Assessing Monitoring and Early Warning Systems for Food Security Risk

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Abstract:

For the last 40 years, international organizations have invested into early warning systems (EWSs) for food crises. Despite today's era of digitalization and big data, current EWSs fall short of informing at-risk populations about food crises. To understand how the dimensions of vulnerability and hazard determine food security risk, we first develop a framework of an optimal EWS based on UNISDR's people-centred EWS. Second, we analyze the main international EWSs for food security risk, i.e. the Integrated Phase Classification, the Famine Early Warning System Network, the Vulnerability Assessment and Mapping, and the Global Information Early Warning System with regard to their information content, monitoring characteristics and communication strategies, and link these to their response capacity. We show that EWS monitor a variety of indicators, covering the availability and accessibility components of food security. Even though EWSs could expand their country coverage and spatial detail, we find that information on accessibility indicators is missing for multiple countries, particularly for those involved in complex emergencies. Furthermore, none of the EWS examined provide real-time information, as they fail to integrate communication technologies and the internet as source for bottom-up information and communities at risk, both as an information source and recipient of warnings.

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1 Introduction

As of March 2017, 108 million people globally are at risk of being affected by a food crisis (FSIN 2017), while four countries - Yemen, Somalia, South Sudan and Nigeria - are at risk of famine. Over the coming six months, 70 million people in 45 countries are estimated to be in need of food assistance (FEWS NET 2017). In addition to these developments, the last decade witnessed a global food price crisis in 2007/08 (Kalkuhl, von Braun, and Torero 2016) and a famine in Somalia in 2011 (Hillbruner and Moloney 2012). Table 1 shows the four hazards types that have the largest impact in Africa. Drought, as one of the major contributors to food insecurity, affects by far the largest number of people and ranks as the third deadliest natural hazard.

Table 1. Hazard types and their contribution to affected people and deaths in Africa, 2000-2017.

Hazard Type	Percentage of Affected People[1]	Percentage of Deaths
Drought	77.5	18.4
Riverine Flood	13.5	8.5
Bacterial Disease	0.6	38.2
Viral Disease	0.4	22.2

Source: Data from Centre for Research on Epidemiology of Disasters at http://emdat.be/emdat_db/, accessed May, 2017.

In a crisis scenario, timely, detailed and reliable information plays an essential role in decision making. Immediate action is crucial to save lives and livelihoods at risk (Buchanan-Smith and Davies 1995; Davies and Gurr 1998). The need for better information on food security risks, however, has long been recognized by the global community: already the Sahel crisis in the 1970s triggered the development of a variety of famine early warning systems, with the objective of better information provision (Wisner et al. 2004). Current developments come, hence, against the background of more than 40 years of investment in the development and improvement of EWSs (early warning systems) for food crises, including early action initiatives and humanitarian response mechanisms.

Monitoring systems for food security risks have been associated with a range of limitations regarding *inter alia* their scope (Devereux 2001), disconnection from the response capacity (Buchanan-Smith and Davies 1995) and, partially, insufficient performance (Ververs 2012). In developing countries also data itself, as the main input of EWSs, have constraints: High frequency information is difficult to obtain, official statistics are published with a considerable time lag, and lack the necessary spatial detail for precise monitoring and early warning (Carrière-Swallow and Labbé 2013; Dubey and Gennari 2015).

Due to these challenges, increasing adoption rates of information and communication technologies (ICTs) and the internet hold promising prospects particularly for developing countries and early warning initiatives, as they have paved the way for the integration of innovative data sources into

[1] Affected people refers to “people requiring immediate assistance during a period of emergency” (CRED 2017, Glossary).

food security monitoring (Morrow et al. 2016). Big data, *inter alia*, holds the potential of being available in near real-time and of providing bottom-up information, i.e. information from the at-risk population itself or people on the ground, which would be a step in the direction of a participatory approach and the democratization of information. A factor which has largely been ignored by early warning systems thus far (Buchanan-Smith and Davies 1995; Kelly 2003; Twigg 2003a).

The objective of this paper is threefold: we add to the literature by developing a theoretical framework of an efficient monitoring system for food security risk, by providing the first comprehensive overview of early warning and monitoring systems for food security risk that analyzes a holistic set of system components, and by comparing the existing systems to each other and the conceptual benchmark. We base our analysis on four major international monitoring and early warning systems for food security risks: the Integrated Food Security Phase Classification (IPC), the Famine Early Warning System Network (FEWS NET), Vulnerability Analysis and Mapping (VAM), the Global Information and Early Warning System (GIEWS). These four systems were chosen due to their large geographical coverage and because they publish their own analyses and early warning information. All monitoring systems engage to varying degrees in information pooling, which enables the maximum dissemination of available information. Systems that are largely based on the collection and dissemination of existing reports are not considered in this study.

This paper is structured as follows: In section 2, we engage in a literature review that enables us to identify long-standing problems associated with EWSs for food security risk. In section 3, we develop a theoretical framework for an efficient early warning system for food security risk, by combining the official United Nations framework for EWS for disaster risk reduction with drivers of food insecurity. In section 4, we compare the systems to each other with respect to their information content and monitoring characteristics. In chapter 5, we discuss our findings in relation to the previously developed theoretical framework of an efficient early warning system. We summarize our findings and give an outlook for future research in chapter 6.

2 Literature Review

The literature shows multiple long-standing problems associated with EWSs. These are (1) a focus on the availability component of food security and a lack of information on accessibility of food, (2) a lack of spatial disaggregation, timeliness and comprehensive geographical coverage of indicators, (3) a lack of participation of the affected population itself, both as information source and recipient of early warning information and (4) a disconnection between early warning information and response capacity.

Most EWSs for food crises focus on production forecasts and the monitoring of droughts, hence, on the availability component of food security. Wisner et al. (2004) and Devereux (2001) criticize famine EWSs for being supply side focused and, hence, for not covering the access and utilization criterion of food security. Data availability and quality plays an essential role for the functioning of monitoring systems (Brown 2008). The information and indicators that are being published, as well as the underlying data which are being collected, are associated with multiple problems regarding their spatial unit, frequency and comprehensiveness. Buchanan-Smith and Davies (1995) argue that multi-level and localized indicators are necessary to detect risks to food security at the early stages of development, to issue a timely response, and to monitor how food insecurity processes develop within different parts of a society. High frequency information, however, is still missing in many developing countries, official statistics are published with a considerable time lag, and lack the necessary spatial detail for precise monitoring and early warning (Carrière-Swallow and Labbé 2013; Dubey and Gennari 2015). Further, data collection is at risk of breaking down in periods of emergency and crisis (Bauer, Mouillez, and Husain 2015). In addition, an up-to-date and comprehensive global picture of the food security situation is still unavailable, due to the incomplete geographical coverage of data on food security (FSIN 2017).

The literature also discusses the role of affected local communities in EWSs, regarding their representation as a bottom-up information source (see Buchanan-Smith and Davies 1995; Twigg 2003; Kelly 2003; Basher 2006). Affected local communities are rarely included as an information source for risks, risk perception and coping strategies. EWSs are typically expert-led, top-down monitoring systems (Twigg 2003b). There are, however, strong arguments in favor of the inclusion of bottom-up information: Twigg (2003b, p.20) argues that perceptions of risks are very different from the perspective of a community and individuals, compared to the perception of experts. Hence, individuals at-risk hold valuable information that could improve the functioning of EWSs. These shortcomings have consequences for the outcomes of monitoring systems, as they are not able to pinpoint which part of a population will be at risk of having limited access to food, due to their position within a society.

The typical recipients of early warning information are actors and decision makers. The creation of an effective EWS, however, requires timely, non-technical and understandable warnings that can also be communicated to communities at risk, most of which are not usually included in communication strategies (Twigg 2003b). Basher (2006) identifies communication as one of the typical points for failure of EWSs. Kelly (2003) further argues that effective early warning comprises more than mere warning; it ideally offers potential strategies to communities on how to cope with the situation itself, e.g. providing information on feeding centers and employment options.

Throughout the 90s, a line of thinking emerged that more precise and better information is crucial for the prevention and tackling of famines (Buchanan-Smith and Davies 1995). Many resources have been invested in the development of EWSs and in making famines predictable. This progress in EWSs, however, has not been equally followed by improvements in humanitarian response (Devereux 2001; Bailey 2012). Buchanan-Smith and Davies (1995) extensively discuss the missing connection between early warning information and humanitarian response. Also Basher (2006) identifies the response capacity as one typical point of failure of EWSs. This highlights the importance of systematically communicating early warning outcomes and having strong ties to the response capacity.

Different case studies already addressed one problematic component in the design of EWS: their performance. Hillbruner and Moloney (2012) as well as Ververs (2012) analyze the capacity of various systems to issue warnings in the context of the Somalian famine of 2011 – with mixed results. Both studies construct an *ex-post* timeline of events and warnings. Hillbruner and Molony (2012) find that during the 2011 famine in Somalia, both FEWS NET and the Food Security and Nutrition Analysis Unit for Somalia (FSNAU) issued timely and accurate warnings to decision makers. They identify a late emergency response as a key driver to a deteriorating situation. Also Ververs (2012) finds that FEWS NET and FSNAU issued timely warning during the 2011/12 food crisis in East Africa; three others analyzed EWS, however, failed to do so, because their reporting frequency is not sufficiently high enough for forecasts to be on time. Both studies focus, however, on a singular event and do not provide a comprehensive analysis of EWSs components, indicators and outputs.

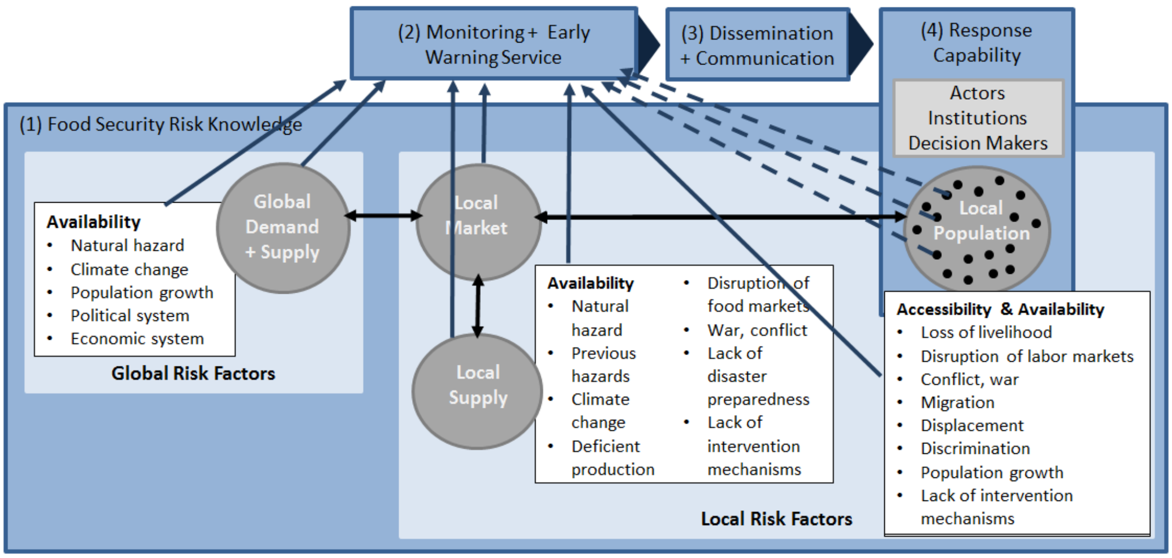
One factor is the development and adoption of ICTs and the opportunities that this development holds to overcome the above discussed data limitations and to engage in the (near-) real time monitoring of the food security situation. The potential of big data and increasing adoption rates of mobile phones (including smartphones) for food security monitoring, particularly in developing countries, as means to reach hard-to-access areas and to gather bottom-up information, has entered the discussion over the last years (see Bauer, Mouillez, and Husain 2015; Morrow et al. 2016; Meier 2015). There is, however, a lack of literature that analyzes EWSs in light of technological innovations and that assesses the progress of EWSs in adopting innovative data sources for their monitoring purposes.

This review shows that the largest share of literature that systematically deals with early warning information has been published in the 90s and 2000s and, hence, does not provide an updated assessment of EWSs, also with respect to recent technical innovations; while the more current studies focus only on one component in the design of EWSs, i.e. the performance. This review shows that there are multiple issues associated with the different elements of monitoring systems. Most analyses, however, focus on one aspect of EWS or on the performance of EWS, in consequence they conclude with hypotheses about the shortcomings in the design of EWS. This indicates that a holistic approach and perspective is required to assess the complete early warning cycle, from data collection and analyses, to the communication of information to decision makers and communities, to the provision of coping strategies and the coordination of the response capacity.

3 A Theoretical Framework for an Efficient Early Warning System for Food Security Risks

The purpose of EWSs for food security risks is to inform about emerging food scarcities and to prevent a potential food crisis. An efficient system manages to gather information across a variety of drivers that are linked to people's vulnerability and to natural hazards, to use this information in meaningful models, to translate this information into warnings and to communicate its analysis to individuals at risk and responsible institutions (Basher 2006; Brown 2008, Twigg 2003a). According to the UN, EWSs aim to: "empower individuals and communities threatened by hazards to act in sufficient time and in an appropriate manner so as to reduce the possibility of personal injury, loss of life, damage to property and the environment and loss of livelihood" (UNISDR 2006, p. 2). Figure 1 shows the adapted UN framework for early warning systems for the case of food security risk. It stands on four pillars: (1) risk knowledge, (2) monitoring and warning, (3) dissemination and communication and (4) response capability (UNISDR 2006; Basher 2006).

Figure 1. Elements of an Early Warning System for Food Security Risks.



Note: Solid arrows: information flow; dashed arrows: bottom-up information flow.
Source: Own development, based on UNISDR (2006) and Basher (2006).

The first pillar, risk knowledge, deals with the systematic conceptualization of drivers of food security risk. We adopt the framework of determinants of famine as developed by von Braun, Teklu, and Webb (1998) and map them into our network of risk drivers. Risk knowledge can be separated into global and local risk factors. Local risk comprises socio-economic, political and institutional factors. For instance, the state of the agricultural production at a given area and time has to be monitored, as well as governance capacity, or existence and management of emergency stocks. In parallel, global risk factors have to be identified, due to the ever increasing integration of agricultural markets. Events on international markets can have strong (adverse) effects on the food security situation. For example, extreme price surges on international commodity markets during the 2007/08 food crisis had strong negative impacts in many developing countries (Kalkuhl, von Braun, and Torero 2016). Risk factors can be associated with the availability and accessibility pillars of food security. The factors discussed so far relate to the supply side and hence affect the availability of food. Also the demand side, i.e. the population itself, is associated with risk factors regarding the accessibility of food. Here, disruptions in labor markets and loss of livelihood can determine capacities of individuals to buy food. Also political aspects, like conflict, displacement and the position of individuals within a society, e.g. discrimination against gender and ethnicity, or the extreme case of starvation as measure of "ethnical cleansing" impact accessibility of food (Wisner et al. 2004).

The second pillar, the monitoring system, collects and processes data on a comprehensive set of risk factors and their proxies, e.g. weather, market prices and livelihood coping strategy indices (see solid arrows in Figure 2). Usually, EWS engage in top-down monitoring of secondary data. The risk factors and there weighting should vary across regions, as, e.g., migratory pressures are of varying importance across countries. The monitoring entity needs to define transparent thresholds for different crisis scenarios, and use this to decide on how, when and with which frequency potential warnings and updated information should be issued and disseminated.

The first and second pillars are connected by an information flow (see arrows in Figure 1). As a complex web of factors drives food security risks, their monitoring requires information with specific characteristics. We argue that fast and spatially dis-aggregated information is an essential input into EWSs. Drought, which is one driver of food security risk, is typically a slow-onset disaster, which has become rather predictable, due to the wide availability of remotely sensed weather and vegetation monitoring (Source). The majority of food crises in Africa, however, have been caused by complex emergencies (von Braun, Teklu, and Webb 1998). War, civil unrest and riots can involve and trigger a chain of events. The monitoring of volatile situations and rapidly changing environments requires timely, near real-time and geographically detailed information on the events, emerging pressures and the population at risk. This is a prerequisite for the identification of food insecurity (also localized events of food insecurity) at an early stage of development.

Our framework explicitly includes the local population as bottom-up information source (dashed arrows). With increasing ICT adoption rates being experienced in developing countries (World Bank Group 2016), the possibilities of including the population at risk as an information source is becoming more available. Bottom-up information, i.e. information provided from the population itself or representatives of the population, has been gaining importance in the realm of food security monitoring. Bottom-up information is of particular interest for food security monitoring due to a variety of reasons: (1) an effective EWS gathers information on a range of risk factors, this explicitly includes information on the vulnerability associated with the population at risk. Information on accessibility of food and sensitive topics, like discrimination within societies, is usually not easily obtained on a continuous basis. (2) Official statistics lack transparency and food security is still a politically sensitive topic. (3) In emergency scenarios, official data collection initiatives tend to break down, leading to a lack of information about the situation at hand. This was, e.g., the case during the 2014 Ebola outbreak in West Africa (Bauer, Mouillez, and Husain 2015). Including the population has the potential to overcome the limitations mentioned above, as well as it enables people to communicate directly about current developments and their environment. Bottom-up information is possibly available in a timely fashion, at a faster pace than traditional surveys and at a high spatial resolution. Furthermore, institutional decision making requires information to be convincing and reliable. We hypothesize that bottom-up information has the potential to put actors under pressure and, hence, to potentially trigger an earlier response or to impede the development of a full-scale food crisis

The third pillar, dissemination and communication, distributes early warning information to actors, decision makers and the population at risk. In a people-centered EWS, the at-risk population plays an essential role in receiving early warning information. Availability, accessibility and understandability of information are essential for fast decision making. Therefore, information dissemination strategies and access to the most up-to-date information are important aspects when assessing EWSs. The recipients of information, however, are diverse and have, presumably, different information needs, regarding the content and the timing of messages as well as the communication channels that are being used. For example, while humanitarian actors require detailed information on the cause, the location, the number of affected people and the severity of a crisis to coordinate their intervention efforts, the population at risk needs to be informed when and how they will be affected and how to cope with the situation at hand. This also holds for the timing of information: Humanitarian actors and affected people need the information as soon as possible, and the information on affected people and coping strategies would need to be continuously adapted to a changing environment. This shows that each recipient of early warning information has specific communication and information needs, which would, in an efficient early warning system, be incorporated into an effective and well-developed communication strategy.

The fourth pillar reflects the response capability, comprising the population at risk, actors, institutions and decision makers. The provided information enables responders to manage the situation at hand, take action and to reduce risks for the affected people at the crisis start, throughout the event, and in its aftermath. A people-centered EWS explicitly considers the population at risk as a part of the response capability. This enables individuals to undertake timely and appropriate responses, as well as pursue coping strategies to minimize their exposure to risk, thus increasing their resilience. This could be facilitated by, as stated previously, explicitly communicating up-to-date information about the event itself as well as potential coping strategies, for example, where to find support structures. This is particularly important due to the weak link between EWSs and the response capacity. As mentioned, there is a lack of knowledge on whether early warning information is able to trigger a response (see Hillbruner and Moloney 2012; Ververs 2012), and, if a response is triggered, how fast this response takes place after the original receipt of the early warning information.

4 Empirical Strategy and Data

Based on the theoretical framework for an efficient EWS for food security risks developed above, we evaluate the selected EWS and their reports according to the four elements of a people-centered EWS. These are:

(1) Risk Knowledge
   i. Global and local food security risk factors that are being monitored
(2) Monitoring service
   i. Classification of information
   ii. Spatial unit of analysis
   iii. Number of countries covered
   iv. Top-down, bottom-up information
   v. Ex-post, real time analysis or forecasting
   vi. Frequency of analyses
(3) Dissemination and communication

    i. How and what kind of information is communicated
    ii. Who are the main recipients

(4) Response capacity

    i. Direct link to the response capacity (humanitarian actors, decision makers, population at risk).

Based on those aspects, we engage in a systematic comparison of EWSs according to risk knowledge, monitoring service, dissemination and communication as well as the link to the response capacity.

Our theoretical framework shows the importance of information and its characteristics within early warning processes, as well as the importance of reliable information for decision making in emergency situations. Therefore, we subsequently analyze the reporting frequency, reliability and spatial coverage of reports. Based on the comparison in step 1, we select in a second step the report of each EWS that covers the most comprehensive set of risk factors to assess the availability of information for two time horizons, a long term period of eight months and a short term period of one month. The objective is to understand what information is *de facto* being provided and updated in a timely manner and to identify the countries, for which no information is available.

We base our analysis on four major and international monitoring and early warning systems for food security risks: IPC, FEWS NET, VAM, and GIEWS. These four systems were chosen due to their large geographical coverage and because they publish their own data, analyses and early warning information. We focus our analysis on reports that are updated on a continuous basis with the aim to provide information on the current situation. Hence, baseline studies are excluded from the analysis. Table 2 provides an overview over the reports that are included in the analysis. The number of reports varies across EWSs, according to availability. The analysis covers a total of 15 reports.

Table 2. Overview over analyzed EWS and reports.

EWS	Report / Tool	Source
IPC	Acute Food Insecurity Situation Overview	http://www.ipcinfo.org/
FEWS NET	Integrated Food Security Analysis Price Bulletin Global Price Watch Food Assistance Outlook Brief Global Weather Hazards	http://www.fews.net/
VAM	Agro-Climatic Monitoring Market Watch Market Monitor Mobile VAM	http://vam.wfp.org/
GIEWS	Country Briefs Food Price Monitoring and Analysis Earth Observation Crop Prospects and Food Situation Food Outlook	http://www.fao.org/giews

Source: Own compilation.

5 Comparison between Systems and to Theory

In this section, we compare the four analyzed EWSs, and the information they provide, to each other and to the theoretical benchmark. We start with a systematic comparison of risk knowledge and monitoring characteristics which is followed by reliability tests of frequency and spatial coverage

5.1 Risk Knowledge and Monitoring Characteristics

Table 3 gives an overview of the four analyzed EWSs, i.e. IPC, FEWS NET, VAM and GIEWS, and shows which local and global risk factors are monitored along with their monitoring characteristics. From a risk knowledge perspective, the monitoring systems cover a range of global and local indicators, such as agricultural prices, weather, vegetation, livestock and livelihood indicators as well as migration flows and the political situation. Six out of fifteen analyzed reports provide information on a holistic set of risk factors, covering both availability and access indicators and the political situation, while the nine remaining reports have a more narrow scope, covering mostly prices and supply (six reports) as well as agro-climatic conditions (three reports). FEWS NET and IPC cover the most holistic set of global and local risk factors, providing information on a range of indicators that serve as proxy for both the availability and accessibility component of food security, followed by GIEWS and VAM. In particular FEWS NET publishes the largest number of reports (five) that provide information on a variety of risk indicators. Five reports estimate the number of people at risk, and three reports list the number of counties requiring emergency assistance. IPC and FEWS NET include mortality rates, and three reports contain information on internally displaced people (IDPs) and refugee flows.

We find that ten of the analyzed reports and tools engage in *ex-post* reporting, while five engage in forecasting. Three out of these five reports are published by FEWS NET, which, according to this overview, has an above average forecasting capacity and output. All EWSs still engage exclusively in the top-down monitoring of events. The only system that is moving into the direction of actively integrating bottom-up information is WFP's mVAM initiative.

Our analysis further shows that six of the reports exclusively provide information that is at the sub-country level and, thus, spatially dis-aggregated, two reports provide information on a national level and five reports mix global, regional, national and sub-national information. The number of countries that are covered and the frequency in which reports are published varies highly across EWS and reports. The country coverage is particularly high in the case of agro-climatic monitoring, which is provided by FEWS NET, VAM and GIEWS with near-global coverage. This is due to the wide availability of remotely sensed weather and vegetation data. When it comes to the monitoring of a more varied set of indicators, GIEWS still provides quarterly information for *de facto* 81 countries and on a variety of risk factors. The number of countries monitored, however, drops significantly for the remaining, more frequent reports. VAM still covers 78 countries through its monthly market watch, exclusively focusing on food prices. With regards to accessibility and livelihood indicators, the number of countries reduces substantially to thirty or less. IPC, for example, publishes reports for 15 countries, while FEWS NET provides different reports with information for 30 countries.

Regarding the frequency of reports, FEWS NET achieves the maximum velocity with its weekly weather forecasts. Also VAM and GIEWS engage in earth monitoring and have a comparatively high frequency with regards to satellite-data-based weather and vegetation monitoring, which is provided in 10 day intervals. However, the majority of assessments that do not deal exclusively with earth observation, but with availability and accessibility indicators have a monthly (6 reports), or a bi-monthly, quarterly or bi-annual frequency (7 reports). GIEWS' country reports, for example, are only available every quarter. Apart from the agro-climatic monitoring, the highest reporting frequency is, thus, still monthly. We find that none of the systems engages in near real-time analyses, i.e. the daily, sub-daily or live monitoring of indicators.

With respect to the third pillar, i.e. the communication and dissemination of results, we find that nearly all analyzed EWSs publish their assessments in the form of reports, whereas only three assessments are provided as tools, i.e. VAM's agro-climatic monitoring and market watch and GIEWS's earth observation tool. The recent introduction of visualization tools shows a transition towards the integration of results into more interactive systems and maps, like WFP's new visualization platform (WFP 2017). We, hence, conclude that targeted recipients of early warning information are decision makers at the international, national and local level, governments and NGOs. We find no documentation on efforts of EWSs to integrate the population at risk as a target group for their early warning messages.

Table 3. Overview over Early Warning Systems, Risk Monitoring* and Monitoring Characteristics.

EWS	Report / Tool	Prices	Supply	Weather	Vegetation	Demand	Livestock Markets	Livelihood Indicators	IDPs, Refugees	Mortality Rate	Civil Unrest, Conflict, War	Policies	Humanitarian Assistance	Prices	Supply	Policies	Spatial Unit	Assessment	Frequency	No. Countries	Published as	Recommendations for Action	Bottom Up
IPC	Acute Food Insecurity Situation Overview	x	x	x	x		x	x	x	x	x	x	X				SC	EX	IR	15	R	x	
FEWS NET	Integrated Food Security Analysis	x	x	x	x	x	x	x	x	x	x	x	X				SC	FC	M	30	R		
	Price Bulletin	x	x														C	EX	M	23	R		
	Global Price Watch													x	x		G	EX	M	-	R		
	Food Assistance Outlook Brief	x	x	x	x	x		x	x	x	x	x					C, SC	FC	M	33	R		
	Global Weather Hazards			x													R	FC	W	-	R		
VAM	Agro-Climatic Monitoring			x	x												SC	EX	Dek	122	T		
	Market Watch	x												x			SC	FC	M	78	T		
	Market Monitor	x												x			G, C, SC	EX	Q	-	R		
	mVAM	x	x	x				x	x		x		X				SC	EX	M	22	R		
GIEWS	Country Briefs	x	x	x	x		x		x								C	EX	Q	81	R		
	FPMA	x	x											x	x		G,R,C	EX	M		R		
	Earth Observation			x	x												SC	EX	Dek	-	T		
	Crop Prospects and Food Situation	x	x			x					x			x	x		G, R, C, SC	EX	Q	-	R		
	Food Outlook													x	x	x	R, C	FC	BA	-	R		

Note: * This table gives an overview over regular assessments and does not account for baseline studies.

Spatial Unit: G: global, R: regional, C: county, SC: sub-country. **Assessment**: FC: forecast, EX: ex-post. **Frequency**: Q: quarterly, M: monthly, Dek: Dekads, W: weekly, IR: irregular. **Published as**: R: Report, T: Tool.

Source: Own compilation, based on content provided on the websites of the respective early warning system and own frequency analyses

Regarding pillar four, the direct connection of the EWS to a response capacity, we find mixed results. Three out of four systems, i.e. FEWS NET, GIEWS and VAM are directly embedded in potential response organizations, USAID, FAO and WFP respectively; so theoretically, a connection to the response capacity exists. Only one report, IPC's Acute Food Insecurity Situation Overview, however, contains direct recommendations for action. We observe that all EWSs strongly cooperate with each other, as information is shared, integrated into reports and cross-published. FEWS NET's information, for example, is integrated into GIEWS reports (FAO 2017) , while many reports include IPC assessments. Furthermore, IPC was established inter alia by FAO and WFP, which suggests that information is incorporated in the decision-making. In this analysis, we could however not find clear cut information or protocols that show the connection between systems, decision making and intervention.

5.2 Reliability Tests: Country Coverage and Reporting Frequency

Based on the results in Table 3, we are able to identify the report of each EWS that contains the most comprehensive set of risk factors. These are IPC's Acute Food Insecurity Situation Overview, FEWS NET's Integrated Food Security Analysis, VAM's mobile VAM and GIEWS's country reports. We use these reports to test the reliability of information provision. We analyze (1) how reliably information is published and (2) which spatial coverage is *de facto* provided by EWSs, based on two different time horizons, i.e. a long term period of eight months and a short term period of one month.

Table 4 shows the number of countries for which the respective reports were updated between January and August 2017, compared to the actual number of countries that the EWSs claim to cover. We find that FEWS NET has the most reliable update-ratio, providing updated information for more than 90 per cent of their monitored countries, followed by VAM and GIEWS. IPC's update-ratio is, however, less than 50 per cent, having provided updated information for 13 out of 37 countries between January and August 2018. The results show a strong variation in reliability across EWSs.

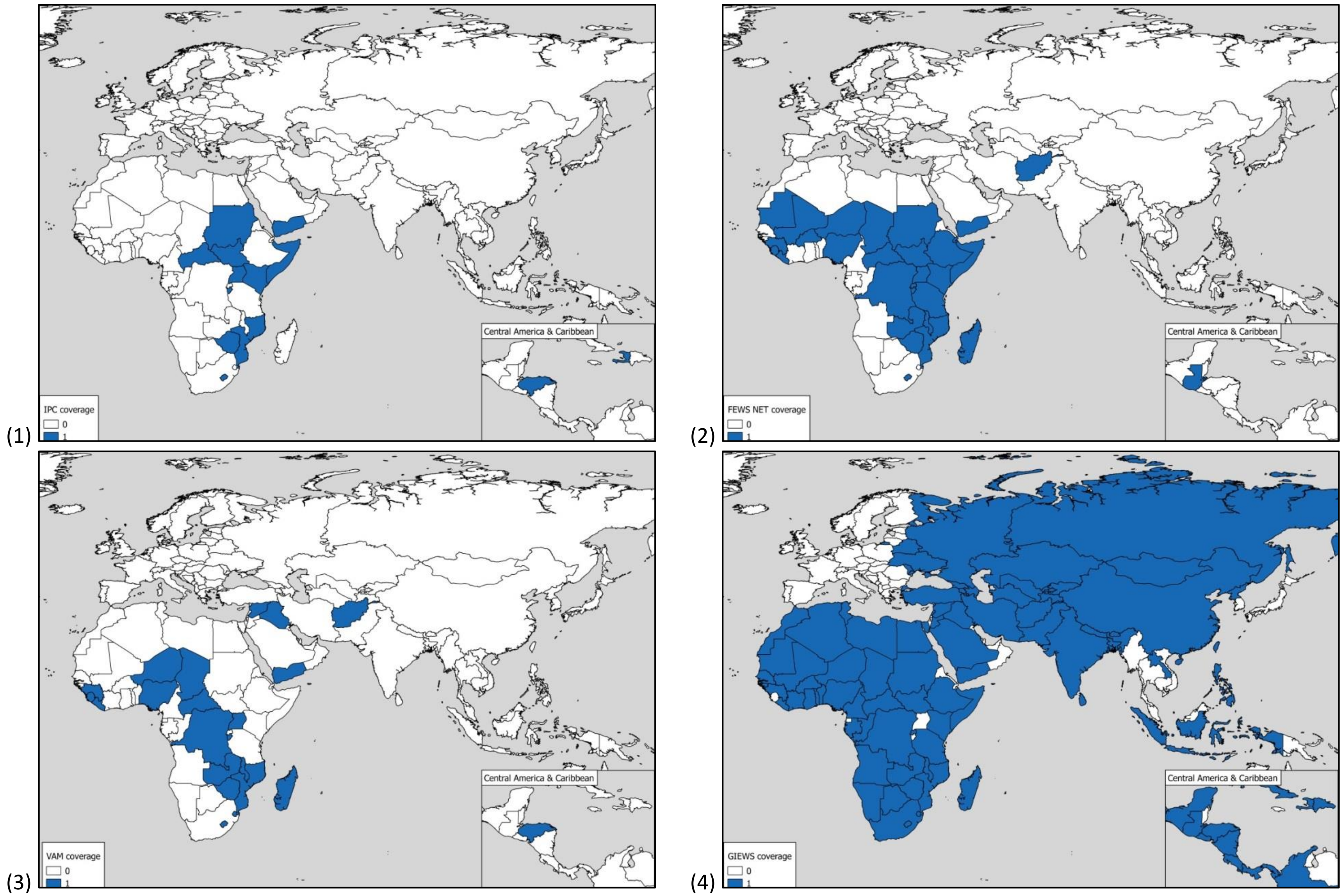
Table 4. Number of countries with updated information, Jan – Aug 2017.

EWS	Report	No. of Countries
IPC	Acute Food Insecurity Situation	13/37
FEWS NET	Integrated Food Security Analysis	33/36
VAM	mVAM	22/30
GIEWS	Country Briefs	81/112

Source: Own compilation based on selected reports published by IPC, FEWS NET, VAM and GIEWS.
Last assessed on September 1st, 2017.

Based on this analysis, Figure 2 shows the spatial coverage for which information *de facto* has been published within the eight month time period. Here, GIEWS covers the largest amount of countries, followed by FEWS NET, VAM and IPC. The only system that covers Iraq and Syria is WFP's mVAM, providing regular, monthly information on selected regions within the two countries since 2016. Afghanistan, however, is covered by three out of four systems.

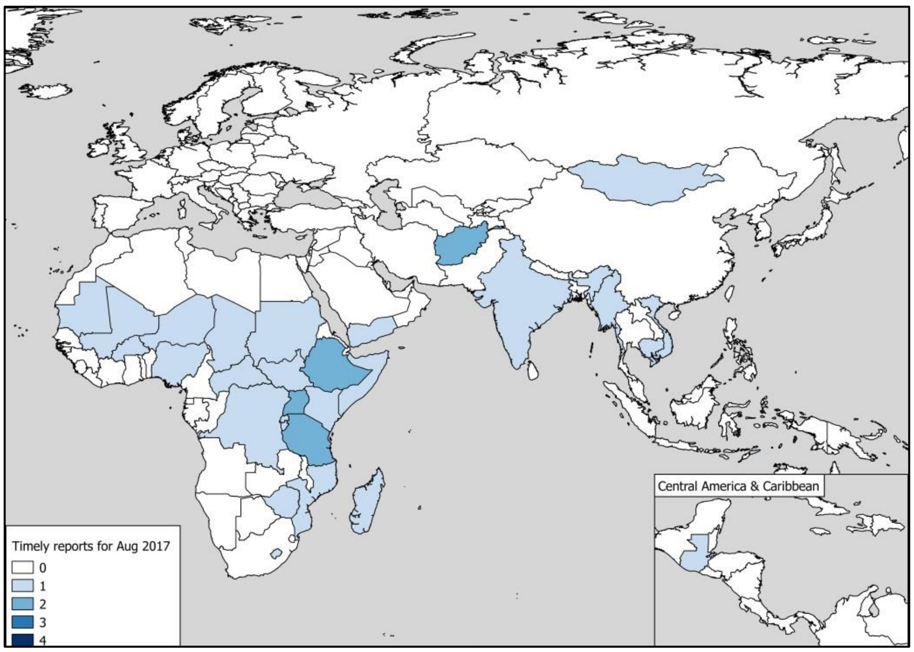
Figure 2. *De facto* spatial coverage of selected reports of (1) IPC, (2) FEWS NET, (3) VAM and (4) GIEWS.



Source: Own compilation based on selected reports published by the four EWS, Jan – Aug 2017, assessed on Sep, 1st 2017.

To understand which most up-to-date information is *de facto* available for decision making at the first day of a given month, we further analyze for which countries monitoring systems have provided information for August 2017, assessed on September 1st. Figure 3 shows the number of reports published in August 2017 and the spatial coverage of information. Information is available for 30 countries, while the maximum number of timely reports that can be found is two (Tanzania, Uganda, Ethiopia and Afghanistan), while one report is available for the remaining countries. We can identify that up-to-date information is missing for a variety of countries that are engaged in complex emergency, i.e. Syria, Iraq, Djibouti, and Eritrea. We further find that two reports are available for Afghanistan, which are reports published by mVAM covering single provinces within Afghanistan.

Figure 3. No. of reports published per country in August 2017.



Source: Own compilation based on a count of reports published by the four analyzed EWS, assessed on Sep 1st, 2017.

6 Discussion

The analyzed early warning systems addressed part of the long standing critique, i.e. (1) the focus on droughts and availability of food, (2) the lack of spatial disaggregation, timeliness and comprehensiveness of geographical coverage, (3) the missing integration of the affected population itself, both as an information source and recipient of early warning information and (4) the missing connection between early warning information and the response capacity.

We show that the reported focus on the availability of food, prices, weather and supply (see Wisner et al. (2004); Devereux (2001)) has shifted towards covering also the accessibility pillar of food security and that EWSs have started to engage in a comprehensive, multi-indicator analysis of the food security situation.

With regard to the lack of spatial disaggregation, timeliness and geographical coverage of indicators, we find that EWSs have transitioned towards geographically more disaggregated information and hence disconfirm the claim that EWS engage in pure country-level analyses (see Buchanan-Smith and Davies 1995). We show that a large part of the analyses has shifted to the inclusion of spatially detailed, sub-country information. Regarding the spatial coverage of EWS, we find that the country coverage varies substantially. Agro-climatic monitoring has a near global coverage, as satellite data is widely integrated into EWSs and three out of four systems provide weather and vegetation data. The coverage of accessibility indicators is less holistic, with a maximum coverage of 30 countries (in the case of FEWS NET). When looking at the reliability of information and the *de facto* spatial coverage of EWSs, we find that there is a deviation from the coverage and frequency of reports as claimed by EWSs. Our analysis of frequency and country coverage shows that all EWS provide less information than stated and that there are reporting irregularities - a finding that undermines the reliability of EWSs. We further show that there are blank spots on the map, as there is no up-to-date information for countries like Syria, Iraq Djibouti and Eritrea. This finding underlines the vulnerability of data collection initiatives in complex emergencies and shows the need for systems that are able to provide information to humanitarian actors also in challenging environments.

We find that all EWSs engage in top-down monitoring; only WFP's mVAM initiative has started to directly obtain information from the population at risk. Thus, our findings are in line with Kalkuhl, von Braun, and Torero (2016), who also conclude that bottom-up information has not been systematically integrated into EWSs. We further find that some of the analyzed EWSs engage in forecasting, but the majority still only engages in *ex-post* analysis. We also show that highest frequency is achieved by weather data that is published in ten day intervals, while the majority of reports are published at a monthly or less than monthly frequency. No near-real time monitoring has been implemented to date, contrary to what is claimed by some EWSs.

Despite the fact that rising mobile phone and internet adoption rates are paving the way for the integration of bottom-up information and potentially near-real time and real-time data sources, in practice, we observe that the analyzed EWSs are still one step behind. No EWS makes use of user-generated online content and WFP's mVAM initiative is the only example that demonstrated the integration of bottom-up information through an SMS- and voice-call-based system. Despite today's era of digitalization and advances in rapidly available big data, current EWSs fall short of their potential to use innovative data sources for bottom-up monitoring.

Furthermore, no progress was made to tackle the dis-connection between early warning systems and the people at risk, neither from a data collection perspective (apart from WFP mVAM), nor from a communication perspective. None of the analyzed EWS integrated the population at risk in an information loop, neither regarding the information itself nor regarding situation-specific communication of coping strategies. Hence our findings corroborate the findings of Twigg (2003b), Basher (2006), Kelly (2003), who highlighted the importance of timely, non-technical and understandable information for the communities at risk. Even though the recent tendency to include interactive tools is a necessary change to increase the understandability and accessibility of information, this development still caters to the needs of affluent people with a good internet access and ignores communities at risk. Hence, we find that EWS fall short of their potential to inform the at-risk population about an impending crisis.

We show that, in theory, EWSs have a direct or in-direct link to a response capacity. So our results show that Buchanan-Smith and Davies' (1995) observation of a missing link between early warning information and humanitarian response, has improved. However, the existence of a link does not necessarily show that information is used and that it is acted upon. Much of the decision making processes are not transparent and even though there might be a direct connection to, for example, WFP and USAID, we find that none of the analyzed early warning systems or corresponding humanitarian agencies provide a clear-cut protocol or a contingency plan on the retrieving of early warning information. Bailey (2012) and Hillbruner (2012) already discussed the issue of political unwillingness to respond to probabilistic warnings issued by EWSs in the context of the Somalia crisis of 2011. Thus, we identify a research gap with regards to the evaluation and testing of how early warning information contributes to decision making and its impact on triggering preparedness measures, emergency funds and emergency assistance, not only from an international organizations perspective, but also across national governments and NGOs.

7 Conclusion

The years 2016 and 2017 witnessed a high level of food insecurity, with multiple food insecurity hotspots across East Africa and Nigeria (Source), an unclear food security situation in complex emergencies like Iraq and Syria (Source) and an estimated number of 108 million people at risk of being affected by a food crisis over the upcoming six months (FSIN 2017). Over the last 40 years, EWSs have been developed to detect and provide information on food crises. These systems, however, have been criticized for not providing a holistic picture of the food security situation by focusing on availability indicators, for lacking timeliness, geographical coverage and detail, for excluding the population at risk and for being detached from response agents.

We find that EWSs partly addressed this critique and moved towards the diversification of risk monitoring from availability to accessibility indicators, towards the expansion of country coverage and the inclusion of geographically more detailed information. We find that the majority of information is published at a monthly or less than monthly frequency. Also timely information is missing for a number of countries and the geographical coverage of EWSs is smaller than stated. Furthermore, bottom-up information is hardly integrated into EWSs and generally, the population at risk is still dis-connected, both as information source as well as recipient of early warning information. Hence, we conclude that monitoring systems fall short of their potential to inform the population at risk about an impending food crisis.

This study aims to provide an overview over monitoring systems for food security risk, the information that they provide and their monitoring characteristics. Our analysis does not account for the assessment of information and data quality, which has formerly been criticized (see Kalkuhl, von Braun, and Torero 2016) and mixed results were found when analyzing the performance of EWSs (see Hillbruner and Moloney 2012; Ververs 2012). Further research is needed to systematically assess EWSs regarding the quality of information and the validity of warnings that are issued.

Food security monitoring is at an innovative stage of development given increasing ICT adoption rates and the potential these data sources hold for bottom-up monitoring and for EWSs We find that EWSs have not yet fully tapped into the possibilities that emerge with this development, as the vast majority of analyzed EWSs have not adopted potential, innovate data sources or engage in (near-) real time analyses. We expect this to change in the upcoming years, given the amount of newly emerging initiatives that seek to integrate big data for crisis monitoring, like price monitoring through pictures of price tags (Premise 2017) or food price monitoring using social media signals (UN Global Pulse 2014). Future research is needed to understand how online content and the direct contact to the population through mobile phones can be used and integrated into EWSs, which would be particularly interesting and beneficial for hard-to-access areas and complex emergencies and has the potential to decrease the number of blank spots on the map, for which information is still unavailable.

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