



# IP4: Harnessing Disruptive Technologies for Earthquake Resilience

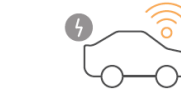
---

**Nirmal Nair and Garry McDonald**

# IP4 Structure



Renewable energy throughout communities



Autonomous electric transportation



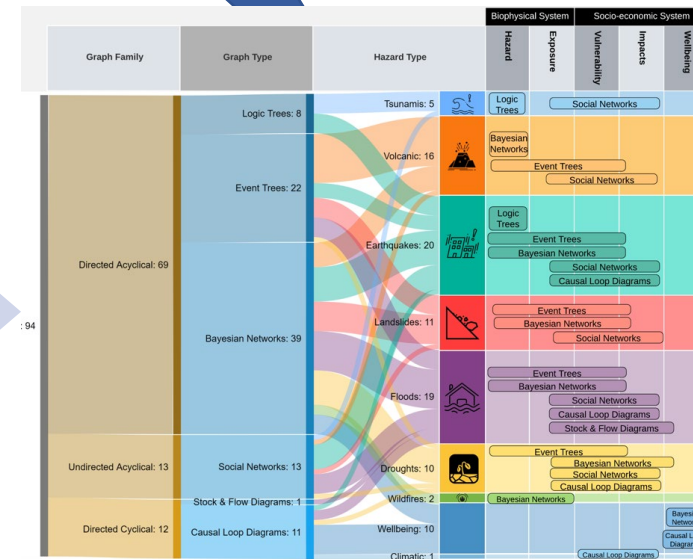
Smart cities and real-time sensing



Modelling and evaluation of benefits and pitfalls



Adoption pathways for disruptive technologies



# Renewable Distributed Energy

## AHP Analysis for Disaster Hazard Mapping to Optimize Solar and Wind Farm Site Selection

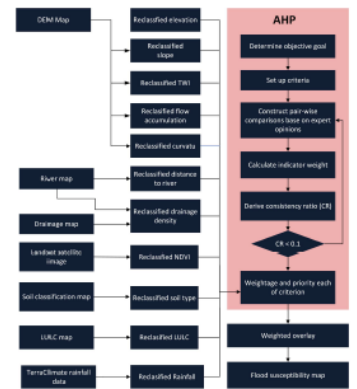
Rizki D Rahayani, Dr. Nirmal K-C Nair  
Department of Electrical, Computer and Software Engineering, University of Auckland

### Introduction

Constructing solar and wind power plants is a significant long-term investment that requires intensive consideration. The objective is to generate optimal power while minimizing investment and operational expenses, all while ensuring minimal environmental impact. Thus, identifying the most optimal location becomes crucial. Unfortunately, countries prone to natural disasters, including floods, landslides, earthquakes, bushfires, and storms, consistently experience damage and power loss. This study aims to explore the Analytical Hierarchy Process algorithm, which incorporates input from stakeholders and planners, to establish a comprehensive disaster mapping criterion. By identifying and prioritizing crucial parameters, we can effectively mitigate the impact of natural hazards on solar and power generation and make informed decisions for sustainable and resilient energy infrastructure.

This study will perform the AHP analysis for establish flood hazard mapping, a study case of Hawkes Bay.

### Methodology



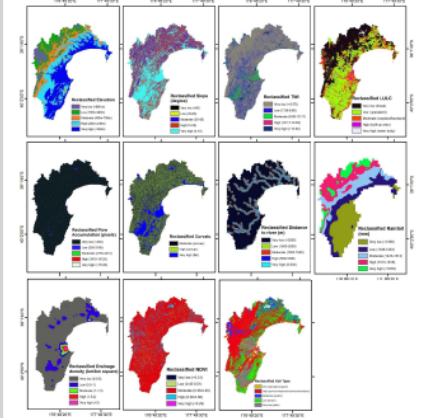
Abbreviations:  
- DEM : Digital Elevation Model  
- LULC : Land Use Land Cover  
- TWI : Topographic Wetness Index  
- NDVI : Normalized Difference Vegetation Index

### AHP Calculation

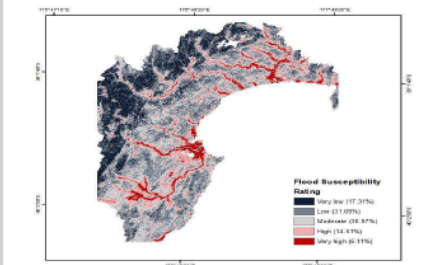
Criteria	Sub-criteria	1	2	3	4	5	6	7	8	9	10	Priority	Rank
Criteria	1	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	0.176	1
	2	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	0.240	2
	3	0.33	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	0.176	3
	4	0.25	0.33	0.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	0.176	4
	5	0.20	0.25	0.33	0.50	1.00	2.00	3.00	4.00	5.00	6.00	0.176	5
	6	0.16	0.20	0.25	0.33	0.50	1.00	2.00	3.00	4.00	5.00	0.176	6
	7	0.14	0.16	0.20	0.25	0.33	0.50	1.00	2.00	3.00	4.00	0.176	7
	8	0.12	0.14	0.16	0.20	0.25	0.33	0.50	1.00	2.00	3.00	0.176	8
	9	0.10	0.12	0.14	0.16	0.20	0.25	0.33	0.50	1.00	2.00	0.176	9
	10	0.09	0.10	0.12	0.14	0.16	0.20	0.25	0.33	0.50	1.00	0.176	10

Consistency Ratio (CR) = 0.051  
Principal eigen value = 11.77

### Data Reclassification



### Flood Risk Mapping

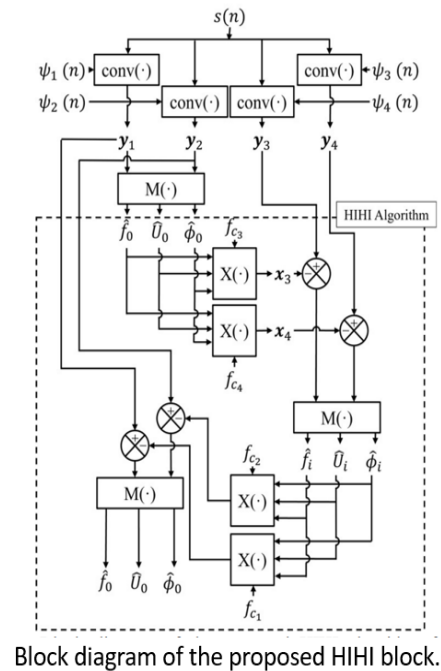


### Data Source

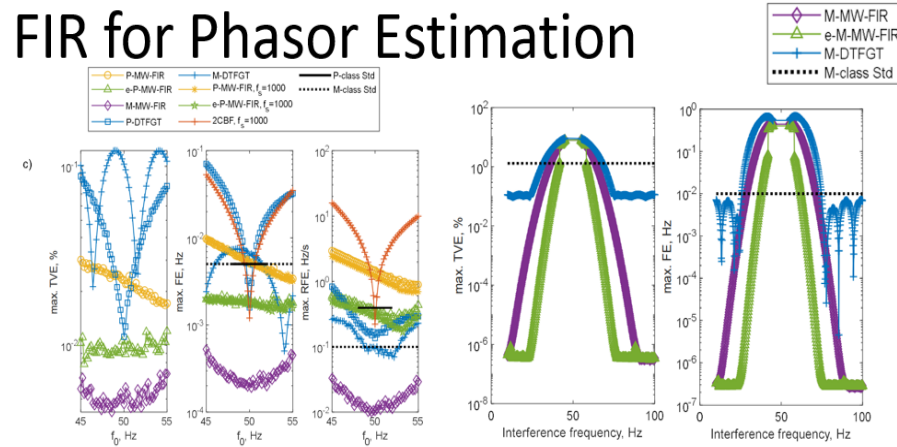
Data Type	Source
DEM Map	Land Information New Zealand
Slope Map	Land Information New Zealand
Drainage Map	Hawkes Bay Regional Council
LULC Map	LULC, Ministry for the Environment New Zealand
SMAP Soil Classification Map	Land Resource Information System, Landcare Research New Zealand
LandUse Satellite Image	USGS Earth Explorer
Rainfall data	TerraClimate

Liu and Nair  
in IEEE Transactions  
on Smart Grid (IF: 10.2)

## Enhanced Morlet Wavelet-Based Two-Point FIR for Phasor Estimation



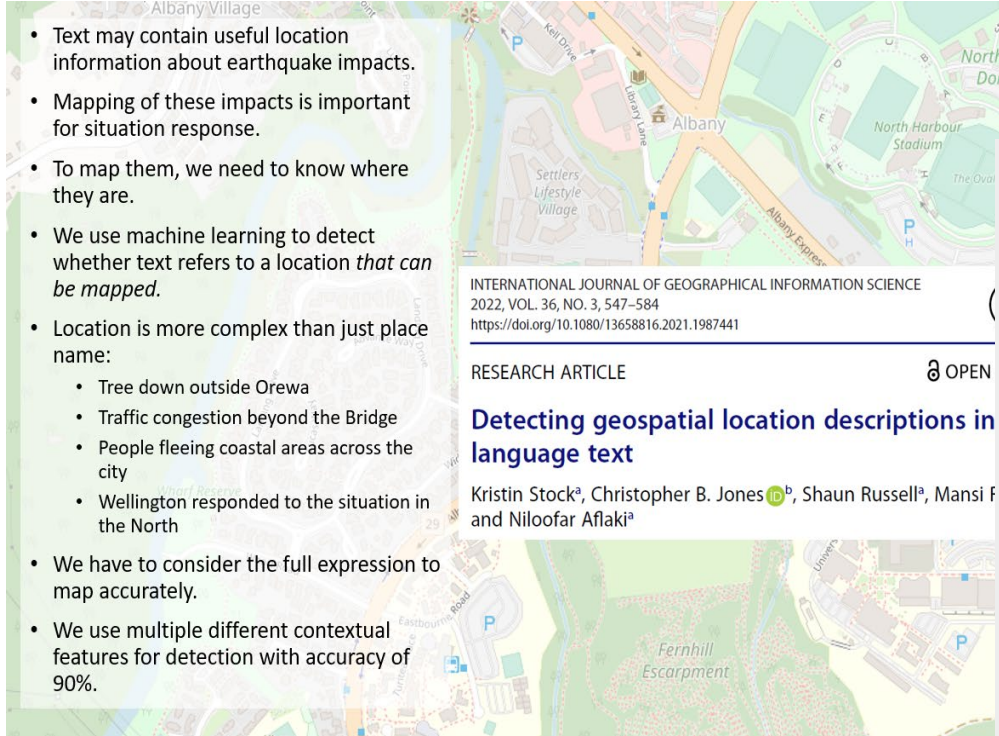
Block diagram of the proposed HIHI block.



**Results:** Summarizing the results of compliance tests, the enhanced P-class estimator outperforms the conventional version on almost all tests, and it has become a compliant P-class estimator. The OOB efficiency for M-class estimators is improved by about 10 % and 20 % for TVE and FE, respectively.

These advanced instruments with accuracy, fast and robust phasor measurements in the distribution system could enable multiple applications, such as **situational awareness** in distribution grid, **early detection of network degradation** prevent, identification of **failure hierarchy** of a renewable distributed energy system, etc.

# Smart Cities



- Text may contain useful location information about earthquake impacts.
- Mapping of these impacts is important for situation response.
- To map them, we need to know where they are.
- We use machine learning to detect whether text refers to a location *that can be mapped*.
- Location is more complex than just place name:
  - Tree down outside Orewa
  - Traffic congestion beyond the Bridge
  - People fleeing coastal areas across the city
  - Wellington responded to the situation in the North
- We have to consider the full expression to map accurately.
- We use multiple different contextual features for detection with accuracy of 90%.

INTERNATIONAL JOURNAL OF GEOGRAPHICAL INFORMATION SCIENCE  
 2022, VOL. 36, NO. 3, 547–584  
<https://doi.org/10.1080/13658816.2021.1987441>

RESEARCH ARTICLE 

### Detecting geospatial location descriptions in language text

Kristin Stock<sup>a</sup>, Christopher B. Jones<sup>b</sup>, Shaun Russell<sup>a</sup>, Mansi F and Niloofar Aflaki<sup>a</sup>

## P-wave-based S-Wave intensity estimation with PLUM detection to extend the warning window for Earthquake Early Warning

Student: Chanthujan Chandrakumar      Investigators: Raj Prasanna, Caroline Holden, Max Stephens Amal Punchihewa, Marion Lara Tan

### Stage 1: Selection of P-wave Detection Algorithm

- Our project commenced with a thorough selection process to identify an optimal P-wave detection algorithm. This choice is crucial as it accurately identifies P-wave arrivals within seismic waveforms. [1][2]
- We assessed multiple algorithms, considering their performance metrics and capacity to handle diverse seismic data. This comprehensive evaluation guarantees the reliability of our subsequent analysis. [3][4]

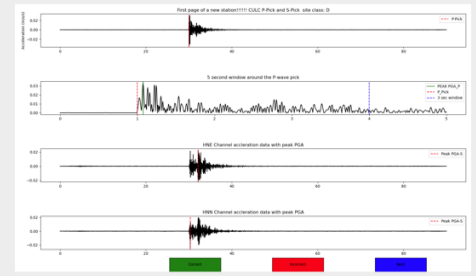
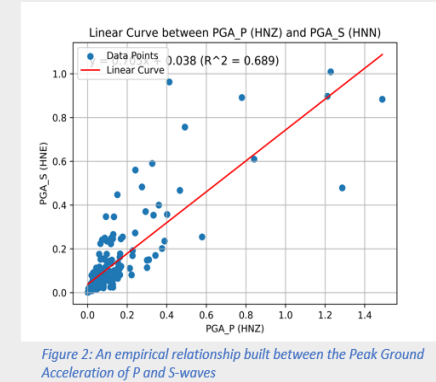


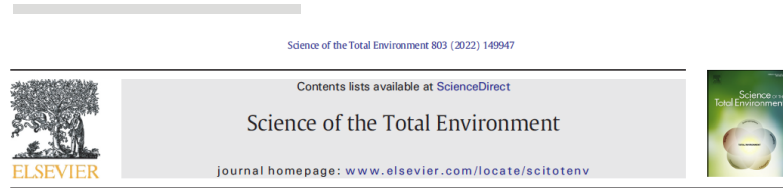
Figure 1: Our Custom-Built Tool P and S-wave parameter picking



### Stage 2: Building a relationship between P and S-wave's intensity

- **Data Source Selection:** Our study is centred on CUSP stations in Canterbury (2015-2022) with labelled P-wave picks, ensuring robust data quality.
- **Waveform Collection:** From the selected stations, we acquired 3085 waveforms, forming a substantial dataset for analysis.
- **P-wave and S-wave Parameters:** Extracted key parameters within three seconds of P-wave arrivals and during the S-wave using a tool (Figure 1) developed by the research team.
- **Relationship Building:** Our ongoing work involves correlating the extracted parameters, and building an empirical relationship between P-wave and S-wave intensities (e.g., Figure 2).[5]

# Modelling and Evaluation



Review

A review of graphical methods to map the natural hazard-to-wellbeing risk chain in a socio-ecological system<sup>☆</sup>

Juan J. Monge<sup>a,\*</sup>, Nicola McDonald<sup>b</sup>, Garry W. McDonald<sup>b</sup>

<sup>a</sup> M.E Research, Digital Basecamp, 1132 Hinemoa Street, Rotorua 3010, New Zealand  
<sup>b</sup> M.E Research, Level 5, 507 Lake Road, Takapuna, Auckland 0622, New Zealand



Article

**Towards a Dynamic Equilibrium-Seeking Model of a Closed Economy**

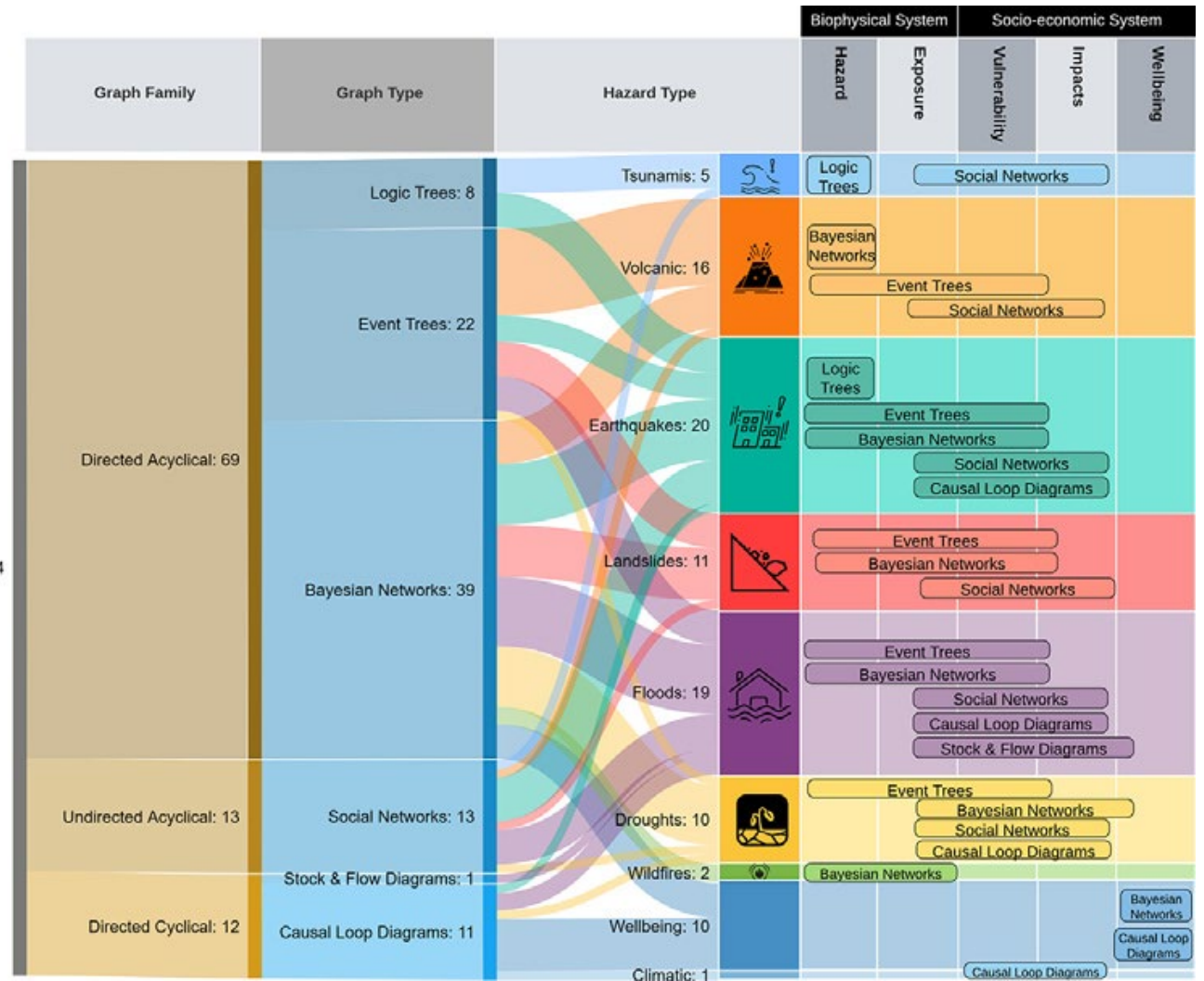
Nicola J. McDonald and Garry W. McDonald <sup>\*</sup>

MEResearch, Level 5, 507 Lake Rd, Takapuna, Auckland 0622, New Zealand; nicky@me.co.nz  
<sup>\*</sup> Correspondence: garry@me.co.nz; Tel.: +64-9-915-5520



**Using an integrated dynamic economic model to support infrastructure investment decision-making**

Charlotte Brown,<sup>a)</sup> MEERI Nicola McDonald,<sup>b)</sup> Garry McDonald,<sup>b)</sup> Michele Daly,<sup>c)</sup> Erica Seville,<sup>a)</sup>



Reviewed: 94



Te Hiranga Rū | QuakeCoRE  
 Aotearoa New Zealand Centre for Earthquake Resilience

# Key Challenges

Expanding Associate Investigator (AI) and Early Career Researcher capability through aligned opportunities and research programmes

- Jun 2023 IP4 Annual Meeting
- Establishment of QC Artificial Intelligence Group
- Running conferences to better connect researchers with stakeholders
  - Nov 2022 eGRID – 7<sup>th</sup> IEEE Electronic Grid conference
  - Nov 2023 ISGT – 12<sup>th</sup> IEEE PES innovative smart grid technologies conference
- Grant writing workshops for Endeavour Smart Ideas (4 applications x 2 AI's, \$1m grants)

## Endeavour Programmes



[1] *Transitioning Taranaki to a Volcanic Future*  
\$16m, 2019-24

McDonald & Cronin

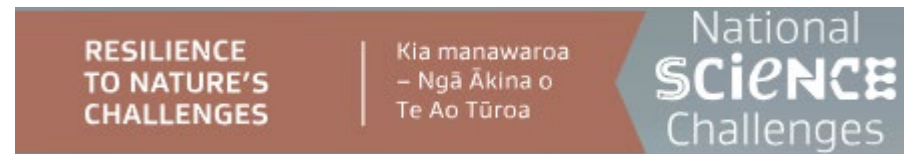
[2] *Future Coast Aotearoa*  
\$16m, 2021-26

Stephens, McDonald, et al.

[3] *Adapting to Climate Change through Geothermal Enterprises*  
\$8m, 2022-27

Cronin & McDonald

## National Science Challenges



[1] *Multi-hazard Risk Model*  
\$4.5m, 2019-2024

Bebbington & McDonald

# Questions

---

---