminated evacuation as one of their potential actions because one-fourth of the respondents said that they were unwilling to evacuate a community in vain because of the lost trust that would occur (Coughlan et al. 3551). Educating the community about the preventative initiative and informing them of the nature of probabilistic forecasts—that just because an event is likely to happen does not mean that it will happen—can help maintain their trust in the system.

Further research into maintaining community trust in spite of false alarms could help humanitarian and government decision makers know what trigger thresholds to choose for implementing actions.

INSTITUTIONAL CAPACITY AND MANDATE

Even if a forecast is perfectly able to predict a future flood or cyclone hit, a Forecast-based financing program will fail unless the institutions involved in the implementation have the capacity and proper organization to implement the plan (Emerton et al. 14). In order to implement the predefined actions of an Fbf program, humanitarian and government institutions need a sufficiently large and competent labor force to implement the predefined actions within the window of opportunity. This organizational structure and establishment of standard operating procedures are critical for the success of an Fbf program. Without sufficient institutional capacity and the mandates to act, the best planning will be useless.

CONCLUSION

A reliable global forecast is necessary for the success of a Forecast-based financing program. Although the reliability of ECMWF's global cyclone forecasts is highly reliable according to one study (Macleod et al. 1), the reliability of GloFAS' flood forecast is inconclusive. More research in this area is needed to determine if GloFAS flood forecasts are generally reliable in identifying areas that are the most susceptible to floods that result from cyclone induced rains.

Taking preventative actions that have a long action lifetime (long lasting benefits) will reduce the economic losses due to acting in vain (Bischiniotis et al. 11). If an action has too long of a lifetime though, it throws the general reliability of Fbf into question.

Regarding methods of implementing Forecast-based financing, most sources seemed to agree that there are three main components of Fbf: 1) flood forecast model triggers that are activated a certain probability thresholds 2) financial mechanisms that secure and release pre-allocated funds once a trigger is activated, and 3) standard operating procedures (SOPs) that designate who, how, and when to act when a warning is triggered (Hagen et al. 1, Jiemba et al. 238, Coughlan et al. 3551). Although it was suggested that further research into decision science could improve how actors decide on trigger thresholds (Coughlan et al. 3557), it seems that the issue of choosing proper probability thresholds to trigger actions is a data optimization problem and not an issue of lack of skill by the decision makers.

Regarding the two-stage Fbf approach, decision makers should be aware that If preliminary actions are taken at a frequency that makes false alarms common, the community may start to disregard such actions, therefore causing more harm than good.

Further research into the development of methods to verify and calibrate global models, like GloFAS, in the absence of local measured data would help make Fbf feasible in more areas across the globe. When it comes to maintaining community trust, educating the community about the preventative initiative and informing them of the nature of probabilistic forecasts—that just because an event is likely to happen does not mean that it will happen—can help maintain their trust in the system. Further research could also be done in maintaining community trust in spite of false alarms could help humanitarian and government decision makers know what trigger thresholds to choose for implementing actions.

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