Deliverable D1.3

Impact, damage and loss data related to the considered events in the four core cases. Wiki-type structured Database

Revision	Organization	Date
Written by	EURAC	29-05-2024
Checked and approved by	ITC UT	30-05-2024
Validated and released by	UT	31-05-2024

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Information table

Deliverable Number	D1.3
Deliverable Title	Impact, damage and loss data related to the considered events in the four core cases. Wiki-type structured Database.
Version	V3
Status	Final
Responsible Partner	EURAC Research
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Contractual Date of Delivery	31-05-2024
Actual Date of Delivery	31-05-2024
Dissemination Level	PU – Public

Abstract

Deliverable 1.3 aims to present the Impact Chain Wiki, an online database of Impact Chains, developed within the PARATUS project. Impact Chains (ICs) are conceptual models of climate and disaster risks that have been developed to streamline the analysis of climate-related impacts and provide a structured framework for the comprehensive assessment of related risks. They do not consist only of a visual illustration but also provide a semantic representation of risk components (hazards, impacts, vulnerabilities, and exposure), where pre-defined elements and connection types are defined and described through metadata. In PARATUS, Impact Chains have been developed for the four Application Case Studies (Alps, Istanbul, Romania and Caribbean), supported by the analysis of different past disaster events (Learning Case Studies). The aim of the Impact Chain Wiki is to store the knowledge related to the Impact Chains and to facilitate its interactive consultation by project partners as well as by external stakeholders. The Wiki is available online, on the Disaster Risk Stakeholder Hub and is based on KUMU, an online tool which allows to build and store Impact Chains, while assisting in managing this complexity. This Deliverable provides the links to access the Wiki as well a synthesis of its main functionalities.

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This project has received funding from the European Union's Horizon Europe Research and Innovation program under grant agreement No 101073954

Document history

Version	Date	Author	Description
	Continuous process	All the authors	Developed the Impact Chains which feed into the Wiki, supported by Forensic Analysis
V0	29-01-2024	Silvia Cocuccioni (EURAC)	Made the concept note
V1	09-02-2024	Silvia Cocuccioni, Federica Romagnoli, Liz Jessica Olaya Calderon (EURAC)	Adapted the concept note
V2	15-05-2024	Silvia Cocuccioni, Massimiliano Pittore, Federica Romagnoli, Liz Olaya Calderon (EURAC), Cees van Westen (UT)	Provided inputs and wrote the Introduction and the Impact Chain methodology / Wiki Chapters
V2	24-05-2024	Silvia Cocuccioni (EURAC)	Provided inputs on next steps
V2	27-05-2024	Silvia Cocuccioni, Federica Romagnoli, Liz Jessica Olaya Calderon (EURAC)	Completed the editing and made the deliverable ready for review
V2	30-05-2024	Cees van Westen (UT ITC)	Internal Review
V3	30-05-2024	Silvia Cocuccioni, Federica Romagnoli, Liz Jessica Olaya Calderon (EURAC)	Addressed the comments and final check
V3	31-05-2024	Cees van Westen (UT)	Submitted the deliverable

Disclosure Statement:

The deliverable 1.3 submitted to the European Commission on 31/05/2024 and is waiting for approval by the Research Executive Agency. Therefore, this current version may not represent the final version of the deliverable.

About PARATUS:

The PARATUS project aims to increase the preparedness of first and second responders in the face of multi-hazard events and to reduce the risks related impacts on various sectors resulting from complex disasters. The outcome is to develop an open-source cloud-based Online Service Platform that offers support in reducing dynamic risk scenarios and systemic vulnerability caused by multi-hazard disasters. To achieve these objectives, the project will perform in-depth assessments of complex interactions between hazards and their resulting impacts on various sectors, analyse the current risk situation and study how alternative future scenarios could change multi-hazard Impact Chains. Based on these analysis, scenarios of multi-hazard impacts will be co-designed and developed with stakeholders in four case study areas (including the Caribbean, Romania, Istanbul, and Alpine regions).

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List of Acronyms

Acronym	Definition
ACS	Application Case Study
CS	Case Study
DRR	Disaster Risk Reduction
EURAC	Eurac Research
IC	Impact Chain
LCS	Learning Case Study
PARATUS	Increasing Preparedness and Resilience of European Communities by Co-Developing Services Using Dynamic Systemic Risk Assessment
UT	University of Twente
WP	Work Package

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Executive summary

Work Package 1 "*Learning from the past: understanding the dynamic and interactive conditions of risk*" focuses on utilizing information from historical disaster events (so-called Learning case studies) and combining this information with disaster history in application case studies. This includes analysing how the hazardous events directly and indirectly impacted and would impact different sectors, such as health, cultural heritage, environment and biodiversity, public finance, and key economic sectors. Learning from past events allows us to advance risk science and achieve improved multi-hazard impact forecasting.

This Deliverable D1.3 aims to present the Impact Chain Wiki, an online database of Impact Chains, developed within the PARATUS project.

Impact Chains (ICs) are conceptual models of climate and disaster risks that have been developed to streamline the analysis of climate-related impacts and provide a structured framework for the comprehensive assessment of related risks. They do not consist only of a visual illustration but also provide a semantic representation of risk components, where pre-defined elements and connection types are defined and described through metadata. The different elements addressed by Impact Chains are hazards, exposure, vulnerabilities and impacts.

In PARATUS, Impact Chains have been developed for the four Application Case Studies (Alps, Istanbul, Romania and Caribbean), supported by the analysis of different past disaster events (Learning Case Studies). In particular, the Forensic Analysis Framework (see Deliverable 1.2) supported the development of the Impact Chains by compiling evidence related to past disaster events, providing the missing metadata (e.g. description, references, sources) and identifying elements which were initially overlooked (mainly related to social aspects, such as vulnerabilities and impacts).

These Impact Chains are collected in an online database under the form of an Impact Chain Wiki. The aim of the Wiki is to store the knowledge related to the Impact Chains and to facilitate its consultation by project partners as well as by external stakeholders.

The Wiki was co-developed on an online tool, KUMU, which allows to build and store Impact Chains, while assisting in managing this complexity. The Wiki is accessible from the Disaster Risk Stakeholder Hub (https://www.cmine.eu/topics/35391/page/impact-chains-WIKI). Through the tool it is possible to explore interactively the metadata related to different elements and connections. For example, each impact is described in text, and where possible figures or maps are presented, as well as the supporting references. Moreover, the available Impact Chains are supported by informative material, among which a tutorial on how to use KUMU, guidelines for their development and forensic analysis narratives describing specific past events.

This Deliverable provides the link to access the Impact Chain Wiki as well a synthesis of the main functionalities (including those of KUMU). Basic functionalities include the structured development of Impact Chains, through a pre-defined PARATUS view, their consultation both from the visual and table interface, the download options in different formats (e.g PNG, JSON). Please note that this Deliverable does not present any specific data on past disaster events as these are stored within the Impact Chain Wiki, which can be consulted interactively online at the above mentioned link. Currently, the Impact Chain Wiki is collecting data about hazards, exposure, vulnerabilities and impacts in the form of text or narrative. In following stages of the project, more structured quantitative data will be collected, based on the identified Impact Chain elements.

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Table of Contents

1 Introduction to WP1 and D1.3

Work Package 1 (WP1) "*Learning from the past: understanding the dynamic and interactive conditions of risk*" focuses on utilizing information from historical disaster events (so-called Learning case studies) and combining this information with disaster history in application case studies. This includes analysing how the hazardous events directly and indirectly impacted and would impact different sectors, such as health, cultural heritage, environment and biodiversity, public finance, and key economic sectors. Learning from past events allows us to advance risk science and achieve improved multi-hazard impact forecasting. Moreover, WP1 activities include the exploitation of satellite remote sensing data for providing risk components for systemic risk assessment.

In particular, within PARATUS a series of past disaster events (Learning Case Studies, see Deliverable 1.2 for more details) and four different Application Case studies (see Deliverables 6.1, 6.2 and 6.3) have been selected and are at the core of the project activities. Within WP1, the different Case Studies are studied through the development of Impact Chains, with the help of forensic analysis, remote sensing, and disaster databases. The final objective of this work is to achieve a qualitative and quantitative conceptualization of systemic risk related to complex disaster events. PARATUS Impact Chains are developed following a two-fold approach. On the one hand, they can be built through a participatory approach with contributions from specific stakeholders. This includes interviews, testimonies, virtual workshops for learning cases and presence meetings for application cases organized in WP6. On the other hand, they can be developed through a desk-based analysis and be validated by stakeholders at a later stage.

In total WP1 includes 6 deliverables (see Table 1.3). Impact Chains and the Forensic Analyses which contributed to their development are described in Deliverables 1.1 and 1.2. These Impact Chains are collected and consultable in a Wiki-type Database, which is presented in this Deliverable (D1.3).

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Table 1.1: The list of deliverables in WP1

#	Name	Due date (month)	Description
D1.1	Report on participatory workshops in the four application case study sites, including Impact Chains diagram for each analysed event.	10	Lead Beneficiary: EURAC
D1.2	Report on virtual participatory workshops in all learning and application case study sites, including Impact Chains diagram	20	Lead Beneficiary: EURAC
D1.3	**Impact, damage and loss data related to the considered events in the four core cases. Wiki-type structured Database.**	**20**	**Lead Beneficiary: EURAC**
D1.4	Guidelines on the actionable assessment of hazards interactions in compound / cascading events	24	Lead Beneficiary: UNIVIE
D1.5	Methodology to project LU-LC in a given area based on the analysis of existing remote sensing data and AI	24	Lead Beneficiary: DLR
D1.6	Report on the exemplification of the use of remote sensing services analysis solutions	36	Lead Beneficiary: DLR

After this introduction which summarises the main links to the PARATUS project, this deliverable provides a short description of the Impact Chains approach (Chapter 2) followed by a presentation of the Impact Chain Wiki, available on the Disaster Risk Stakeholder Hub (https://www.cmine.eu/topics/35391/page/impact-chains-WIKI), and its main functionalities (Chapter 3). Finally, Chapter 4 present the next steps and outlook connected to the Wiki. Please note that this Deliverable does not present any specific data on past disaster events as these are stored within the Impact Chain Wiki, which can be consulted interactively online at the above mentioned link.

2 Impact Chains methodology

Impact Chains (ICs) are conceptual models of climate and disaster risks that have been developed to streamline the analysis of climate-related impacts and provide a structured framework for the comprehensive assessment of related risks following the comprehensive risk management framework (UNDRR, 2022). Impact Chains help elicit, conceptualize, represent, and share knowledge about multi-hazard risks within a given geographical and temporal scope. The method follows a framework which is consistent with the IPCC AR5 concept of climate risk. Consistently, the different factors which compose an Impact Chain are assigned to the risk components of hazard, exposure or vulnerability, while the cascading effects are considered as intermediate impacts (Zebisch et al., 2022).Within the resulting conceptualization of hazard and impact cascades, adaptation measures of different types can be identified, such as early warning systems, ecosystem-based adaptation, capacity building, and technical as well as socio-economic measures.

Different approaches exist to develop Impact Chains. They are usually developed through participatory processes, where expert elicitation fosters the identification of local dynamics and challenges. On the other hand, their development can also rely on desk-based research, providing scientific references to support the participatory development.

In the latest developments, Impact Chains do not consist only of a visual illustration but are moving towards a semantic representation. A machine actionable standard format is being adopted, where the different

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elements and connection are described and characterised. For example, in the Impact Chain, each impact is described, with examples provided deriving from the analysis of past events (and where possible quantified). The use of semantic tools enables dynamic querying of the resulting knowledge structure and facilitates its integration into decision-support systems.

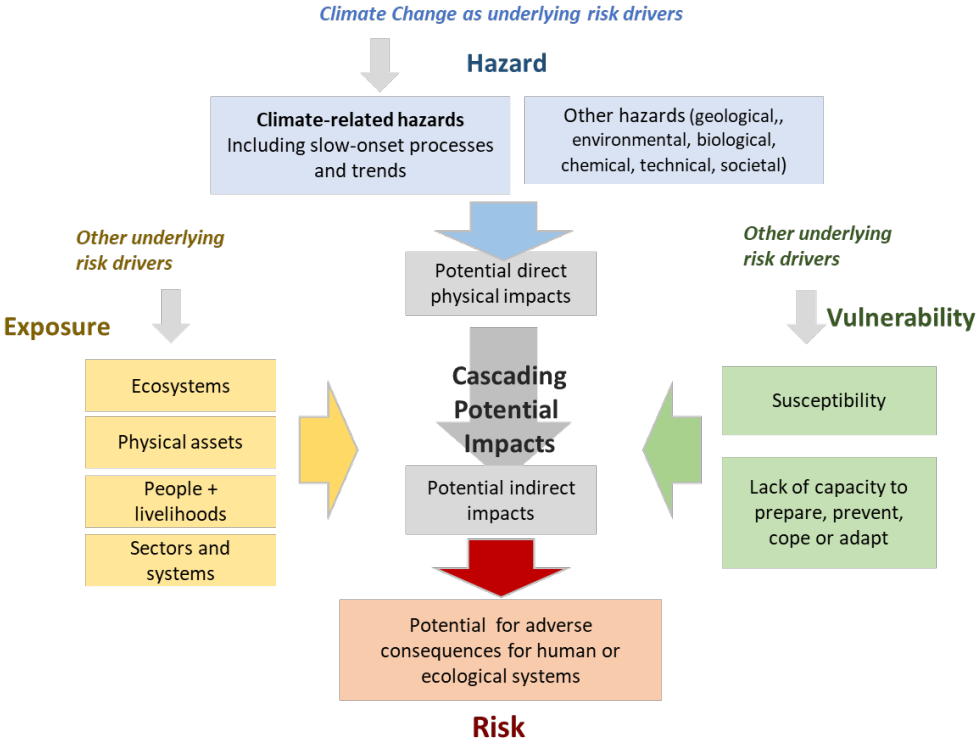

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Figure 2.1General structure of an Impact Chain of conceptualisation of cascading and compounding hazards and impacts and their adverse consequences for various human and ecological systems

In order to achieve such standardisation, pre-defined components have been established. These are elements and connections. While the elements (the boxes) constitute the main building blocks of the Impact Chains, the connections (arrows) represent the relationship among the elements. The different types of elements and connections are presented in Table 2.1and Table 2.2 respectively.

Table 2.1The different element types which can be found in an IC (source: edited from Pittore et al.,in publication)

Element type	Description
Hazard	Climatic influence, event or trend that may constitute a hazard to the exposed assets and systems and result in an impact and possibly a risk (with damage or loss)
Impact	Possibly negative effect caused by a hazard or another impact
Exposure	People, assets, systems, functions and values possibly exposed to impacts and susceptible to be damaged, disrupted or negatively affected
Vulnerability	Intrinsic, environmental or institutional condition possibly amplifying the negative effect of an impact to the considered exposure elements. It includes sensitivity / susceptibility as well as lack of capacity to cope and adapt
Adaptation / mitigation	Measure to decrease the negative consequences of an impact by addressing one or more vulnerabilities or impacting mechanisms

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Risk (Key Risk)	Combined impacts, exposure elements and vulnerabilities that describe potential risks (a key risk is highly relevant in the scope of the Impact Chain and should be prioritized in the assessment and evaluation phases)
External Driver	Other drivers that may significantly alter the socio-economic or environmental situations and possibly amplify negative consequences of impacts but cannot be mitigated or controlled within the scope of the Impact Chain

Table 2.2The different connection types which can be found in an IC (source: edited from Pittore et al., in publication)

Element type	Description
"Causes"	(as in "Increase of average temperature ***causes*** melting of glaciers". Indicates a (likey) causal relationship between the two elements. This relationship can only be defined among elements of type „Hazard", „Impact" and „Risk".
"Impacts "	(as in "increase of power outages **impacts** industries"). Indicates mainly a relationship between an impact and an exposed asset.
"Affects"	(as in "Increase of average temperature ***affects*** the phenological cycle of vegetation"). Indicates a generic relationship where one element is supposed to affect the second one in some way (not necessarily in a causal link). This relationship can be defined among every type of element but could be partially hidden in the visualization.
"Relates to"	(as in "population ***relates to*** buildings") – this relationship can be used to indicate connections between elements, it has more relevance for knowledge base systems - to be further discussed
"Mitigates"	(as in "improving irrigation techniques ***mitigates*** decrease of yield of crops" e.g., due to drought). This relationship can be defined only between adaptation / mitigation options and vulnerability elements or between adaptation options and impacts.

Each element and connection are characterized by defined features (see Table 2.3). These help to store the knowledge gathered during participatory processes or desk-based research, enhancing the understanding for users who consult the Impact Chains.

Table 2.3 List of features belonging to each element or connection of an IC (source: Pittore et al., in publication)

Element type	Description
Type	Type of the element or connection. It must be one of the types listed in Table 2.1or Table 2.2.
Label	Synthetic description / title of the element for visual depiction
Description	Extended description of the element providing all necessary information to understand the role and significance of the element or the connection in the IC scope
Source	Source of the element/connection, if already standard or authoring institution / author
References	References to the information sources used to justify, validate and possibly monitor the element/connection.
Confidence	Confidence in the validity of the element/connection, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively (or by means of ordinal numbers) [IPCC]
Time range	Time indication in which the element is considered active or unchanged

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3 The Impact Chain Wiki

In general terms, a Wiki is "*a website that allows users to add, delete, and edit the contents, or the program that makes this possible*"(Cambridge Dictionary, 2024). Wikis are commonly used for knowledge management, allowing the sharing of information quickly and efficiently. Wikis can consequently be used for knowledge gathering, storage and organization as well for its distribution and use.

In the PARATUS context, the Impact Chain Wiki consists in the database of PARATUS Impact Chains, containing not only the visual representation of the interactions among different risk components (hazards, exposure, impacts, vulnerabilities) but also the features associated to the different elements (e.g. descriptions, figures, reference, confidence level). The goal of this Wiki is to store the knowledge related to the Impact Chains generated from PARATUS activities, in order to exploit it within subsequent work packages and to facilitate its interactive consultation by project partners as well as by external stakeholders.

The PARATUS Impact Chain Wiki was developed through a combination of activities (see Figure 3.1), involving a large part of the PARATUS consortium. These activities encompass workshops in Application Case studies, a forensic analyses of past disaster events, and consultation of existing disaster databases. In particular, the Forensic Analysis Framework (see Deliverable 1.2) supported the development of the Impact Chains by compiling evidence related to past disaster events, providing the missing metadata (e.g. description, references, sources) and identifying elements which were initially overlooked (mainly related to social aspects, such as vulnerabilities and impacts). In order to achieve a certain degree of standardization, Impact Chain Guidelines where shared, including instructions for their co-development during workshops as well as for their implementation on the online platform.

The Wiki is publicly accessible online and can also be consulted interactively through the Disaster Risk Stakeholder Hub (https://www.cmine.eu/topics/35391/page/impact-chains-WIKI).

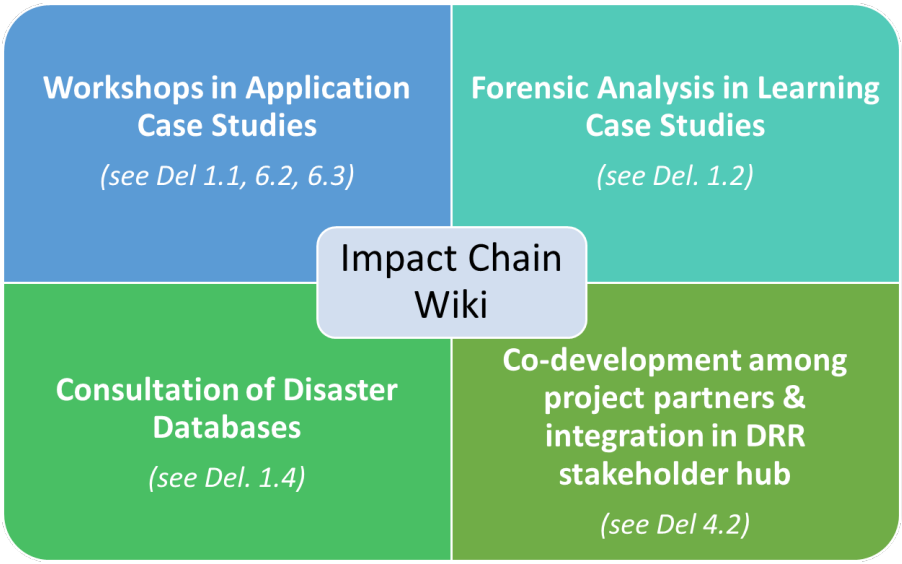

Figure 3.1 PARATUS activities which contributed to the development of the Impact Chain Wiki

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The PARATUS Impact Chain Wiki was built on KUMU. KUMU (https://KUMU.io, proprietary, commercial) is an effective tool that allows to build Impact Chains in a structured environment. In KUMU, the visual representation is based on a table repository, ensuring all elements and connections are systematically stored and easily accessible online. KUMU can effectively be used to gather and organize a wide range of knowledge and information, serving as a foundation for further discussion and consultation, and for initiating or updating structured data management, such as with Excel. Additionally, it requires technical expertise and may not be as user-friendly as other tools for beginners.

Since we aim to account for the complexity of processes and interconnections between factors, the representation becomes more intricate, posing challenges mainly in terms of visualization. While interactive tools like KUMU can assist in managing this complexity, the challenge lies in determining the relevance of factors and in achieving a meaningful synthesis. Indeed, although at the current stage KUMU can be seen as the best solution for building Impact Chains, its visual appeal may not match that of other tools.

The following two sub-sections will present the Impact Chain Wiki section of the Disaster Risk Stakeholder Hub (section 3.1), the back end available on KUMU and its main functionalities (section 3.2).

Please note that this Deliverable does not present any specific data on past disaster events as these are stored within the Impact Chain Wiki, which can be consulted interactively online at this link.

3.1 Impact Chain Wiki overview

The Impact Chain Wiki is accessible from the Disaster Risk Stakeholder Hub specific Tab.

At the top of the page, supportive informative material on the Impact Chain methodology and KUMU is available (Figure 3.2). Scientific references and consultable guidelines for the Impact Chains development are provided. This section also includes a Tutorial Kumu Map to guide the user in understanding the different Impact Chains elements and connection types as well as the links to related PARATUS deliverables.

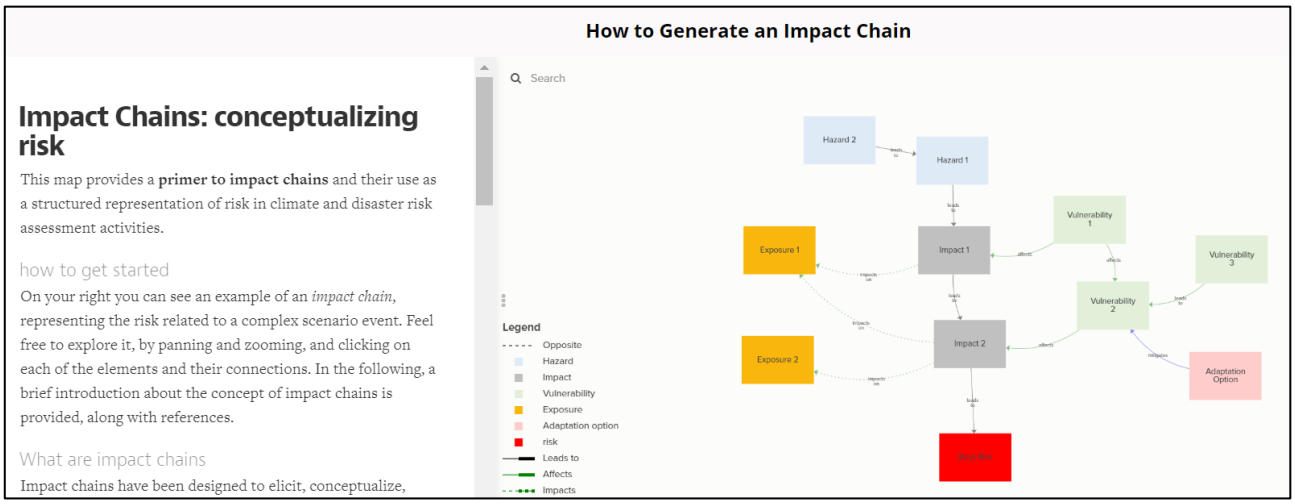

Figure 3.2 The Impact Chain Wiki guidance section. Here informative material is provided to guide the user in understanding and developing Impact Chains

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Scrolling down the page, Impact Chain can be consulted, divided per Application Case Study (Figure 3.3). For each Application Case Study, a general Impact Chain describing the current risk situation is available as well as others related to different associated Learning Case Studies. These are a series of past disaster events, which support the development of the general Impact Chain (see PARATUS Deliverable 1.2). They have been selected due to their unique characteristics concerning stakeholders, hazard interactions, impacts on different combinations of sectors, their diverse vulnerabilities, scale, and planning decisions. For each Impact Chain a brief description is available to guide the user navigating throughout the collection.

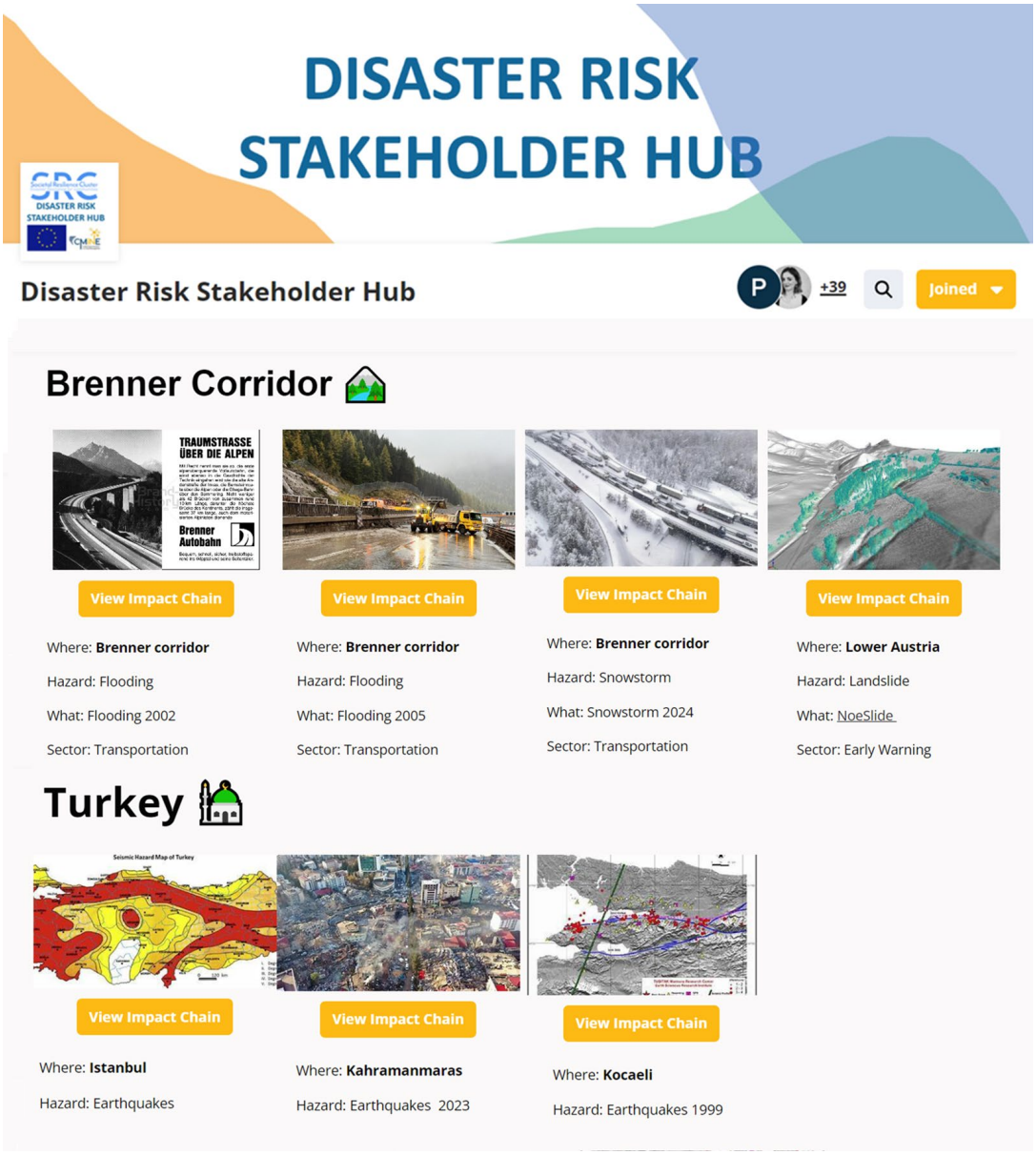

Figure 3.3 Example of Impact Chains available on the Wiki for different Application Case Studies.

Learning Case Study Impact Chains are also supplemented by the Forensic Analysis narrative (see Deliverable 1.2). This is also accessible from the Stakeholder Hub.

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3.2 The use of KUMU

The Impact Chains were developed on KUMU which serves as a back end to the Impact Chain Wiki. On KUMU Impact Chains are clustered under different projects, one per Application Case Study (ACS). Moreover, a specific KUMU project focuses on Learning Case Studies with a geographical focus that does not coincide with any ACS. The general user should access the Impact Chains from the Stakeholder Hub and not from KUMU. Please note that the links below (Table 3.1) are provided for explicatory purposes.

Table 3.1 Links to the Impact Chain Wiki on KUMU under different links for the different Application Case Studies

KUMU project	Link	Associated Learning Case Studies
Istanbul Case Study	https://KUMU.io/PARATUS/istanbul-case-study	Marmara (1999) and Kahramanmaras (2023) Earthquakes
Alps Case Study	https://KUMU.io/PARATUS/alps-case-study	Landslides observatory VAIA (2018) Flood Tyrol (2005)
Caribbean Case Study	https://KUMU.io/PARATUS/caribbean-case-study	Maria and Irma (2017) La Soufriere eruption(2021)
Romania Case Study	https://KUMU.io/PARATUS/romania-case-study	Vrancea earthquakes (1940; 1977) Covid-19 pandemic (2020-2021)
Other Learning Case Studies	https://KUMU.io/PARATUS/other-learning-case-studies	Hurricane Katrina (2005) Eyafjallajökull eruption(2010) Tohoku earthquake and Tsunami (2011) Space weather event (2017) India: Kerala floods(2018) Gloria (2020) Haiti earthquake and tropical storm(2021) India- Chamoli District flood (2021) European floods (2021) Southern European heatwaves and wildfires (2021)

The reader should also keep in mind that the Impact Chain Wiki is a living database, built collaboratively within and beyond PARATUS. Therefore, new Impact Chains and projects can be added, leading to an update of the previously presented structure.

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In KUMU the following functionalities are available.

3.2.1 Development of Impact Chains

- KUMU supports collaboration, allowing multiple users to edit models. Users need to Login and be members of the individual KUMU PARATUS Projects (presented above in Figure 3.2) in order to add or edit Impact Chains.
- A tutorial on how to use KUMU is present on the Stakeholder Hub. Moreover a KUMU Impact Chain primer is available to explore the different elements and connection types.
- Impact Chains can be created manually using either the visual or table interfaces; in addition, they can be imported from spreadsheets or json files.
- A pre-defined PARATUS View is available to foster standardisation in which pre-defined element and connection types are present (see Figure 3.3). On the downside, KUMU does not limit the user in changing the legend and in adding new types of elements and connections. Consequently, PARATUS IC s can be consistent from the visual and semantic point of view only if all the users follow strictly the guidelines provided.

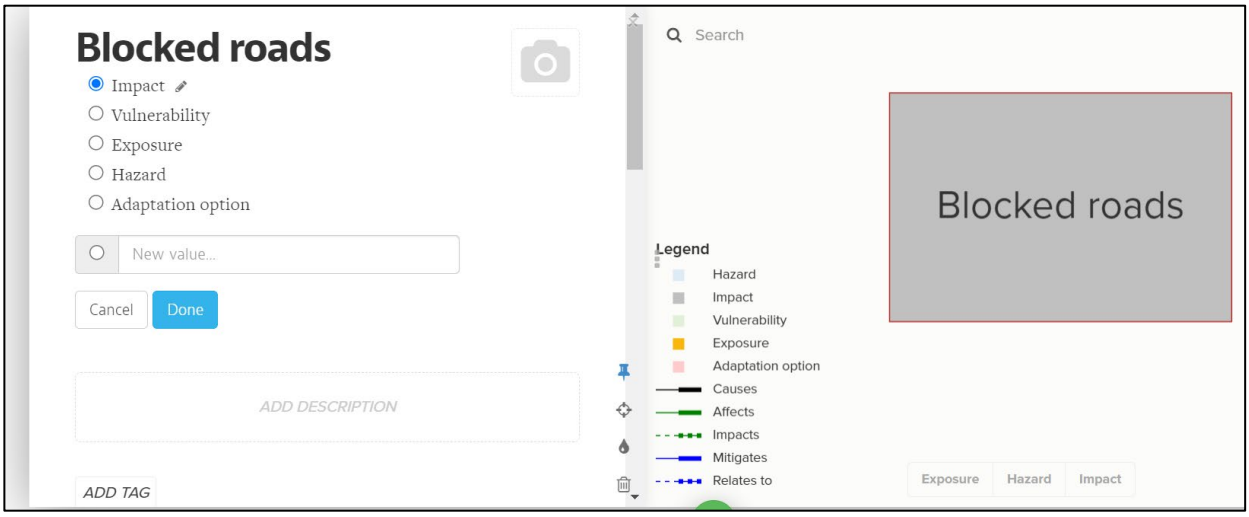

Figure 3.4. Screenshot of Impact Chain development on KUMU, using the PARATUS View. When adding a new element predefined categories (to be selected by the user) are present, as it can also be seen from the interface on the left and from the legend.

- Another factor which requires attention is the following. The elements of different Impact Chains which are part of the same project are all connected, so changing the fields of one element in one Impact Chain (e.g. loss of lives) entails that this element will be changing in all the other Impact Chains where this element appears. This is the reason why separate PARATUS projects have been created for the different application case studies.

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- When developing a new Impact Chain, KUMU allows to move elements and connections and to change the format of the text to improve the visualisation (see Figure 3.4). However, these options are limited and less intuitive with respect to other tools (e.g. Miro Board).

Figure 3.5. Editing an Impact Chain element (e.g. font size and style) on KUMU

3.2.2 Consultation of Impact Chains

- The developed Impact Chains are visible publicly on KUMU. Therefore, the interested viewer does not need to be registered to KUMU. Single Impact Chains are linked individually, embedded and consequently viewed on the Stakeholder Hub.

- KUMU also allows to insert and view metadata for each element and connection, allowing storage of knowledge which goes beyond the simple visual representation of boxes and arrows. This includes all the features (e.g. description, confidence, references etc). In addition to text, figures can also be added, such as photographs (Figure 3.6)and maps (Figure 3.7).

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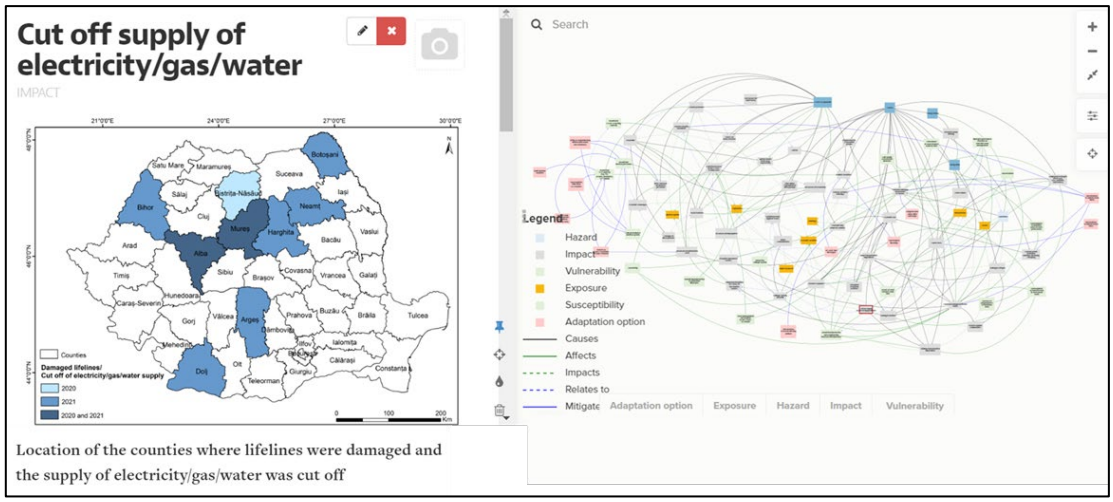

Figure 3.6. Example of feature (impact map) which can be added in KUMU to describe a single Impact Chain element.

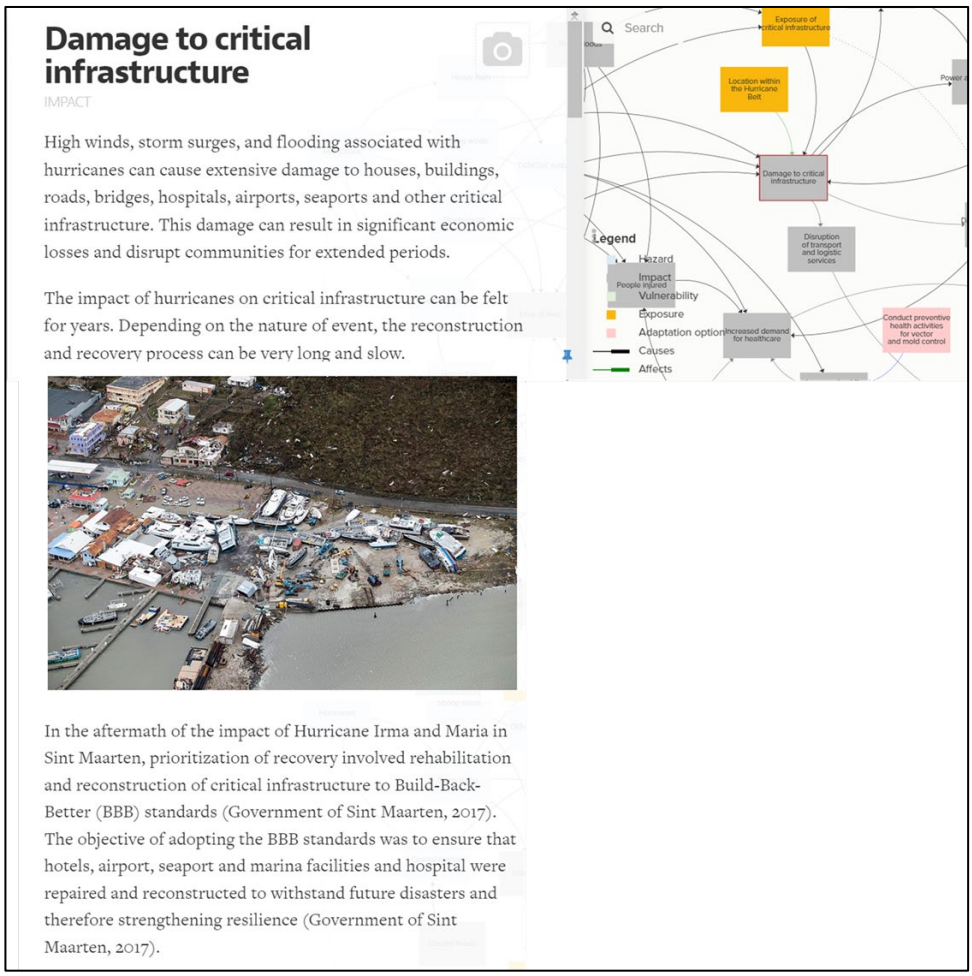

Figure 3.7 Example of features (description and photograph) which can be added in KUMU to describe a single Impact Chain element.

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- Through KUMU, it is also possible to refine what is visible or emphasized on the map using filters, focus, and cluster options. For example, it is possible to filter the elements according to their type (Figure 3.8) as well as searching for specific elements within a single Impact Chain or an entire project (Figure 3.9). Moreover, the user can view the direct (first degree connections) and indirect connections (second degree connections) of a specific element.

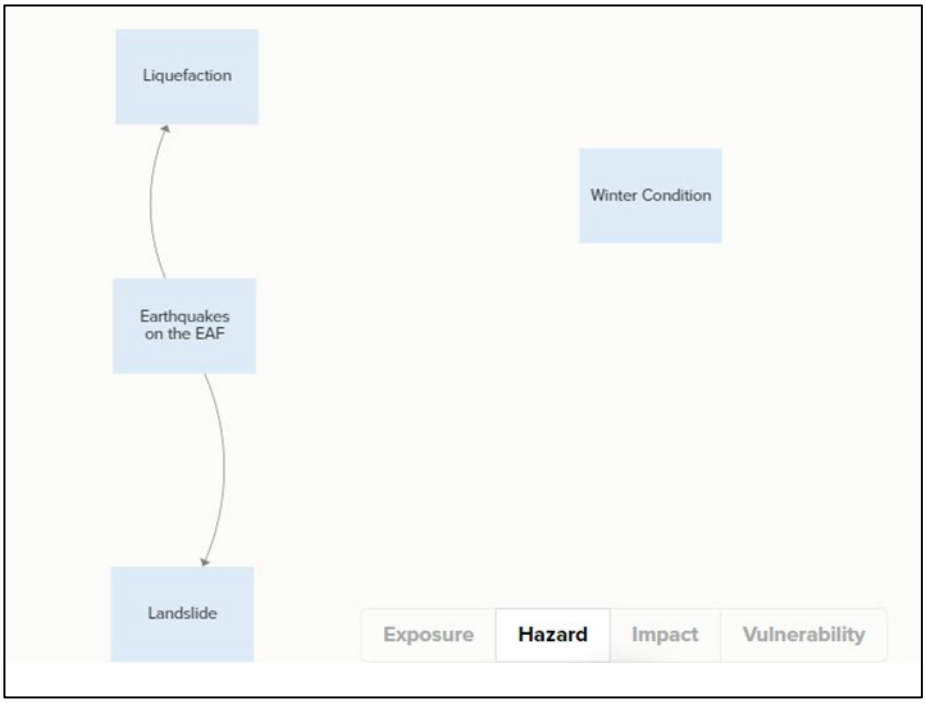

Figure 3.8 Example of filtering: viewing only the hazard elements of the Impact Chains

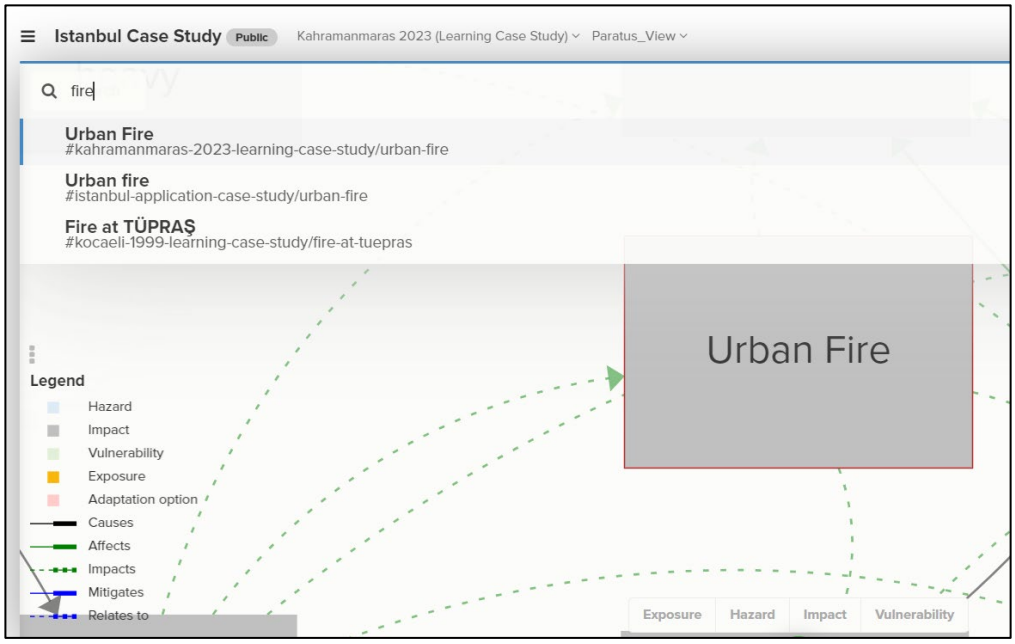

Figure 3.9 Example of application of the search function within the overall Istanbul CS KUMU project

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3.2.2.1 Table interface and Excel

At the moment, this function is only available when assessing the Impact Chains directly from KUMU.

In KUMU the visual representation builds upon a table repository (Figure 3.10); consequently, all the elements and connections, which are added and viewed as boxes and arrows, are also systematically stored in a table together with all the features associated with them. The table interface can easily be accessed and used to build the Impact Chain, to add the missing features of the different elements and connections and to verify that such features are complete.

	Label	Type	Tags	Description
1	Adoption of Build-Back-Better (BBB) standards	Adaptation Option		Building back better involves constructing infrastructure that is more resilient
2	Build storage areas for emergency supplies	Adaptation Option		Construction of storage areas is another mitigation measure that can be cons
3	Coastal erosion	Hazard		Coastal erosion is an adverse impact of extreme water levels during major hu
4	Coastal floods	impact		Coastal floods are a result of a combination of high tides, storm surges and o
5	Conduct preventive health activities for vector and mold control	Adaptation Option		The Sint Maarten national recovery and resilience plan 2017, proposes measu
6	Damage to critical infrastructure	Impact		High winds, storm surges, and flooding associated with hurricanes can cause
7	Damage to healthcare facilities	impact		Hospitals, clinics and other healthcare facilities in Sint Maarten were affected
8	DENGUE outbreak	Hazard		Hurricanes often bring heavy rainfall and flooding, leading to the accumulatio
9	Dependency on imports	Underlying risk driver		Sint Maarten's supply chains are vulnerable to disruptions caused by hurrican
10	Disruption of transport and logistic services	Impact		During and in the aftermath of hurricanes, the damage and disruption of trans
11	Enhancing emergency preparedness and response	Adaptation Option		Hurricane Irma exposed shortcomings in national capacity, most prominently
12	Expanding psychosocial care	Adaptation Option		One of the focus areas identified after hurricane Irma in the Sint Maarten reco
13	Exposure of critical infrastructure	Exposure		Sint Maarten is located within the Caribbean hurricane belt, with the result tha

Figure 3.10 Example of a table interface of an Impact Chain. The different entries of the table consist in the elements of the Impact Chains. For example, the entry number 6 "Damage to critical infrastructure" is the element previously presented in Figure 3.7. This function is available only when accessing the Impact Chain directly from KUMU.

3.2.2.2 Download function

At the moment, this function is also only available when assessing the Impact Chains directly from KUMU.

The user can export and download from KUMU the Impact Chain (or parts of it) in different formats: PDF, PNG, XLSX and JSON.

By exporting the PNG and PDF format, only the visual interface is downloaded. Therefore, the metadata shown in Figure 3.10 will not be part of the download.

The JSON format allows to download in a single file all the Impact Chains belonging to the same project. The JSON also allows to download the PARATUS view (layout) and all the features associated to the elements and connections. The JSON can be uploaded on a separate KUMU project, making it possible to edit or build upon the Impact Chain independently, even if the user is not member of the PARATUS projects. Via the JSON file it is also possible to copy the PARATUS Impact Chain format (using the PARATUS View). This way external users can build structured Impact Chains which are visually and semantically consistent with those of the project.

The Excel (XLSX) format allows to download most of information and knowledge that the Impact Chain can convey, in a well-structured and possibly machine-actionable format (Figure 3.11). This however only refers

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to the textual content, therefore excluding the visual representation and figures within the element descriptions. The use of such spreadsheet largely improves the interoperability and shareability of Impact Chains, especially for researchers and practitioners in the field of risk.

	A	B	C	D	E
1	Label	Type	Description	Confidence	References
2	Limited healthcare infrastructure, resources, and personnel	Vulnerability	With a small land area and high population, Sint Maarten faces challenges in maintaining robust healthcare facilities and adequate medical resources to meet the needs of its residents, especially during times of crisis such as hurricanes. The island's hospitals, clinics, and medical facilities are likely to be affected during and after hurricanes through structural damage, power outages, and water supply disruptions, reducing their capacity to provide essential medical services. In addition to the limited infrastructure, resources such as medical supplies, equipment, and medication, are not always sufficient to meet the increased demand for healthcare services following a hurricane. Access to quality healthcare is further impacted by shortages of healthcare personnel, including doctors, nurses, and emergency responders, particularly during hurricanes when staff may be unable to report to work due to transportation disruptions, personal safety concerns, or the need to attend to their families and home.	4	Government of Sint Maarten (2017), Sint Maarten National Recovery Plan and Resilience Plan
3	Damage to critical infrastructure	Impact	High winds, storm surges, and flooding associated with hurricanes can cause extensive damage to houses, buildings, roads, bridges, hospitals, airports, seaports and other critical infrastructure. This damage can result in significant economic losses and disrupt communities for extended periods. The impact of hurricanes on critical infrastructure can be felt for years. Depending on the nature of event, the reconstruction and recovery process can be very long and slow. ![800px-Alh-08-09-sint-maarten-foto-6-duo](https://s3.amazonaws.com/cloud.kumu.io/accounts/433073/912088/ac806173-b509-448c-9fdf-1fc6abe0fd01.jpg) Destruction of the seaport in Sint Maarten after Irma Image source: https://commons.m.wikimedia.org/wiki/File:Alh-08-09-sint-maarten-foto-6-duo.jpg#mw-jump-to-license In the aftermath of the impact of Hurricane Irma and Maria in Sint Maarten, prioritization of recovery involved rehabilitation and reconstruction of critical infrastructure to Build-Back-Better (BBB) standards (Government of Sint Maarten, 2017). The objective of adopting the BBB standards was to ensure that hotels, airport, seaport and marina facilities and hospital were repaired and reconstructed to withstand future disasters and therefore strengthening resilience (Government of Sint Maarten, 2017).	5	Government of Sint Maarten (2017), Sint Maarten National Recovery Plan and Resilience Plan

Figure 3.11 Example of an Impact Chain Excel download.

4 Outlook and next steps

Impact Chains offer a practical solution for conceptualizing risk with a practical focus. They serve as a powerful instrument for extracting expertise and harmonizing insights from various sources, encompassing both quantitative and qualitative dimensions. By adhering to specific guidelines for their development, Impact Chains foster standardization by establishing a common language and a structured visualization framework. Consequently, on one hand they constitute a knowledge base themselves, and on the other hand, they can be adopted as a fundamental conceptual tool to support quantitative risk assessments. Currently, the Impact Chain Wiki is collecting data about hazards, exposure, vulnerabilities and impacts in the form of text or narrative. In following stages of the project, more structured quantitative data will be collected, based on the identified Impact Chain elements.

Moreover, the Impact Chain Wiki will be further developed, firstly adding new Impact Chains, also linked to other EU projects, and secondly, improving its accessibility.

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Under the current configuration, a log-in and membership to the PARATUS KUMU project is required to create and add new Impact Chains to the Wiki. To further empower users and foster the co-development of Impact Chains, we plan to develop an ad-hoc tool that allows external users to create their own custom Impact Chains in a structured and accessible environment. By adding these newly developed Impact Chains to the Wiki, the knowledge base can be expanded, including additional hazard interactions, sectors and geographical contexts.

Moreover, we aim to explore additional functionalities of KUMU; firstly, to improve how Impact Chains are presented, making them more intuitive and visually appealing and secondly to better query them, easing user understanding and interactions with the Impact Chains.

By implementing these steps, we aim to create a more robust, user-friendly platform that supports comprehensive disaster risk management and empowers stakeholders to make informed decisions.

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Co-funded by the European Union

This project has received funding from the European Union's Horizon Europe Research and Innovation program under grant agreement No 101073954