Bowtie Diagrams for Natural Disaster Risks

Using a new method for analyzing natural disasters impacting food security

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Introduction

According to the World Food Programme (WFP) more than 80% of the world's food-insecure people live in settings that are prone to climate-related disasters, such as floods, droughts, and storms. With climate change, these populations are more likely to slip back into hunger. To support vulnerable countries and communities, WFP provides analysis highlighting the links between natural disasters and food security, as well as the present and future impact of climate change on food security and nutrition.

Although much information is available, the problem with performing disaster risk assessments is that many disasters are not attributed to the root causes. Specialists say that they are rather attributed to the final type of disaster, giving less insight in its complexity. Another problem is that information about risks that is not understandable and does not make transparent the cause-effect chain of probable natural disasters and its consequences will lead to a lack of trust in the risk assessment capacity. One of the indicators that describe a disaster-resilient society is 'knowledgeable people on the cause-effect relationship of natural disasters'. Another indicator is having knowledge of risks and risk reduction actions. To be better prepared for the uncertain future, the people at risk need to receive relevant information in a clear and understandable way.

To overcome these problems, the use of Bowtie Diagrams is proposed. The authors believe that this methodology provides new means to experts and non-specialists for better understanding the dynamics behind natural disasters and their impact on food security. The goal of this article is to introduce and describe in a general way several natural disasters impacting food security, while using the Bowtie methodology for making clear the cause-effect chain behind these disasters. With this article, the authors hope to contribute to societies being better prepared in a highly uncertain world.

First the methodology of Bowties is explained, after which four examples of natural disasters impacting food security are given. Although conflicts, the climate crisis, and economic shocks are the key drivers of hunger, this article will focus only on the second driver.

Bowties

There are many well-developed methodologies in safety-conscious industries, such as aviation, nuclear, and defense that may be applied to risk analysis. The Bowtie Diagram has been used since the 1970s as a concept in safety management disciplines, and in 2004 the U.S. Federal Aviation Authority (FAA) even mandated that its regulated entities employ the Bowtie diagram as the main mechanism for safety analyses. The Bowtie Diagram is a graphical model with logical relationships between the causes and consequences of an undesired event. In other words, it is a diagrammatic representation of hazardous events (see Figure 1).

In the center of the diagram we can see a hazard or incident (which can be defined as an undesirable event) – to its left are possible causes, and to its right are possible consequences (outcomes) of the hazard. Between the causes and the hazard are possible preventative (proactive) controls. Between the incident and consequences are possible mitigative (reactive) controls.

The Bowtie Diagram is an effective way to identify and communicate risks and required responses. The diagram displays the links between potential causes, preventative controls, and mitigation controls. The diagram is often used for *what-if* and *root-cause* analyses, where quantification is not possible or desirable.

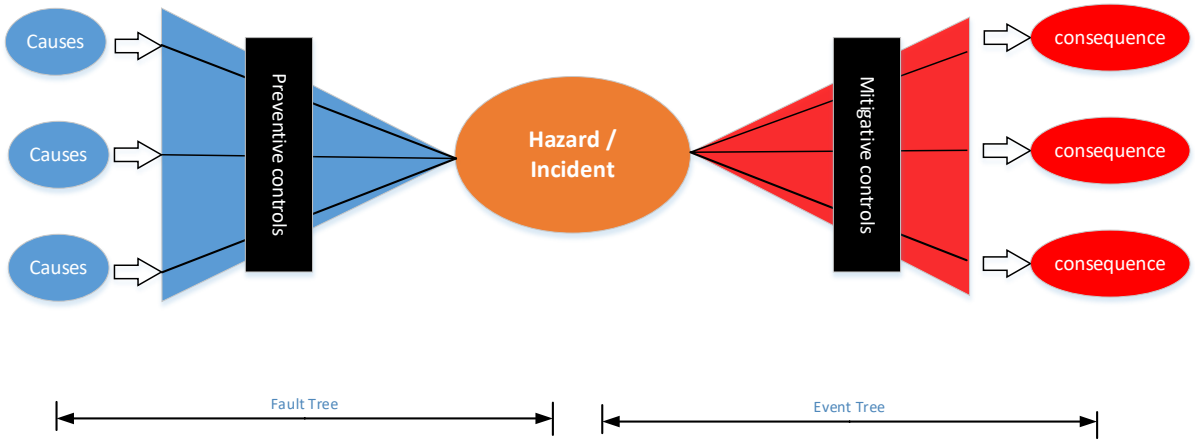

Figure 1: Bowtie diagram (own graph)

The key components of a Bowtie diagram are:

- Causes: potential causes of an undesirable incident;
- Proactive controls: actions taken to reduce the likelihood of an undesirable incident occurring;
- Hazard/incident: an event that can cause undesirable outcomes;
- Reactive controls: actions taken to reduce the impact of an undesirable incident;
- Outcomes: potential results of an undesirable incident.

Natural disasters impacting food security

Before giving examples of Bowtie Diagrams, first give some important definitions. There are several definitions of hazard, disaster, and risk; the following ones are given by the United Nations Office for Disaster Risk Reduction (UNDRR):

- Hazard: "A potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural or induced by human processes."
- Disaster: "An event caused by human or natural forces resulting in an enormous loss of life and property."
- Risk: "Risk is the product of the exposure of a society to a hazardous natural or mankind generated hazard situation, that may result in (physical, psychological, social, financial, etc.) threats to the individual or the society and its/their living environment, juxtaposed to the capacity of the society or the individual to cope with the impact."

Of the many hazards, natural hazards are generally divided into two main categories:

1. Geotectonic hazards: Natural processes that have their origin in earth's crust and mantle resulting in convectional movements. Most of those hazards are normally short in onset and duration, and are quite local. Examples are earthquakes, tsunamis, volcanic eruptions, and mass movements.
2. Hydrometeorological hazards: Natural processes that have their origin in the earth's atmosphere. Examples are flash floods, droughts, storms, and extreme weather (heat wave). Some of these climate-related disasters, like droughts and heat waves, are very slow in their onset and can last over many years. They are often transnational and might cover continents.

Four example Bowties of natural disasters are given below. Each one explains the mechanics behind a disaster and its impact on food security. Specific information was provided by WFP documents and specific literature. Several other factors influencing natural hazards are not taken into account in creating the Bowtie Diagrams, for example:

- Global factors: world population and population growth, level of economic growth, world food demand, technological solutions, etc.
- Regional/local factors: economic context (low-income or high-income country), energy demand, amount of arable land, system of precipitation distribution, specific hydrometeorological effects (amount of local saltwater intrusion).

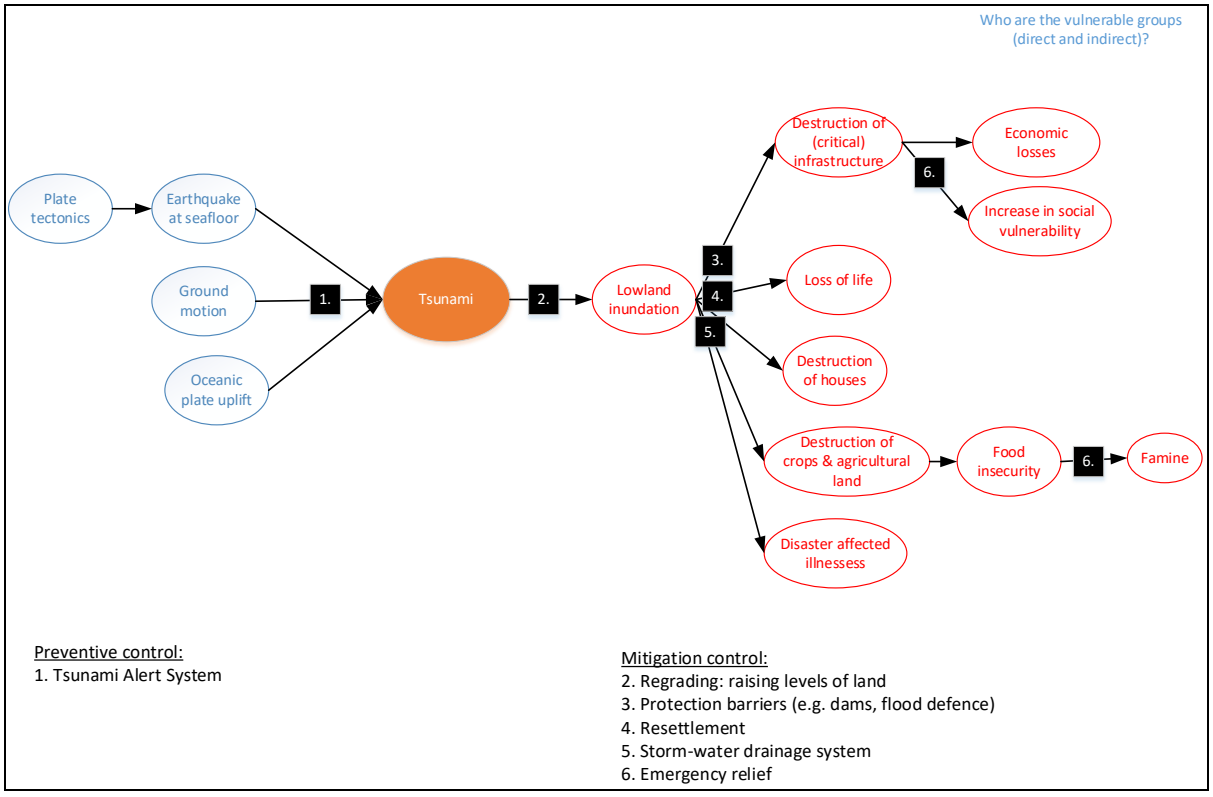

Figure 2: Tsunami (own graph)

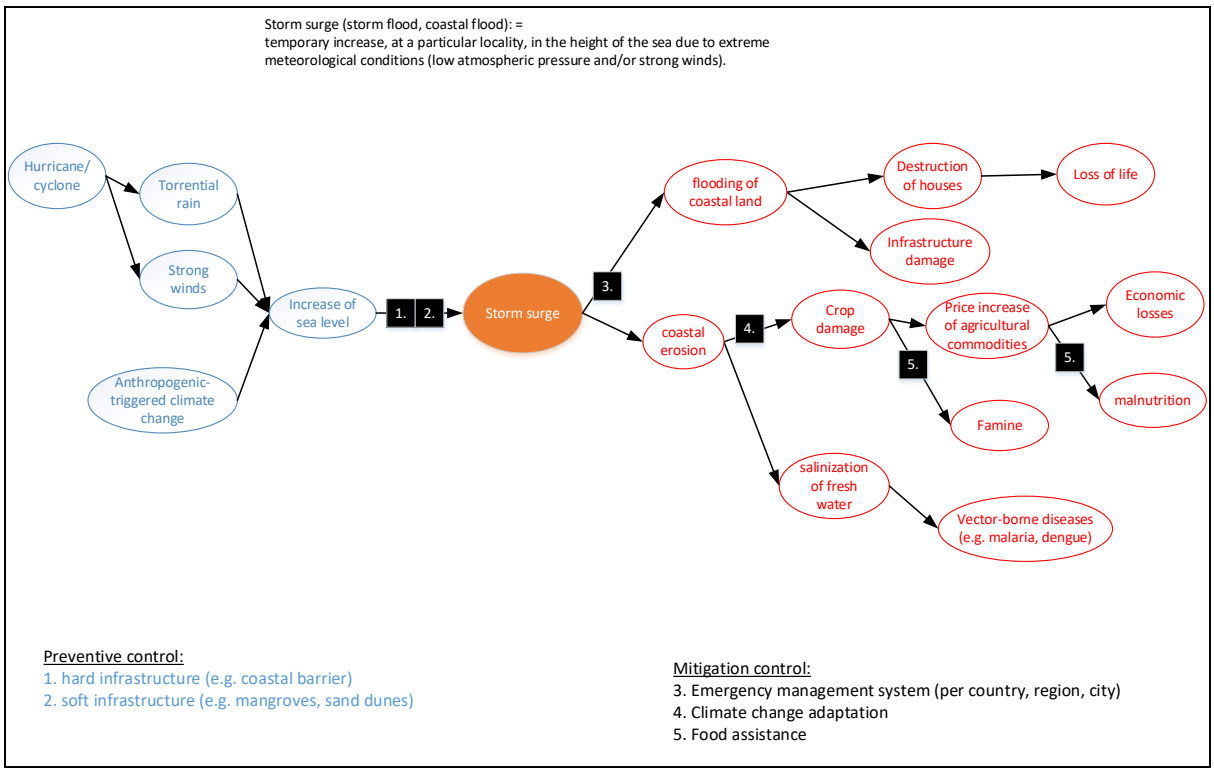

Figure 3: Storm surge / coastal flood (own graph)

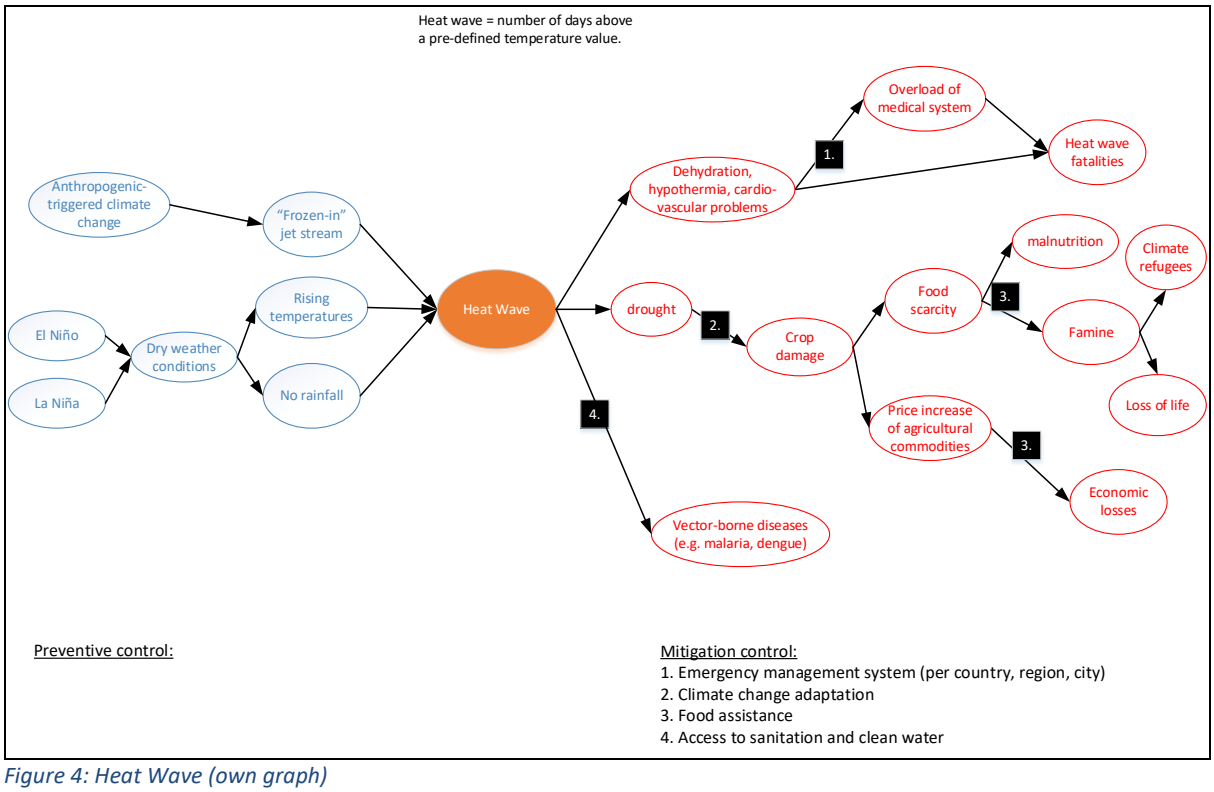

Figure 4: Heat Wave (own graph)

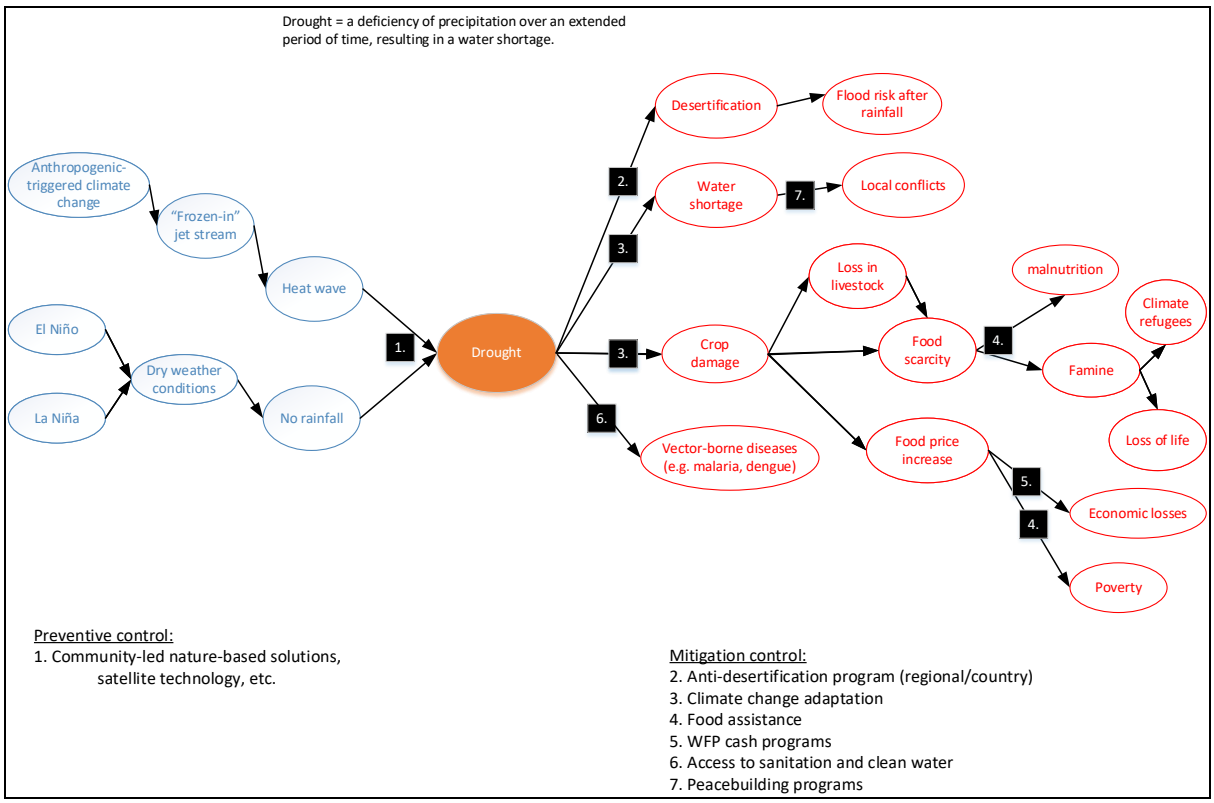

Figure 5: Drought (own graph)

Conclusions and final remarks

While the diagrams are set-up in a generic and high-level way, they nevertheless give a quick and understandable overview of the cause-and-effect chains behind the disasters. Everybody, whether an expert or not, can quickly grasp its dynamics. They can be a first step in the process of understanding the cause-effect relationships of natural disasters and their impacts on food security. Moreover, the Bowties can be used as a means to communicate with experts in the field and, if developed into more detail, as a way to inform the greater public to make people more disaster-resilient.

Because of their generic nature, they must be made more specific according to local and regional specificities. It is recommended to further develop the generic Bowties into more detailed ones, even made specific for each country or region. Mitigation measures that proved perfect in one location, may be unsuitable for another. Top-down mitigation, without the involvement of the population at risk, will also be prone to fail. Broad involvement is necessary. Experience from risk-affected communities and technical expertise must therefore be included in order to enrich the current diagrams.

Bowtie Diagrams need to be continuously improved, especially with specific data and expertise currently unavailable to the authors. We believe that developing Bowtie Diagrams of natural disaster risks is a starting point[1]. They are an effective means to contribute to resilient and sustainable societies, as they give insight into the cause-effect chains of natural disasters impacting food security and the related mitigations.

[1] Once a Bowtie Diagram of a natural hazard is constructed, it provides an effective tool for the understanding of its root causes and potential mitigation, prevention, and preparedness measures. It also assists in the communication of the hazard analysis process—particularly to nonspecialists. In a later stage, when backed-up by international statistics from the most comprehensive databases on natural disasters (e.g. UNDRR, CRED EM-DAT, HAZUS), semi-quantitative analyses and vulnerability assessments can also be performed.

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