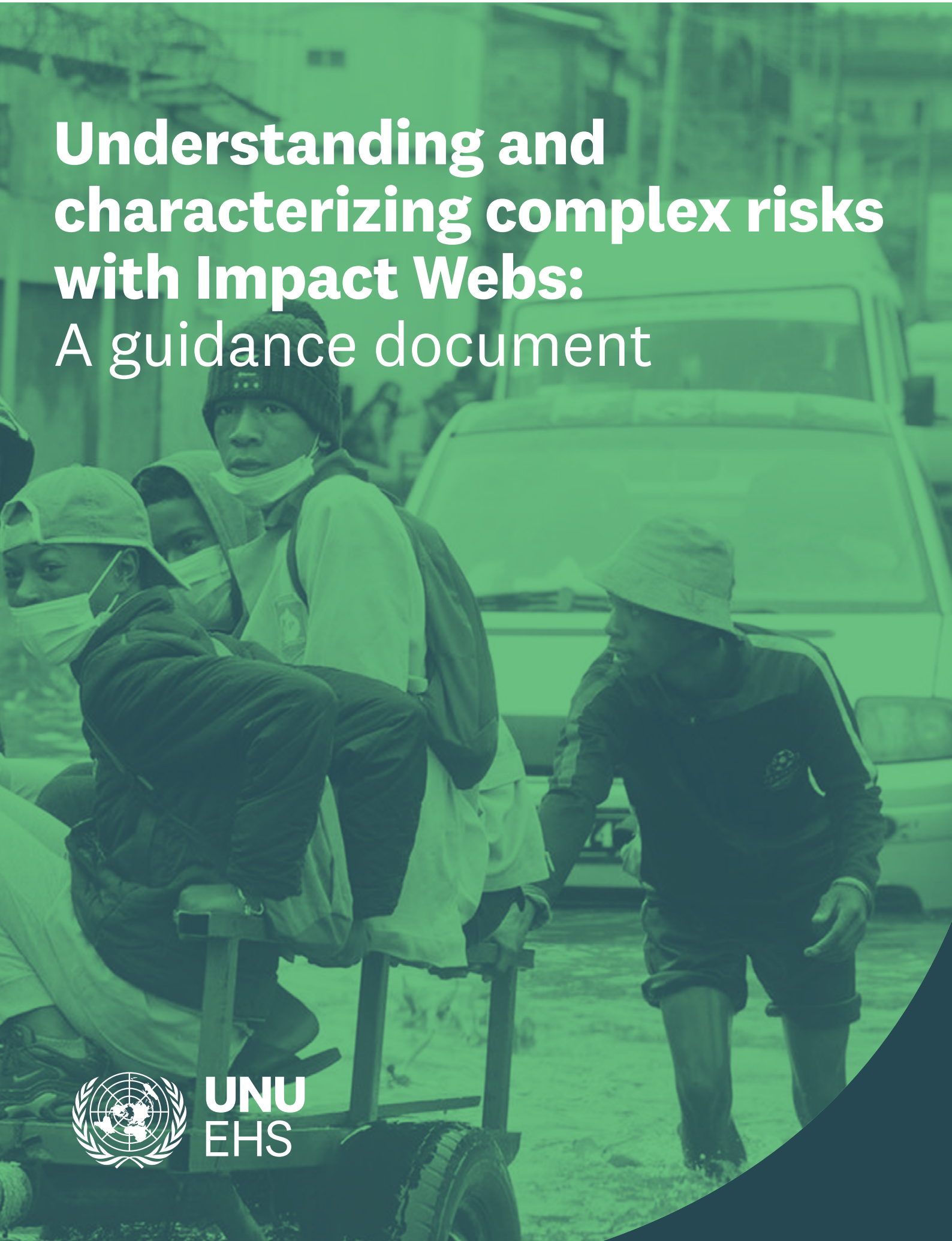
United Nations University
Institute for Environment and Human Security

Understanding and characterizing complex risks with Impact Webs:
A guidance document



UNU EHS

Understanding and characterizing complex risks with Impact Webs: A guidance document

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January 2022 in Ilanivato district, Antananarivo, Analamanga Region of Madagascar, people make their way by cart through waterlogged streets, having paid small amounts of money to be transported. On the night of 17 to 18 January, a torrential rain fell on Antananarivo, causing a sharp rise in water levels in the lower districts of the capital, including the main roads. This is due in large part to the obstruction of the evacuation channels by human waste. © UNICEF/UN0580095/Ramasomanana

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Table of Content

Table of Figures

1. Introduction

This guidance document provides “how to” instructions for the development of Impact Webs. Impact Webs are a novel methodological tool which are designed to better understand and characterize complex risks, such as compounding, cascading and systemic risks. See 1.3 for a quick guide for the user.

Impacts and risks from climate change, natural hazards and other shocks do not occur in isolation. As economic sectors and systems (e.g. financial, trade, health, ecosystems) become increasingly interconnected, the space in which impacts and risks cascade is expanding (Sillmann et al., 2022; Renn 2021; Centeno et al. 2015; UNDRR, 2022). As a result of interdependencies, impacts from hazards, threats or shocks, as well as responses to them, can create cascading impacts throughout systems, leading to consequences that extend far beyond the original threat and sometimes even beyond the region that was originally affected. For example, this became highly apparent throughout the COVID-19 pandemic (UNDRR & UNU-EHS, 2022) but can also be seen in the compounding and cross-border effects of climate change and connected extreme events (Hagenlocher et al., 2023; Raymond et al., 2020; Zeischler et al., 2018) or from global ripple effects of armed conflicts (Lin et al., 2023).

Understanding the complexity of risks, including possible compounding, cascading and systemic effects, is a key step in reducing and managing disaster risks, as recognized also in the Sendai Framework for Disaster Risk Reduction, in particular Priority 1 “Understanding Disaster Risk” (UNDRR, 2022). To do this effectively, there is a need to develop tools and methodological approaches that can account for this complexity. Impact Webs aim to do this by combining risk analysis with a systems perspective. In helping to better understand the complex nature of risks, Impact Webs can also provide important entry points for comprehensive risk management.

Dhaka, May 2022 – Over 1.5 million children are at increased risk of waterborne diseases, drowning and malnutrition due to extensive flooding in north-eastern Bangladesh. © UNICEF/UN0657787/Rony

1.1. What are Impact Webs

Impact Webs are a conceptual and analytical tool designed to investigate risks in complex systems. They characterize and "map" the complex nature of risks and impacts through a systems approach (see Chapter 2 for understanding complex risks), and are co-developed in close collaboration with relevant stakeholders. An Impact Web can be produced across various spatial scales, i.e. from the global to national scale or even for a more local context such as a river catchment. Impact Webs account for (i) multiple interacting hazards, (ii) interconnections between different risks/impacts for communities, economic sectors or systems and (iii) their underlying risk drivers as well as (iv) the root causes behind them. Further, they also tackle (v) risks and impacts linked to responses (e.g. policy interventions aimed to reduce risks).

Figure 1 illustrates the **graphic structure** and key elements of an **Impact Web** using the example of complex risks linked to COVID-19 and concurring hazards. **Step-by-step guidance** on how to construct an Impact Web and how to use it to identify entry points for risk management is provided in Chapter 3.

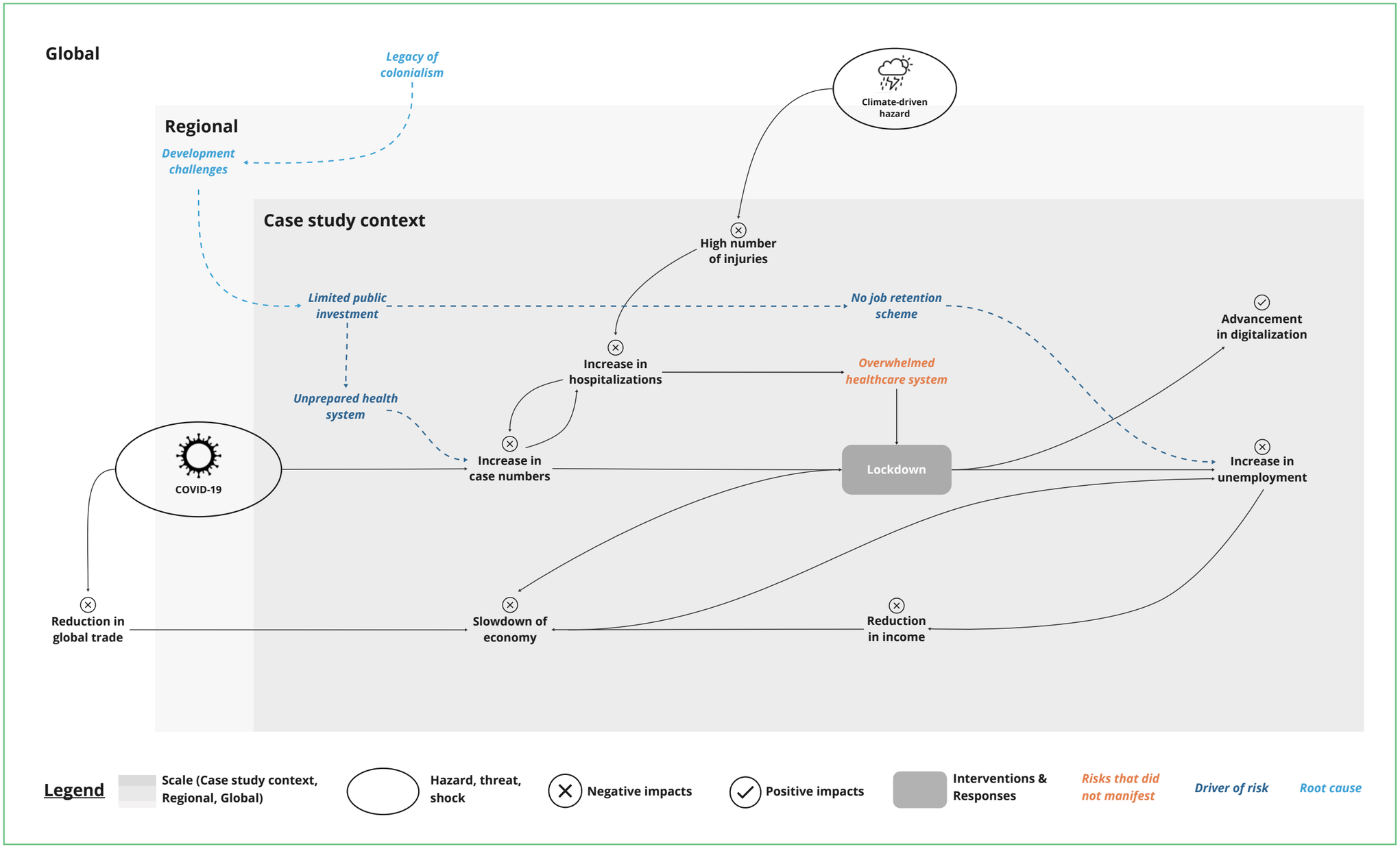


Figure 1: Illustrative structure and elements of an Impact Web. Note: This is a hypothetical and simplified example for illustration purposes. An explanation of the elements in the model legend is given in Chapter 3.1 (Source: Authors).

1.2. Why use Impact Webs to understand and characterize complex risks

While there are many approaches that aim to break down the complexity of risks, single-hazard and single-risk approaches are becoming increasingly insufficient for comprehensively analysing and managing risks. Instead, system approaches, i.e. methodologies and tools that consider risks in the context of complex interconnected systems (Simpson et al. 2021), are needed. Integrating conceptual risk models and a system-oriented approach, Impact Webs can be a useful way to distil complexity into a manageable form by characterizing various interconnected risk elements such as hazards, exposures, vulnerabilities, impacts and responses. This helps shed light on the complexity of risks in our highly interconnected world, and forms the basis for the development of narrative storylines (van den Hurk et al., 2023; Dessai et al., 2023), which can be used for risk communication purposes. An Impact Web can reveal connections about how multiple interacting system components can propagate risks and impacts within and across systems, geographical scales and borders. This gives a representative overview of the complex nature of risks we face and increases understanding of the main characteristics and elements of the system of interest. This can then inform preventive planning and provide guidance on the management of compounding, cascading and systemic risks.

1.3. Quick guide for the user

This guidance document provides step-by-step guidance for co-creating Impact Webs (Figure 2, Steps 1–6), and gives recommendations on moving from understanding complex risks to risk management (Figure 2, Steps 7-8). It is designed as a stand-alone document. Following the introduction (Chapter 1), Chapter 2 briefly introduces what we mean by the complex nature of risks (Chapter 2.1) and discusses the role of conceptual risk models for better understanding and characterizing them (Chapter 2.2). Chapter 3 provides detailed, practical, step-by-step guidance on how to co-create Impact Webs with relevant stakeholders (Steps 1-6) and how to use them for identifying entry points for risk management (Steps 7-8). Each of the guiding steps includes an explanation of its scope within the conceptual model. This is followed by a set of suggested questions to guide users undertaking the risk assessment. Each step closes with expected outcomes, and recommended data and information sources. We also provide guidance for workshop development and drafting narrative storylines to complement the Impact Web conceptual model. Concluding remarks are provided in Chapter 4.

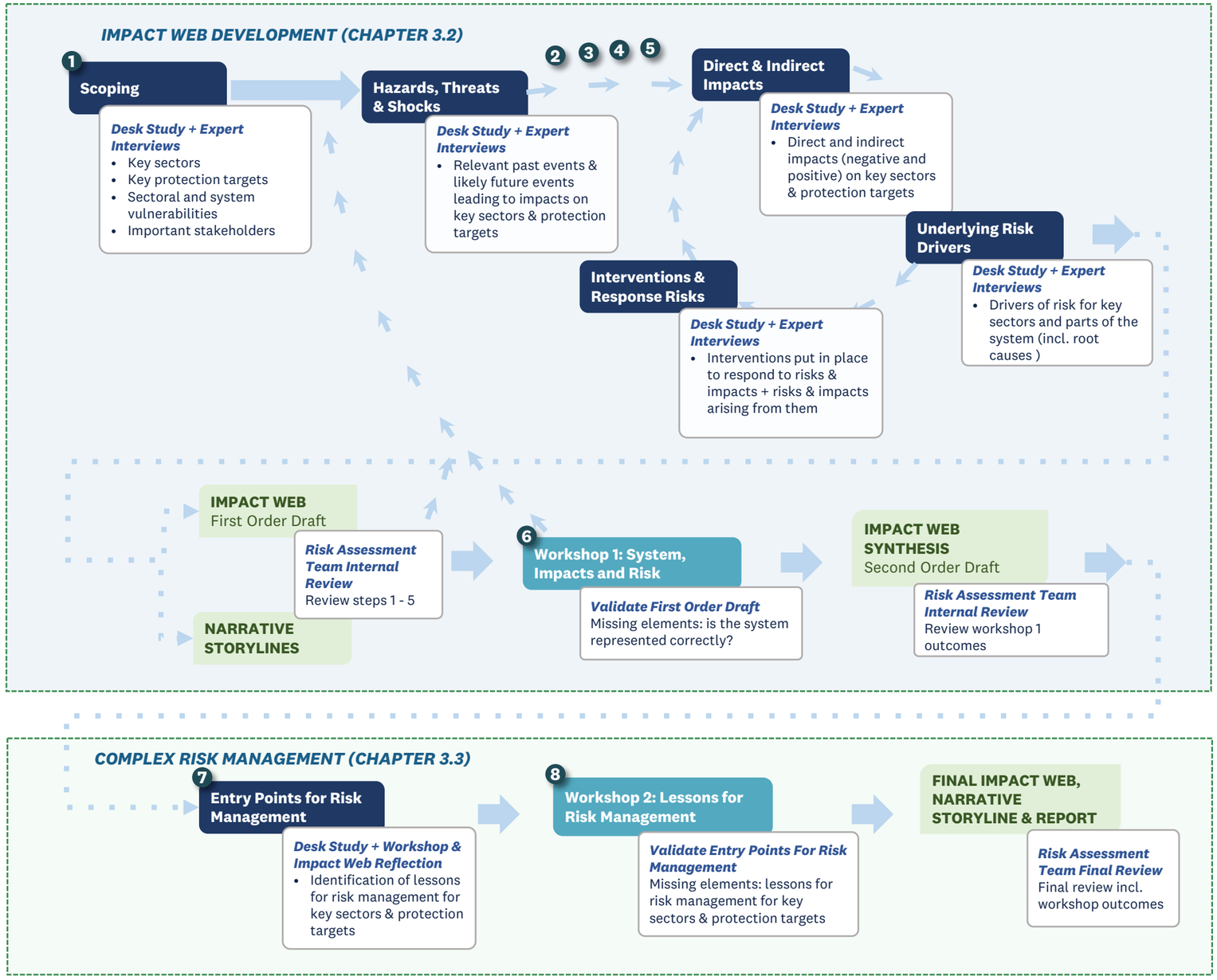


Figure 2: Steps in this guidance document for the co-creation of Impact Webs (Steps 1-6) and their application for risk management (Steps 7-8) (Source: Authors).

2. Understanding complex risks

2.1. Understanding the complex nature of risks

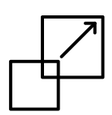
Over the past decades, the conceptualization of risk has evolved from a hazard-centric perspective to a much more encompassing notion that integrates the dynamic interactions between hazards, exposure, vulnerability (IPCC, 2014) and, more recently, responses (IPCC, 2022). Different risk concepts have been elaborated, including cascading, compound, and systemic risks. This guidance document uses "complex risks" to encompass these different risk framings. The Impact Web approach has been developed to understand these types of risks.

To investigate and assess risks from this wider perspective, tools are needed that allow in-depth analysis by providing context-specific information about the drivers and interactions that are conducive to risks for one or more elements of interest. This is ever more pressing as our perspective on risk becomes more complex and systemic (see Box 1), e.g. by including multiple hazards (compounding, concurring, consecutive or even unrelated), multiple elements at risk (for instance, livelihoods, infrastructure and ecosystems), and root causes that shape their exposure and vulnerabilities. A key challenge for risk management is to develop tools and models that can enhance understanding of and effectively communicate the characteristics of complex risks and their manifestation as impacts. The Impact Webs approach presented here aims to capture some of these key characteristics.

The Netherlands is famed as a "land of water" where canals and dikes protect against rising seas, but the country declared an official water shortage earlier in August 2022. One key factor in the drought has been the low water levels in the Rhine. Drought impacts go beyond direct impacts on transportation, and through supply chain disruption, also have cascading impacts on other societal areas. © Rob Engelaar/ANP/AFP

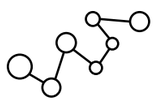
Box 1: Characteristics of the systemic nature of risks

Among complex risks, systemic risks are emerging as an important framework for research and policy alike. Despite the large-scale repercussions of many events that have shown the systemic nature of risks within systems, there is no commonly agreed definition of the concept of systemic risk. Figure 3 builds on the existing terminology to provide key attributes of systemic risk falling under five themes. These relate to the scale of the system; the relationship of the elements within a system; the level of system understanding; transboundary effects and the outcomes of systemic risk (Sillmann et al., 2022).



Scale

- Global
- National
- Regional
- Local

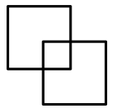


Relationship

- Feedback loops
- Interactions
- Interconnections
- Interdependencies
- Interlinkages
- Interwined

System Understanding

- Unknown
- Lack of knowledge
- Unpredicted
- Uncertainity
- Ambiguity
- Underestimated
- Tipping points/ events
- Stochastic effects



Transboundary Effects

- Cascading effects
- Complexitiy (Complex causal structures)
- Contagion
- Indirect impacts
- Knock-on effects
- Non-linearity (Non-linear cause effect relationship)
- Ripple effects
- Spillover effects
- Wider effects

Outcomes

- Breakdowns
- Collapse
- Critical services to society
- Disruption of systems and essential services
- Failure of economic, financial or social systems
- Impacting/ affecting an entire systems
- Serious negative consequences
- Threats to system survival
- Unbound damage

Figure 3: Key characteristics of the systemic nature of risks (adapted from Sillmann et al., 2020)

2.2. Conceptual models as a tool for understanding complex risks

Conceptual models can be understood as heuristics aimed at breaking down and simplifying the complexity of risks. An example of this type of models are impact chains (Hagenlocher et al., 2018; Schneiderbauer et al., 2013; Zebisch et al., 2021) that aim to represent how specific impacts emerge as a result of the causal dependencies and interaction between drivers of risk, considered in its components of hazard, exposure and vulnerability. Impact chains have a strong participatory focus and allow for knowledge to be co-constructed with stakeholders and experts. From a conceptual perspective, they can be described as "directional" as the cause-effect relationships represented all converge to a specific element (i.e. risk), which is then seen as an outcome. However, while this in-depth approach allows one to dig deep into how certain risks emerge, it is not designed to account for the wider context within which this risk occurs, i.e. how different risks interact; what the social, institutional, economic and environmental contexts are in which interactions take place; or how different scales become relevant for certain risks, etc. In other words, impact chains do not provide a general overview of the system in which risks exist. For this, a more system-oriented perspective is needed.

The field of system mapping provides useful inputs. System-mapping approaches describe the main characteristics and state of a certain system through a visual model (or "map"). While many different approaches exist, a common feature is the presence of elements (or "nodes", usually represented with boxes) and connectors (or "edges"), which imply some form of relationship, causal or other, between the elements (Barbrook-Johnson and Penn, 2022). Among the most well-known examples of system-mapping approaches are causal loop diagrams, fuzzy cognitive maps, system dynamics and Bayesian Belief Networks. System-oriented approaches are designed to engage with complexity, but this can become overwhelming if the boundaries of the system being represented are not well-defined and an acceptable level of simplification is not identified. These decisions inevitably contain a certain element of subjectivity as no absolute one-size-fits-all metric exists.

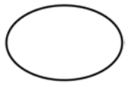
Combining system mapping with the risk-centric focus and participatory approach of impact chains can provide a very effective angle to better understand and represent risks in complex systems: Impact Webs achieve this by expanding the single-risk, sectoral, and often rather linear focus of impact chains towards a more system-oriented view using elements from system-mapping approaches.

3. Steps for co-creating and using Impact Webs

This chapter provides information on key elements of Impact Webs (Chapter 3.1) as well as detailed instructions on how to co-create Impact Webs (Chapter 3.2) and use them to identify entry points for risk management (Chapter 3.3). It is structured along eight key steps (see Figure 1). These are described in more detail below.

3.1. Elements of Impact Webs

System analysis requires dealing with complexity. To be accessible, however, complexity needs to be broken down to its foundational components. Table 1 provides an overview of essential system components that can/should be considered in the co-development of Impact Webs.

Element	Symbol (Impact Web visual)	Description, guiding question and example	
Hazards, threats, shocks		*Description:*	A potentially damaging, sometimes unknown natural or human-made phenomenon, event or activity that may have adverse effects on vulnerable and exposed elements and systems. They may emerge slowly (e.g. sea level rise, droughts) or rapidly (e.g. flash flooding, earthquakes) and can be from a single phenomenon, event or activity (e.g. cyclone) or multiple interacting phenomena, events or activities (e.g. cyclone occurring during a pandemic; compounding heat and drought, etc).
		Guiding question:	"What hazards, threats and shocks (and their interactions) have led/might lead to impacts?"
		Examples:	COVID-19, tropical cyclone, flood, drought, armed conflict
Impacts		*Description:*	Effects caused by one or multiple hazards, shocks, threats or policy responses to them. They can be positive, negative, direct or indirect (i.e. cascading).
		Guiding question:	"What were the positive, negative, direct and indirect impacts resulting from the hazards, threats and shocks (and/or the responses to them)?"
		Examples (negative): *Examples (positive):*	Increased mortality, loss of income, disruption in remittances, mental health effects Advances in digitalization, improved early warning systems, increased risk awareness
Risks (impacts that did not manifest)	***Risks that did not manifest***	*Description:*	The potential for adverse consequences for human, technological and/or ecological systems, recognizing the diversity of values and objectives associated with such systems. Risks can be thought of as negative impacts that did not manifest.
		Guiding question:	"What were the potential impacts that were avoided, did not manifest or persist?"
		Examples:	Collapse of the health-care system due to COVID-19; crop failure leading to food system collapse; fuel shortage crisis
Interventions (responses)		*Description:*	Actions that are taken in response to an impact, risk or hazard, threat or shock.
		Guiding question:	"Which actions were taken in response to impacts, risks, hazards, threats or shocks?"
		Examples:	Lockdown during COVID-19; provision of food and shelter items during a tropical cyclone; trade embargo with a country due to armed conflict; water reservoirs to deal with droughts
Drivers of risk	***Driver of risk***	*Description:*	Processes or conditions that influence the level of risk by increasing levels of hazard, exposure and vulnerability.
		Guiding question:	"What drivers (processes or conditions) influence the risk of negative impacts?"
		Examples:	Poverty; lack of functioning/actionable early warning systems; limited capacity to cope with hazards, shocks and threats, etc.
Root causes	***Root cause***	*Description:*	Underlying factors influencing drivers of risk. They may be geographically or temporally remote as they often stem from structural as well as social, economic, cultural and political conditions, practices, priorities, choices and values/norms that are difficult to influence directly by e.g. local communities. Understanding root causes is essential for understanding why a particular community, sector, system or place is at risk, and is essential for risk management to be effective and sustainable.
		Guiding question:	"What are the underlying (structural) root causes influencing drivers of risk?"
		Examples:	Regional development challenges, endemic corruption, colonial legacies

3.2. Co-creating Impact Webs

The development of Impact Webs is an iterative and flexible process, where initial choices and steps can and should be revisited once new information and data becomes available. Critical reflection and creativity are encouraged when following the guiding steps.

It is important that your Impact Web is co-created in a participatory process based on close collaboration with relevant stakeholders and supported by extensive desk study. Key informant interviews, stakeholder workshops and expert backstopping strengthen outputs and provide better understanding of otherwise hidden system elements, compounding effects, and cascading and systemic risks and impacts that cannot be captured through desk study alone, and are key to co-developing Impact Webs.

Figure 4 provides an overview of **key steps needed** to co-develop an Impact Web (including guiding questions, recommended data and information sources, and expected outcomes). We recommend that you follow Steps 2-5 in an iterative manner as it is likely that you will produce new information and knowledge will be generated throughout the process of co-developing the Impact Web.

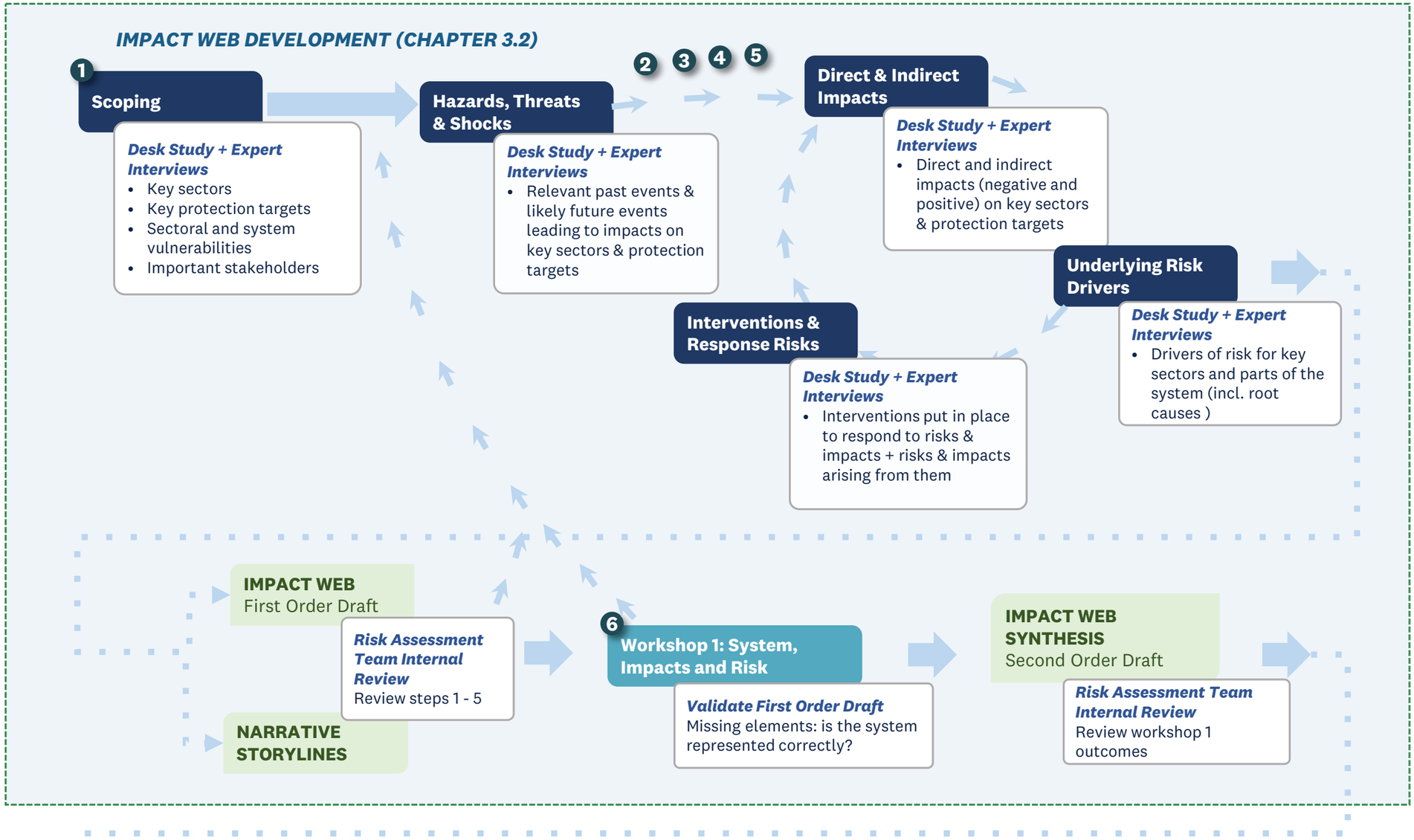


Figure 4: Guiding steps in developing an Impact Web. Steps 2-5 do not follow a particular sequence but are the result of an iterative process (Source: Authors)

You can develop Impact Webs in a variety of ways. In order to visually map the relationships between the different elements in Table 1, it is useful to work with graphic media that allow multiple corrections and iterations. For instance, a pen and paper exercise with flashcards is a simple but very effective way to conduct a first brainstorming session with the research team or with stakeholders during the workshop. The use of digital tools can facilitate the storing and editing of the growing amount of information. Virtual boards such as PowerPoint or online collaborative tools such as Miro (https://miro.com) or Kumu (https://kumu.io) are well suited for this. Online collaborative tools can also be an advantage when working remotely with stakeholders (for instance, in virtual workshops or interviews) as participants can directly interact with the model by adding elements, connections, notes and comments while additional users can be invited at later stages to adjust and edit the Impact Web. Regardless of which interface you use, it is highly important to keep track of how the Impact Web is developing by taking notes and photographs, and making multiple copies to review the evolution of the models through time.

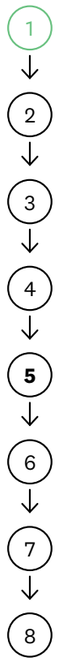
In addition to the graphic development of the Impact Web, we encourage you to document the information in the model in a database. This can be in a simple table format that keeps track of the elements and their relationship to one another (e.g. cascading effects) as well as any supporting evidence (e.g. relevant publications, data, etc.) linked to elements in the Impact Web. This will be useful for the workshops and when developing storylines and reports.

1 → Step 1: Scoping

Each risk assessment takes place in a unique setting that needs to be fully explored and understood. To this aim, this step is designed to frame the **context** of the assessment – which is vital for the identification of key system characteristics as well as sharpening the preliminary aims and objectives of the risk assessment. As a starting point, the boundaries of the system of interest should be indicatively identified. While this is a challenging task, you can do this by identifying the geographic extent of the risk assessment, the most essential sectors and systems of interest (e.g. agriculture, education, ecosystems), the critical/vital societal functions (e.g. energy, transport, health services, water provision, etc.) and/or main protection targets/adaptation goals (e.g. preventing the loss of life).

A review of relevant documents (e.g. policies, reports, academic studies, etc.) should be conducted to support the scoping. Moreover, we strongly recommend complementing the desk study with a set of key informant interviews with relevant stakeholders/experts who can bring valuable knowledge of the context. Such interviews can help, for instance, to identify important vital societal functions that are at risk in the case study area or the most pressing risk management and adaptation challenges. These could be experts in public policies, disaster risk reduction, adaptation, social, environmental and economic issues, or other cross-cutting themes of possible relevance for the study (e.g. gender, ecosystem-based adaptation, risk communication, risk governance).

Please note: *Given the complexity and huge number of interacting elements within a system, you will not be able to map all connections with an Impact Web. The scoping is therefore a key step to narrowing the context. Remember that the Impact Web is a simplification of reality, that when co-created with stakeholders, it provides a mutually agreed-upon representation of complex risks and impacts in a system.*



Guiding questions for inspiration:

What is the context and purpose of the risk assessment?

What are the most essential sectors, systems and vital societal functions stakeholders want to protect from current and future hazards, threats and shocks?

What are the most pressing risk management and adaptation challenges in the study area?

Which institutions and stakeholders should be engaged in the co-development of the Impact Web (think about the different sectoral/policy/thematic experts in your case study area), i.e. who are the most important actors stakeholders (e.g. from policy, practice, civil society, academia, media) that can influence risk within the system?

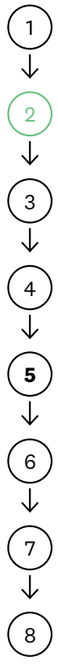
What are potentially relevant data and knowledge sources for your assessment?

Expected outcome:
Defining the scale, scope and objectives of the risk assessment, including the main characteristics and elements of the system

Data & information sources:
Desk review, key informant interviews (e.g. sectoral/ policy experts), national/ regional policy plans

2 → Step 2: Hazards, threats and shocks

Building on the scoping, the second step marks the start of developing the Impact Web. Step 2 aims to map the most relevant **hazards, threats and shocks** to the system of interest in the case study area. These can include climate-related extreme events, socio-natural hazards (e.g. heat waves, tropical storms, floods), man-made or technological threats (e.g. political unrest) as well as biological hazards (e.g. COVID-19 or other emerging infectious diseases). You should consider low-frequency/high-impact as well as unprecedented (but likely future) events; for example, stresses resulting from climate change. Furthermore, you should also consider the effects of possible interacting, i.e. compounding (e.g. heatwaves and droughts), concurring (e.g. COVID-19 and cyclones) and cascading (e.g. floods and mudslides or cholera outbreaks) hazards, threats and shocks in the co-development of the Impact Web.



Please note: Follow Steps 2-5 iteratively, i.e. by revisiting previous steps to see if any relevant elements are missing in the Impact Web (also after stakeholder workshops).

Guiding questions for inspiration:

What are the most relevant hazards, threats and shocks that may lead to adverse/negative impacts (on different parts of the system and/or critical/vital societal functions) in the case study area?

Are there relevant hazards, threats and shocks that occurred outside of the case study area but resulted in cascading effects within it as a result of interdependence?

What has "stressed" the system in the past and will likely also happen in the future? (e.g. climate-related extreme events such as floods and droughts)

Are there possible low-frequency (less likely) but high-impact events that could affect the study area in the future?

Have multiple hazards concurred together to have a compounding impact?

Are there hazards, threats and shocks that will become more relevant in the future (e.g. due to climate change)?

Graphic model

Use large oval shapes (see Figure 5) to add different types of hazards, threats and shocks to the Impact Web. This can also include major events that happened in other parts of the world but have led – or might lead – to impacts in the system of interest. You can also use icons or images to quickly and visually communicate different hazards, threats and shocks.

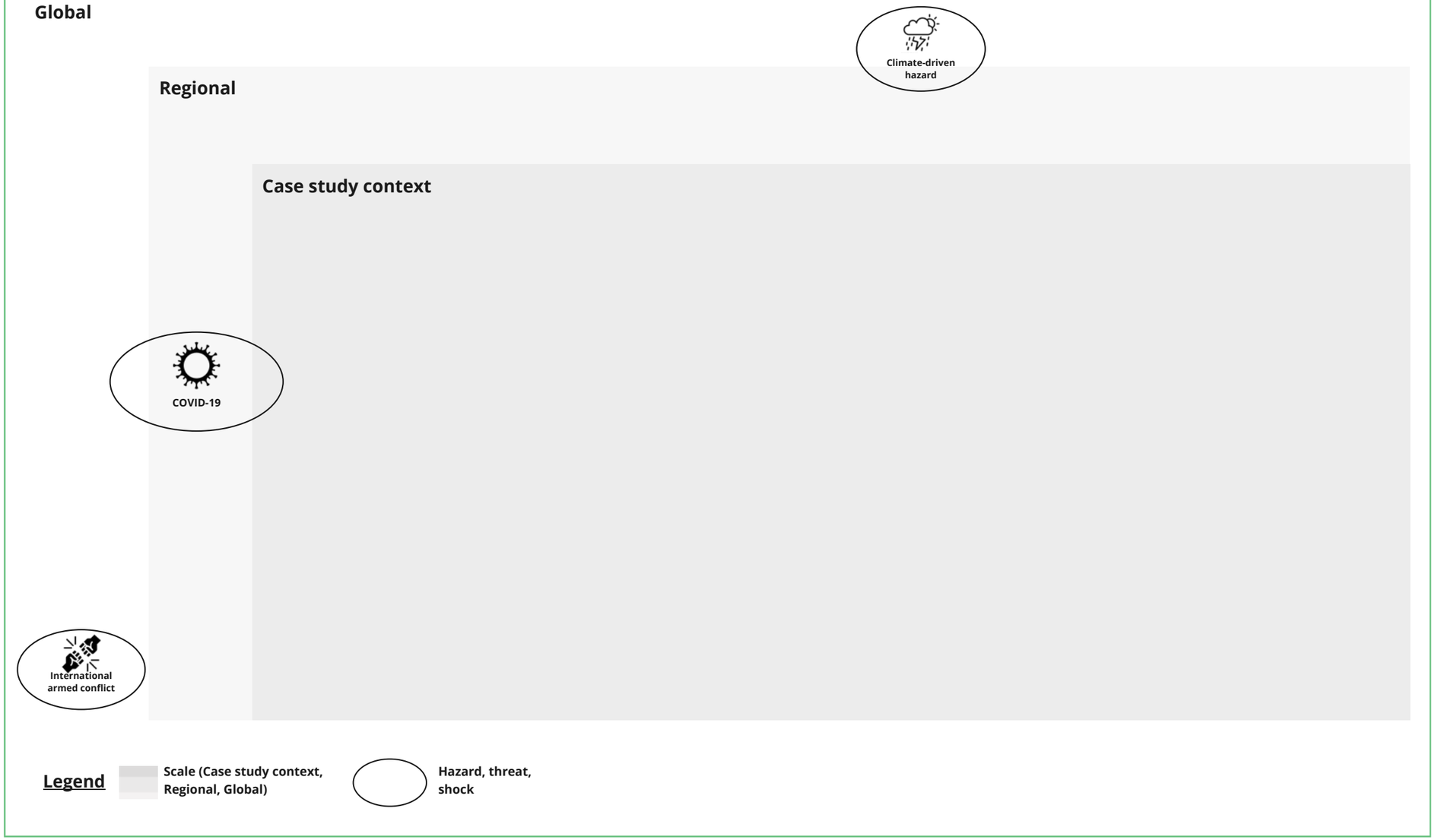


Figure 5: Illustrative example: COVID-19, a climate hazard and an international armed conflict have been added as hazards, threats and shocks to the system. Note that for the scale in this illustrative example, we take the national – regional – global context (Source: Authors)

Expected outcome:
Inclusion of most relevant hazards, threats and possible shocks (incl. low-frequency/ high-impact events as well as possible unprecedented but likely future events such as climate stresses) that affected (or might affect in the future) the study area

Data & information sources:
Desk study, impact data, key informant interviews (e.g. sectoral/policy/thematic experts)

3 → Step 3: Direct and indirect impacts

This step aims to identify relevant and observable **direct and indirect (i.e. cascading)** impacts or effects on different interconnected parts (e.g. social, economic, financial, health or ecosystems) of the case study area. With this, you want to understand how impacts have affected critical/vital societal functions and the most essential exposed sectors identified in the scoping as well as the ripple effects on the most vulnerable segments of society. It can be useful to build from the most critical hazards, threats and shocks in the case study area, thinking about interaction with other hazards, threats and shocks identified in Step 2.

Include relevant external impacts that are not directly found in the system you are mapping but affect it (e.g. international trade or tourism restrictions that affect informal livelihoods and economies). Impacts can be negative as well as positive (e.g. improved international cooperation following a regional drought, acceleration of digitalization due to the COVID-19 pandemic).

Graphic model

Use black circles to represent direct and indirect impacts. Use a cross for negative impacts and tick for positive impacts (see Figure 7 for examples of positive impacts). Negative and positive impacts could also be distinguished by using different colors (e.g. red and green). Connect impacts using black lines.

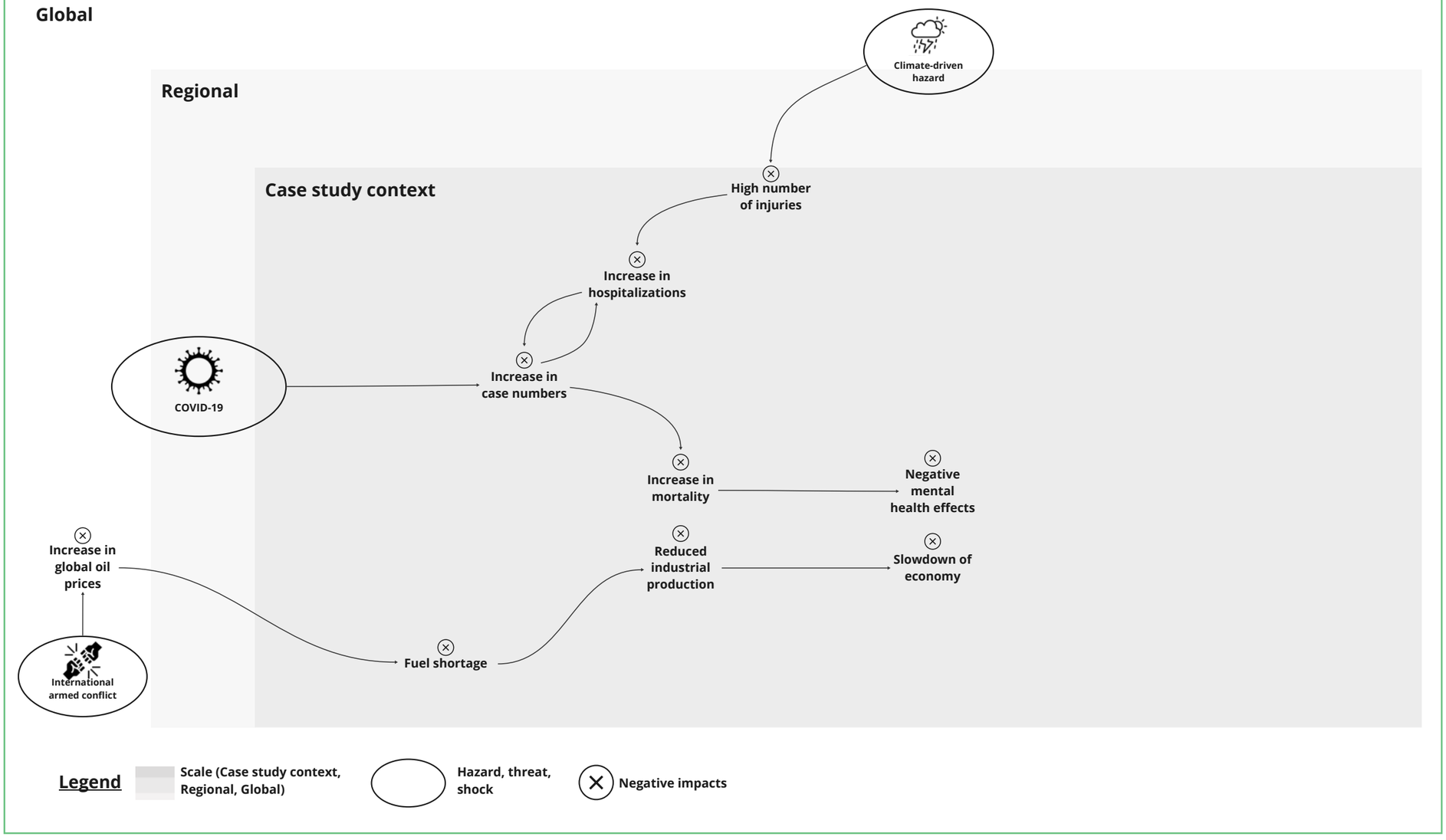


Figure 6: Illustrative example: Direct and indirect impacts of COVID-19, a climate hazard and an international armed conflict (Source: Authors)

1 → 2 → 3 → 4 → 5 → 6 → 7 → 8

Guiding questions for inspiration:

What direct impacts did hazards, threats and shocks (identified in Step 2) have on different parts of the system in the system (e.g. loss of life due to floods; rapid rise of infections due to COVID-19)?

How did these impacts lead to cascading effects within the same system as well as to other parts of the system (incl. effects on vital societal functions and key sectors)?

How have impacts, risks, hazards, threats and shocks in other regions affected the study area (e.g. supply-chain disruptions; reductions in aid provision; cross-border travel restrictions from COVID-19; remittance flows; etc.)?

Have direct or indirect positive impacts occurred as a result of hazards, threats or shocks (e.g. improved coordination in disaster risk management; advances in digitalization from COVID-19 lockdowns)?

Expected outcome:

Expected outcome: Inclusion of most relevant hazards, threats and possible shocks (incl. low-frequency/high-impact events as well as possible unprecedented but likely future events such as climate stresses) that affected (or might affect in the future) the study area

Data & information sources:
Desk study, impact data, key informant interviews (e.g. sectoral/policy/thematic experts)

4 → Step 4: Interventions/response risks and impacts

In Step 4, you should include interventions/responses that were put in place as countermeasures to (or in anticipation of) impacts from different hazards, threats and shocks (e.g. water-use restrictions due to drought; restrictions in fuel purchases due to supply shortages; the closure of informal food markets to prevent COVID-19 transmission). The intention of doing so is to understand whether or not such interventions have led or can potentially lead to response risks (i.e. intended and unintended negative risks and impacts that arose from the intervention). Some examples could be the loss of crops due to water-use restrictions; loss of mobility due to fuel restrictions; loss of work due to COVID-19 lockdown or improved air quality due to restriction of movement. This step also includes risks, i.e. impacts that did not manifest. These can be connected to impacts averted due to interventions (e.g. food system collapse; prevention of healthcare facilities collapsing during an epidemic/pandemic) or independent of them.

Guiding questions for inspiration:

What interventions/responses have been put in place in response to or anticipation of risks and impacts arising from hazards, threats and shocks?

What response risks and impacts (incl. positive impacts) have arisen as a result of interventions (e.g. improved crop irrigation systems from water-use restrictions; accelerated digitalization due to COVID-19)?

How have response risks and impacts affected other parts of the system as well as vital societal functions?

What risks did not manifest due to interventions?

Expected outcome:
Overview of the interventions put in place to respond to hazards, threats and shocks as well as the effects these had (i.e. preventing risks from manifesting as impacts and response risks)

Data & information sources:
Desk study, observations, key informant interviews (e.g. sectoral/policy/thematic experts)

1 → 2 → 3 → 4 → **5** → 6 → 7 → 8

Graphic model

Use grey rectangles to specify which interventions were implemented in response to risks and impacts from hazards, threats or shocks. Include risks that did not manifest due to interventions in a different colour (here in orange). Use lines to establish connections (e.g. with other impacts or risks).

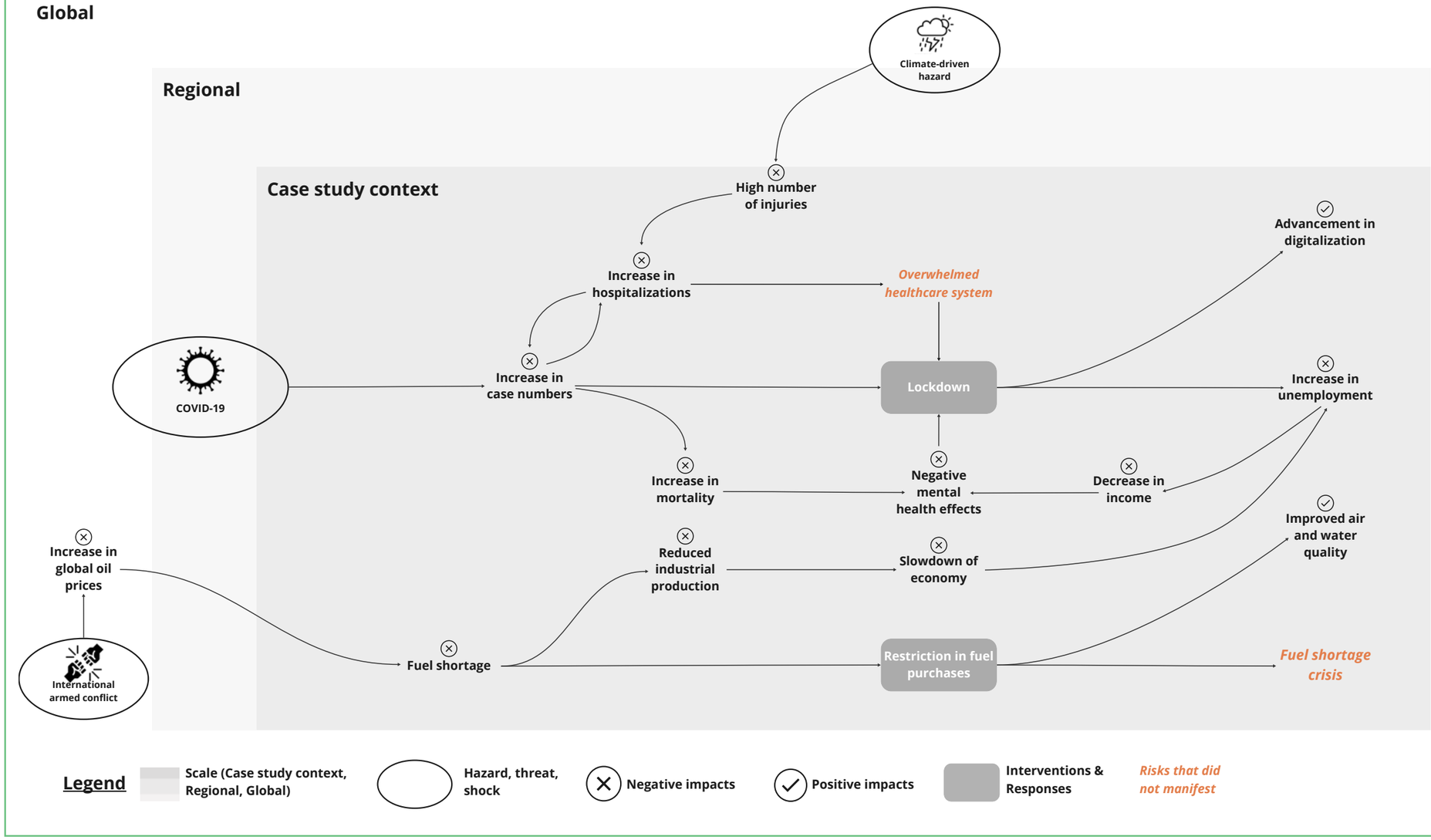


Figure 7: Illustrative example: Interventions (here: lockdown & restriction in fuel purchases); risks that did not manifest (here: overwhelmed health care system & fuel shortage crisis) and response risks and impacts (e.g. loss of work/advances in digitalization) (Source: Authors)

5 → Step 5: Underlying drivers of risk and root causes

In Step 5, include **drivers of risk** and their **root causes** in the Impact Web. Drivers of risk ask for critical reflection on how and, notably, why some communities, sectors or systems have been adversely affected (e.g. due to high susceptibility or low coping capacity). Further, this step aims to explore the underlying reasons (i.e. root causes stemming from socioeconomic and political structures, processes, choices and values) for these risk drivers. Some drivers of risk that you identify might also be relevant for multiple risks and impacts.

Guiding questions for inspiration:

Why are sectors and systems at risk, i.e. which drivers of risk explain how previously identified risks and impacts emerged in the case study area and system of interest?

Why were specific parts of the system susceptible or did not show sufficient capacity to cope?

Which vital societal functions have been most affected and what has been driving this?

Graphic model

Include drivers of risk and root causes in a different colour (here dark blue and light blue) for the risks and impacts identified in the previous steps. Use different colour lines to to establish connections between root causes, drivers of risk and impacts (here also dark and light blue).

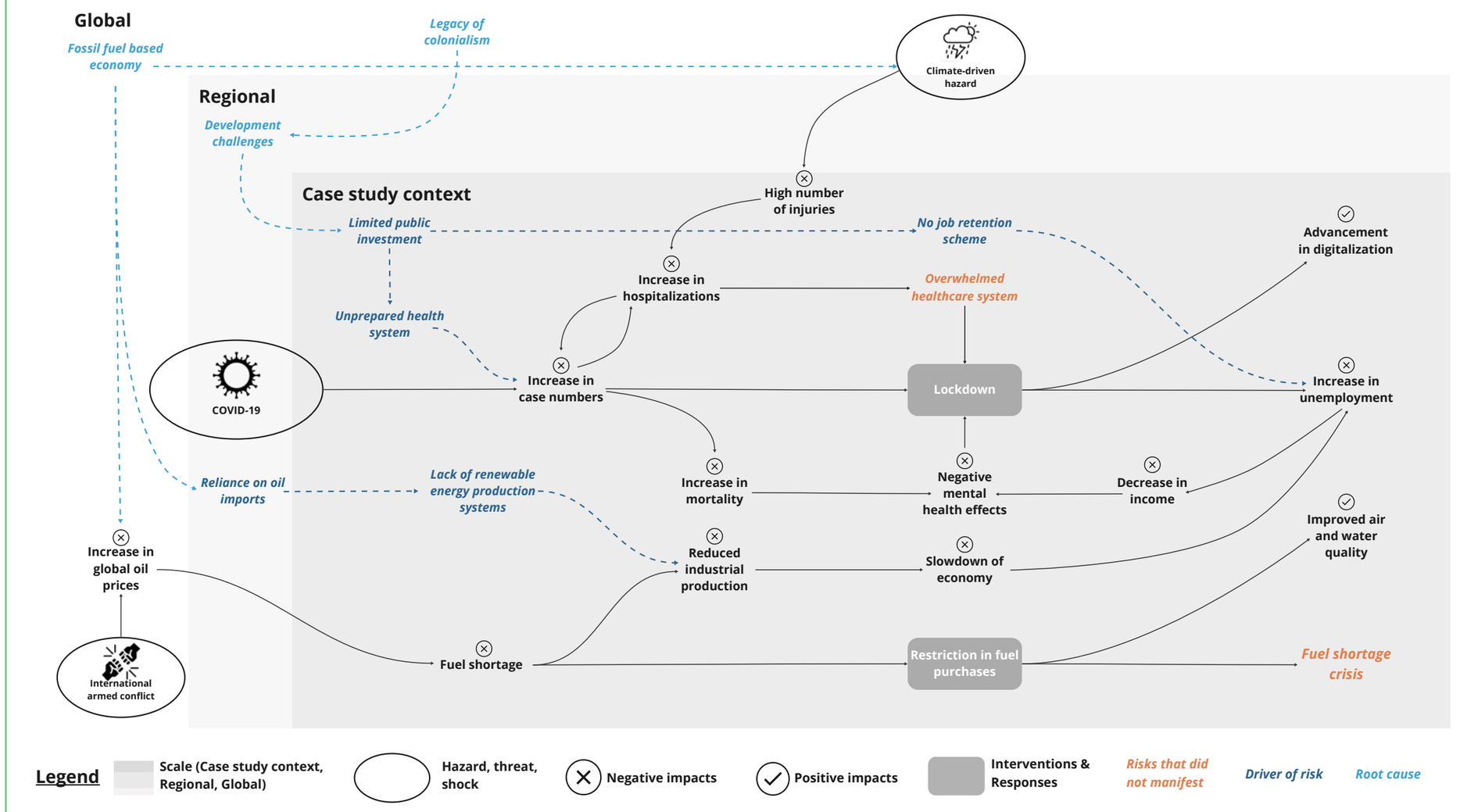


Figure 8: Illustrative example: Drivers of risk and root causes now added (Source: Authors)

5 → Step 5: Underlying risk drivers and root causes

Take time to review the elements in your Impact Web and identify **key sectors** that have been affected as well as **key stakeholders within and across sectors**. This will be useful to identify stakeholders for the workshops (see workflow in Figure 2); for example, sectoral and policy experts, government ministry, international organization and NGO employees, and civil society representatives. Where possible and relevant, it is important to ensure representation of local as well as vulnerable and marginalised groups; for example, representatives from community groups or women's groups. Reflect if sectors and stakeholders align with those that were identified in the scoping to ensure the model is aligning with the context and purpose of the risk assessment.

Expected outcome:
Inclusion of how and why impacts have arisen or might arise and how stakeholders may have influenced impacts and risks (possible impacts = risks)

Data & information sources:
Desk study, observations, key informant interviews (e.g. sectoral/policy thematic experts)

1 → 2 → 3 → 4 → 5 → 6 → 7 → 8

Output: Impact Web (first order draft)

By following Steps 1-5, you will have produced the first order draft of an Impact Web for your case study area/system of interest. **In this intermediary step, you should reflect upon and revise your Impact Web**. Critically analyze the Impact Web, engaging with other experts where possible, aiming to identify blind spots and examining connections and elements in the conceptual model. In preparation for the first stakeholder workshop, the elements that you have mapped (i.e. hazards, impacts, risks, interventions, risk drivers) as well as review of key affected sectors and stakeholders can be used to **identify relevant stakeholders** that could contribute to the discussion.

Output: Narrative storylines

Storylines are useful to complement the visual model. Storylines are short narratives that explain in simple language what the model visualizes, i.e. the elements and their interconnections. They will be useful in presenting the results of your Impact Web analysis to external stakeholders and help you test and understand if the model is underpinned by a coherent logic (van den Hurk et al., 2023; Dessai et al., 2023). To develop the storylines, you can start by taking short notes about each element and its connections during the desk study phase. Then, when the first draft of the visual model is finalized, organize your notes into a short and concise text. In the interest of transparency, provide reference to which data and knowledge sources were used. Storylines are an important part of the outputs of the analysis and should help the iterative process of creating the Impact Webs.

Guiding questions

Does the logic of the Impact Web make sense?

Are the main elements and characteristics of the system sufficiently captured?

Are the most relevant impacts and risks from hazards, threats and shocks in the appropriate positions in the network?

How do elements align with what was identified in the scoping from key informant interviews? Which additional sectors and critical societal functions have you identified?

Which sectors are linked to drivers of risk and why?

What does interconnectivity of different parts of the system tell us about cascading and systemic risks?

Now review:
Revisit your Impact Web and review the elements you have identified. Is anything missing? Do interlinkages make sense? How do impacts, risks and drivers, and root causes of vulnerability influence each other? Do you see feedback loops? Are key sectors sufficiently represented?

Expected outcome:
Impact Web first order draft. Analysis of logic of the conceptual model, including identification of the most vulnerable elements in the Impact Web and endogenous risks. Identification of additional stakeholders for the workshops.

6 → Step 6: Workshop 1 “System impacts and risks”

Following your development of a draft Impact Web using desk study and key informant interviews, we strongly encourage you to co-develop a revised version with relevant stakeholders through the organization of a **workshop** and through expert consultations. These will aim to validate “ground truth” in the first order draft of the Impact Web. You should engage stakeholders with relevant sectoral/policy/thematic expertise that were identified during the scoping (Step 1) and throughout the development of the first order draft. Additionally, you should ensure there is representation of vulnerable and marginalized groups (e.g. informal sector workers or women's groups). Their expertise can provide important insights on the logic and missing elements in the Impact Web. Consulting experts at this stage will allow validating past, current and possible future impacts and risks. It will also include new observations that have likely been missed and expert insights on drivers of risk from each person’s sectoral and/or thematic areas of expertise. During the workshop, attendees should be given the possibility to review the Impact Web in plenary and/or group sessions (e.g. breakout groups), providing insights to validate and improve it. You will revisit the Impact Web based on these feedbacks.

Possible guiding questions for inspiration:

What are missing elements in the Impact Web and does it sufficiently capture key system characteristics, risks and impacts?

Are there elements that are contested or should be removed?

Do the interlinkages and connections make sense?
Any to add/remove or change?

Does the Impact Web sufficiently capture important critical societal functions, sectoral and system vulnerabilities at risk in the case study area?

Expected outcome:
Identification of missing elements and validation of the representation of the system, including key elements of focus for risk management, and expert insights on endogenous and exogenous risks.

Information & data sources:
Workshop 1 and bilateral consultations.

Output: Impact Web synthesis (second order draft)

After the workshop and bilateral consultations, you should revise and process inputs from stakeholders. Reflect here again on the scoping to see if your Impact Web is aligning with your original goals and targets.

Guiding questions:

Was stakeholder representation in the workshops sufficient (e.g. certain sectoral or thematic experts that could provide useful insights for the Impact Web)? Did relevant voices get heard (including vulnerable and/or marginalized groups)?

Which prevailing themes emerged from the workshop and consultations and how do they link to the Impact Web?

Expected outcome:
Reflection on the previous steps and Workshop 1; second order draft.

Now review:
Revisit your Impact Web and review the elements you have identified. Is anything missing? Do interlinkages make sense? How do impacts, risks and drivers, and root causes of vulnerability influence each other? Do you see feedback loops? Are key sectors sufficiently represented?

Box 2 : A conceptual model of the systemic nature of COVID-19 risks and impacts based on Impact Webs from five countries

The Impact Webs approach was developed by UNU-EHS and partners in the CARICO project to explore cascading and systemic risks, and impacts of the COVID-19 pandemic and policy responses to it (see UNDRR & UNU-EHS, 2022). Using case studies in five different countries, Impact Webs were created by local experts using a combination of stakeholder consultations and information from scientific and grey literature. The Impact Webs helped visualize the complex interactions of risks connected to the COVID-19 crisis in the case studies. They created an overarching conceptual model (Figure 2), which shows how direct and cascading effects emerged across interconnected systems from the COVID-19 pandemic and associated responses/policy interventions.

The conceptual model was developed based on the results of Impact Webs developed in Ecuador, Togo, India, Bangladesh and Indonesia by local experts. It illustrates how direct risks and impacts from COVID-19 and concurring hazards resulted in decision-making processes (i.e. responses and interventions) which interacted with various system components (pre-existing vulnerabilities, dependencies, feedback loops and tipping points) to generate interconnected cascading risks and impacts across systems, borders and scales. For a full breakdown of the conceptual models logic, see Chapter 4 of the scientific report here.

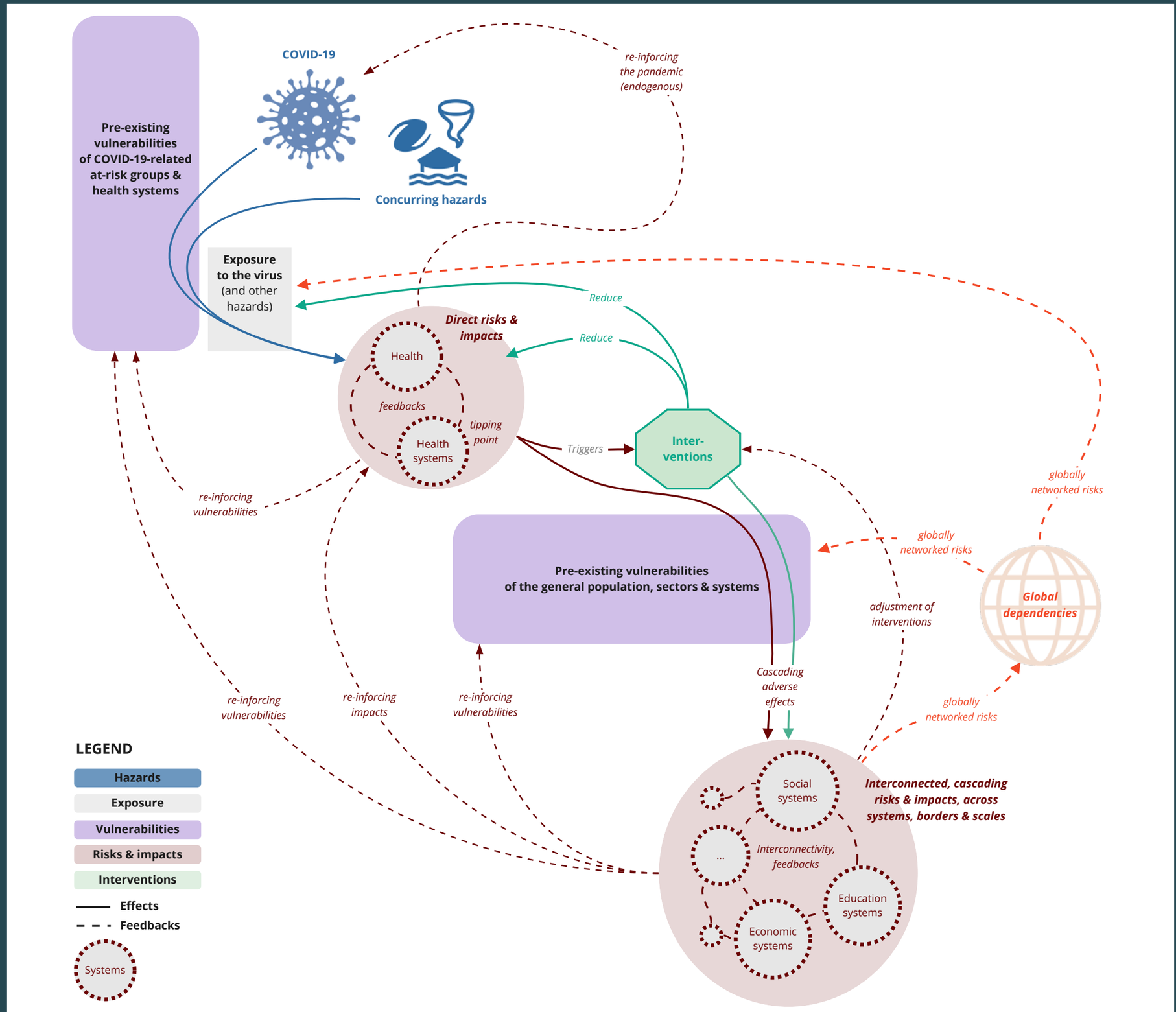


Figure 9: Conceptual model of the systemic nature of COVID-19 risks and impacts (Source: UNDRR & UNU-EHS, 2022)

3.3. Using Impact Webs to identify entry points for risk management

The core objectives of developing an Impact Web are to strengthen understanding of complex risks and identify elements where compounding, cascading and systemic effects can be minimized through risk management.

By risk management we mean plans, actions, strategies or policies to reduce the likelihood and/or magnitude of adverse potential consequences. Following the previous steps to co-develop the Impact Web, entry points for risk management will have likely already emerged (e.g. from mapping previous interventions and their cascading effects or from engaging with stakeholders in interviews and workshops). This part of the proposed workflow (Figure 10) explicitly focuses on identifying entry points for risk management.

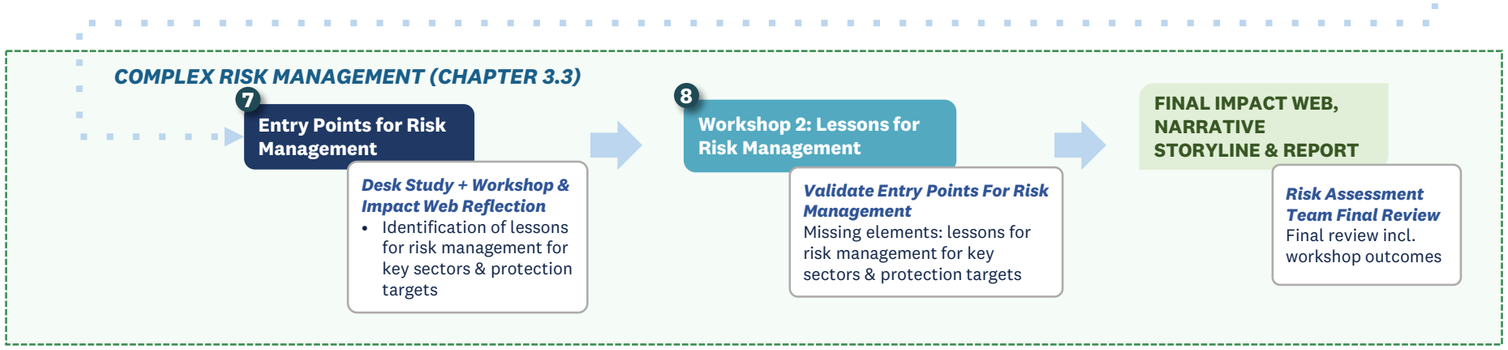


Figure 10: Guiding steps for using Impact Webs for complex risk management (Source: Authors)

A villager walks through the rubble of destroyed houses in Douzrou, Morocco, following a 6.8-magnitude earthquake that killed more than 2,800 people in September 2023, most of them in remote villages of the High Atlas Mountains. © Fadel Senna/AFP

7 → Step 7: Entry points for risk management

The Impact Web can serve as a useful tool to identify entry points for managing complex risks. By “entry points” we mean places in the Impact Web where a targeted risk management option could “break”, “re-direct” or “minimize” impact or risk creation for one or multiple elements at risk. We encourage engagement with sectoral/policy experts who can be invited to a planned second stakeholder workshop. As a start, it can be useful to review past and current disaster risk management plans and policies to learn what has worked well and what has not worked so well.

Additionally, it is important that you think about comprehensive risk management packages that will increase diversity, sustainability and effectiveness of options (e.g. combinations of structural, behavioural, institutional risk management plans/policies and early warning systems, etc.). When thinking about comprehensive risk management packages, be cognizant of the possible trade-offs and negative outcomes (e.g. response risks).

Guiding questions:

What past and current risk management options have been discussed or implemented in the case study area. What went well and not so well in these efforts (e.g. unwanted cascading effects)?

Where can you see entry points for risk management options in the Impact Web (e.g. when reviewing drivers of risk, their root causes or interdependencies of sectors and systems)?

Are there any leverage points that can be targeted to address multiple risks at once?

Have any future risk management plans/policies been made in the key sectoral areas or to protect critical societal functions?

Information & data sources:
Desk study, observations, workshop and Impact Web reflection sessions

8 → Step 8: Workshop “Lessons for risk management”

In Step 8, we recommend organizing a second workshop, focusing explicitly on identifying lessons for risk management. Following the same guidance as for the first workshop (Step 6), the potential guiding questions below can inform the concept note, aims and objectives of the workshop.

Potential guiding questions for inspiration:

Where are entry points for risk management in the Impact Web?

What does the Impact Web tell us about complex risk management?

What risk management options could support protecting critical societal functions, as well as sectoral and system vulnerabilities that are affected by risks in the case study area?

What risk management options could be effective at reducing the likelihood and/or magnitude of adverse potential consequences for elements in the Impact Web?

Where could risk management options trigger potential positive and/or negative cascades in the Impact Web?

What are barriers to implementing risk management options, what are enablers?

Who are key stakeholders in risk management and how could they support developing and taking forward risk management options?

Output: Final Impact Web, narrative storyline and report

The final step will be to review the Impact Web and outcomes of the workshops. Reflect on the strengths and weaknesses of the process and output. Upon completion of this step you will have produced an Impact Web that has enabled you to identify hazards, threats and shocks to the system, vulnerable sectors and how stakeholders influence risk, root causes of vulnerabilities and risk management options. Your findings can be synthesized in a final case study report, building on the narrative storylines and the interim report that documents the main outcomes of the Impact Webs development.

Expected outcome:
Final Impact Web and final case study report (incl. narrative storyline, recommendations for enhanced risk management).

Box 3: Application example: COVID-19 and concurring hazards in Guayaquil, Ecuador

Background

The COVID-19 pandemic has been an unprecedented shock, the effects of which have been felt across borders, systems and scales globally. The methodology and steps in this guidance document were applied to a case study in Guayaquil, Ecuador to characterize the interaction of risks linked to COVID-19, concurring hazards and the responses to them during the first year and a half of the pandemic (UNDRR & UNU-EHS, 2022). Guayaquil is the largest and most densely populated city in Ecuador (approx. three million people) and has the highest rates of poverty (11.2 per cent), largest informal work sector (45.9 per cent) and the most overcrowded housing in the country (Lucero, 2020). Additionally, the city is exposed to various hazards including earthquakes, volcanic eruptions, ash fall, tsunamis, high-tide floods, pluvial floods, landslides, wildfires, vector-borne diseases, droughts, sea level rise (Sarmiento, 2010). These characteristics, and the drivers and root causes behind them made the city of Guayaquil highly vulnerable to COVID-19 and concurring hazards, and thus an important case to understand and characterize cascading and systemic risks.

Impact Web

Figure 11 shows the Impact Web that has been co-created with relevant stakeholders in the case study area based on desk study and stakeholder workshops.

Narrative storyline

Following the first confirmed case on 29 February 2020, there was a rapid rise in case numbers and increase in hospitalizations. The hospitalizations and resulting high mortality were unmanageable. A tipping

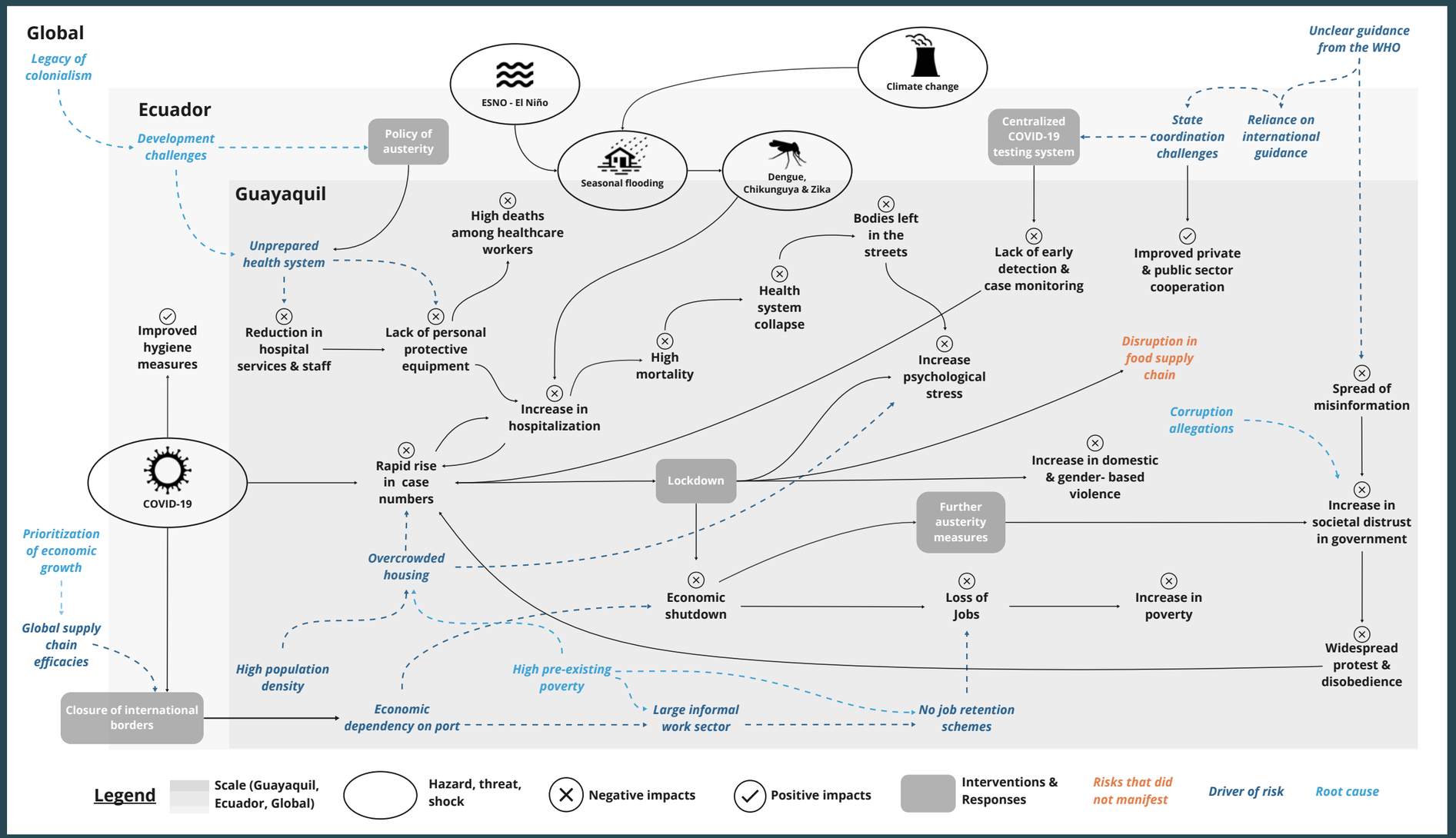


Figure 11: Impact Web on COVID-19 and concurrent hazards in Guayaquil, Ecuador (Source: Authors)

point was reached in a matter of weeks and the health system collapsed, resulting in a large number of bodies being left in the streets, hospitals and care homes (Alava & Guevara, 2021). The images of bodies accumulating in the streets circulated throughout global media, presenting an early example of how COVID-19 could rapidly spread in a densely populated urban area and trigger a near total collapse of a health-care system. In March of 2020, the city had an excess mortality rate five times that of the same month in 2019 (Cabrera and Kurmanaev, 2020) and the highest COVID-19 mortality rate of any Latin-American city (WHO, 2021).

In the five years leading up to the pandemic, government interventions of policies of austerity had led to a reduction in hospital services and staffing, which had dropped between 20-35 per cent in 2019-2020 alone (Organización Internacional del Trabajo, 2021). It was highlighted by experts in Workshop 1 that the under-prepared health system in a city with a high population density was not able to manage the rapid rise in case numbers. There was a lack of personal protective equipment and not enough medically trained staff to treat the sick. The lack of personal protective equipment resulted in a high number of cases and deaths among health-care workers, which further burdened the health-care system and increased psychological stress for health-care workers. Compounding with this, the health system was already under pressure from seasonal flooding intensified by climate change, which resulted in increases in vector-borne diseases such as Dengue, Chikunguya and Zika viruses.

As well as having an under-prepared and insufficient health system capacity, the case of Guayaquil presents an example of how prioritization of economic growth and global supply chain efficiencies have resulted in high levels of dependency across scales and social systems (Gordon & Williams, 2020). Participants in Workshop 1 stressed that disruptions resulting from the intervention to close international borders were particularly evident in Guayaquil due to the city's economic dependency on the port. The closing of borders triggered economic shutdown with widespread adverse effects on employment and livelihoods. People working in the informal sector, many of whom were already living in poverty before the pandemic, were left without income opportunities, increasing poverty and psychological stress. It was flagged in Workshop 2 that the lack of job retention schemes exacerbated this issue. Additionally, it was noted by experts in Workshop 1 that the high population density and overcrowded housing throughout the city became more of a problem when people lost their jobs. Due to the limited availability of space per person, the lockdown intervention and social distancing were difficult to follow for a large segment of the population and was not sustainable over longer time periods of weeks and months and with increased psychological stress. The lockdown also resulted in sharp increases in domestic and gender-based violence. One risk that did not manifest as a result of lockdowns was disruption in the food supply chain. As Ecuador is a food-producing country, there were far fewer food shortages than in some other countries in the region.

Workshop 2 findings further highlighted that there was a lack of an integrated, cross-sectoral and multi-scale response between Guayaquil's and Ecuador's public institutions. State coordination challenges and the intervention to maintain a centralised COVID-19 testing system hindered the effectiveness of local institutions to set up early-detection, warning and monitoring systems such as contact-tracing and testing facilities (Alava & Guevara, 2021). The limited capacity of data processing at the national level further highlighted cross-scale dependence as it led to a less comprehensive response at the city level.

Participants in Workshop 2 stressed the fact that the response of state actors was also influenced by their dependence on the flow of information from global to local scales. As in many low-income and middle-income settings, there is a reliance on international guidance, collaboration and support, which are imperative components for comprehensive risk management, especially in times of disaster. Unclear guidance from the WHO resulted in the output of unclear information, which prompted a slower uptake of protocols and ambiguous communication from the Ecuadorian government. Workshop 2 participants noted that this was one of the factors that contributed to the spreading of misinformation throughout digital networks. One positive impact that was identified concerned the improvement of hygiene measures across the country (including wearing of masks, provision of hand sanitizers, etc.) to reduce the risk of infection from COVID-19 and other respiratory infections such as influenza. Additionally, it was noted that there is now enhanced public and private sector cooperation as a result of the state coordination challenges that arose in the early stages of the pandemic.

In response to the economic disruptions, the government of Ecuador brought in further austerity measures. This intervention intensified the many cascading impacts for already vulnerable citizens. Furthermore, corruption allegations were brought against some city and state-level actors for capitalizing on the emergency health-care situation (Brown, 2021). These factors saw increasing societal distrust in the government, which was already underlying through policies of austerity. This came to fruition in Guayaquil when a societal tipping point was reached in May of 2020, resulting in widespread protest and civil disobedience.

The case of COVID-19 in Guayaquil highlights how under-preparedness in the health-care system, overcrowding, the shutdown of global networks and incomprehensive state and international coordination and response present characteristics of dependence and tipping points in a densely populated, urban context.

4. Closing remarks

To be better prepared for the increasingly complex risks our societies face, we must first understand them. Impact Webs can be a powerful tool for understanding complex risks as they allow for an in-depth analysis of risks while accounting for their interactions within the systems in which they exist. Impact Webs can be used to provide guidance for data-driven risk assessment and to identify risk management options.

As with any other approach that attempts to model reality, Impact Webs can only offer a simplified version of the complexity that characterizes the systems we live in and depend on. This means that there will inevitably be elements, scales, connections, dynamics and other details that will not be represented in the final conceptual model. This is an unavoidable limitation. However, there is already profound merit in reaching a shared agreement on which are the most essential risks in and to our systems and which elements characterize them: far from being trivial, this is a first step in building the space for identifying shared and comprehensive solutions.

Besides its outputs, the Impact Web approach is also relevant as a process. The essential role of stakeholders in co-constructing and validating Impact Webs should not be seen only in terms of data collection carried out by the researcher or consultant conducting the risk assessment but, rather, in the wider scope of promoting a critical reflection and discussion among relevant stakeholders on the complex nature of risks for which shared and systemic solutions need to be found and evaluated across sectors and scales.

A couple in a flooded road as they walk towards their house after Storm Elias hit the region in village Sotirio, central Greece, September 2023. © Angelos Tzortzinis/AFP

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Massive destruction in the city of Derna in the wake of Storm Daniel. Mismanagement and neglect driven by persistent conflicts, together with an extreme weather event, led to the collapse of dams triggering a disaster of incredible scale. © Mahmud Turkia/AFP

Imprint

Publisher:
United Nations University, Institute for Environment and Human Security (UNU-EHS), Bonn, Germany
October 2023

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Suggested citation:
Sparkes. E., Hagenlocher, M., Cotti, D. et al. (2023). Understanding and characterizing complex risks with Impact Webs: a guidance document. UNU-EHS, Bonn, Germany

Copy editor: Clara Young and Jelke Brandehoff

Acknowledgements:
This publication has been developed within the CARICO (“Understanding Systemic and Cascading Risks: Learnings From COVID-19”) and CARICO SADC (“Lessons from the COVID-19 pandemic for understanding and managing cascading and systemic risks in the SADC region”) projects. The CARICO project has received financial support from the UN Office for Disaster Risk Reduction (UNDRR) and the Government of Germany, notably the Federal Ministry for Economic Cooperation and Development (BMZ) and the Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The CARICO SADC project (Grant Agreement 81292321) is funded by BMZ and supported by GIZ. Views and opinions expressed are those of the authors only and do not necessarily reflect those of UNDRR, GIZ or BMZ.

Federal Ministry
for Economic Cooperation
and Development