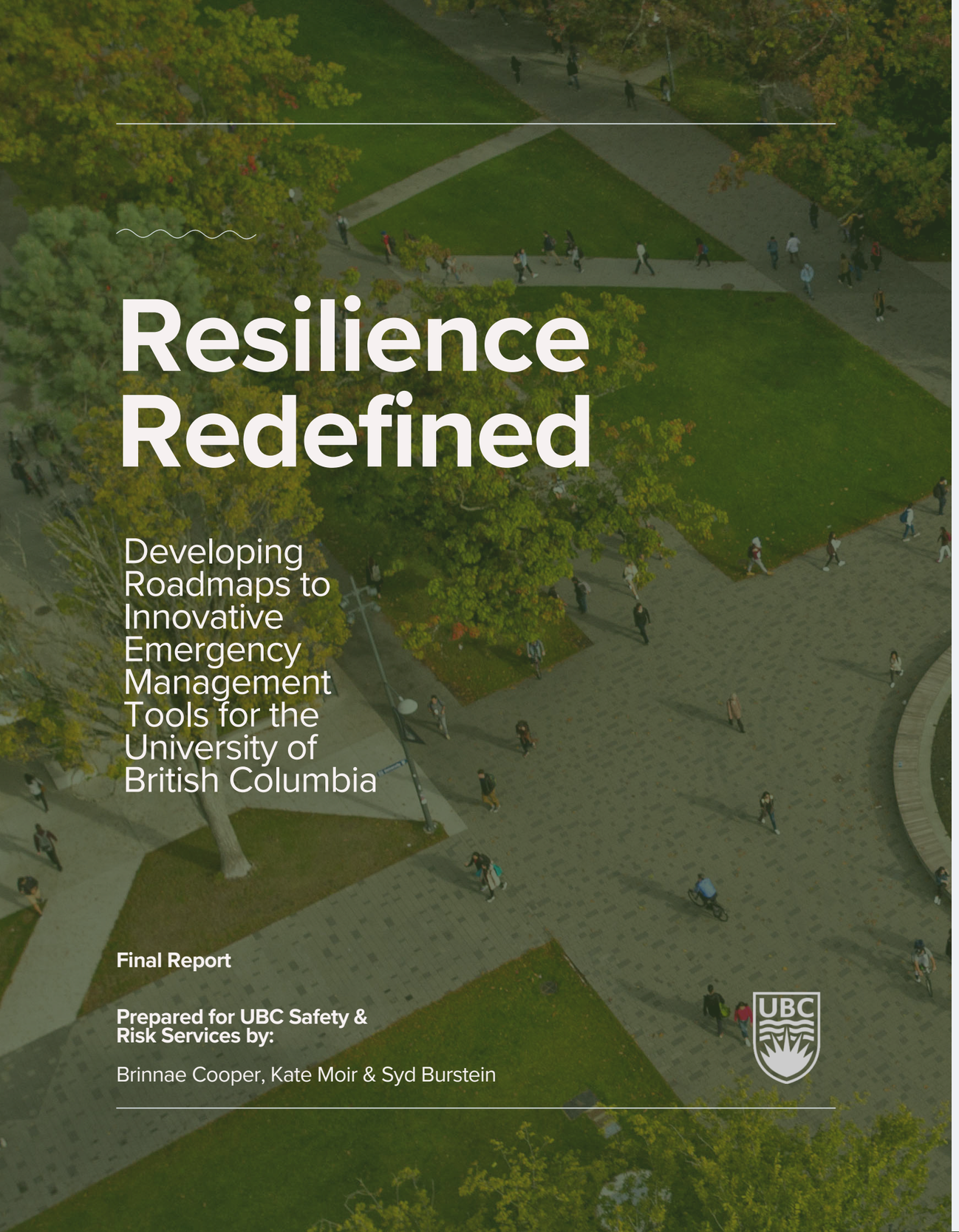

Resilience Redefined

Developing Roadmaps to Innovative Emergency Management Tools for the University of British Columbia

Final Report

Prepared for UBC Safety & Risk Services by:

Brinnae Cooper, Kate Moir & Syd Burstein

What does an innovative Hazard, Risk, and Vulnerability Analysis look like for the University of British Columbia?

Land Acknowledgement

This report was developed on the stolen land of the Coast Salish Peoples, primarily including the territories of the xʷməθkwəy̓əm (Musqueam), Sḵwxwú7mesh (Squamish), and_ Səl̓ilwətaɬ (Tsleil-Waututh) Nations.

We recognize that for Indigenous communities, the realities of risk and vulnerability are directly rooted in an ongoing colonial history of land dispossession and settler risk-management processes. As a result of the elevated risks faced disproportionately by Indigenous communities, it is our intention to ensure our work is consistently grounded in decolonial, reciprocal practice.

Acknowledgements

This project was produced in partnership with UBC Safety & Risk Services as a component of UBC's School of Community and Regional Planning (SCARP) Planning Studio Course.

We would like to thank the professors and partners who have supported our team throughout this project:

- **Hailey Maxwell,** Director, UBC Safety & Risk Services
- **Mariyam Syed,** Advisor, UBC Safety & Risk Services
- **Paul Gill,** Manager, UBC Safety & Risk Services
- **Maged Senbel,** Professor, UBC SCARP
- **Erick Villagomez,** Professor, UBC SCARP
- **Clare Mochrie,** Adjunct Professor, UBC SCARP
- **James Connelly,** Professor, UBC SCARP

In addition to this, we would like to thank the key informants who have provided valuable interviews and guidance.

- **Dr. Michael Schwandt,** Medical Health Officer, Vancouver Coastal Health
- **Heidi Lam,** Senior Policy and Planning Analyst, Metro Vancouver
- **Kerry Shaw,** Senior Neighbourhood Climate Action Planner, University of British Columbia
- **Christopher Godley,** Director of Emergency Management, Stanford University
- **Grant Madden,** Emergency Manager Healthcare Ransomware Resiliency and Response, UC San Diego
- **Craig Dedels,** Regional Manager, Climate Risk & Resilience, Vancouver Coastal Health

Executive Summary

This report outlines a comprehensive roadmap to support UBC Safety and Risk Services in the development of a Hazard, Risk and Vulnerability Assessment (HRVA) that is informed by a flexible and capacity-driven understanding of people, place, and practice within UBC Vancouver.

Risk and vulnerability to hazards are dynamic and constantly evolving. In British Columbia, climate change is increasing the frequency and severity of wildfires, floods, and heat domes [1]. However, environmental hazards are only part of the equation. Cyber threats, public disturbances, national security risks, and critical infrastructure disruptions—such as power outages, telecommunications failures, and supply chain interruptions—pose growing challenges.

Despite these increasing threats, many HRVA approaches remain static, relying on short-term data rather than adaptive strategies. UBCV presents a unique challenge to the typical development of these strategies, as it falls under regional rather than municipal governance. This gap in jurisdiction has led to a lack of localized risk assessment and emergency planning, while also offering a unique opportunity to design an HRVA that reflects the intricacies of this highly populated, complex environment. On invitation from UBC Safety & Risk Services, the report intends to develop pathways to reach unique HRVA options.

In order to face these challenges, UBCV requires modern, adaptive risk management approaches. The roadmap combines data-driven and community-based solutions to support the project's adaptive, community-centered risk management approach—recognizing the university as both a place of institutional resilience and a hub of immense social potential. Understanding these contextual strengths and building on them further enhances a community's resilience. This project facilitates and details the development of a roadmap for UBCV, with internal actions tailored to 3 HRVA approaches suited to organizational and populous capacity:

1. **Compliance with BC Emergency and Disaster Management Act Guidelines and Legislation**
2. **Flexibility & Forecasting**
3. **Community Capacity building**

The frameworks provided intend to capture evolving risks while supporting community and organizational capacity. This result is a plan with actionable recommendations to guide a unique HRVA development, ensuring it remains responsive to evolving threats.

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1.0 Background

The Project

UBCV has relied on the Metro Vancouver Regional District's (MVRD) Hazard Risk and Vulnerability Assessment as its primary tool for predicting the impact of potential hazard events on its campus. UBC's current cross-municipal tool is no longer viable due to the campus's unique population and context.

As climate change and social sciences produce evolving understandings of both risk and vulnerability, the development of a site specific HVRA (Hazard, Risk and Vulnerability Analysis) that anticipates and accounts for variability allows for strategic planning measures that evolve as understandings change.

Traditional HRVAs typically only come to understand a community's potential risks and vulnerabilities within a limited timeframe. The development of a novel HRVA for UBCV will act as a risk-informed and flexible predictor of vulnerability as the community, climate, and our understanding of both develop.

Guiding values for the project were developed in alignment with the methodologies and learnings outlined in section three.

Guiding Values

Community-Centered

To recognize the unique position UBCV holds in both population and context, it is crucial that we develop dynamic, preemptive understandings of these aspects and recognize key gaps contributing to understanding of place.

Proactive Resilience

Resilience and capability are often conceptualized as static features inherit to a given place or community. The intent is to expand these understandings to incentivize proactive interactions between policy and resilience.

Flexible Approach

To acknowledge that a single point in time is unable to capture the essence of a people and place in flux. Our intent is to act alongside and highlight this dynamism in our work.

Project Objectives

This project aims to support UBC Safety & Risk Services in implementing a novel HRVA for UBCV's academic and residential lands, ensuring it reflects and accommodates the campus's unique context. This document will cover:

1. Explore Existing HRVA Approaches

This included an analysis of both Metro Vancouver's current HRVA as utilized by UBCV in addition to a literature review and case studies of existing novel HRVAs

Key Deliverable(s): HRVA/Plan Analysis, Novel HRVA Case Studies, Literature Review

2. Key Data Analysis

Due to the unique demographic context, a data scan will be preformed in order to catalogue existing available information of the area and identify key gaps in knowledge

Key Deliverable(s): Key Data Findings Report

3. Exploration of Potential Approaches for a Novel HRVA

This will include the development of a methodological framework and analysis techniques to inform decisions regarding a novel HRVA for UBCV

Key Deliverable(s): Stakeholder Engagement Guidelines, Data Collection Guidelines, Novel HRVA Framework Development

4. Develop a Strategic Framework for Implementation

Establish a develop a systematic approach and timeline to the implementation of the project

Key Deliverable(s): Roadmap for the Implementation of an HRVA

Our Team

Aster Consulting is a Vancouver-based Planning team comprised of three graduate students enrolled in UBCV's School of Community and Regional Planning. As we undertake work on behalf of a community as diverse as UBCV, and on the land of the xʷməθkʷəy̓əm peoples, we remain mindful of our identities as privileged, white, settler women pursuing advanced degrees.

As settlers on this land, we recognize the care with which our decisions must be made, and the potential reverberations of each action on this land and its people. This recognition is one grounded in action, as we intend to maintain our commitment to the community through critical examination of our own biases throughout this process.

Brinnae Cooper (she/her)

Brinnae wields an education in the natural sciences, with specific interests in ecosystem restoration, disaster risk reduction, and climate change mitigation. She aims to create healthier, more inclusive communities by developing strategies that enhance resiliency and protect biodiversity. She is from Clever, Missouri, which is situated on the unceded and ancestral territory of the 𐓏𐓘𐓻𐓘𐓻𐓟 𐒼𐓂𐓤𐓣 𐓄𐓣𐓆𐓟 𐓨𐓘^𐓻𐓘^ (Osage), Kiikaapoi (Kickapoo), and Očhéthi Šakówiŋ (Great Sioux Nation) people.

Kate Moir (she/her)

Kate has a background in Geography and GIS, with a keen interest in health planning and disaster risk reduction. She aims to build communities that promote healthy living and safety through sustainable and equitable solutions to environmental and public health challenges. She is from Ottawa, Ontario, which is situated on the un-ceded and ancestral territory of the Anishinabe Algonquin people.

Syd Burstein (she/they)

Syd was raised on the stolen territory of the xʷməθkʷəy̓əm people, at the mouth of the Fraser River. With a background in design and nature education, Syd's primary passions focus on integrating intersectional and human-scale principles into resilience and hazard projects in the Lower Mainland. Her work aims to create sustainable solutions that prioritize both community needs and environmental solutions, recognizing the reciprocal relationships that exist between communities and the natural world.

1.1 Understanding Place

Context Oveview

Context Boundaries

Conceptualizing Hazard

Understanding Place

Overview of UBCV

The UBCV campus is located at the western tip of the Point Grey Peninsula, bordering Metro Vancouver and nestled within the University Endowment Lands (UEL). Spanning over 400 hectares, the campus allocates approximately 75% of its land for academic purposes, while the remaining 25% is designated as residential lands [2]. These neighbourhoods provide a unique living environment, blending academic and residential life within a scenic setting surrounded by ocean and forest.

Population

Notably, UBCV offers the largest student residence in Canada, the campus accommodates around 22% of its student population, with approximately 13,000 beds available through its student housing program [2]. The university provides a range of housing options tailored to diverse needs, including residences for undergraduate and graduate students, families, and postdoctoral fellows.

Beyond student housing, the campus neighbourhoods are home to approximately 15,000 residents, including faculty, staff, alumni, and families [2].

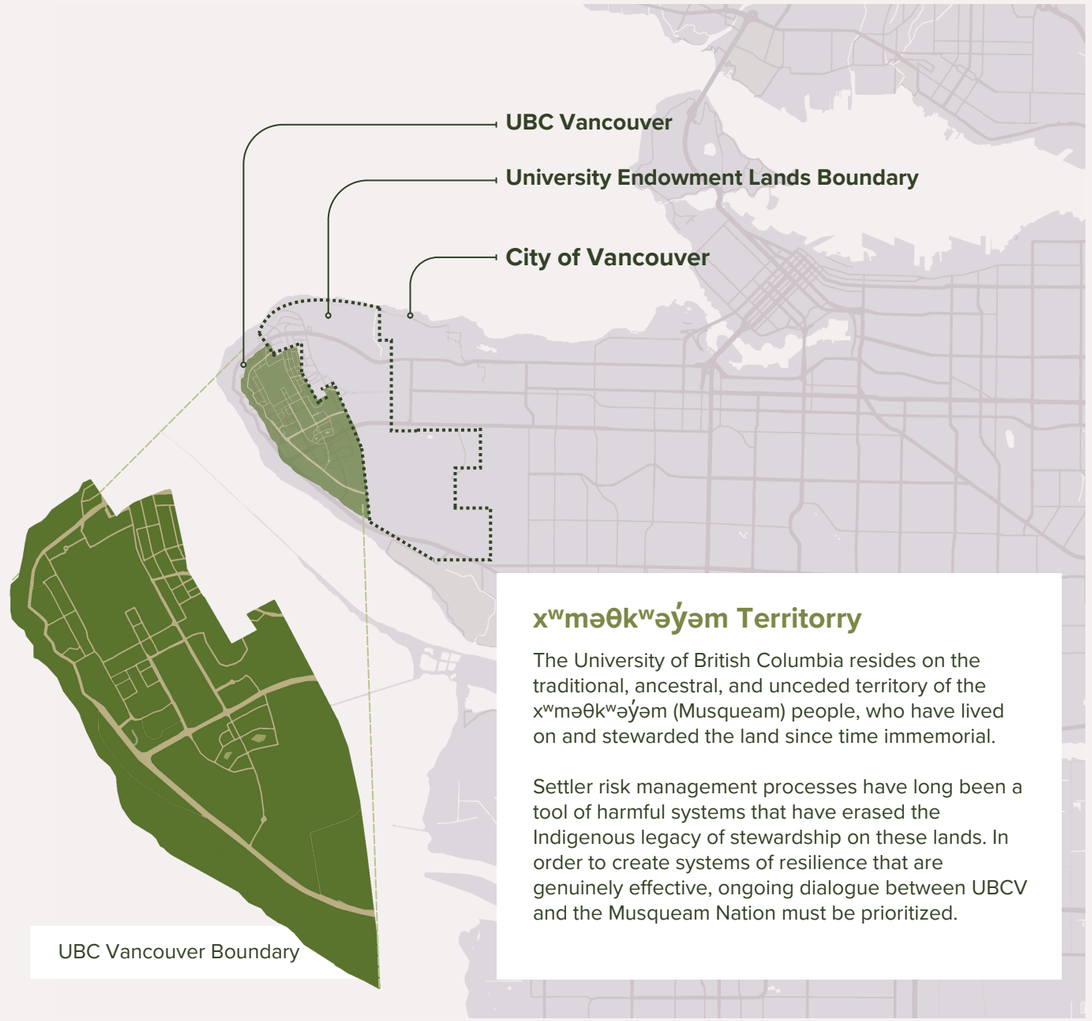
Regional Complexity

UBCV operates within a unique context regarding its population and governance. The area's 2021 census revealed that the university's population resided at approximately 15,103 individuals [2]. However, with faculty staff and 72,585 enrolled students [2].

The dataset exemplifies the complex nature of planning for a university that does not reside within its neighbouring municipal grounds. With this, we recognize the inevitability that our planning work must support and understand the reciprocal and transient relationship that exists between UBC and its surrounding municipalities.

UBCV's day time population peaks at approximately **80,000** people on campus, while its night time population drops significantly to **30,000 residents,** therefore strategies will have to address two distinct scenarios of risk and vulnerability [2]

Context Map



UBC Vancouver Boundary

xʷməθkʷəy̓əm Territorry

The University of British Columbia resides on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam) people, who have lived on and stewarded the land since time immemorial.

Settler risk management processes have long been a tool of harmful systems that have erased the Indigenous legacy of stewardship on these lands. In order to create systems of resilience that are genuinely effective, ongoing dialogue between UBCV and the Musqueam Nation must be prioritized.

Conceptualizing Hazard

The university faces a range of hazards, from environmental threats to security concerns. The following page outlines key risks that could impact the university.

This list is based on regional insights and the Emergency Management British Columbia Hazard Reference Guide [3], but additional hazards may exist.

UBC Comprehensive Hazard Compendium

The following lists possible hazard events that could potentially take place on UBC campus as of January 2025. It is notable that climate change and other external factors have the potential to exacerbate the effects of listed hazards, or to expand the range of potential hazard events previously not considered for the region.

1.0 Volcanic

1.1 Ash Fall
1.2 Volcanic Flow

2.0 Flooding

2.1 Lake, River, and Stream Flooding
2.2 Coastal flooding
2.3 Storm Water Flooding (urban, local, pluvial)

3.0 Seismic

3.1 Earthquake
3.2 Liquefaction
3.3 Tsunami (Telegenic and Terrestrial)

4.0 Geological

4.1 Avalanche
4.2 Landslide/ Debris Flow
4.3 Land Subsidence
4.4 Submarine Slides
4.5 Sinkholes

5.0 Hydrological

5.1 Drought
5.2 Seiche
5.3 Storm Surge

6.0 Atmospheric

6.1 Air Quality
6.2 Extreme Heat
6.3 Extreme Cold
6.4 Fog
6.5 Freezing rain or drizzle
6.6 Space weather
6.7 Hail
6.8 Hurricane/ Typhoon/ High wind Event
6.9 Wind event
6.10 Lightning
6.11 Snowstorms and Blizzards
6.12 Tornado
6.13 Extreme Precipitation
6.14 Wildfire

7.0 Disease & Epidemic

7.1 Animal Disease
7.2 Human Disease (includes pandemic and epidemic)
7.3 Plant Disease
7.4 Pest Infestation
7.5 Public Health Crisis

8.0 Hazardous Materials and Explosions

8.1 Explosions
8.2 Hazardous Materials Spill
8.3 Mine Incident
8.4 Nuclear Incident
8.5 Oil or Gas Pipeline Spill
8.6 Space Debris

9.0 Interruptions to Critical Services

9.1 Electrical Outage
9.2 Food Source Interruption (Supply chain, or community food stores)
9.3 Telecommunications Interruption
9.4 Transportation Route Interruption
9.5 Water service interruption (includes shortage and contamination)
9.6 Fuel Source Interruption

10.0 Security

10.1 Cyber Security Threat
10.2 National Security Threat
10.3 Public Disturbance
10.4 Major Planned Event

11.0 Transportation

11.1 Aircraft Incident
11.2 Marine Vesel Incident
11.3 Motor Vehicle Incident
11.4 Rail Incident

12.0 Infrastructure Failure

12.1 Dam and Spillways Failure
12.2 Dike Failure
12.3 Structure Failure

In addition, many hazards exist in connection with one another and can potentially occur in tandem. Strategies to manage hazard risk will need to anticipate and adapt to multiple exposures.

This Hazard List was provided by the BC HRVA Tool Guidelines [3].

1.2 Understanding People

Demographic Review

Characterizing UBCV

Demographic Review

Overview of UBCV

The region is highly diverse, with UBCV serving as a major hub for international students, who made up 27% of the student body in 2020, totaling 15,508 students [2]. The largest group among international students is East Asian (47%), followed by South Asian (18%) and North American (10%). Other major represented regions include Southeast Asia, Europe, Africa, and South America [2]. While English is the most commonly spoken language, 45% of students speak a non-official language [2].

The population is predominantly young, with most residents and daily campus visitors between 18 and 39 years old [2]. Housing in UBCV primarily consists of student dorms, rentals, and apartments. There are 13 residences, two colleges and one neighbourhood [2]

Community Partnerships for Hazard Resilience

Community Organizations

UBCV is home to a diverse range of community-run organizations and clubs, making it a valuable resource for fostering resilience among students and residents. By collaborating with these organizations, UBC can strengthen disaster preparedness, social support networks, and climate adaptation efforts. These groups provide localized knowledge, peer-driven initiatives, and direct community engagement, all essential for building a more connected and resilient

campus and surrounding area. The potential for leveraging these organizations is explored further in Section 4: Strategic Opportunities.

The following page is a selection of community organizations well-suited for partnerships in disaster preparedness and response, climate mitigation, social support, and hazard education. While not an exhaustive list, these organizations represent strong candidates for collaboration in resilience-building efforts.

UBC-Associated Organizations

Emergency & Disaster Preparedness

- UBC Emergency Management
- AMS Safewalk
- UBC Campus Security
- UBC Student Emergency Response Team (UBC SERT)

Climate Resilience & Sustainability

- UBC Sustainability Initiative
- UBC Climate Hub
- UBC Climate Action Mobilizers

Social & Community Resilience

- AMS (Alma Mater Society) of UBC
- UBC Wellbeing
- UBC Indigenous Research Partnerships
- UBC Sprouts & AMS Food Bank
- UBC Equity & Inclusion Office
- UBC Longhouse & First Nations House of Learning

UEL-Associated Organizations

Emergency & Safety Preparedness

- UEL Community Advisory Council (CAC)
- UBC RCMP Detachment

Climate Resilience & Sustainability

- Pacific Spirit Park Society
- Metro Vancouver UEL Administration

Social & Community Resilience

- University Neighbourhood Association
- UBC Old Barn Community Centre
- West Point Grey Community Centre

Other Organizations

- Musqueam Indian Band
- Pacific Immigrant Resources Society
- Neighbourhood Emergency Preparedness Program

Characterizing UBCV

The site, in both its social and physical characteristics, presents both positive (+) and negative (-) conditions regarding our considerations of hazard, risk, and vulnerability.

(-) Transient Population

UBC's unique demographics pose distinct challenges. With a high student population, many who occupy UBC's campus are not counted in demographic surveys and censuses for the area.

(-) Unincorporated Municipality

UBCV is a part of Metro Vancouver's Electoral Area A, composed of several unincorporated communities. Due to this, UBC's HRVA remains the responsibility of regional and provincial services, resulting in generalized and less specific services to the distinct region.

(+/-) Proximity to Vancouver

Despite our research being limited to UBCV, it is an inevitability that the campus and its grounds are viewed as an extension of Vancouver's services. Therefore, we acknowledge that in the event of a hazard, UBC's preparation and choices will impact the populations of Vancouver as well as other adjacent municipalities, adding a layer of complexity to all scenarios.

Understanding People

(+) Organized Community

An involved, vocal student body comprises a large quantity of UBC's community. This, in cooperation with university governing body and administration. has the potential to lead to robust community engagement opportunities.

(+) University Resources & Incentive

As a major University, there is incentive to remain at the forefront of research endeavours, notably in relation to the campus itself. The research evolving on campus will provide a major resource for the data required as this project develops.

2.0 Methodologies

Literature Review

Regional Report Analysis

Vulnerability Calculations

Case Studies

Understanding Vulnerability

There is no single means of understanding, nor applying vulnerability

Key Takeaways:

Vulnerability is rarely understood or applied singularly. It involves a wide breadth of characteristics informed by a multitude of disciplines. Given this; how, when and why it is utilized can differ significantly, depending on the purpose under which it is being examined. Understanding and characterizing vulnerability within an HRVA or other hazard-related context can include methodologies ranging from short-term identification and mapping, to seeking root cause understanding and policy change, to understanding individual or community perceptions of vulnerability [4]. To move forward in our understanding, we need to solidify our understanding, and intended outcome in applying the concept.

Dynamic understanding of Social Vulnerability is critical to assessing accurate impacts of a hazard event.

Key Takeaways:

Social vulnerability has long been an integral component of hazard literature. The impact of its integration into effective hazard, risk and vulnerability predictions, however, is highly dependent on how the data is conceptualized temporally. **Appropriate disaster and risk mitigation work must endeavour to model both hazard, risk, and social data as factors in flux, rather than as static data.** The Social Vulnerability Index was developed to work alongside single-point census data, and although this can aid in determining short timeframe resource allocation, it has less success in how we understand the development of risk and vulnerability over time [5][6]. When vulnerability data is gathered and analyzed as static, predictions likely underestimate the full impacts of both hazard events and the proportion of the population to be impacted by them. This approach has also been shown to empower local bodies to develop vulnerability mitigation strategies that are aligned with long-term community needs and goals, rather than incentivizing short-term solutions [6].

Perceiving Hazard

Perceptions of hazard by the public can be as important as the hazards themselves.

Key Takeaways:

Much like their impacts, perceptions of hazard risk are not singular. As climate change amplifies and exacerbates hazard events, communication of the potential effects becomes crucial. Case studies have found that before experiencing a hazard event, perception of risk tends to be highly dependent on experience with past hazard events in the area [7]. Given the typically transient nature of university populations such as UBC, short-term institutional memory has the potential to diminish understanding of past events and their impacts.

As a result, it is vital that institutions adopt comprehensive and ongoing risk communication strategies that integrate hazard awareness into the culture of the campus community, ensuring that even new members understand and are prepared for potential risks.

Recognizing Social Capital

Community collective capacity is key to fostering resilience.

Key Takeaways:

Research found that collective capacity is a key component of community resilience and adaptation in the aftermath of hazard events. Community, in this context refers to a number of different social compositions- from geographic neighbourhood proximity to affinity-based social groups. The idea of collective capacity stems from the idea that a resilience is the result of a set of networked capacities. The intrinsic idea in this is that the capacity of a population's individuals may be of less importance than that of the community, and that communities are able increase capacity through "the cultivation and use of transferable knowledge, skills, systems, and resources that affect community- and individual-level changes". Given this, efforts to increase community resilience may be better targeted at the community- rather than the individual level. [8]

Existing Community-Based Organizations are a crucial, yet underutilized resource in the wake of a disaster.

Key Takeaways:

Novel methodologies have come to understand community knowledge and social infrastructure as crucial and ongoing components of hazard planning. Previous efforts in the realm of hazard planning had focused on formalized infrastructure rather than civic society in their efforts toward widescale disaster risk reduction (DRR). Modern planning reports, such as those highlighted in the key reports above, define the need for clear and concise communication with social infrastructure (SI) and civic stakeholders, ranging from non-profits to faith-based organizations.

Social organizations are a widespread yet often unacknowledged resource in hazard planning, mobilizing to facilitate community services that can aid in reducing vulnerability in both pre and post-hazard events [10]. The enhancement of this partnership is thought to be a crucial extension of disaster risk reduction work. The sector can also open further opportunities in the dissemination of disaster risk information to vulnerable members of the public and those who work alongside them directly [9]. In providing streamlined communication and understanding through public-centered hazard management strategies, both SI and DRR are better able to understand the local specific local context and the mutual role they play within it [9].

Existing Regional Reports

The following outlines the University of British Columbia's context within the regions HRVA literature

British Columbia Documents

Hazard Reference Guide [3]
Provides information on each of the 57 hazards listed in the HRVA tool, including definitions and links to subject matter expert sources.

Companion Guide to the Hazard Risk and Vulnerability Analysis [11]
A Companion Guide to the HRVA developed as a support document to the Hazard, Risk and Vulnerability Analysis tool for Local Authorities and First Nations

Regional Planning Documents

Electoral Area A Emergency Response Plan [12]
Legislated mandate to protect the safety of all Electoral Area A residents

Fraser Valley Regional District Hazard Report [13]
Compile hazard information of the FVRD and development an associated emergency management plan

UBC Documents

Cost of Doing Nothing Report 2024
This report provides the University of British Columbia (UBC) decision-makers with guidance on using locally relevant data to weigh the costs of action vs. inaction.

Climate Science Report 2023
The purpose of this report is to summarize localized projections. These climate projections will be used to help determine the impacts of what vulnerabilities and risks the UBC community faces.

Risk and Vulnerability Summary Report 2024
This project, along with subsequent adaptation action planning work, will enable UBC Vancouver to minimize the negative impacts of climate change by addressing locally identified risks

Vancouver Documents

Summary of Hazard, Risk, and Vulnerability Analysis 2024 [14]
Hazard, Risk and Vulnerability Analysis (HRVA), its purpose, methods, results, and key findings for consideration in forthcoming plans and strategies.

CoV Hazard and Risk Explorer [15]
Interactive hazard and risk tool intended to educate the public about risks and vulnerabilities faced by the city.

Key Takeaways

*Across the regional reports we reviewed, three recurring themes emerged: **engagement, hazard identification, and vulnerability measurement**. These consistent elements highlight their importance as foundational components of comprehensive, effective hazard planning and resilience-building efforts.*

Engagement

Most reports utilized a **collaborative and inclusive approach**, combining community engagement, expert assessments, and stakeholder consultations. This approach gathered diverse perspectives by involving government representatives, first responders, Indigenous community members, and industry stakeholders. Some reports further distinguished themselves by incorporating Indigenous knowledge and aligning with international disaster risk reduction frameworks, like the **Sendai Framework**, promoting a more equity-focused methodology.

Hazard Identification

The reports identified hazards using a mix of scientific data, historical event analysis, and expert input. Hazards were determined **through collaborative workshops, localized climate projections, and community engagement**, with a focus on climate-related risks. A notable methodology utilized in these reports was the **ICLEI Canada Building Adaptive and Resilient Communities** framework. Various assessments prioritized environmental and infrastructural hazards, such as wildfires, flooding, and landslides, particularly those expected to increase in frequency due to climate change.

Vulnerability Measurement

Vulnerability was assessed using a blend of qualitative and quantitative methods. These included **risk matrices** to evaluate the likelihood and consequences of hazards, vulnerability surveys to gauge adaptive capacity, and indices like a **Social Vulnerability Index (SoVI)** to identify areas with heightened social vulnerability based on factors such as housing, financial agency, and social capital.

Calculating Vulnerability

Hazard Impact Analysis

Completing a hazard impact analysis on an area involves systematically evaluating potential hazards based on their likelihood and consequences.

The process begins by identifying hazards relevant to the specific context, such as natural hazards, technological failures, or social disruptions. Each hazard is then assessed using qualitative or quantitative data to determine the probability of occurrence (likelihood) and the severity of its impacts on people, infrastructure, and essential services (consequence).

Possible Consequence Factors

- *Area of Impact*
- *Physical Impact*
- *System Dependent Mental Health Impact*
- *Property Impact*
- *Continuity of Operations*
- *Institutional Reputation*
- *Warning Time*
- *Duration*
- *Social Vulnerability Community Impact*
- *System Preparedness*

Scaling Likelihood and Consequence

Likelihood and consequence are to be rated on scales from 1 to 5. This provides a structured approach to assessing risk. Likelihood, rated from 1 (rare or not previously considered) to 5 (almost certain), reflects the probability of a hazard occurring within a given timeframe based on historical data, expert judgment, and predictive modeling. Consequence, also rated from 1 (insignificant) to 5 (catastrophic), evaluates the potential impact on people, infrastructure, the environment, and essential services. A higher consequence rating indicates more severe disruptions, such as loss of life, economic damage, or long-term environmental harm. There will be multiple consequence ratings per hazard, as there are multiple consequence factors to consider.

We'd like to extend an additional thanks to Grant Madden for assistance in the development of these pages [17]

Calculating Risk Percentage

The final component of the hazard impact analysis is calculating the percentage that a particular hazard is a threat to the community. To do this, the given likelihood rating is divided by the highest possible rating, and then it is multiplied by the sum of impact ratings for that hazard, divided by the total possible hazard impact ratings. This total is multiplied by 100 to determine the risk percentage. Once the risk percentage has been calculated, the relative threat can be understood as very low (less than 19%), low (20-39%), moderate (40-59%), high (60-79%), and very high (80-100%).

$$\left(\frac{\text{likelihood rating}}{\text{highest possible rating}}\right)\left(\frac{\text{sum of hazard impact ratings}}{\text{sum of total possible hazard impact ratings}}\right) \times 100$$

***RISK* =**
LIKELIHOOD x CONSEQUENCE

Social Vulnerability

To accurately assess a hazard's risk to a community, social vulnerability must be factored into the calculations. This section details how social vulnerability data is used to complete risk index calculations.

Hazard Impact Analysis X **Social Vulnerability Index** = **Risk Index**

A Social Vulnerability Index (SoVI) quantitatively analyzes socio-economic variables to assess relative vulnerability within a defined geographic area. It assigns a score (e.g., low, moderate, or high) based on standard deviations from the mean, highlighting how social vulnerability in one area compares to another. In essence, a SoVI score reflects how much each variable (e.g., Census data) deviates from the average within the given boundary [16].

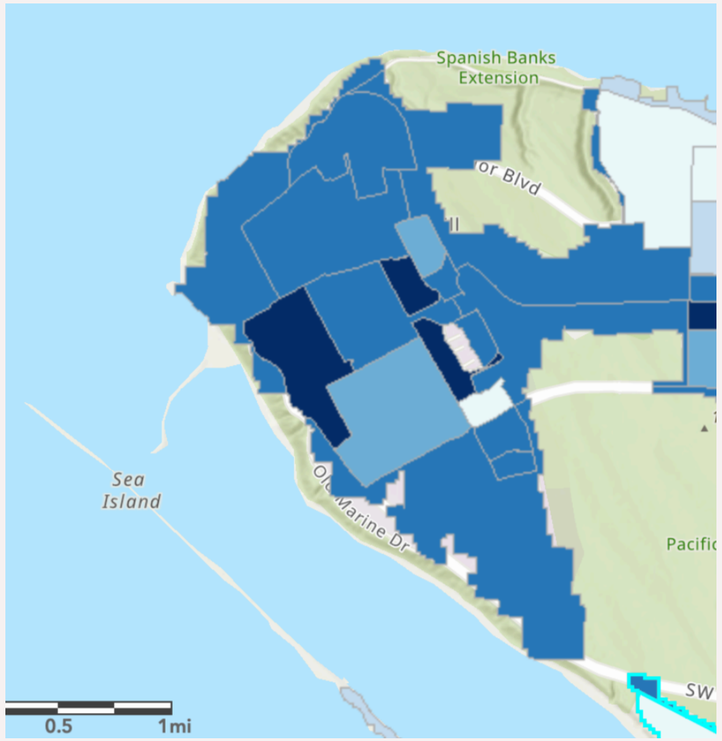
As an alternative, the Canadian Red Cross has developed a succinct guide on creating a SoVI model, which can be utilized by UBCV to understand the population's vulnerability. See Appendix A.

Natural Resources Canada (NRCan) has developed a Social Vulnerability component of the National Human Settlement Layer, which provides broad patterns of social vulnerability at the neighborhood scale. Though NRCan did not release the component with the intention of site-specific use, the resource does provide social vulnerability scores for the UBC campus.

Natural Resources Canada - National Human Settlement Layer

The SVIt_Score within the National Human Settlement Layer categorizes social vulnerability into five levels: Very Low (0–1), Low (1–3), Moderate (3–5), High (5–7), and Very High (7–20).

While the highest possible SoVI score is 20, the highest score given was 13. For UBCV, the highest score is 8, and the average is 6. Even though the maximum possible score is 20, the highest observed score is only 13, suggesting that very high vulnerability scores are rare.



Score of 8 → 99.97th percentile

A score of 8 is extremely high relative to the dataset, placing it in the top 0.03% of all observations.

Score of 6 → 98.90th percentile

A score of 6 is also high, but more common than 8, sitting just below the top 1% of all values.

Either of these scores can be used in the SoVI index calculation.

Risk Index

The Risk Index is calculated by multiplying the Hazard Impact Analysis by the Social Vulnerability Index (SoVI) to capture both physical hazard intensity and community vulnerability. Higher values indicate greater overall risk due to both hazard exposure and community vulnerability, helping prioritize mitigation efforts.

Hazard Impact Analysis x **Social Vulnerability Index** = **Risk Index**

Here, an example has been provided to visually showcase how to calculate a risk index [17]. The identified hazard, tropical storm/hurricane, has been evaluated for current and future likelihood, as well as through 10 different consequence factors.

EVENT	CURRENT PROBABILITY	CLIMATE VULNERABILITY INDEX FORECAST	BREADTH OF IMPACT								PREPAREDNESS	
			AREA OF IMPACT	PHYSICAL IMPACT	SYSTEM DEPENDENT MENTAL HEALTH IMPACT	PROPERTY IMPACT	CONTINUITY OF OPERATIONS	INSTITUTIONAL REPUTATION	WARNING TIME	DURATION	SOCIAL VULVERABILITY COMMUNITY IMPACT	SYSTEM PREPAREDNESS
	Current likelihood this will occur.	Likelihood this will occur by **2050**	Locations of facility, buildings or utility impact.	Possibility of death or injury at facility by event.	Within 90 days of start of event, need for mental mental health services.	Amount of hospital infrastructure potentially damaged by event.	Complete interruption / shutdown of facility to carry out any essential function.	Imoact oin stakeholders leading to a negative impact on the reputation of the facility	Event anticipation time	Time event may continue	Socially Vulnerable Community preparedness.	Staff trained, equipped, and drilled for event.
	5 = Almost Certain	5 = Highest Vulnerability	5 = All buildings, infratsurcture or utilities.	5 = 10 or more deaths	5 = Significant resources or services needed	5 = Total Loss or <$250M	5 = >30days	5-Permanent loss of key support by key stake holders.	5= < 1 hour	5 = > 30 days	5 = Event not previously considered.	5 = Event not previously considered
	4 = Highly Likely	4 = Higher Vulnerability	4 = Area wide - groups of buildings or more than one utility system	4 = 5 -9 deaths	4 = Moderate resources/services needed.	4 = >50% or $100M - $250M	4 = 7 - 30 days	4 = Long term loss of support by key stake holders.	4 = < 24 hours	4 = 7 - 30 days	4 = Event identified and/or JEDI preparedness documentation	4 = Event identified and/or staff not trained.
	3 = Possible	3 = Average Vulnerability	3 = General - a one mile area or one utility system.	3 = Injuries result in permanent disability or less than 5 deaths	3 = Regular level of resources/servcies required.	3 = 25-50% or $51M - $100M	3 = 3 - 7 days	3 = Short term loss of key stakeholders.	3 = 1-3 days	3 = 3 - 7days	3 = JEDI preparedness documentation completed.	3 = Event staff trained, no equipment.
	2 = Unlikely	2 = Lower Vulnerability	2 = Limited - a while building or to a complete utility system.	2 = Injuries do not result in permanent disability	2 = Minimal resources/services needed.	2 = 10-25% or $11M - $50M	2 = 1 - 3 days	2 = Key stake holders respons negatively with some impact.	2 = 3 - 7 days	2 = 1 - 3 days	2 = JEDI Event Annex exercised and/or evaluated.	2 = Most staff trained, some equipment.
	1 - Rare or not previously considered	1 -Lowest Vulnerability	1 = Localized - a portion of a building or a section of a singl eutility system.	1 = Injuries treatable with first aid	1 = Little to no resources/services needed.	1 = <10% or <$10m	1 = 24 hours or less	1 = Little to no inpact on or from key stakeholders.	1 = >7 days	1 = 24 hours or less	1 = JEDI Mitigation for Event Commenced	1 = Event staff identified, trained, properly equipped and drilled.
Tropical Storm/ Hurricane	2	3	4	3	2	2	2	2	1	4	3	3

After walking through the hazard impact analysis, the next step is to calculate the risk percentage. This is done by utilizing the risk percentage formula, showcased here.

$$\left(\frac{\text{likelihood rating}}{\text{highest possible rating}}\right)\left(\frac{\text{sum of hazard impact ratings}}{\text{sum of total possible hazard impact ratings}}\right) \times 100$$

For the tropical storm/hurricane event, the formula looks like this:

$$\left(\frac{2}{5}\right)\left(\frac{26}{50}\right) \times 100$$

This equals 20.8%, which is rounded up to 21%, as seen below. It is important to remember to only use the current probability when calculating current risk, and the climate vulnerability index forecast probability when calculating future risk.

After calculating risk percentage, the next step is to multiply risk percentage by SoVI percentage. Here, the SoVI percentage is 25.3%. This final output gives us the current percentage of the population at risk for this event, which is 5.31%. The relative threat for tropical storms/hurricanes is low.

[**Risk Percentage** x **Social Vulnerability Percentage**] x **100**

CURRENT RISK	CLIMATE VULNERABILITY FORECAST	CDC SVI RATING	CURRENT % COUNTY POPULATION AT RISK	FORECAST % COUNTY POPULATION AT RISK
Relative Threat	Relative Threat		Relative Threat	Relative Threat
80% - 100% = Very High	80% - 100% = Very High		80% - 100% = Very High	80% - 100% = Very High
60% - 79% = High	60% - 79% = High		60% - 79% = High	60% - 79% = High
40% - 59% = Moderate	40% - 59% = Moderate		40% - 59% = Moderate	40% - 59% = Moderate
20% - 39% = Low	20% - 39% = Low		20% - 39% = Low	20% - 39% = Low
> 19% = Very Low	> 19% = Very Low		> 19% = Very Low	> 19% = Very Low
21.00%	31.50%	25.30%	5.31%	7.97%

Taking Inspiration: Case Studies

Case studies were conducted to better understand hazard resilience policies and approaches in regions and universities similar to UBC, or those with HRVA features considered best practices.

UC San Diego Health, Climate HVA

Reason For Selection:

The UC San Diego Health Climate HVA employs an analysis framework that informs the risk level qualification and calculation for UBC's HRVA, particularly through its use of the Social Vulnerability Index as a key variable in assessing overall risk.

Description:

UC San Diego Health developed an innovative Climate HVA approach to assess and mitigate risks associated with climate events by integrating cumulative risk assessments with the CDC's Social Vulnerability Index (SVI) [17]. By integrating social vulnerability data, the HVA generates a vulnerability score that accounts for local socio-economic factors influencing specific demographics' susceptibility to climate events[17].

This approach provides critical insights into "who" within the population is likely to be adversely affected, thereby enhancing the community's capacity to mitigate, prepare for, and respond to such events.

Key Takeaways

- Wide range of risk indicators
- Integrates current and future risk
- Demographic specific
- Combines cumulative assessments with CDC Social Vulnerability Index (SOVI)
- **This case study will shape the analysis framework and methodology for calculating hazard risk at UBC, specifically by incorporating SVI.**

A note on decentralized hazard strategies:

Understanding various hazard-response strategies was crucial to this project. Notably, Stanford University served as a reference for decentralized HRVA approaches, as it operates independently of state and municipal mandates—similar to UBC[18].

Stanford's model grants individual schools and businesses autonomy in emergency preparedness, highlighting potential benefits for small-scale community resilience [18]. However, with upcoming provincial legislation requiring coordinated municipal responses and studies emphasizing community capacity, decentralized HRVAs were not pursued for UBC's HRVA.

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University of Oregon

Reason for Selection:

This case study was selected because the University of Oregon is renowned for it's disaster research and is home to André Le Duc, founder of the Disaster Resilient Universities Network.

Description:

While the University of Oregon does not have a publicly available HRVA, it has developed a series of complementary plans to address both immediate emergency response and long-term risk mitigation. These include the Emergency Operations Plan (EOP) for coordinated crisis management, the Natural Hazards Mitigation Plan (NHMP) to reduce disaster vulnerabilities, and Individual Department Continuity Plans to ensure operational resilience [19][20]. The risk assessment explores hazard exposure, system vulnerabilities, and adaptive capacity across key domains, such as infrastructure, academic functions, and economic impacts [19].

Additionally, the university integrates its emergency management efforts with local agencies, adhering to FEMA's National Incident Management System (NIMS) and the Incident Command System (ICS) standards while conducting joint training and exercises [20]. This collaborative and comprehensive approach enhances preparedness, response, and long-term resilience [20].

Key Takeaways

- *Integration with local agencies to facilitate effective communication and resource sharing.*
- *Complementary plans address both immediate response and long-term risk mitigation.*
- ***Given UBCV's close ties with surrounding municipalities and organizations, it can foster mutually beneficial partnerships to enhance mitigation and response efforts.***

Halifax Regional Municipality (HRM) HRVA

Reason For Selection:

HRM's HRVA was chosen for its coastal location and strong community-centric approach to hazard assessment and risk communication in the development of their HRVA.

Description:

Halifax is developing an HRVA that prioritizes community engagement by integrating traditional knowledge and emphasizing public education. The framework includes clear, accessible messaging and interactive initiatives to raise awareness about high-risk hazards [21]. Engagement strategies such as meetings, focus groups, webinars, and surveys ensure meaningful dialogue with diverse stakeholders [21].

Additionally, HRM is creating an online dashboard to provide an interactive platform for exploring data, visualizing risk assessments, and analyzing social vulnerability metrics [21]. This comprehensive approach enhances public preparedness and resilience.

Key Takeaways

- Robust Public Messaging & Educational Initiatives
- Interactive engagement & Meaningful Dialogue
- Development of an Online Dashboard for Public Data Exploration
- **The HRM HRVA engagement framework could be adapted for UBCV, with events engaging students, residents, and key stakeholders.**

Roadmap

3.0 The Roadmap

At a glance:

UBC's HRVA Roadmap

The following section presents a roadmap with actions tailored to three HRVA options best suited to UBCV. These options are interconnected, with actions from one serving as a foundation for the others.

The goal is to help UBC Safety and Risk Services eliminate redundancies as organizational capacity, funding, or resources increase, enabling the seamless integration of progressively more robust disaster management actions.

Throughout the development of the options and roadmap, several key considerations guided the project. These considerations were shaped by partner input, research, and UBC policy requirements, which collectively determined the project's overall direction and objectives.

Project Development Priority Considerations

1. BC Emergency Disaster Management Act Compliance

All considerations regarding the strategic implementation of Novel HRVAs for UBC must align with the content, timelines and procedures outlined in the British Columbia Emergency and Disaster Management Act.

2. Predictive and Flexible Understanding

The static documents typical of HRVAs do not allow for a comprehensive understanding of hazard nor community. The development of a predictive and flexible tool is able to dial up/down key elements as the university experiences them evolving.

3. Community-Centered Resilience

Resilience and capacity are often conceptualized as static features inherit to a given place or community. The intent of this project is to expand these understandings, incentivizing community capacity building prior to, during, and post-hazard event.

Overview of the Three HRVA Approaches:

Three approaches were developed, all fully aligned with the BC Emergency Disaster Management Act standards. However, Approaches 2 and 3 go beyond these requirements, while Approach 1 is designed to meet the guidelines without further expansion.

Depending on capacity and objectives, UBC Safety and Risk Services can develop an HRVA for UBCV by following the steps outlined in the Roadmap. The three options are broadly as follows:

APPROACH 1:

The Development of a Hazard, Risk and Vulnerability Analysis that Aligns with British Columbia's HRVA Standards*

This option follows the standards outlined in British Columbia's comprehensive 9 step HRVA process. The resulting report will provide and outline UBC's understanding of physical and social impacts of hazards, as well as potential reduction strategies.

APPROACH 2:

The Creation of a Novel Hazard, Risk and Vulnerability Analysis, Informed by Climate and Data Projection

In accordance with the model informed by Grant Madden, this option will entail the development of a risk-informed and flexible HRVA intended to provide projections of climate and vulnerability. This model will entail integrated data monitoring, robust community understanding, and population and climate forecasting.

APPROACH 3:

The development of a community centred and informed Hazard, Risk and Vulnerability Analysis

This option builds on the quantitative work of the previous options. In this, concentrated efforts to to build the adaptive capacities of these actors is enacted to ensure a comprehensive community response to hazard preparation and aftermath.

How to use the Roadmap:

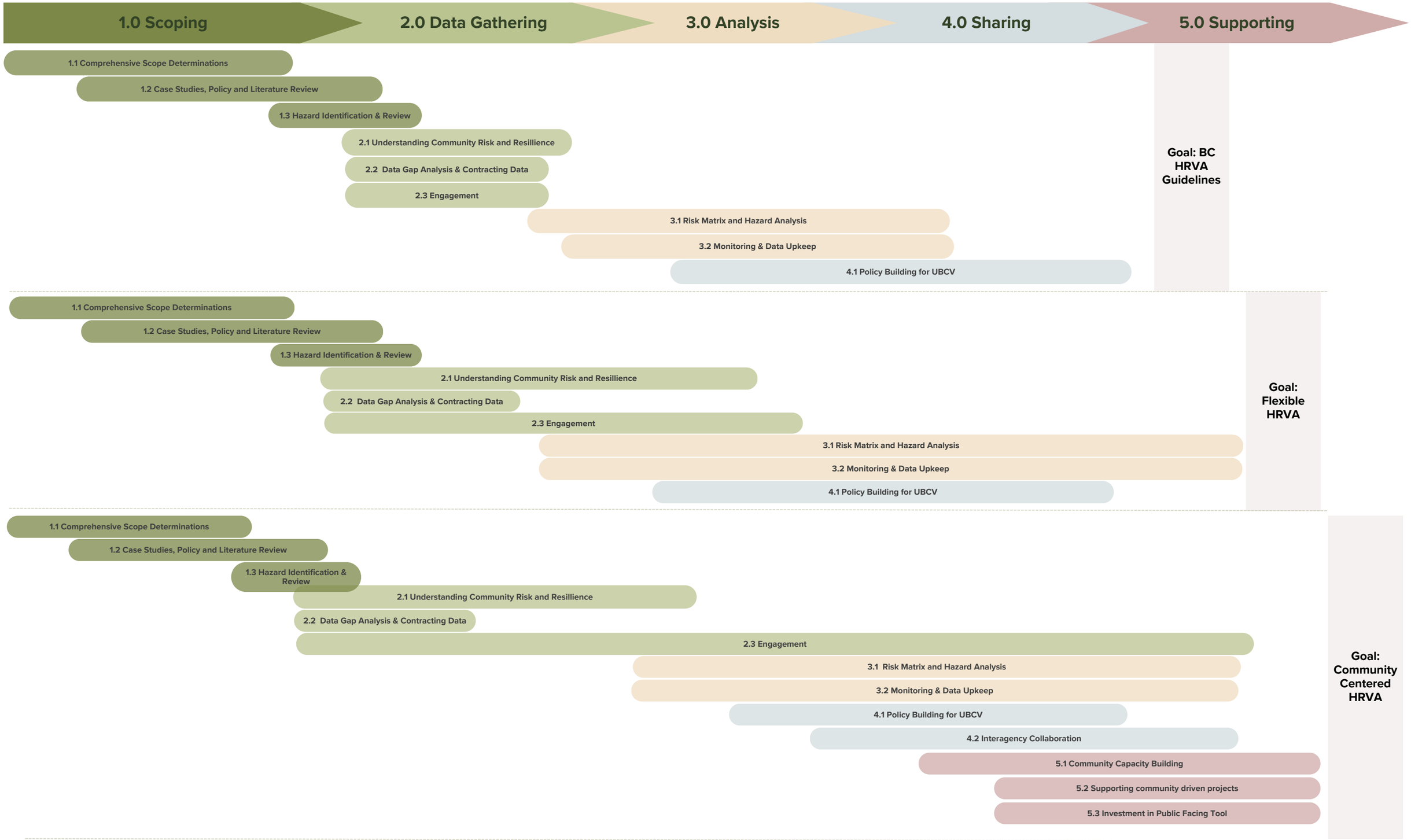
The proposed roadmap is intended to provide detailed steps over 5 distinct phases, guiding UBC Safety & Risk Services in the completion and implementation of 3 HRVA approaches for UBCV. The roadmap lays out 40 actions of different lengths depending on the focus, intensity and depth of the HRVA option decided upon.

Although the nature of the Roadmap focuses on 3 distinct linear options, many actions amid the roadmap stand on their own. The roadmap was designed linearly in accordance of best practice (eg. extensive community engagement prior to calculating risk index).

However, many actions in the later stages can be completed on their own as organizational capacity allows. Given this, the roadmap presents a framework for an HRVA that could grow, develop and expand in conjunction with organizational and community capacity.

This scale is used to establish the variation in the steps required to implement each distinct action, in accordance to the 3 approaches

Lightest Colour: Standard Effort to complete, aligns with Approach 1
Medium Colour: Moderate Effort to complete, aligns with Approach 2
Darkest Colour: Intensive Effort to complete, aligns with Approach 3


1.0 Scoping
2.0 Data Gathering
3.0 Analysis
4.0 Sharing
5.0 Supporting
1.1 Comprehensive Scope Determinations
1.2 Case Studies, Policy and Literature Review
1.3 Hazard Identification & Review
2.1 Understanding Community Risk and Resillience
2.2 Data Gap Analysis & Contracting Data
2.3 Engagement
3.1 Risk Matrix and Hazard Analysis
3.2 Monitoring & Data Upkeep
4.1 Policy Building for UBCV
Goal: BC HRVA Guidelines
1.1 Comprehensive Scope Determinations
1.2 Case Studies, Policy and Literature Review
1.3 Hazard Identification & Review
2.1 Understanding Community Risk and Resillience
2.2 Data Gap Analysis & Contracting Data
2.3 Engagement
3.1 Risk Matrix and Hazard Analysis
3.2 Monitoring & Data Upkeep
4.1 Policy Building for UBCV
Goal: Flexible HRVA
1.1 Comprehensive Scope Determinations
1.2 Case Studies, Policy and Literature Review
1.3 Hazard Identification & Review
2.1 Understanding Community Risk and Resillience
2.2 Data Gap Analysis & Contracting Data
2.3 Engagement
3.1 Risk Matrix and Hazard Analysis
3.2 Monitoring & Data Upkeep
4.1 Policy Building for UBCV
4.2 Interagency Collaboration
5.1 Community Capacity Building
5.2 Supporting community driven projects
5.3 Investment in Public Facing Tool
Goal: Community Centered HRVA

Phase One: Scoping

Comprehensive project scoping allows for significant and well-defined understanding of project's goals, objectives and underlying research; as well as external influencing factors and limitations. Dedicated time for the development of this phase provides the foundation on which the entirety of the project is developed.

1.1 Comprehensive Scope Determinations

This will require a comprehensive understanding of how the designated team intends for the HRVA tool to function. This should include **intentions for the tool's function and audience, alongside understanding budgeting, key timelines and other constraining factors.**

1.1.1 Understanding Goals, Intentions, and Functions

- Establish project intentions that aim to recognize the comprehensive social, community, environmental, economic, and infrastructural impacts of hazard events.
- Define clear, measurable objectives to meet these goals that align with UBCV's risk profile, resilience goals, and relevant emergency management frameworks.
- Determine audience and dependant considerations

1.1.2 Budgeting

- Establish key funding streams crucial to the development of primary goals
- Advocate for funding that can support innovative and resilient hazard preparedness
- Identify grants and other additional means of further funding to support innovation

1.1.3 Timeline Planning

- Create internal action plans with timeline, milestone and resource allocation
- Coordinate interdepartmental roles and responsibilities
- Confirm intended timelines align with governing bylaws, ordinances and goals

1.2 Case Studies, Policy, and Literature Review

Case studies, literature reviews, and other data gathering intended to inform subsequent project actions. Literature should aim to understand vulnerability and hazards on UBC's campus from a **risk-informed perspective that aims to understand and work alongside population and physical intricacies.**

1.2.1 Identify Industry Leadership and Innovations

- Identify leading policies, actions and / or strategies developed by industry leaders that build and expand on commonplace HRVA development strategies
- Identify components of respective HRVAs and other hazard related work that contributed to the success of their development and / or application.
- Develop ongoing connections with representatives.

1.2.2 Understand Interagency Connections

- Work to recognize and understand preexisting departmental connections on campus and outside UBCV.
- Understand how existing research partnerships are able to further objectives and goals outlined in project scope.
- Review existing legislation and guidelines.

1.2.3 Examine Literature

- Conduct literature reviews aimed at supporting the development of well-informed guidelines and best practices.
- Utilise novel research to inform development of innovative hazard practice and to drive project goals and intentions

1.3 Hazard Landscape Identification & Review

Conduct a comprehensive review **identifying all potential hazard events** that may occur within UBCV, specifically noting potential events unique to the UBC community. These will later be used analyse to understand risk and vulnerability in totality.

1.3.2 Hazard Identification

- Consider and identify a diverse hazard profile for UBCV, paying specific attention to locale and population-specific hazards
- Define potential exacerbation of climate change to identified hazards

1.3.1 Physical Disaster Risk Drivers

- Define potential disaster risk factors (Processes or conditions that influence the level of disaster risk by increasing levels of exposure and vulnerability or reducing capacity [22])
- Analyze a wide range of potential drivers, including but not limited to: demographics, policy, land management etc.

Phase Two: Data Gathering

The data gathering phase pulls together key information to assess hazards, risks, and vulnerabilities. This includes collecting historical hazard data, climate projections, infrastructure inventories, and socio-economic indicators from sources like government reports, GIS databases, and community input. Engaging stakeholders through surveys, interviews, and participatory mapping helps fill data gaps and ensures the assessment reflects real, on-the-ground experiences.

2.1 Understanding Community Risk and Resillience

A successful HRVA comprises of community-specific data, which indicates how the population might be vulnerable to a number of hazards.

2.1.1 Community Vulnerability Mapping

- Utilizing a SoVI model, such as the National Human Settlement - Social Fabric and Capacity Thresholds model by Natural Resources Canada, can help visualize where the community is most vulnerable as indicated by a number of characteristics. When determining the percentage of population at risk to a certain hazard, the SoVI indicator can be multiplied by the risk percentage. At this stage, the SoVI model that will be utilized, or made, needs to be determined.
- The more variables and data inputs included in a SoVI, the longer the development process will take due to increased data collection, processing, and analysis requirements.

2.1.2 Critical Asset Infrastructure Inventory

- A critical asset infrastructure inventory is essential, as it helps identify key infrastructure vulnerabilities, assess risks, and enhance emergency preparedness. Mapping critical assets—such as power grids, water supply, and transportation networks—enables better impact forecasting, resource allocation, and resilience planning.

2.1.2 Critical Asset Infrastructure Inventory Ctd.

Below are the steps to complete this analysis:

- Define Scope & Objectives – Determine which infrastructure assets are critical based on their role in public safety, economic stability, or emergency response.
- Identify & Categorize Assets – List essential facilities, utilities, and transportation systems, categorizing them by function (e.g., energy, water, healthcare, communication, education).
- Gather Data & Assess Vulnerabilities – Collect information on asset location, capacity, condition, and hazard exposure using GIS mapping, facility records, and stakeholder input.
- Evaluate Interdependencies – Analyze system dependencies to prevent cascading failures.
- Prioritize Assets Based on Risk – Rank assets by their criticality and vulnerability to hazards, considering factors like redundancy, accessibility, and potential impact of failure.
- Maintain & Update Inventory – Store data in a GIS or database and update regularly.

2.1.3 Understanding Risk Reduction Measures

- Existing measures—such as UBC emergency response plans, infrastructure reinforcements, land-use policies, and education initiatives—help mitigate hazards and reduce vulnerabilities. Assessing them beforehand ensures the HRVA builds on current efforts, avoids redundancy, and prioritizes areas that need to be improved.

2.1.4 Understanding Socio-Economic Vulnerabilities

- A SoVI index often does not tell the complete story of vulnerability within a community. It is important to explore context-specific factors that impact UBC residents, such as lived experiences.
- Analyze a broad range of factors influencing social vulnerability, including but not limited to demographics, policy, and resource management.

★ 2.2 Data Gap Analysis & Contracting Data

- Explore existing data to pinpoint missing, outdated, or incomplete information, such as lack of social vulnerability data, future climate projections, or outdated risk maps.
- If specialized data is needed, such as high-resolution climate projections or infrastructure assessments, contract data providers, such as consulting firms or research institutions.

Much of the contents of these pages are adapted from the BC HRVA Tool Guidelines

2.3 Engagement

Community engagement in HRVA development can range from minimal, one-way communication to deep, collaborative partnerships that empower communities in decision-making. Multiple factors influence the type of engagement that is possible for HRVA development, such as timeline and budget constraints. It is important to fully understand your project's scope before engaging the community.

Here are different engagement approaches that can be used in this process [23][24][21]

- Informing – Providing the community with risk assessment findings through reports, websites, or public meetings without seeking input. This is a one-way communication approach.
- Consulting – Gathering community input through surveys, public forums, or focus groups to understand local concerns and experiences, but decision-making remains with planners and officials.
- Involving – Actively engaging community members in discussions, workshops, or participatory mapping exercises to incorporate their knowledge and lived experiences into the HRVA process.
- Collaborating – Partnering with community organizations, local leaders, and residents to co-develop risk assessments, ensuring shared decision-making and integrating local expertise.
- Empowering – Shifting control to the community by providing tools, training, and resources to lead risk assessments, advocate for resilience strategies, and influence policy decisions.

Moreover, different types of engagement can be utilized at different steps of the HRVA development process. For example, an 'involving' engagement approach can be utilized to determine community risk, resilience, and vulnerability, whereas collaborating or empowering approaches can be utilized during the policy building phase.

2.3.1 Engagement Considerations

A successful engagement process requires input from a diverse range of people, departments, partner groups, and subject matter experts. Engagement should be tailored to community needs and capacity. Key stakeholders include:

- Community: Leaders, student organizations, and community organizations.
- Local Government: Public health officials, planners, policy experts, social service employees, and various government agencies.
- Emergency Professionals: Emergency management staff, first responders, healthcare providers, and response organizations.
- Private Industry: Major employers, utilities, financial services, and essential retailers within the UBCV campus.
- Subject Matter Experts: Infrastructure operators, IT professionals, researchers, engineers, and designers.

Collaboration among these groups ensures informed and effective decision-making.

Phase Three: Analysis

This section outlines the process of assessing hazards and risks through a structured methodology involving data collection, analysis, and periodic updates. The risk matrix is central to this process, helping quantify the likelihood and impact of various hazards.

3.1 Risk Matrix & Hazard Analysis

The risk matrix is a critical component of hazard analysis, integrating all preceding steps. By using context-specific data, the hazard likelihood can be assessed to UBCV. Once these determinations are made, the tool is populated with hazard likelihood and social vulnerability data to calculate an approximate risk level for UBCV to a given hazard as it presently stands, or in the future.

3.1.1 Assessment of Hazard Likelihood

- Utilize gathered data to identify potential hazards
- Historical data and community input can be used to assign a likelihood rating for each hazard in the risk matrix (see Quantifying Vulnerability)

3.1.2 Assessment of Consequence

- Numerically evaluate the severity of consequences based on affected populations, infrastructure damage, and economic disruption. See Quantifying Vulnerability.

3.1.3 Calculating Risk Index

- Multiply hazard risk impact by social vulnerability factors to quantify overall risk percentage for each hazard.

3.1.4 Future Projections Analysis

- Complete 3.1.1, 3.1.2, and 3.1.3 while utilizing future climate projections.
- Here, there is a possibility of using multiple climate scenarios to understand potential future risks, accounting for variables like temperature rise, sea level change, and extreme weather patterns.

3.2 Monitoring and Data Upkeep

Regular monitoring and updates are crucial to maintaining the HRVA tool's accuracy and effectiveness. This involves tracking changes in hazard patterns, demographics, and environmental factors that may impact regional vulnerability. Periodic data updates ensure the tool remains relevant to evolving conditions.

3.2.1 Establish a Monitoring System/ Protocol

- Establish data collection and maintenance protocols with defined timeframes and methods. Specify tools, key informants, and data sources, and assign responsibilities for monitoring and upkeep..
- Establish a training protocol to ensure that staff and stakeholders involved in monitoring and updating are equipped with the necessary knowledge of methodologies and analytical techniques.

3.2.2 Regular Data Collection and Upkeep

- Regularly collect and update data to ensure the accuracy of key variables.
- Continuously assess and update the identified hazards to account for new or changing risks
- Data collection and maintenance should encompass changes in hazards, environmental trends, land-use shifts, policy updates, and demographic information.

3.2.3 Quality Assurance and Data Sources

- Ensure ongoing access to primary data sources while proactively identifying new, reliable sources to enhance HRVA accuracy.
- Validate and verify new or updated data sources for quality and relevance
- Collaborate with stakeholders and experts to ensure data accuracy, gather feedback, and collect new data to improve the tool and track progress.

3.2.4 Analysis and Re-evaluation

- Using updated data, re-assess the likelihood of hazards and subsequently calculate the risk index (revisit steps 3.1.1., 3.1.2, and 3.1.3)

3.2.5 Tool Calibration and Updating

- Review tool outputs to ensure the continued accuracy of the HRVA
- If necessary, adjust the risk model, algorithms, and assumptions within the HRVA as needed to accommodate changing conditions.
- Adopt new technologies or data sources that can enhance the accuracy or efficiency of monitoring.

3.2.6 Documentation and Reporting

- Document all changes made to the data or tool for transparency and accountability.
- If inclined, generate periodic reports on updates and changes in hazard status to keep stakeholders and decision-makers informed about emerging issues or shifts.

Phase Four: Sharing

This section focuses on how UBCV can translate HRVA findings into effective policies that enhance the university's resilience to hazards. By addressing vulnerabilities identified in the HRVA, UBCV can work with stakeholders to develop, implement, and continuously refine risk reduction strategies.

4.1 Policy Building for UBCV

With key insights into vulnerabilities identified by the HRVA, UBC can work in collaboration with the community to develop policies aimed at reducing the region's risk to specific hazards. These policies can target particular vulnerabilities and help build resilience by either mitigating the potential impact of hazards or improving the region's ability to respond effectively

4.1.1 Review of HRVA Findings

- Analyze key risks, vulnerabilities, and potential impacts identified in the HRVA.
- Prioritize hazards based on likelihood, severity, and institutional impact.
- Identify gaps in current policies, resources, and preparedness efforts.

4.1.2 Define Policy Objectives & Goals

- Define clear, measurable objectives that align with UBCV's risk profile, resilience goals, and relevant emergency management frameworks.
- Establish short- and long-term targets for risk reduction.

4.1.3 Engage with Stakeholders & Experts

- Collaborate with students, faculty, emergency responders, government agencies, and community organizations through consultations, interviews, workshops, and feedback sessions to identify policy goals.
- Integrate expert recommendations into policy development.

4.1.4 Develop Risk-Reducation Strategies

- Identify specific mitigation measures (e.g., infrastructure improvements)
- Develop strategies for preparedness, response, and recovery.

4.1.5 Establish Implementation Framework

- For the implementation of policies, define roles and responsibilities across departments and external agencies. Create an action plan with timelines, milestones, and resource allocation.
- Create coordination mechanisms for interagency collaboration and emergency response

4.1.6 Create Monitoring & Evaluation Mechanisms

- Establish key performance indicators to track policy effectiveness.
- Conduct regular drills, assessments, and audits to test readiness.
- Develop a process for reviewing and updating policies based on emerging risks.

4.1.7 Enforce & Continuously Improve Policies

- Develop enforcement mechanisms to ensure policy compliance.
- Implement a feedback loop to refine policies based on lessons learned from incidents, drills, or new research.
- Foster a culture of continuous improvement through adaptive policy-making.

4.2 Interagency Collaboration

Interagency collaboration is essential for mitigating risks, enhancing preparedness, and ensuring a coordinated response to potential hazards. By fostering partnerships both within UBCV and with external organizations, the insights gained from the HRVA can be used to strengthen risk management efforts. These partnerships support key areas, including:

- Information Sharing & Coordination: Ensuring timely communication between university departments, emergency services, government agencies, and community organizations to enhance situational awareness and streamline decision-making.
- Policy & Preparedness Planning: Developing risk-informed policies and emergency response frameworks that align with municipal, provincial, and national standards.
- Ongoing Monitoring & Policy Updates: Collaborate with external agencies and partners to continuously assessing emerging risks, updating emergency plans based on new threats, and refining policies to reflect best practices in hazard mitigation and response. Engage with partners to identify opportunities and challenges on these.
- Training, Drills, & Public Awareness: Conducting joint exercises, simulations, and public education campaigns to ensure all stakeholders—students, staff, first responders, and community members—are prepared for potential hazards.
- Resource Allocation & Mutual Aid Agreements: Establishing agreements between agencies to share personnel, equipment, and facilities during emergencies, ensuring efficient deployment of critical resources.

By integrating these collaborative efforts, UBCV and its partners can build a more resilient and adaptive response system, reducing vulnerabilities and ensuring a safer environment for the university community.

Phase Five: Supporting

The ability of human-scale community actors and organizations to influence the impacts of hazard resilience is often diminished. Concentrated efforts to to build the adaptive capacities of these actors is crucial to ensure a comprehensive community response to hazard preparation and aftermath. [18] [19]

5.1 Community Capacity Building

Community specific capacity building is key to successful contextual and culturally appropriate response to the anticipation, response and recovery of a hazard event. Understanding these strengths and building on them can act to further enhance a community's resilience.

5.1.1 Understanding Community

- Identify existing community-based organizations and coalitions already existing in and around UBCV
- Understand and map key stakeholders and potential gaps in community networks and connections
- Identify ongoing community work that contributes to capacity building

5.1.2 Community Outreach and Learning

- Advocate for departmental developments to support community connections and implement community needs
- Facilitate engagement events intended to gauge current understandings of hazard, risk and vulnerability
- Empower community members to actively participate in decision making processes
- Develop inter-organizational communication streams intended for knowledge sharing and consistent communication
- Conduct outreach campaigns to ensure widespread community awareness. This step can include the development of an interactive online dashboard, similar to that being developed in the HRM HRVA [21]

5.1.3 Understand Community Capacity and Identify Community Priorities

- Work with established partnerships to identify community priorities and needs
- Determine internal capacities available to support community needs

5.1.4 Support Trainings, Drills, Events and Knowledge Sharing Spaces

- Facilitate conversations and activities between organizations aimed at capacity building and knowledge strengthening in preparation for hazard events
- Establish toolkits, trainings and informational materials intended for distribution to key organizations

5.2 Supporting Community Driven Projects

Supporting both the social and capital capacity of organizations, coalitions, and individuals at UBCV that contribute to improved community capacity, resilience, and connection

5.2.1 Financial & Grant Development

- Collaboratively research and develop opportunities at all scales of governance to financially support community projects related to hazard, risk and vulnerability.

5.2.2 Implementation of Community Initiatives

- Assist in the implementation community initiatives of various scales, aimed at strengthening hazard response and community resilience

5.3 Development of Public Facing Tool

HRVAs typically exist within their specific domain, with little connection to existing social, safety, or environmental policies. The development of a public facing tool would work to better connect and explain existing hazard and vulnerability information to the public, thus increasing community resilience and adaptive capacity.

The Potential:

- **Alert and prepare** the public for potential hazard events
- Allow outside entities **access to compiled and changing datasets**
- Allow for an **aligned dialogue** between UBC, the public and hazard policy
- **Encourage public advocacy** regarding social and environmental vulnerability

5.3.1 Identify Community Needs

- Utilizing pre-established communication channels, consult community organizations regarding data needs that will drive tool function

5.3.2 User Interface Design

- Collaborate with UX professionals to determine and optimize tool function
- Consult target audience regarding tool functionality, make adjustments as necessary

5.3.3 Implementation

- Publish tool on official UBC servers for official circulation

5.3.4 Data Management, Monitoring & Evaluation

- Consistently collect and input data to maintain the accuracy of key variables.
- Ensure ongoing access to primary data sources while proactively identifying new, reliable sources to enhance HRVA accuracy.
- Validate and verify new or updated data sources for quality and relevance.

4.0 Concluding Remarks

Strategic Opportunities

With available funding, strategic actions can be implemented alongside HRVA development to enhance community resilience and preparedness. The following outlines a few of these opportunities:

1.0 Institutionalize Capacity Building & Public Awareness

- Collaborate with campus clubs and organizations to implement individual hazard safety measures, such as building an emergency “go bag”, or specific hazard awareness campaigns. Consider adding these campaigns as part of first year orientation.
- Extend training programs past those for specialized roles. Consider adding programs for faculty, staff, and students on risk awareness and emergency response.
- Consider partnering with an outdoor retailer to offer discounts on emergency supplies.
- Leverage social media campaigns to enhance public awareness, educate the community, and encourage both individual and collective preparedness.

2.0 Understanding Community

- Collaborate with existing community-based organizations and coalitions that already exist in and around UBCV to identify existing gaps within their networks.
- Identify ongoing community work that contributes to capacity building
- Determine internal capacities available to support this work.

3.0 Understand Community Capacity and Identify Community Priorities

- Work with established partnerships to identify community priorities and needs
- Determine internal capacities available to support community needs
- Collaborate with First Nations communities to integrate traditional knowledge into emergency preparedness efforts.

4.0 Critical Asset Infrastructure Upgrades

- After building a critical asset infrastructure inventory, priority upgrades will become clear. For example, strengthening campus-wide cooling infrastructure can provide immediate relief and long-term resilience in the face of extreme heat events like a heat dome. These targeted investments ensure that essential services remain operational and communities stay protected during hazard events.

5.0 Digital Alert System

- Ensure UBC maintains a highly accessible emergency alert system capable of rapidly notifying residents and those on campus of potential or imminent threats.
- Deliver alerts via multiple channels, including SMS, digital signage, social media, and email notifications, with clear, actionable steps based on the specific hazard.
- Alerts should be GPS-based and include accessibility features such as text-to-speech, vibration, and sound-based notifications for individuals with disabilities.

6.0 Accessibility Measures

- Ensure emergency preparedness information is available in multiple languages and formats, including braille, large print, and audio versions, to accommodate diverse accessibility needs.
- Develop an inclusive emergency preparedness guide tailored for persons with disabilities, seniors, non-English speakers, and other vulnerable populations, ensuring clear, actionable steps for different hazard scenarios.
- Work with disability advocacy groups and campus accessibility services to identify barriers and improve emergency response strategies.

Concluding Remarks

The University of British Columbia requires modern, adaptive risk management solutions that strive to holistically understand the populations they serve.

At its heart, this project is designed around humanity rather than hazards. Our research has found overwhelmingly that adaptive capacity, resilience and aid are, before anything else, functions of healthy, vibrant communities.

We know that building resilience requires a distinct understanding of both community and capacity. With this in mind, we have built a project that remains flexible - working with departmental capacity to develop systems that meet both immediate legislative and long-term community needs.

In developing a roadmap that does not rest on a traditional linear framework, our intent is to create a system of development that can continue to advocate for more resilient communities at any scale, at any time.

Moving Forward

The SCARP Team truly hopes this document serves as a valuable resource for UBC Safety & Risk Services in their ongoing efforts. We believe UBC has the potential to lead in this field, setting a standard for resilience and community-driven innovation.

We extend our sincere gratitude to our partners at UBC Safety & Risk Services for entrusting us with what initially felt like a daunting challenge—one that ultimately inspired us to envision a stronger, more resilient future for UBCV.

-- Syd, Brinn & Kate

5.0 Appendix

Appendix A: Steps for Constructing the 2023 P4A SoVI for the Canadian Red Cross

The following section has been adopted from the Inclusive Resilience: A Socio-Economic Vulnerability Index to Map Flood Risks for Targeted Communications and Disaster Risk Reduction report by the Canadian Red Cross [16]. Here, the steps for creating a SoVI are outlined, as adapted from the Canadian Red Cross. This process involves data selection, standardization, statistical analysis, and aggregation to assess and map social vulnerability effectively.

Stage 1: Data Collection and Preparation

Step 1.1: Define the Purpose of the Index

Clearly outline the objectives of the SoVI, ensuring alignment on its intended use and audience. Key considerations include:

- **What specific questions should the index address?**
- **Who will use and interpret the results?**

This step is crucial for maintaining a clear definition of social vulnerability, ensuring that the index and its visual representation serve their intended purpose effectively.

Step 1.2: Select Indicators Based on Literature

Identify variables that are widely recognized in research as indicators of social vulnerability.

Consider:

- **How each variable contributes to vulnerability—does it increase or decrease the index score?**

The selection process should reflect the intended purpose of the index. For example, if measuring resiliency, higher values of a variable may indicate greater resilience, whereas in a vulnerability-focused index, higher values may suggest lower vulnerability.

Step 1.3: Determine Indicator Weighting

Decide whether all variables should be weighted equally or if a weighting method is needed. Approaches include:

- Objective methods, such as **Principal Component Analysis (PCA),** which assigns weights based on statistical variance.
- Subjective methods, like Pairwise Comparison Matrices, where expert judgment influences weighting decisions.

Proper weighting ensures the index accurately reflects the relationships between variables and vulnerability.

Step 1.4: Select Data Sources

Assess data availability and ensure consistency across geographical units. Important factors include:

- Accessibility of data at the **required spatial scale** (e.g., census tract, dissemination area).
- Ensuring completeness to prevent misrepresentation due to missing data.

Appendix A Ctd: Steps for Constructing the 2023 P4A SoVI for the Canadian Red Cross

Step 1.5: Transform Input Variables

Determine whether variables require transformation and select an appropriate method, such as:

- **Population-based normalization (dividing values by total population or dwellings).**
- **Areal density calculations (e.g., elderly population per square kilometer).**

Deciding between absolute or relative values depends on the research objective, as each approach carries trade-offs in representation and analysis.

Step 1.6: Address Missing Data and Validate Accuracy

Ensure data completeness and consistency by:

- Replacing missing values with averages where appropriate.
- Conducting statistical checks for counterintuitive values.
- Verifying spatial unit population counts against expected ranges.

This step helps maintain methodological consistency and prevents errors in the final index.

Step 1.7: Normalize Variables

To standardize variables and enable comparison, apply a normalization technique, such as:

- **Z-score normalization (subtracting the mean and dividing by standard deviation), which accounts for extreme values.**

Normalization ensures that all variables are on a common scale, preventing bias in the statistical analysis.

Stage 2: Analysis and Computation

Step 2.1 Apply Principal Component Analysis (PCA) and Create the Index

1. Reduce Dimensionality of Variables

- Identify correlations among selected variables (e.g., median income and percentage of people living under the poverty line).
- Use PCA to consolidate highly correlated variables into principal components, improving efficiency and interpretability.

2. Weight and Aggregate Variables

- Determine an appropriate weighting approach:
  - Equal weighting (all variables contribute equally).
  - Subjective weighting (expert judgment).
  - Objective weighting (data-driven methods, such as PCA-based variance weighting).
- Combine the weighted components to generate a single index score.

Why This Matters:

- **Enhances Efficiency:** Reduces the number of variables needed while preserving key information.
- **Minimizes Noise & Redundancy:** Focuses on the most significant contributors to social vulnerability.
- **Improves Generalization:** Prevents overfitting, making the index more reliable when applied to new data.

PCA is widely used for index construction due to its ability to streamline data while maintaining analytical rigor. Careful consideration of weighting and methodological choices ensures the final index accurately represents social vulnerability.

Appendix A Ctd: Steps for Constructing the 2023 P4A SoVI for the Canadian Red Cross

Stage 3: Geospatial Distribution and Dissemination

Step 3.1 Scale SoVI Scores

Standardize SoVI scores to ensure comparability across geographic areas.

- The Canadian Red Cross P4A report utilized percentage min-max scaling:
  - **Highest SoVI score = 100 (most vulnerable).**
  - **Lowest SoVI score = 0 (least vulnerable).**

- Scaling ensures scores are relative, making comparisons meaningful across adjacent regions.
- Emphasize that scaled scores indicate relative vulnerability within the study boundary to prevent misinterpretation.

Step 3.1 Classify SoVI Scores for Vulnerability Mapping

- Use a standard deviation classification to categorize vulnerability levels.
  - Example classification:
    - **High Vulnerability**: Scores >1.0 standard deviation above the mean.
    - **Moderate Vulnerability:** Scores between -1.0 and 1.0 standard deviation.
    - **Low Vulnerability**: Scores < -1.0 standard deviation.

- This makes results more interpretable by grouping scores into meaningful categories (e.g., high, moderate, low vulnerability).
- Since SoVI scores are relative, classifications depend on the geographic context—results may differ when analyzed at a neighborhood versus municipal scale.

Step 3.3 Visualize and Map SoVI Scores

- **Use GIS-based software to create vulnerability maps** with graduated color symbology.
- Choose a mapping platform based on accessibility and user preference:
  - Licensed software: ArcGIS Webmap (e.g., used by P4A).
  - Free alternatives: Python (Folium, GeoPandas), R (Leaflet, ggplot2).
- Select an appropriate color scheme (e.g., ESRI-recommended color ramps).
- **Clear, well-designed maps help stakeholders interpret results and inform decision-making.**

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