Value Chain Approaches to Evaluate the End-to-End Warning Chain

PROJECT PLAN

v1.2

WORLD WEATHER RESEARCH PROGRAMME

HIWeather

WG SERA

WORLD METEOROLOGICAL ORGANIZATION

Value Chain Approaches to Evaluate the End-to-End Warning Chain

Executive Summary

Effective warnings of weather-related hazards result from the successful interaction of many people and organisations, each contributing their specific capability and knowledge of the weather and associated hazards, impacts, communication, decision making processes, and ultimately community benefit. The information value chain provides a framework for characterising the production, communication, and use of warnings in terms of its processes, inputs and outputs, relationships, contributions, and operational contexts of stakeholders. Measuring and evaluating the effectiveness of information added and exchanged along the warning chain can help to identify where improvements could significantly contribute to reduced economical and societal losses from natural disasters.

This project aims to

◊ review value chain practices used to describe and understand weather, warning and climate services

◊ assess and provide guidance on how to effectively apply value chains in a weather warning context involving multiple users and partnerships, and

◊ create a searchable warning chain database that researchers and practitioners can use to explore the organisation and performance of actual end-to-end warning chains for high impact events and assess their effectiveness using value chain approaches.

This 4-year study is a flagship project of the World Weather Research Programme (WWRP) High Impact Weather (HIWeather) project and the Societal and Economic Research Applications (SERA) Working Group. It will focus on warning chains for a selected set of hazards identified in the HIWeather Implementation Plan, namely: urban flood, wildfire, localised extreme wind, disruptive winter weather, and urban heat waves and air pollution.

Analysing the end-to-end warning chain requires a multi-disciplinary research project that integrates physical and social sciences with practitioner perspectives. Leading researchers in the WWRP HIWeather project and Societal and Economic Research Applications (SERA) working group bring relevant expertise on state-of-the-art weather and hazard prediction, warning communication, and economic analysis. External partners from the academic, emergency management and private sectors provide additional richness of knowledge and experience needed to successfully achieve the aims.

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Images on cover page from top to bottom:
- Image from NASA-NOAA's Suomi NPP satellite of tropical cyclone Debbie making landfall in Queensland/Australia on 28th March 2017. Image by NASA Goddard Space Flight Center via Flickr (CC BY 2.0). Cropped to fit page.
- Disruptive winter weather in Denver/CO in March 2021. Photo by Colin Lloyd on unsplash. Cropped to fit page.
- Flooding in Shaoguan, Guangdong Province, China in October 2020. Photo by Jean Beller on unsplash. Cropped to fit page.
- The Woolsey Fire, California, November 2018. Photo by Forest Services, USDA (Photo courtesy of Peter Buschmann) via Flickr. (Public Domain). Cropped to fit page.

1. Introduction

Since the generation of weather warning and climate services has become more complex, both technically and organizationally, the notion of the value chain has become a popular conceptual tool in studies trying to assess the use and the net benefits of such services (e.g., Weiher et al., 2002; Lazo et al., 2008; Perrels et al., 2013; Perrels, 2020). Weather and associated warning services are developed and provided through a multitude of complex and malleable value chains (networks), often established through co-design, co-creation and co-provision.

The value chain approach facilitates the understanding of the different relationships, processes, inputs, contributions, outcomes, and operational contexts of each stakeholder in the warning chain. The chain can be analysed with different, yet complementary, methods, each emphasizing different sets of characteristics of the value chain. **Figure 1** represents a value chain as a sequence of different scientific disciplines reprocessing information from previous segments and adding additional, unique information (Golding et al., 2019). This is a fairly technical representation of how information segments link. Other representations, for example, emphasize when and by whom value accrues in the chain, in connection to positions of different actors in the weather and climate information service 'market' (Perrels et al., 2020). Thanks to these decomposition capabilities, the value chain approach enables assessment of the effectiveness of the service design and delivery process, and options for improvement.

Such analyses must be supported by evidence. Case studies are an effective mechanism to collect and catalogue successes and failures of warning chains for instances of high impact weather. Applying value chain approaches to case studies to characterise and measure the effectiveness of the tools, processes, partnerships, and infrastructure embedded in existing warning chains can provide the evidence to identify shortfalls and propose investments in new capability and partnerships. For example, Lazo et al. (2020) found in a comparison of value chains for two winter storms in New York that the implementation of an impact-based decision support service in the warning chain reduced economic

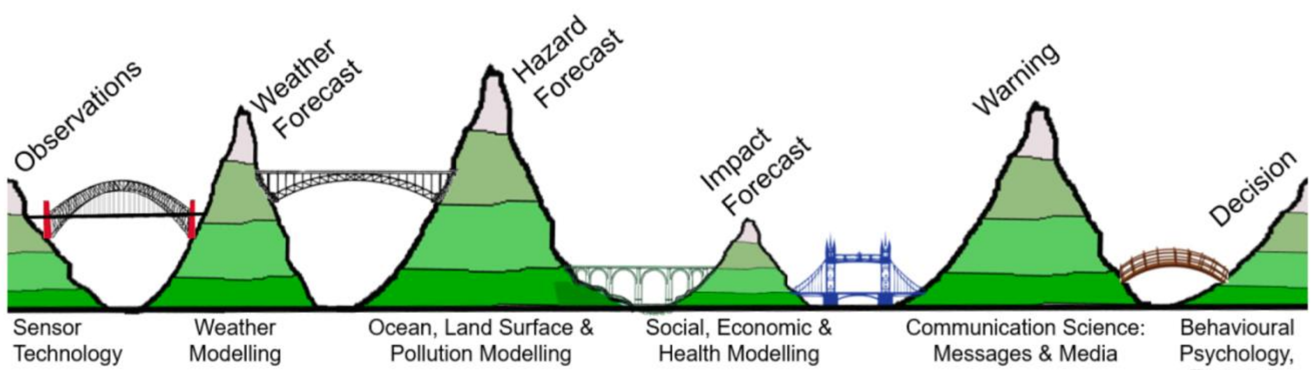

Figure 1: Schematic value chain for high impact weather warning showing the capabilities and outputs (green "mountains") and information exchanges (bridges) linking the capabilities and their associated communities (from Golding et al. 2019).

losses and recovery time. Emerton et al. (2020) established daily emergency flood bulletins in Mozambique as a way of communicating natural hazard forecast information to decision-makers and stakeholders after identifying significant gaps in the national emergency management system. Furnishing open access to a database (catalogue) of case studies contributed by the global weather community, along with a demonstrative analysis, will encourage National Meteorological and Hydrometeorological Services (NMHSs) to conduct similar analyses of their own warning chains.

1.1 HIWeather Mission

The overall mission of the HIWeather project is to:

> **Promote cooperative international research to achieve a dramatic increase in resilience to high impact weather, worldwide, through improving forecasts for timescales of minutes to two weeks and enhancing their communication and utility in social, economic and environmental applications.**

1.2 Key Project Objectives

The project on Value Chain Approaches to Evaluate the End-to-End Warning Chain is a flagship project of HIWeather. It has four main objectives:

1. To review value chain practices used to describe and understand weather, warning and climate services;
2. To assess and provide guidance on how they can be best applied in a weather warning context that involves multiple users and partnerships;
3. To generate an easily accessible means for scientists and practitioners involved in researching, designing, and evaluating weather-related warning systems to review relevant previous experience and assess their efficacy using value chain approaches.
4. To analyse the warning chain data to understand, revise and extend best practice in warning processes.

The four objectives support each other through defining and demonstrating effective value chains for weather warnings as visualised in **Figure 2**.

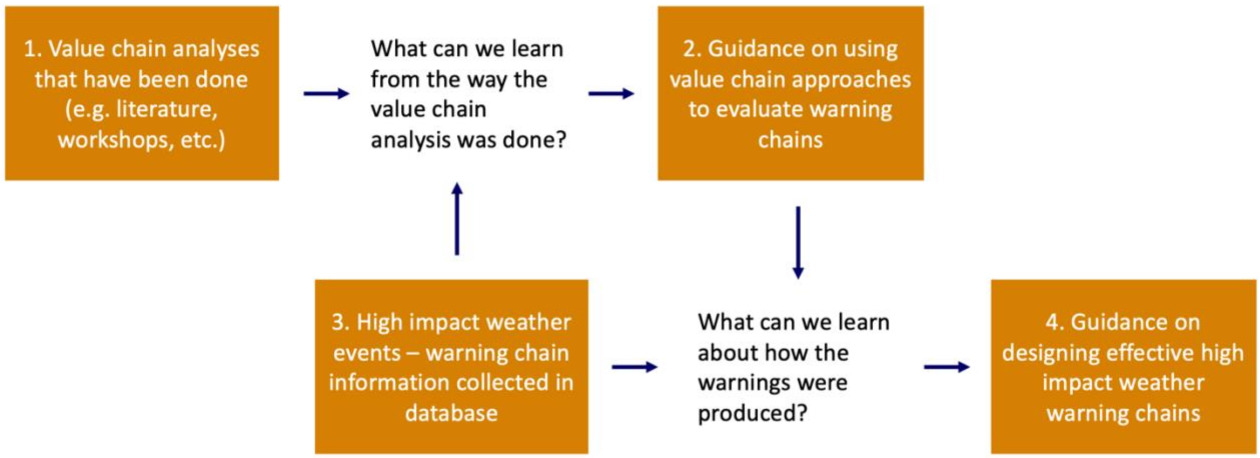

Figure 2: Interaction between the objectives of the project.

2. Benefits

The benefits resulting from the success of the project are manifold. NMHSs as well as private weather and climate service providers will be equipped with a value chain tool allowing them to measure and improve the effectiveness and information transfer of their early warning systems. They will also be able to justify future investments by knowing what could be done easily or at low cost, where investment in new capabilities will bring the greatest benefit and by making societal benefits of weather services more explicit.

HIWeather aims to strengthen the capability of the different groups along the value chain as well as the 'bridges' between them (**Figure 1**). Besides the overall economic benefits, a value chain framework provides tools to measure the effectiveness of changes to, for example, observational inputs, improvements in Numerical Weather Prediction (NWP) and warning dissemination. Even if only one player in the chain improves its processes, all subsequent parts along the chain can profit if the added value is passed on without significant loss. For instance, improving the lead time in NWP models allows a more accurate hazard forecast in terms of location, timing and severity of the event which gives emergency managements a better idea of how, when and where to allocate their resources to reduce the impact. It also allows for more targeted impact warnings which benefit the greater public good through significant reductions in damages, losses and fatalities and quicker recovery.

The database of case studies of hazardous events will enable NMHSs, their partners and researchers to access data and information on warnings chains for past high impact events so they can extract learnings and discern best practice. Good examples of case studies in the database will assist users in conducting their own case studies, including entering the data and information in the warning chain database.

3. Project Plan

Several individual tasks are planned and compiled into working packages (WPs) to allocate and distribute the work of the project team in order to guarantee a successful completion of the project objectives.

To achieve the first two linked objectives, we propose to review and assess current value chain practices from both explicit and implicit warning 'chain' evaluation research and case studies with respect to the use of socio-economic insights in development and delivery of weather, warning and climate services. This will include identifying shortfalls and suboptimal applications of methods. Based on this assessment we seek to critique and identify the 'value added' of applying a value chain and provide guidance and examples and how it can be applied in a useful, flexible and robust way to analyse complex warning chains. We will engage with on-going and recently completed applications and studies of the value chain concept in weather, warning and climate services. We will consult key experts in the WWRP programmes, in several national weather services and various other institutes. We will develop an inventory of value chain applications, catalogue of usage types, and value chain guidance and tools. These tasks are collected in ***WP1 – Review and Guidance on Value Chain Approaches***.

To achieve the third and fourth objectives, we will catalogue, analyse, and supplement where feasible, information from case studies of the performance of warning chains, review the information available about the organisation and performance of warning chains, and perform detailed evaluations of warning chains in selected case studies, noting that catalogued case studies should capture both successes and failures. Initially, the collected case studies will be gathered in a simple, editable interim catalogue which offers flexibility for adjusting the metadata needed. These tasks are collected in ***WP2 – Collection and Analysis of Warning Chains***.

Based on this, a Warning Chain Database will be developed with an intuitive web-based user interface designed to enable warning events and warning systems to be interrogated and compared easily. This task is represented by ***WP3 – Build Warning Chain Database***. The database will provide a valuable source of evidence for what constitutes an effective warning system: one that is useful, usable and used; from which to identify and promote best practice in warning for and reporting on high impact weather so as to support the development of improved warning services. It will be the first database that explicitly represents the end-to-end chain of weather observation and modelling, hazard and impact prediction, warnings, user decisions, impacts and benefits.

Figure 3 visualises the linkage between the WPs. The project team contributes social and physical science expertise to WP1 and WP2, which complement each other. WP3 will require additional technical expertise to be brought into the project. WP1 and WP2 are conducted simultaneously, exchanging information to progress tasks in both WPs to produce the proposed outputs. WP3 is a

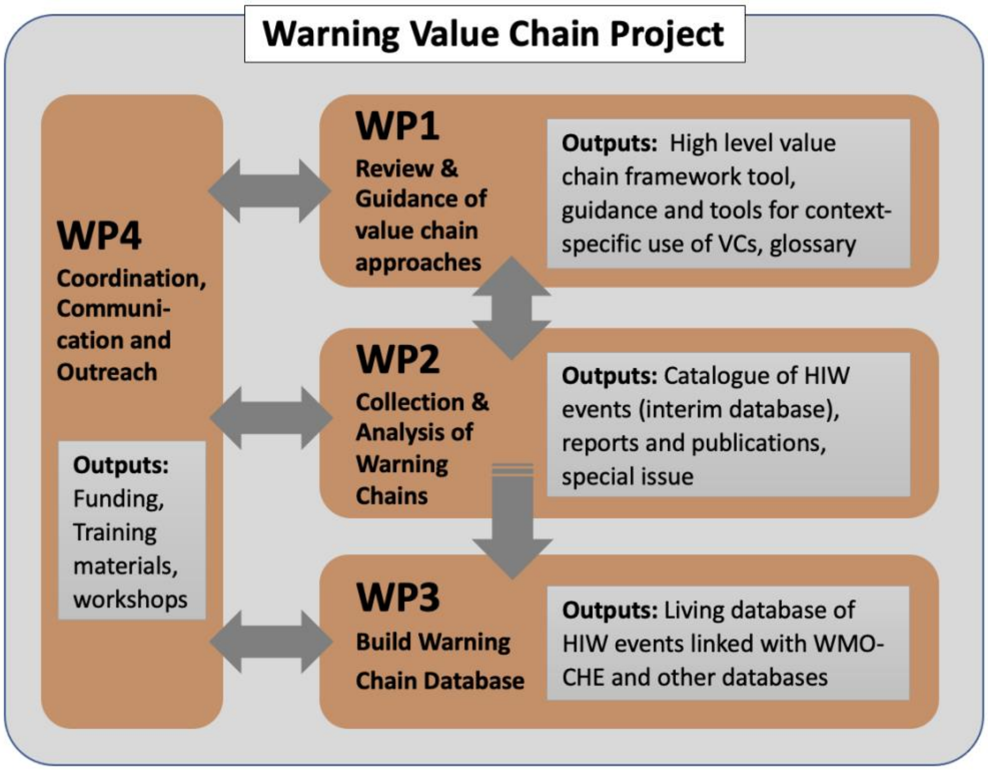

Figure 3: Schematic structure and linkages of the working packages (WP).

follow-up from WP2 as the development of the "living database" is based on the interim database created in WP2 which helps to determine the requirements. External support is most likely needed to execute the programming of the database in order to achieve the WP3 outputs, yet HIWeather supervises WP3 and defines the outline for the database.

WP4 – Coordination, Communication and Outreach coordinates the project including meetings, reporting to WWRP and resourcing. It also conducts outreach by developing training materials and organising workshops and conference sessions.

The individual WPs and their components are described in more detail below.

3.1 WP1 – Review and Guidance on Value Chain Approaches

INVENTORY OF VALUE CHAIN PRACTICES

We will develop an inventory of existing examples of where the value chain in the context of service delivery has been applied, based on a systematic review of academic and grey literature and workshops. Where an example describes a high impact weather warning, its data will be included in the Warning Chain Database (refer to 3.2). Description of the value chain will include information such as:

- Sector the value chain was applied in
- Value chain methodology used
- Components of the value chain, their interactions and contributions to the 'complete whole'
- The question the value chain tried to answer (related to outcome, impact, process, or input)
- The processes and products, including co-development by users
- Sequence of actions
- Metrics and analysis used to quantify/attribute the components of the chain
- Utility of the value chain approach, including constraints and challenges
- Ability of the value chain to alter change policy or decision processes

CATALOGUE OF VALUE CHAIN USAGE TYPES

Based on the inventory of Value Chain practices, we will create a catalogue of usage types according to their suitability for planning and execution, project assessment and evaluation, quality control, and efficiency/scenario assessment and testing replicability.

A gap analysis will be conducted in order to (1) review the catalogue examples to assess where gaps exist in the critique and application of the value chain approach; (2) review whether the examples focus more on evaluating some parts of the value chain more than others; and (3) review its methodologies and identify opportunities for enhancing and even reframing the notion of a value chain that is reflexive of local context and circumstances.

EVALUATION APPROACHES AND MEASUREMENT METHODS

An overview of value chain metrics and evaluation approaches will be prepared, including:

- Evaluation approaches and metrics that are being used or could be used in different parts of the value chain
- Methods to evaluate qualitative aspects (including outcomes) of the value chain not readily amenable to quantification
- Identification of measurement methods from other fields that might be relevant
- Methods for characterizing and quantifying uncertainty

CONCEPTUAL HIGH-LEVEL FRAMEWORK, GUIDANCE AND TOOLS

Based on the outcomes of the previous three stages, we will prepare (1) a high-level value chain framework tool for decision makers, (2) guidance and tools for more specific usage according to the value chain application areas and sectors involved, and (3) a glossary of value chain and warning chain terminology in a hydrometeorological context.

3.2 WP2 – Collection and Analysis of Warning Chains

COLLECT CASES OF HIGH IMPACT WEATHER EVENTS

We will collect information on relevant high impact weather events from case studies, post event reviews/enquiries (e.g. UK Pitt Review 2007; US Harvey Review 2017; Australian Black Saturday Review 2011) and warning service assessments.

Relevant high impact weather events include those for which:

- Lessons learned from the event are relevant to current technology and capability. For forecast accuracy this may imply less than 10 years old, whereas for governance, useful lessons may be learned from 50 years ago or more.
- The event should involve one or more of the hazards focussed on by HIWeather (wildfire, urban flood, localised extreme wind, urban heat wave and air pollution and disruptive winter weather).
- Information should ideally be available on the hazard(s), impact(s), forecasts and warnings and response, together with an assessment of what worked and what didn't.

The information will be recorded in a metadata database, containing links to as much relevant information as possible. Each entry should be referenced to the source in such a way that it can be recovered by subsequent users (for example, using a universally unique identifier number for each event).

Tasks include:

- A project lead to create an interim catalogue or database, that can be accessed by all task team members, formatted to receive the required information and with one or two example entries made.
- A team of volunteers to collect information on selected cases that they have access to and to add it to the database. Members may have preferred access to national evidence and/or to specific parts of the warning chain.

The HIWeather Task Teams and SERA Working Group have contributed key data attributes for many questions that the Warning Chain Catalogue could be used to address, spanning all aspects of the warning chain.

REVIEW SELECTED WARNING SYSTEMS

We will review the governance, structure and organisation of selected weather-related warning systems, identifying the type of value chain used (refer to 3.1) and cross-referencing to relevant cases in the database where appropriate, including any documentary evidence underpinning the choices made.

Tasks include:

- A collaborative team activity (perhaps including a workshop) to draw and record conclusions about the warning chain performance in each case, using value chain metrics where possible (refer to 3.1).
- A project lead to identify sources (possibly in or through WMO) of information on national weather-warning systems and to define an outline database classification.
- A team of volunteers to extract information on selected national weather warning systems that they have access to and to record it in the database. Volunteer participation would be recognised via invitation to participate in workshops, acknowledgement in documents, etc.
- A project lead to relate the information in the event database to the warning system classification.

IN-DEPTH ANALYSIS OF SELECTED EVENTS

We will identify events that highlight an issue of importance to some or all of the warning chain, for in-depth analysis. Ideally, common cases will be selected that address many questions (see below), but this is not essential. The objective is to relate the warning process to current understanding of best practice, to assess improvements that current best practice might have brought to the outcomes, and to revise and extend best practice where required. Questions for research and analysis are listed below but are not limited to:

Predictability and Processes

- How predictable were the atmospheric conditions associated with the HIW event and how did predictability vary with spatial scale and forecast lead time (e.g., did forecast trajectories bifurcate on the convective scale in a meso-scale environment with little forecast uncertainty)?
- What were the dominant processes governing i) the HI-weather event and ii) its predictability?
- What other factors contributed to the severity of the event (e.g., pre-conditioning, stationarity, compoundness), and how did they impact predictability?
- How did multiple NWP models perform and what are the reasons for good/poor performance?
- What diagnostic tools would assist in identifying HIW events in forecasts, better understanding the physical processes underlying them, and assessing their predictability?

Multi-scale Modelling of Hazards

- What models were used for the weather and the hazard?
- Description - Spatial resolution? Update frequency? Ensemble size? Coupled? DA? etc.
- How were ensembles used, e.g., probabilities, scenarios?
- What additional observational data were used as model input, nowcasts and verification, e.g. non-traditional data?
- How did the models & nowcasts perform?

Impacts, Vulnerability and Risk

- What were the impacts of this event and how were they measured?
- What vulnerabilities and exposures were important in producing the impacts?
- What socioeconomic data were used to assess risk?
- Were impacts predicted (i.e., impact-based forecast or impact forecast) and how?

- How did risks and impacts evolve over time?
- How did users make decisions (thresholds)?
- What were the responses to the event?

Communication

- Which providers issued communications and to which users?
- What proportion of the community were exposed to the 'official' warnings/information?
- How were the communications made (channels, protocols)? How do you know these channels are most appropriate?
- What was the timing and frequency of message delivery?
- What elements (source, hazard, impact, guidance, location, etc.) were included in the message and in what order and detail (e.g. local/detailed information, or nationwide)?
- Which graphics/visualisations/augmented reality techniques were used (if any), specifically the colour, labels, scales, communicating uncertainty, comprehension, links to products used?
- What was the behavioural response(s) as a result of receiving the message? If no response - why not?

User-oriented Evaluation

- What were the error characteristics for the weather, hazard, and impact (if predicted) components of the forecast?
- How did error and uncertainty (e.g., estimated from ensembles) propagate along the warning chain?
- What evaluation was done along the forecast/ warning chain and was it effective?
- What sources of information (other than providers) did forecast users access?
- Did forecast users have access to high quality information relevant to their needs?
- What and how much value was added/lost along each part of the warning chain/network (apply value chain methodologies)?
- What were the strongest and weakest links?
- What were the overall benefits of the warning (avoided losses, e.g., $, lives, etc.)?
- Did the warning evolve due to the changing forecast (e.g., TC track uncertainty) leading up to the event, and how did the value chain itself change? What were the implications for warnings and messaging?

Tasks include:

- Organize a workshop with actors involved in value chain, including users, to discuss the various "best practice" candidates and collect different perspective on what a best practice is.
- Scientists or groups of scientists to undertake detailed analysis of selected cases to identify the potential benefits of applying a best practice warnings chain.
- Findings to be written as reports and peer-reviewed journal articles, including publication of a special journal issue or collection on aspects of warning value chains.

3.3 WP3 – Build Warning Chain Database

We will design and build a data storage and access system to enable easy use of the information to answer questions identified by practitioners. This database should complement and link to existing databases (see 5.2) and the WMO Catalogue of Hazardous Events currently being developed for use by all WMO member states (WMO 2019).

Tasks include:

- Team of scientists and practitioners to co-design and co-create a user requirement for a database and web-based access tool for the collected data.
- Funded project to build a searchable database to contain the collected data, with a web front end for addition of new cases and to enable intuitive searching and display of the results as defined by the user-requirement activity.

3.4 WP4 – Coordination, Communication and Outreach

We will coordinate the first three work packages within the project and engage with WMO, other international and national activities, and the broader research and user community.

Tasks include:

- Coordination of project meetings, reporting to WWRP, and applying for and securing external funding for the project.
- Communicating progress and outcomes of the project through the HIWeather Newsletter and website, conference presentations, webinars, etc.
- Development of training materials and organisation of workshops and conference sessions.

4. Outputs and Outcomes

This project will deliver:

- A high-level value chain framework tool for decision makers
- Guidance and tools for more specific and context-appropriate usage of value chain approaches
- A glossary of value chain and warning chain terminology in a hydrometeorological context
- A living database of hazardous weather events with rich information covering (as much as possible) the components of the forecast and warning value chain.
- Analysis and advice on best practice warning value chains (from simple to complex) analysed from the database
- Exchange and integration of practical experiences (NMHSs and partners) and weather-related natural, social, and interdisciplinary science (research community)

5. Strategies to Achieve the Goals

5.1 Project Team

The project team (**Annex 1**) includes members of the HIWeather project, SERA Working Group, academic and private sector communities. Representing ten countries, around half the project team are physical scientists and half are social scientists. New members are welcome to bring relevant knowledge through new connections.

5.2 Leveraging other activities

This project will have limited capacity to generate original data (e.g., model runs, surveys) for high impact weather events; rather, it will build on existing case studies and collections. By linking science and (meta-)data on the prediction and communication of weather hazards to existing DRR databases, post-event reviews and case studies, this project will for the first time enable research that spans the complete end-to-end warning chain.

Some relevant activities and databases that the project will leverage are listed in **Annex 2**.

5.3 Timeframe

The project kicked off in November 2020. The initial components (value chain review and initial case study collection and organisation) are expected to take two years.

Building the Warning Chain Database will require funding and is expected to begin in the second or third year of the project. It should be informed by WMO-CHE with a long-term goal of linking the Warning Chain Database to the WMO-CHE database.

Table 1: Gantt chart for WPs and individual tasks over the four-year duration of VC project.

WP/Task	2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP1 – Review of Value Chain Approaches																
1.1 Inventory value chain practices																
1.1.1 Value chain literature review																
1.1.2 Value Chain glossary																
1.2 Catalogue value chain usage types																
1.3 Prepare overview of metrics/methods																
1.4 Develop conceptual high-level value chain framework, guidance and tools																
Outputs: High level value chain framework tool, guidance and tools for context-specific use of VCs, glossary				Glossary				Release								Update

Continued on next page.

WP/Task	2021				2022				2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP2 – Analysis of Warning Chains																
2.1 Collect cases of HIW events																
2.1.1 Create spreadsheet for collecting HIW events																
2.1.2 Collect cases of HIW events and add them to the spreadsheet																
2.2 Review selected warning systems																
2.2.1 Measure performance of HIW warnings, draw conclusions																
2.2.2 Gather info on national warning systems and create classification																
2.2.3 Relate events to warning system classification																
2.3 Analyse selected events in depth																
Outputs: Catalogue of HIW events (interim database), reports and publications, special issue								Interim database				Call for special issues				Publication of special issues
WP3 – Build Warning Chain Database																
3.1 Define requirements																
3.2 Build database and web interface																
Outputs: Living database of HIW events linked with WMO-CHE												Test database				Final database
WP4 – Coordination, Communication and Outreach																
4.1 Outreach (workshops, training)																
4.2 Project management & reporting																
4.3 Funding proposal(s)																
4.4 Liaison with WMO-CHE and other activities																
Outputs: Training materials, reports				Workshop						Workshop						Workshop, report

6. Governance and Project Management

The Value Chain project is a flagship project of the HIWeather project which sits within the World Weather Research Programme (WWRP) of WMO and is under the overall direction of the WWRP Scientific Steering Committee (WWRP SSC) (**Figure 4**).

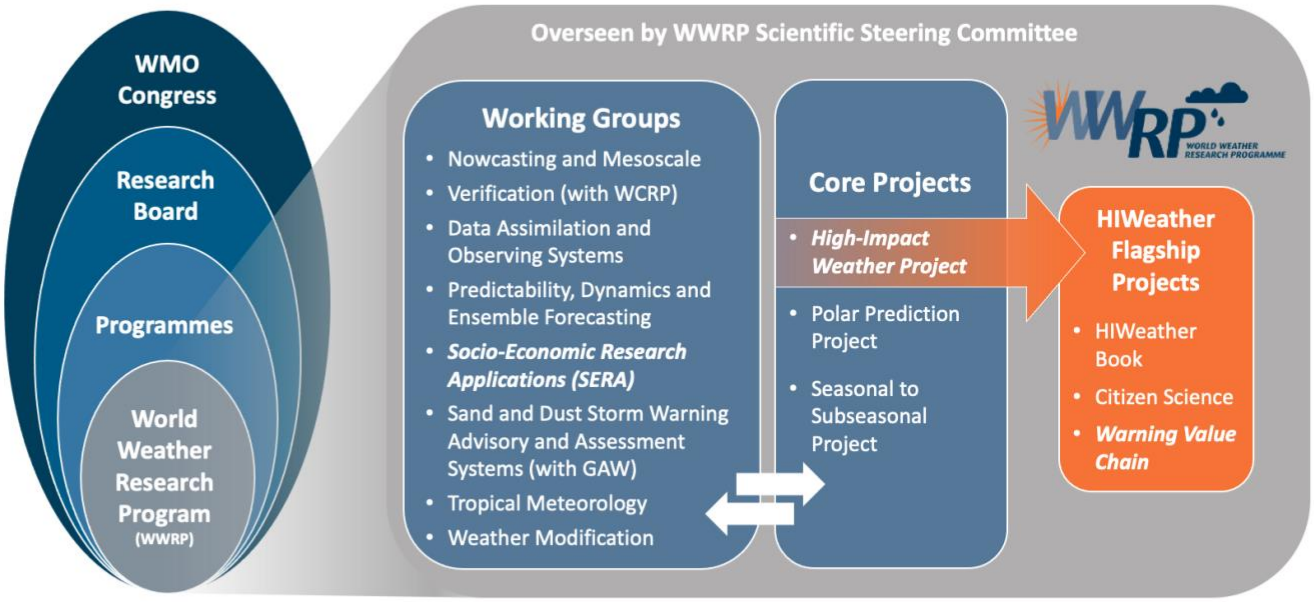

Figure 4. WWRP working groups and core projects.

6.1 Monitoring and Review

The project will report regularly to the Head of WWRP to track progress on the Project Plan. It will be reviewed annually as part of the WWRP SSC review of HIWeather and other WWRP projects and working groups.

6.2 Resource Plan

As with other WWRP projects, the project team members and their host organisations contribute time to the project in alignment with their scientific and organisational research objectives. WMO has provided 11 months salary support for an early career scientist to work on the early phases of the project.

To complete the project, it will be necessary to obtain external funding support for developing and implementing the warning chain database. Funding support for post-docs and PhDs to work on the value chain review and warning chain analysis would also accelerate the scientific outputs from the project.

Team members are currently pursuing funding opportunities to provide resources for this project.

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8. Abbreviations

Comm TT	HIWeather Communication Task Team
DRR	Disaster Risk Reduction
ECCC	Environment and Climate Change Canada
ECMWF	European Centre for Medium-range Weather Forecast
Eval TT	HIWeather User-oriented Evaluation Task Team
IVR TT	HIWeather Human Impact, Vulnerability and Risk Task Team
HIWeather	WWRP High-Impact Weather project
MSM TT	HIWeather Multi-scale Forecasting of Weather-Related Hazards TT
NCAR	National Climate for Atmospheric Research
NOAA	National Oceanographic and Atmospheric Administration
NMHS	National Meteorological and Hydrological Service
NSSL	National Severe Storm Laboratory
NWP	Numerical weather prediction
P&P TT	HIWeather Predictability & Processes Task Team
SERA	Societal and Economic Research Applications
SSC	Scientific Steering Committee
TT	Task Team
VC	Value Chain

WG	Working Group
WMO	World Meteorological Organisation
WMO-CHE	WMO Catalogue of Hazardous Events
WP	Working Package
WWRP	World Weather Research Program

Version history

Version	**Comments**
v0.1	As of 11 March 2021: Initial draft
v0.2	As of 16 March 2021: First revised version with updates throughout for Exec. Summary and Sections 1-5, Changed Figure 3
v0.3	As of 17 March 2021: Further revisions, updates on Sections 2, 4 and 6; added Annex 1 and 2, Figure 4 and 'Outputs and Outcomes' figure
v0.4	As of 23 March 2021: Revision and tightening of Exec. Summary, slight modifications to the main text, Annexes and Figure 3.
v0.5	As of 5 May 2021: Revision of project key objectives and corresponding figures, adding task to WP2 about 'best practice'
v1.0	As of 10 May 2021: First final version of the project plan
v1.1	As of 15 July 2021: Added SERA WG on cover page; Updated member list (joined: Rachel Albrecht, Sara Harrison, Paola Salio; stepped down: Jeff Lazo)
v1.2	As of 4 November 2021: Merged tasks 1.1 (framework) and 1.5 (guideline) into one task, and extend its deadline to end of 2022 for a first release of a high-level framework; Photos on cover paged changed as copyright was violated; Updated member list (joined: Hannah Cloke and Jeff Da Costa)

Annex 1 – Project team

Name	Organisation
Beth Ebert (chair)	Bureau of Meteorology, Australia
Matthew Alto	Accuweather, USA
Rachel Albrecht	University of Sao Paolo, Brazil
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Jeff Da Costa	University of Reading
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Melanie Gall	Arizona State University, USA
Bob Goldhammer	International Association of Emergency Managers
Brian Golding	Met Office, UK
Krushna Gouda	CSIR Fourth Paradigm Institute, India
Sara Harrison	Massey University, New Zealand
David Hoffmann	WMO and Monash University, Australia
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Sharan Majumdar	University of Miami, USA
Chiara Marsigli	Deutscher Wetterdienst, Germany
Brian Mills	ECCC and U. Waterloo, Canada
Carla Mooney	Bureau of Meteorology, Australia
Rebecca Morss	National Center for Atmospheric Research, USA
Hellen Msemo	U. Leeds, Tanzania Meteorological Agency, Tanzania
Adriaan Perrels	Finnish Meteorological Institute, Finland
Rob Rogers	NOAA Hurricane Research Division, USA
Glen Romine	National Center for Atmospheric Research, USA
Paola Salio	University of Buenos Aires, Argentina
Anna Scolobig	University of Geneva, Switzerland
Helen Titley	Met Office, UK
Yi Wang	China Meteorological Administration, China
Nusrat Yussouf	NOAA National Severe Storms Laboratory, USA

Former project members

Name	Organisation
Jeff Lazo	Jeffrey K. Lazo Consulting LLC, USA
Juan Pablo Sarmiento	Florida International University, USA

Annex 2 – Related organisations, networks, databases and projects

Organisation / network	Web Address
PreventionWeb	https://www.preventionweb.net
Knowledge Action Network on Emergent Risks and Extreme Events (Risk KAN)	https://www.risk-kan.org/
Disaster Risk Management Knowledge Centre (DRMKC)	https://drmkc.jrc.ec.europa.eu/
Natural Hazards Center	https://hazards.colorado.edu/

Project	Web Address/Reference
GOES-R Socioeconomic Benefits Study	Lazo, J.K., D.G. Lubar, and M.L. Jamilkowski. 2020. GOES-R Socioeconomic Benefits Study, Phase 1: Hurricane Products Pathfinder – An Intermediate Report. Draft intermediate report: August 27, 2020. Aerospace Corporation – under contract to the GOES-R Program Office.
WWRP High Impact Weather (HIWeather)	http://hiweather.net
HIWeather Citizen Science project	http://hiweather.net/Content/19.html
WWRP Sub-seasonal to Seasonal (S2S) Prediction	http://s2sprediction.net/
WWRP Polar Prediction Project (PPP)	https://www.polarprediction.net/
High Impact Weather Lake System (HIGHWAY) project (UK, Africa)	https://public.wmo.int/en/media/news/early-warnings-protect-lives-africa%E2%80%99s-lake-victoria
Forecasting a Continuum of Environmental Threats (FACETs) (USA)	http://www.nssl.noaa.gov/projects/facets/
Waves to Weather (Germany)	https://www.wavestoweather.de/
WEXICOM (Weather warnings: from EXtreme event Information to COMunication and action) (Germany)	https://www.geo.fu-berlin.de/en/met/wexicom/
Resilience to Nature's Challenges (New Zealand)	https://resiliencechallenge.nz/
POP-ALERT – Emergencies Resilience and Training	http://www.eos-eu.com/pop-alert
iREACT	http://project.i-react.eu
MAPPERS – Mobile Applications for Emergency Response and Support	https://mappers.isig.it
Enhancing emergency management and response to extreme weather and climate events (ANYWHERE)	http://anywhere-h2020.eu

SUPER-FP7 - Social sensors for security assessments and proactive emergencies management	http://www.super-fp7.eu

Relevant databases

Database	Web Address/Reference
Emergency Events Database (EM-DAT)	https://www.emdat.be
DesInventar	https://www.desinventar.net
WMO Catalogue of Hazardous Events	World Meteorological Organisation (WMO) (2019). WMO cataloguing initiative. https://ane4bf-datap1.s3-eu-west-1.amazonaws.com/wmocms/s3fs-public/ckeditor/files/2019.11.21_Ardhasena_Cataloging_Initiative_ET-WCS.pdf
ECMWF Severe Event Catalogue	https://confluence.ecmwf.int/display/FCST/Severe+Event+Catalogue
Spatial Hazardous Events and Losses Database for the United States (SHELDUS)	https://sheldus.asu.edu/SHELDUS/
Disaster Risk Management Knowledge Centre (DRMKC) Risk Data Hub	https://drmkc.jrc.ec.europa.eu/risk-data-hub#/