Towards Understanding Evacuation Behaviour under Emergency Situations

Doctoral Student: Snehalata Thakur

Supervisor: Dr Prakash Ranjitkar

Co-supervisor: Dr Soroush Rashidi

Department of Civil and Environmental Engineering

Faculty of Engineering

University of Auckland

QuakeCoRE
NZ Centre for Earthquake Resilience
Te Hiranga Rū

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

- ✓ **Introduction and background on risk of volcanic eruption in Auckland**

- ✓ **Research objectives**

- ✓ **Literature review and research gaps**

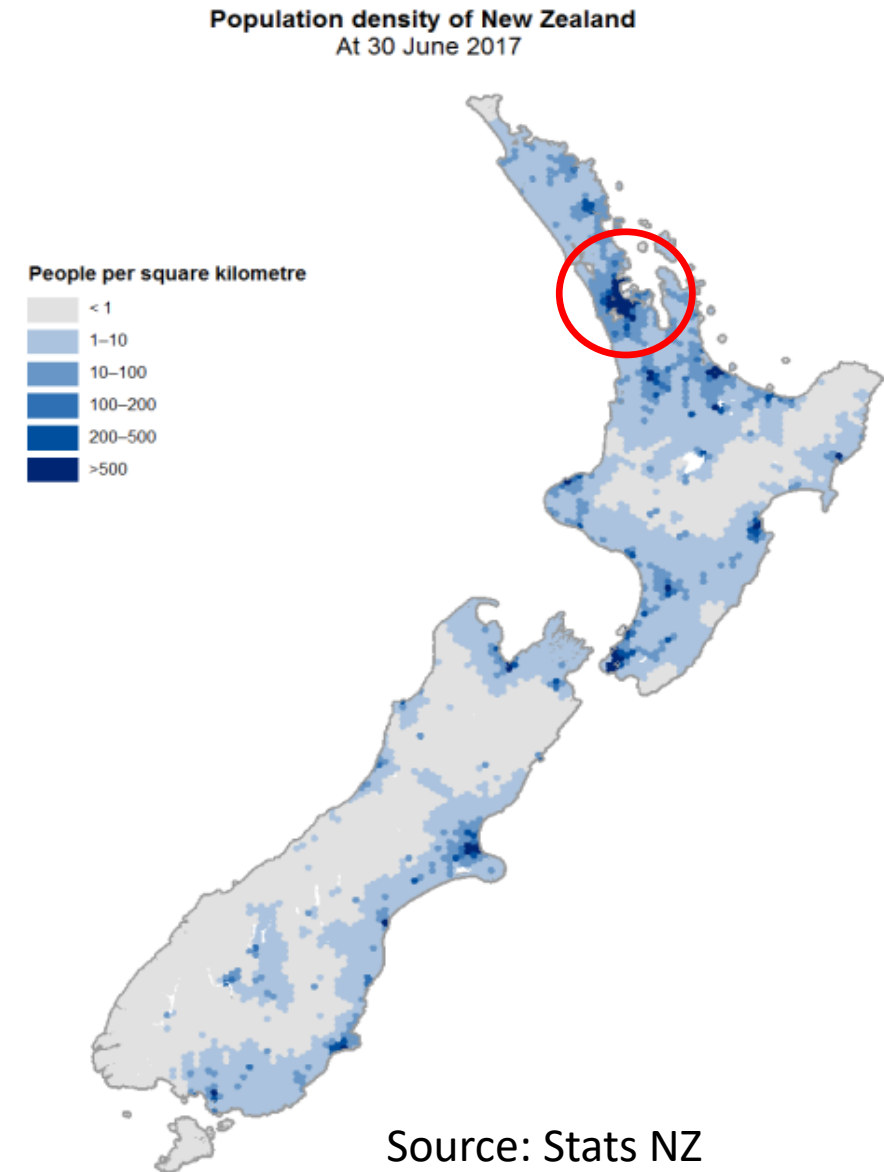- ✓ **Proposed methodology**

- ✓ **Current progress**

Auckland, why?

❖ *One third of New Zealand population resides*

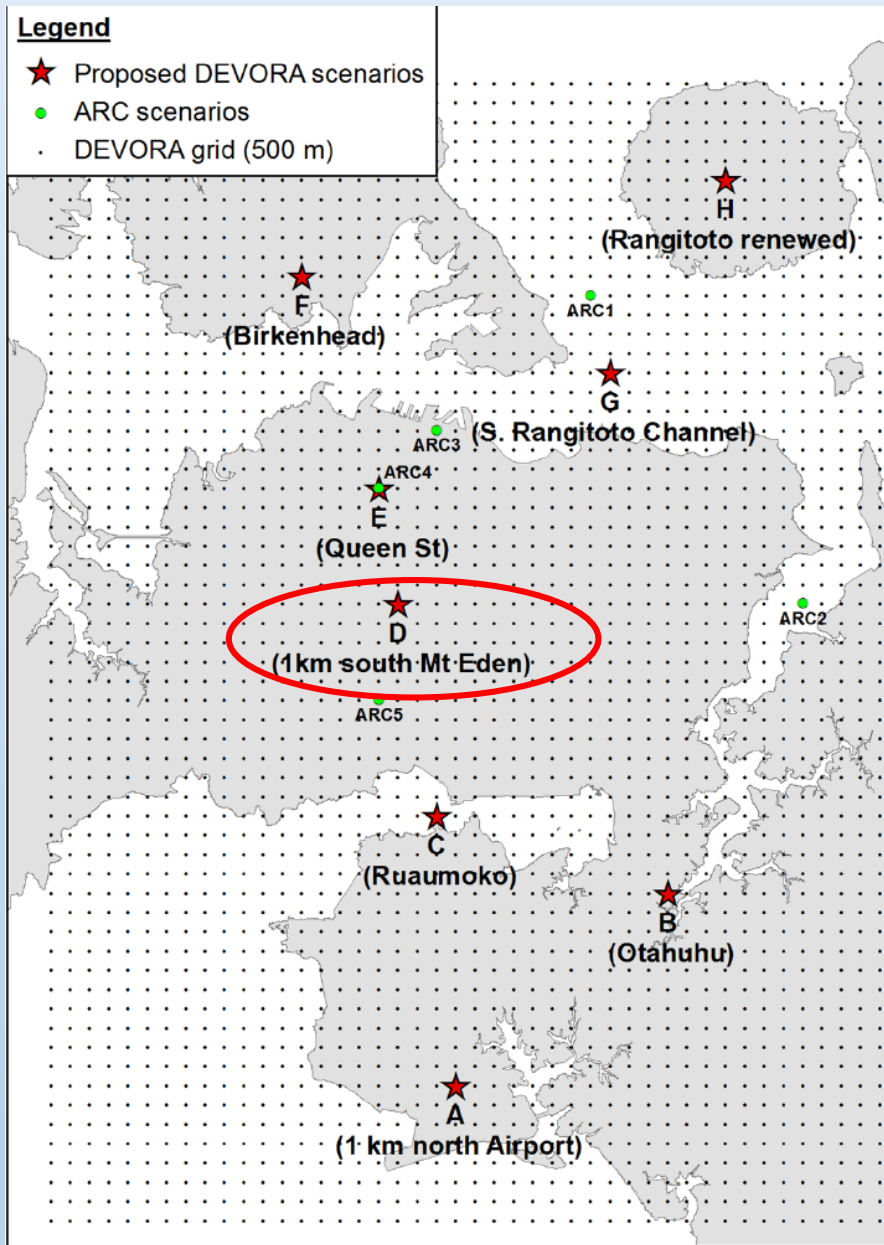❖ *Generates 37.5% of the country's GDP (Statistics New Zealand, 2018)*

What are the emergency situations?
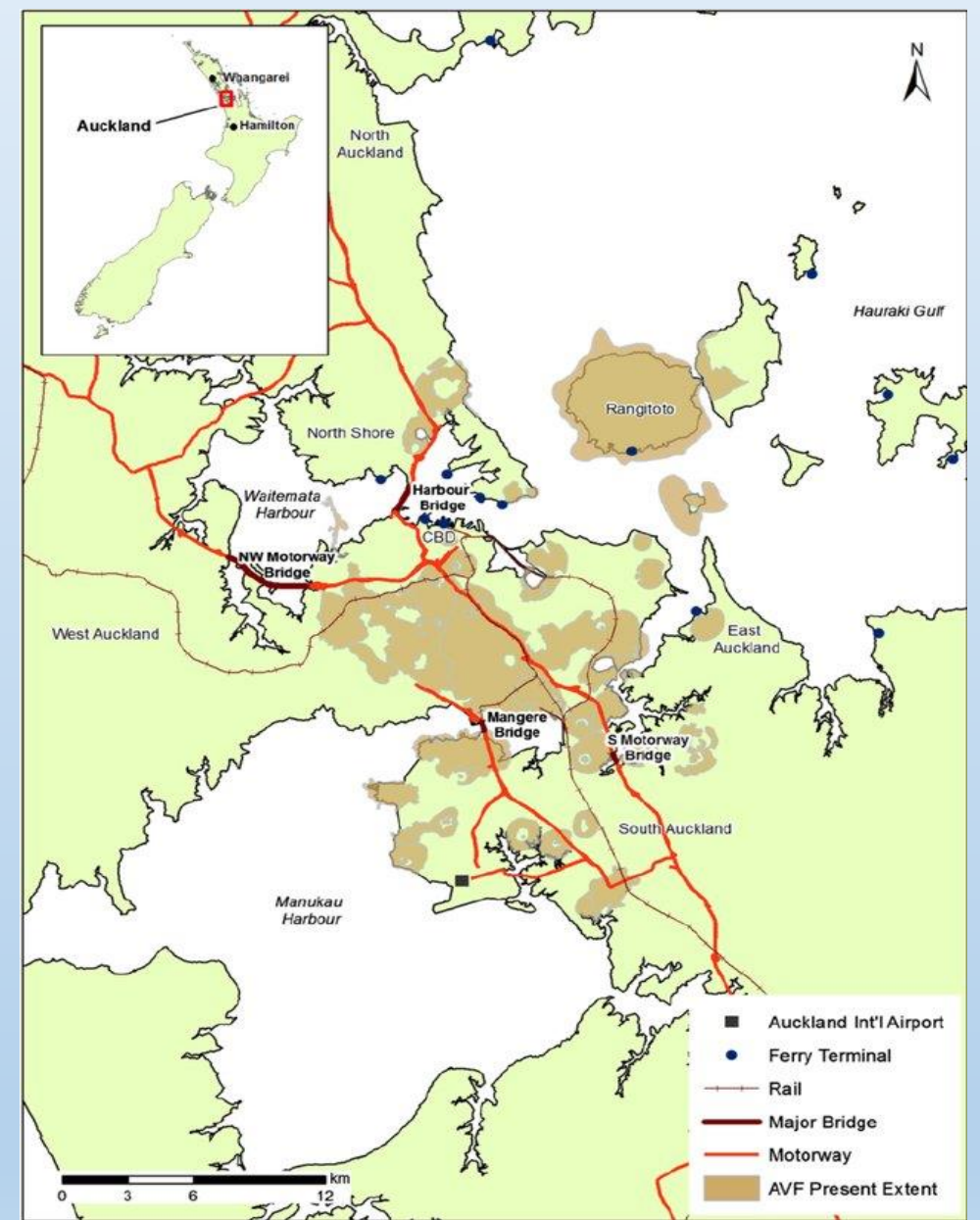
❖ *Prone to a number of natural hazards*

S.N	Natural Hazard	Likelihood	Impact	Number of Evacuees	Priority
1	**Volcanic Eruption (AVF)**	**Rare**	**Catastrophic**	**100,000+**	
2	Volcanic Eruption (Distant Source Eruption)	Likely	Major	-	**Very High**
3	Cyclone	Likely	Major	1000+	
4	Earthquake	Unlikely	Major	10,000+	
5	Flooding Tsunami(Regional/Local)	Unlikely	Moderate	100,000+	High
6	Erosion (Landslide /Land instability)	Almost Certain	Moderate	1000+	
7	Flooding (River / Rainfall /Storm Surge)	Possible	Moderate	1000+	Moderate
8	Fire (Urban)	Possible	Minor	1000+	Low
9	Fire (Rural)	Likely	Insignificant	1000+	Very Low
10	Tornado	Likely	Insignificant	-	

Source: Auckland Natural Hazards (AC & CDEM,2014)

Population density of New Zealand
At 30 June 2017

People per square kilometre
< 1
1–10
10–100
100–200
200–500
>500

Source: Stats NZ

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Source: DEVORA Proposed Scenarios (Leonard et al., 2016)

Source: Tomsen *et al.* (2014)

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What can be the expected behaviour after the warning is announced ?

Answers may be

People assess the risk

How ?

look for information

Where?

How they come to the decision to evacuate?

Call friends and family

Route to evacuate?

No of trips?

Collect family members and pets

Preference to go after evacuating the place?

Important for simulation modelling and behaviour predictions

Officials need to understand the influence of these factors to create the most effective plans
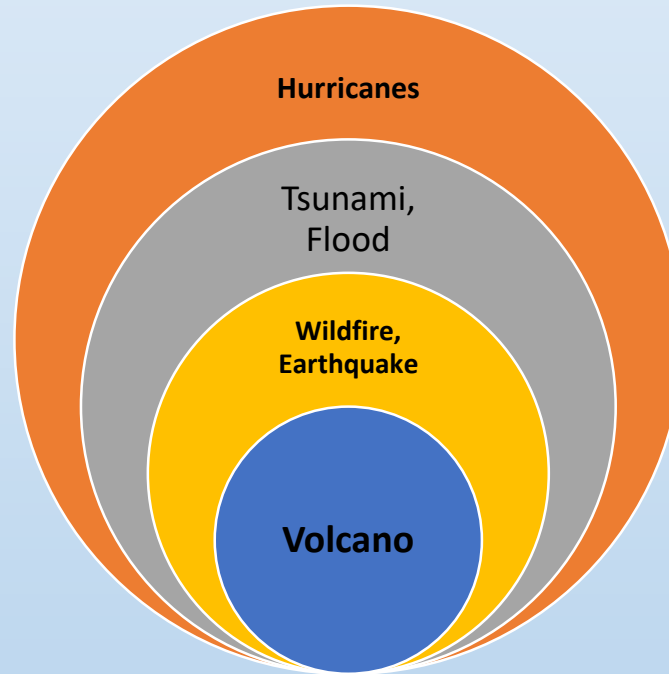
Evacuation due to different natural hazards

Voluminous literature in the area of Hurricanes evacuation *(Dash & Gladwin, 2007)*

Mostly confined to coastal areas of United States (Huang et. al., 2007)

Hurricanes

Tsunami, Flood

Wildfire, Earthquake

Volcano

Limited number of research in evacuation behaviour

Most of the research conducted after the eruption

Limited number in prior to eruption

Limited number on evacuation during volcanic eruptions

Most of them are in vulnerability and risk perceptions

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Factors affecting evacuation behaviour

Research aims and objectives

1. *Conduct a literature review to identify factors influencing evacuation behaviour during a life-threatening natural disasters*

2. *Conduct a pilot questionnaire survey in Auckland CBD to determine factors contributing to individuals' decision-making process during the warning and evacuation phase*

3. *Conduct a detailed questionnaire survey in Auckland based on the factors identified in objective 2 and refine the evacuation decision-making model*

4. *Implement the outcomes of the evacuation decision-making model to refine traffic simulation model outcomes*

Literatures on factors contributing evacuation behaviour

S.N.	Author(s) (year)	Types of Natural Disaster	Studied country or area	General Theme	Main Focus	Methodology	Main conclusion(s) or recommendation(s)	Gap
1	Dash & Gladwin (2007)	Hurricane	Multiple	Literature review	Risk perception		Age, presence of children or elderly in the household, gender, disability, race and ethnicity, income, social and cultural factors influence evacuation behaviour	Evacuation delays and psychological factors
2	Gaillard (2008)	Volcano	Philippines	Risk perception	Volcanic risk perception	Questionnaire survey and interviews	Insufficient opportunity in resettlement centers and strong attachment to native places push people back to the threat	Non-hazard related factors and constraints
3	Lavigne et al. (2008)	Volcano	Indonesia	Evacuation Behaviour (pre-disaster)	Risk perception, cultural beliefs and socio-economic constraints	Questionnaire survey	Volcanic hazard risk relates to socio-economic and cultural context	Socio-economic and cultural aspects

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Risk perception

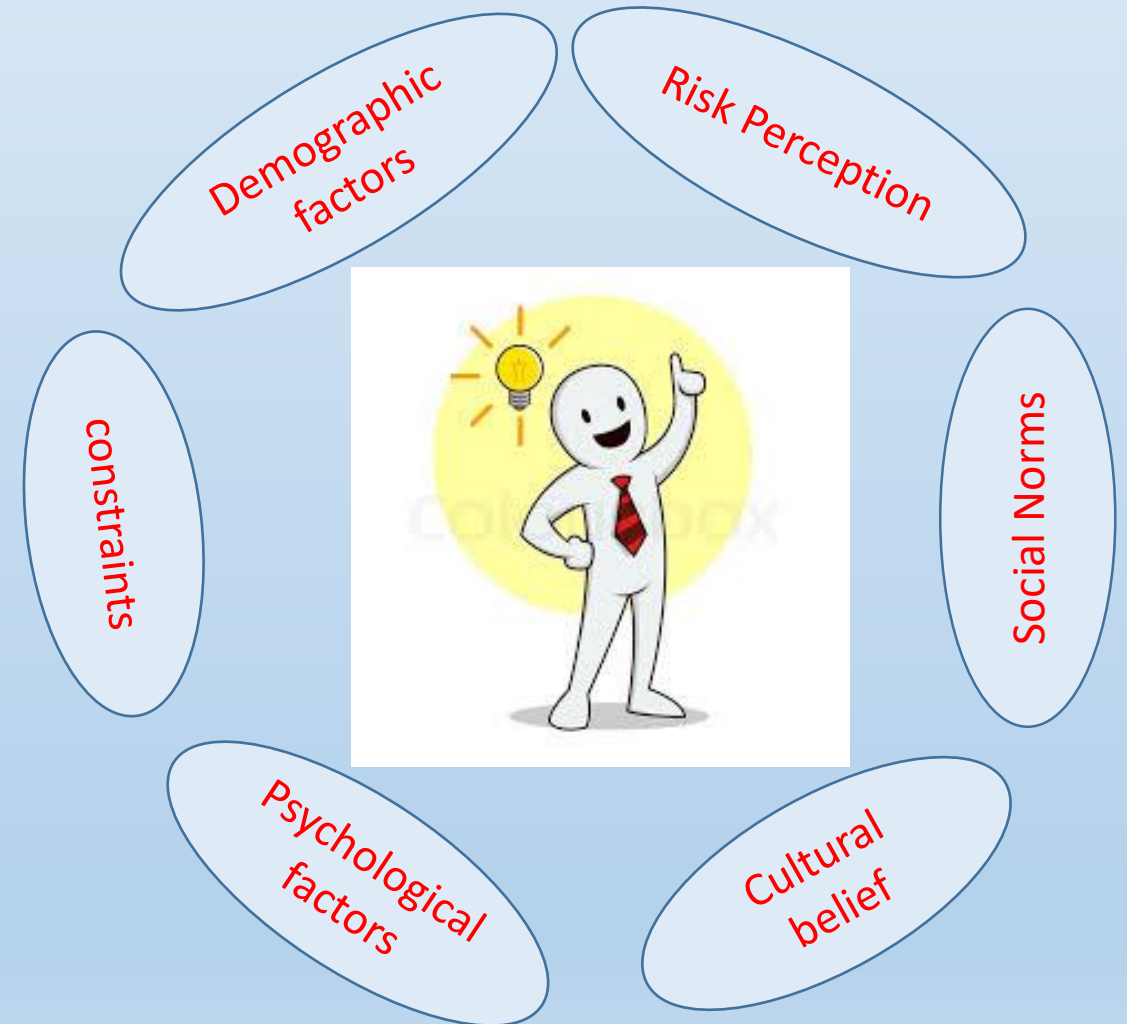Risk perception plays a key role in shaping evacuation behaviour

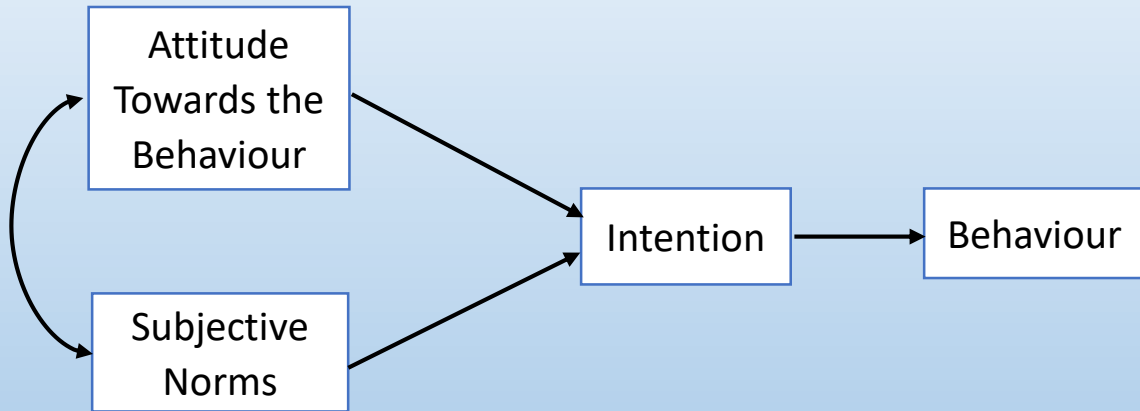| Findings	References
People do not automatically follow the advice and orders, but tend to seek information, assess their personal risk, and make independent evacuation decisions.	(Baker, 1995; Dow & Cutter, 2000; Rasid et al., 2000; Dash & Morrow, 2001; Knowles, 2003; De Jong & Helsloot, 2010; Pet et al., 2012)
Warning people is not enough to motivate evacuation, people must perceive risk.	(Dash & Gladwin, 2007)
There is a need of understanding how volcanic risk perception and behaviour relates.	(Gaillard, 2008; Lavigne et al., 2008; Dibben, 2008)

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Decision to evacuate

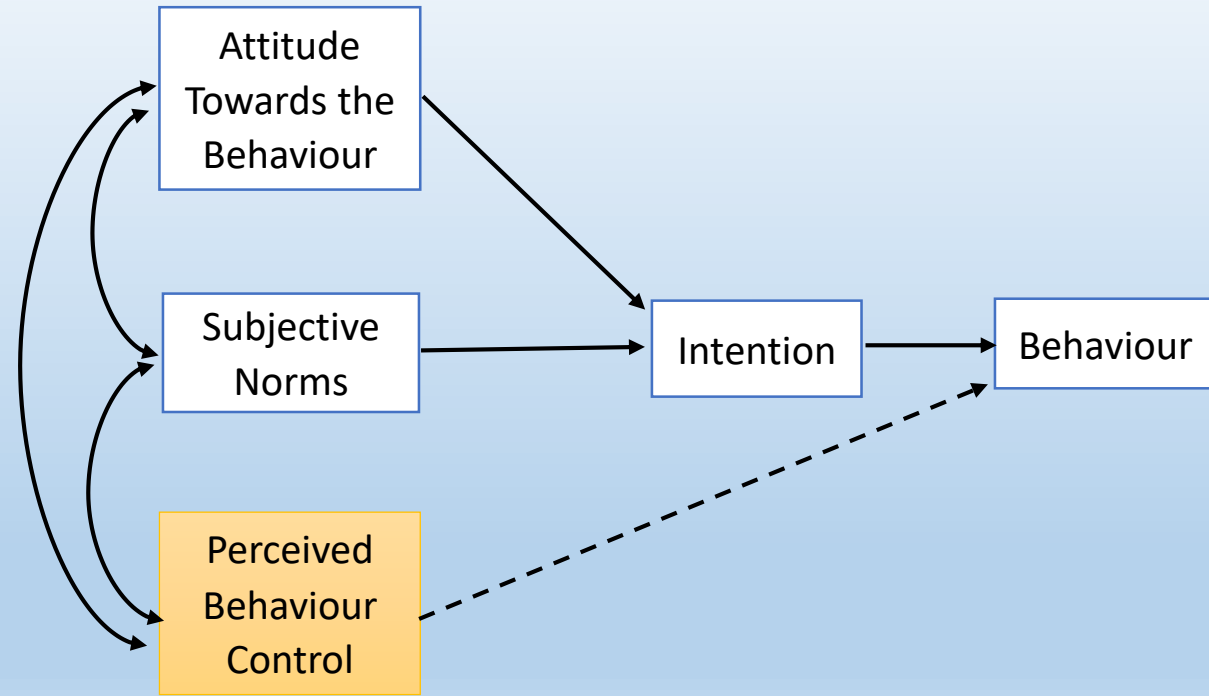| Findings	References
Often the decision to evacuate are made in the **household level**	(Dow & Cutter,2000; Whitehead et al. 2000; Heath et al., 2001; Dash and Gladwin, 2007)
Household members seek each other and then evacuate as a **single unit**	(Murray-Tuite & Mahmassani, 2002)
Understanding of **household evacuation decision-making is limited**	(Padberg, 2011)
Effects of risk communication related to emotions, as well as social, psychological and cultural dimensions needs to be explored	(Rød et al., 2012)

Contributing factors and research gap

❖ *Questionnaire based survey and some descriptive statistics*

❖ *Proper analysis of data is missing*
(socio-psychological) modelling tools and techniques

❖ *Number of factors identified*

❖ *None of the study focuses on most influencing factor for volcanic evacuation behaviour*

Demographic factors

Risk Perception

constraints

Social Norms

Psychological factors

Cultural belief

Models for normal behaviour

Source: Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1975)

Source: Theory of Planned Behaviour (TPB) (Ajzen , 1991)

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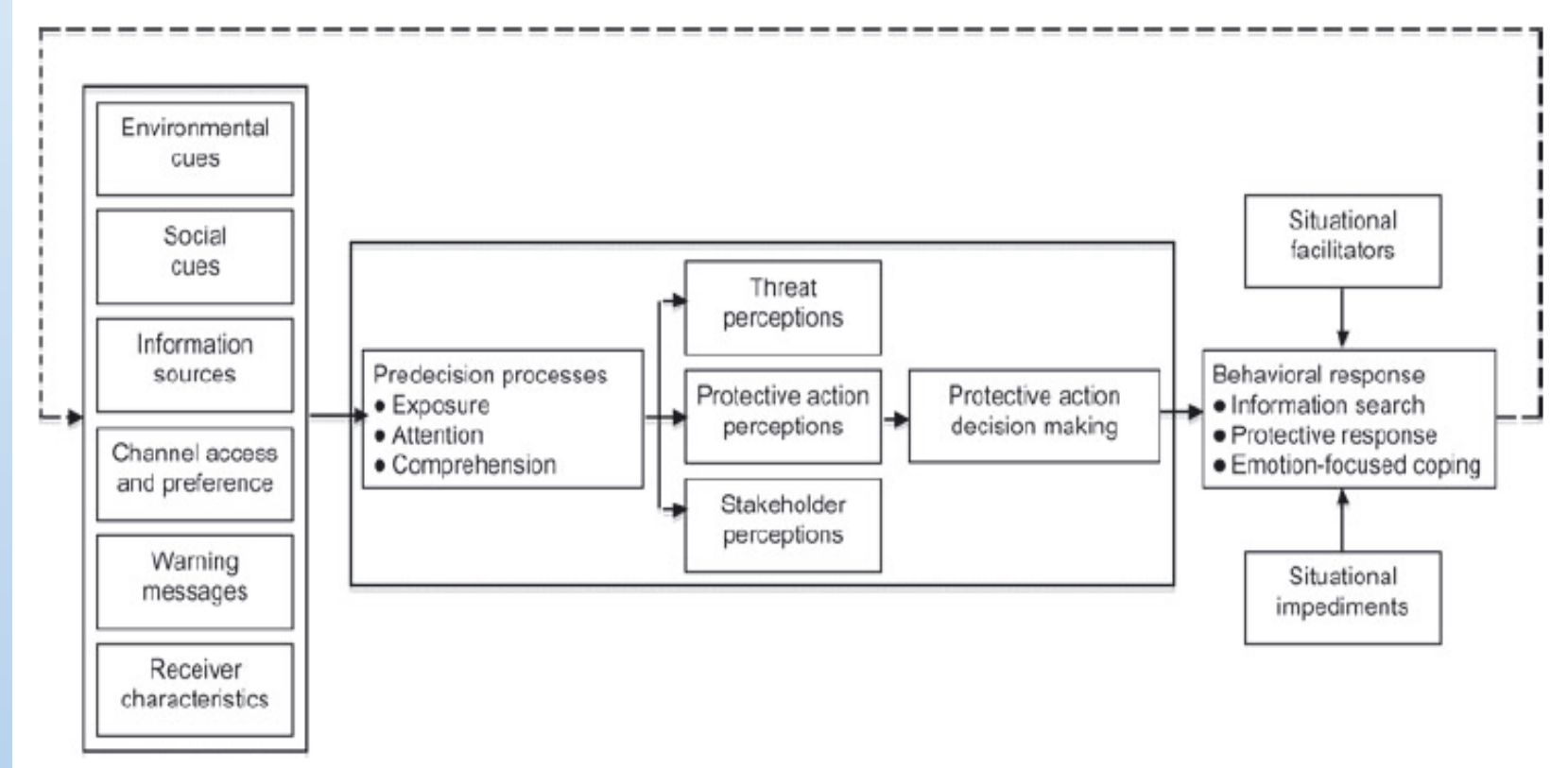
Models for emergency situation

❖ *Used by Lindell & Perry in 1982 for volcanic evacuation behaviour study in Washington State*
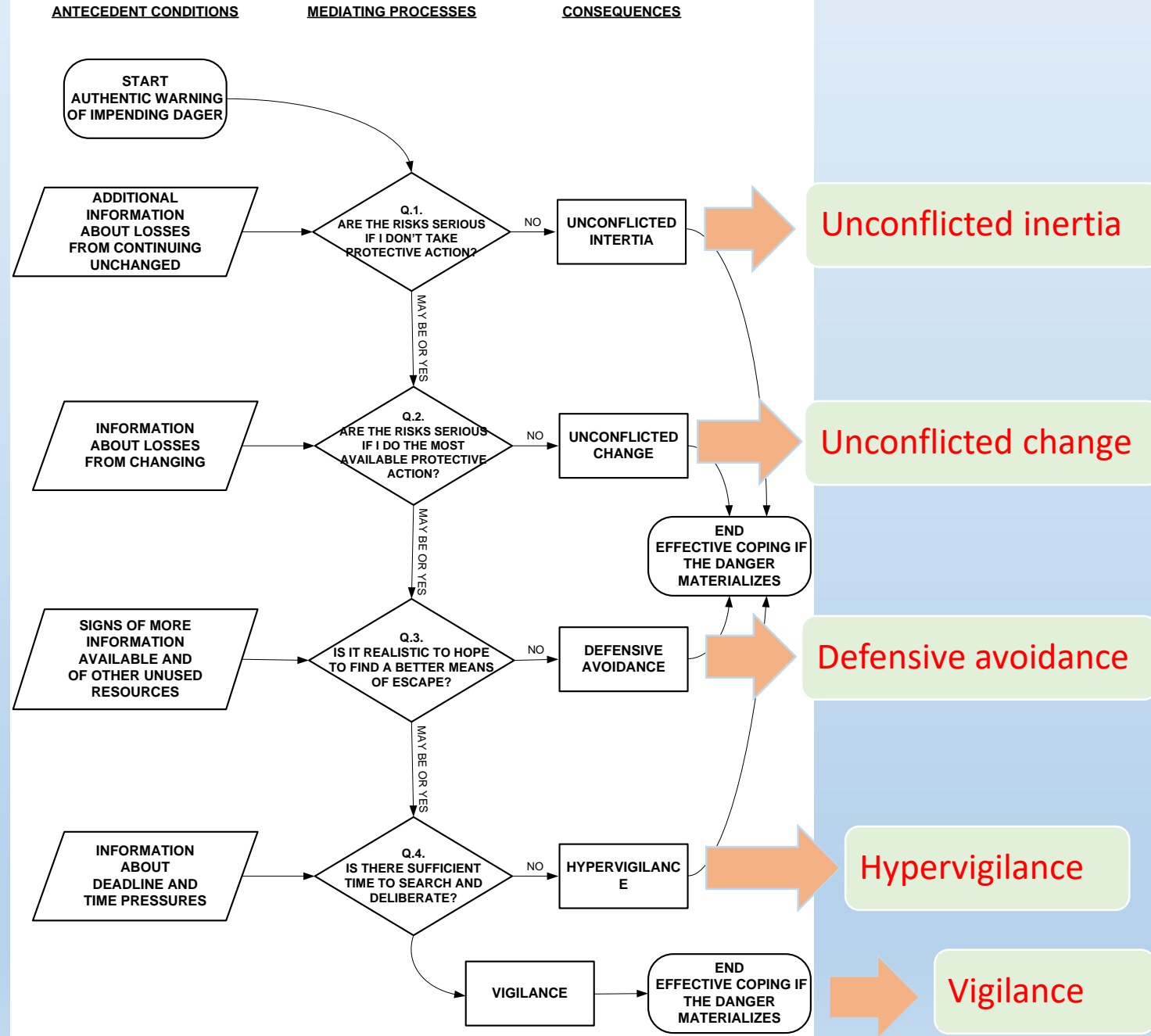
Source: *A conflict-theory model* (Janis and Mann, 1977)

ANTECEDENT CONDITIONS	MEDIATING PROCESSES	CONSEQUENCES

START
AUTHENTIC WARNING OF IMPENDING DAGER

ADDITIONAL INFORMATION ABOUT LOSSES FROM CONTINUING UNCHANGED

Q.1. ARE THE RISKS SERIOUS IF I DON'T TAKE PROTECTIVE ACTION?

NO → UNCONFLICTED INTERTIA

Unconflicted inertia

MAY BE OR YES

INFORMATION ABOUT LOSSES FROM CHANGING

Q.2. ARE THE RISKS SERIOUS IF I DO THE MOST AVAILABLE PROTECTIVE ACTION?

NO → UNCONFLICTED CHANGE

Unconflicted change

END EFFECTIVE COPING IF THE DANGER MATERIALIZES

MAY BE OR YES

SIGNS OF MORE INFORMATION AVAILABLE AND OF OTHER UNUSED RESOURCES

Q.3. IS IT REALISTIC TO HOPE TO FIND A BETTER MEANS OF ESCAPE?

NO → DEFENSIVE AVOIDANCE

Defensive avoidance

MAY BE OR YES

INFORMATION ABOUT DEADLINE AND TIME PRESSURES

Q.4. IS THERE SUFFICIENT TIME TO SEARCH AND DELIBERATE?

NO → HYPERVIGILANCE

Hypervigilance

VIGILANCE

END EFFECTIVE COPING IF THE DANGER MATERIALIZES

Vigilance

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Models for emergency situation

❖ *Conformity with the behaviour of others significant on evacuation decisions*

❖ *No PADM research addressed subjective norm (Lindell & Perry, 2012)*

Source: *Protective Action Decision Model(PADM)* *(Lindell & Perry, 2004)*

Models for emergency situation

❖ *A social-psychology-driven mediated model for the first time*

❖ *New York area after three months of hurricane Irene*

❖ *PA and SN were significant*

❖ *In a disaster situation, TRA is an appropriate model*
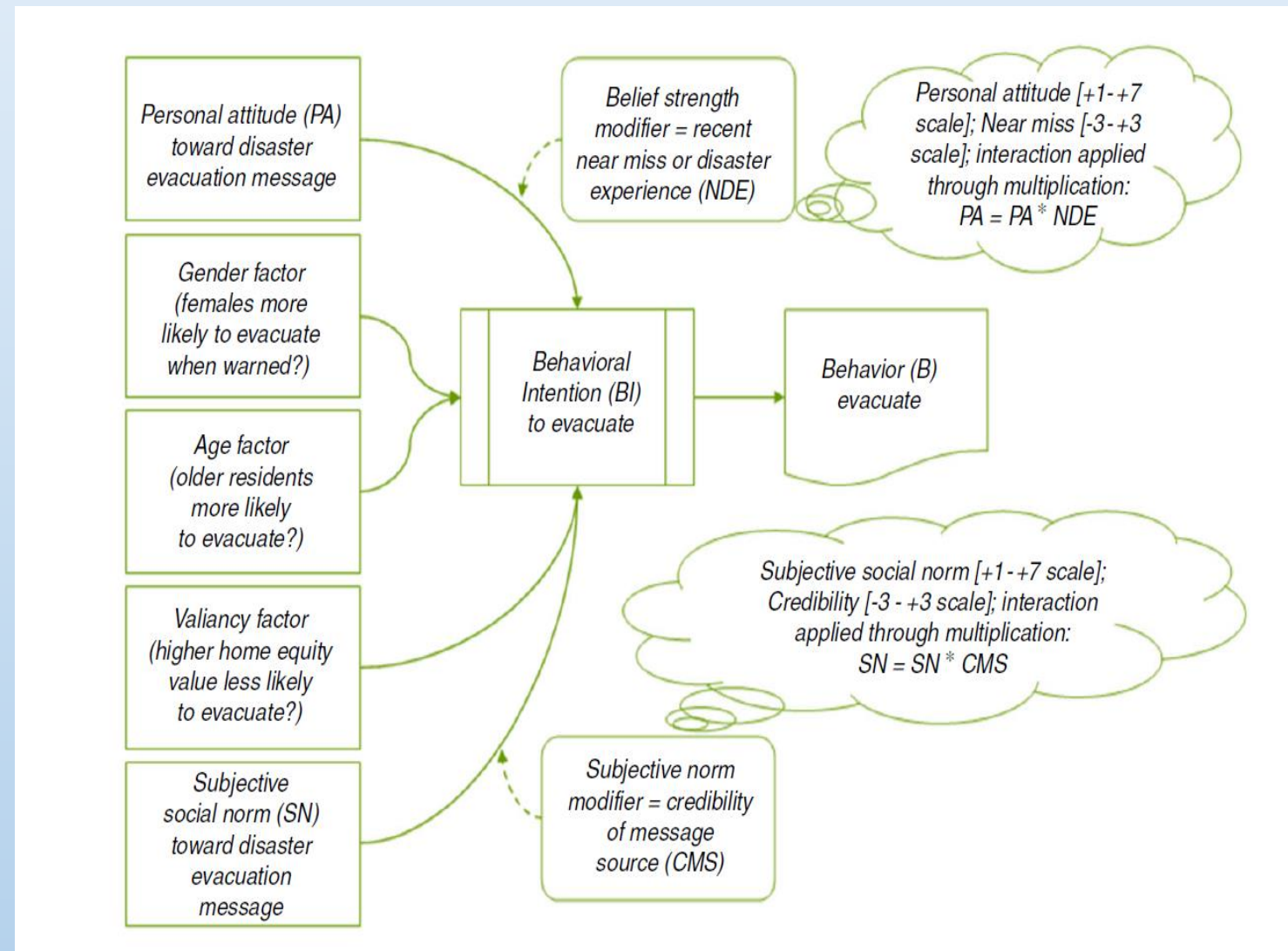
Source : Conceptual factor model of behavioural intend to evacuate natural disaster (Strang, 2014)

Literatures on modelling evacuation behaviour

S.N.	Author(s) (year)	Types of Natural Disaster	Studied country or area	General Theme	Main Focus	Methodology	Main conclusion(s) or recommendation(s)	Gap
1	Lindell & Prater (2007)	Hurricane	Atlantic and Gulf coasts	Evacuation Behaviour	Evacuation time estimates	Behavioral analysis	Household evacuation focused on a very few behavioral variables	Modeling and empirical research be integrated
2	Huang et.al. (2012)	Hurricane	Northern America	Evacuation Behaviour	Evacuation decisions and departure timings	Bivariate correlations, logistic regression analysis	Proposes revised version of PADM	Require further revision of model
3	Strang (2014)	Hurricane	United States	Evacuation Behaviour	Social psychological theories	TRA, regression analysis	TRA is an appropriate model as social influences affect the choice to evacuate (must include socio-demographics)	Relevant social-psychology theories must be researched

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Literature review summary

❖ *Socio-psychological variables can be added to improve behaviour prediction*

❖ *TRA and TPB are suggested to improve behaviour predictions in normal condition*

❖ *Conformity with the behaviour of others significant on evacuation decisions but limited research using social behaviour in modelling*

❖ *Hazard adjustment attributes in the PADM are equivalent to TRA's attitude toward the act (Lindell & Perry, 2012)*

❖ *In a disaster situation, TRA is an appropriate model (socio-demographic factors should also be considered)*

❖ *Behavioural control not included in the disaster planning model*

Knowledge gaps summary

❖ *Number of factors identified but no study on the most influencing factor for volcanic evacuation behaviour*

❖ *In a disaster situation, TRA is an appropriate model which was proposed but never used*

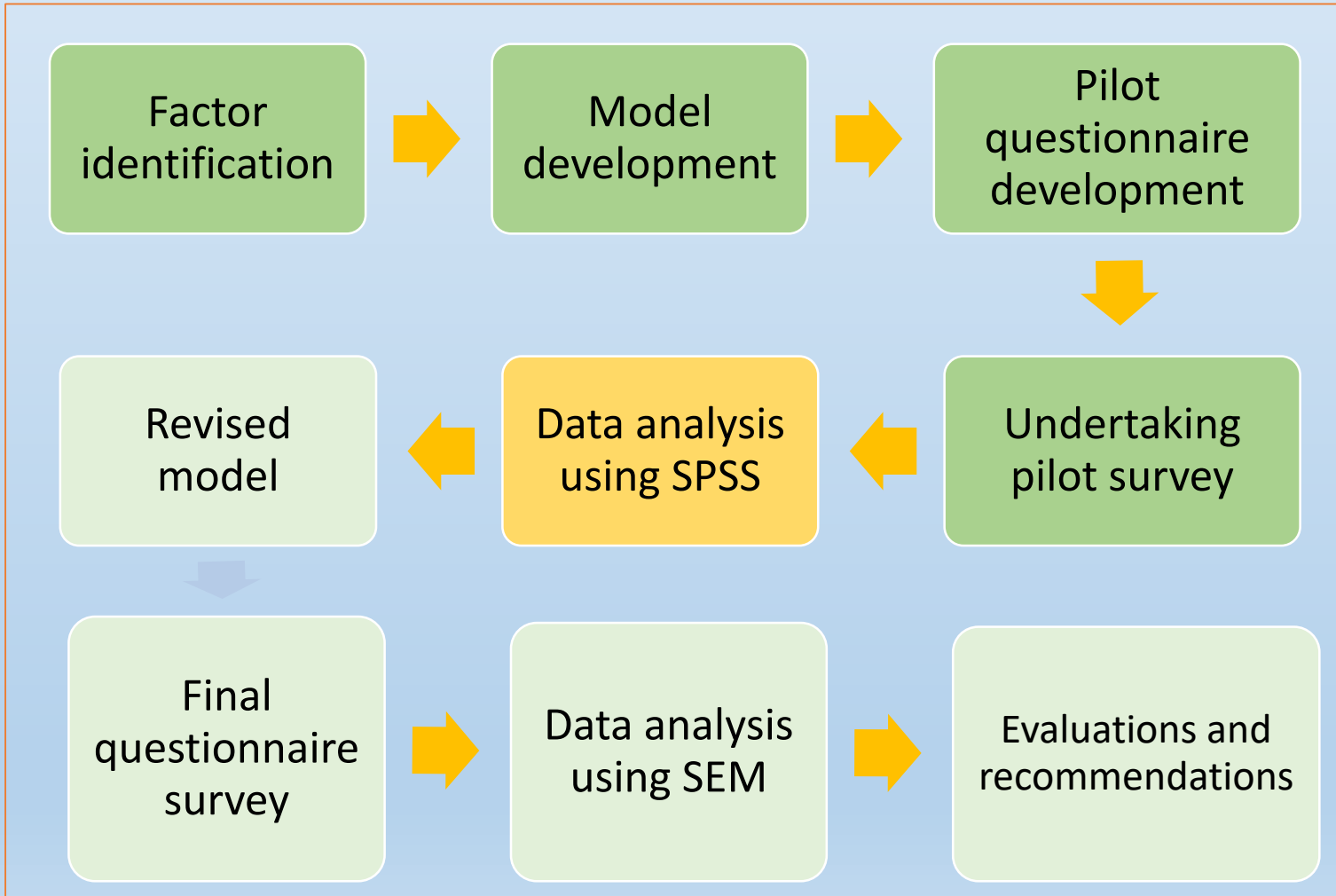❖ *Behavioural control not included in the disaster planning model*

How to fill the Gap

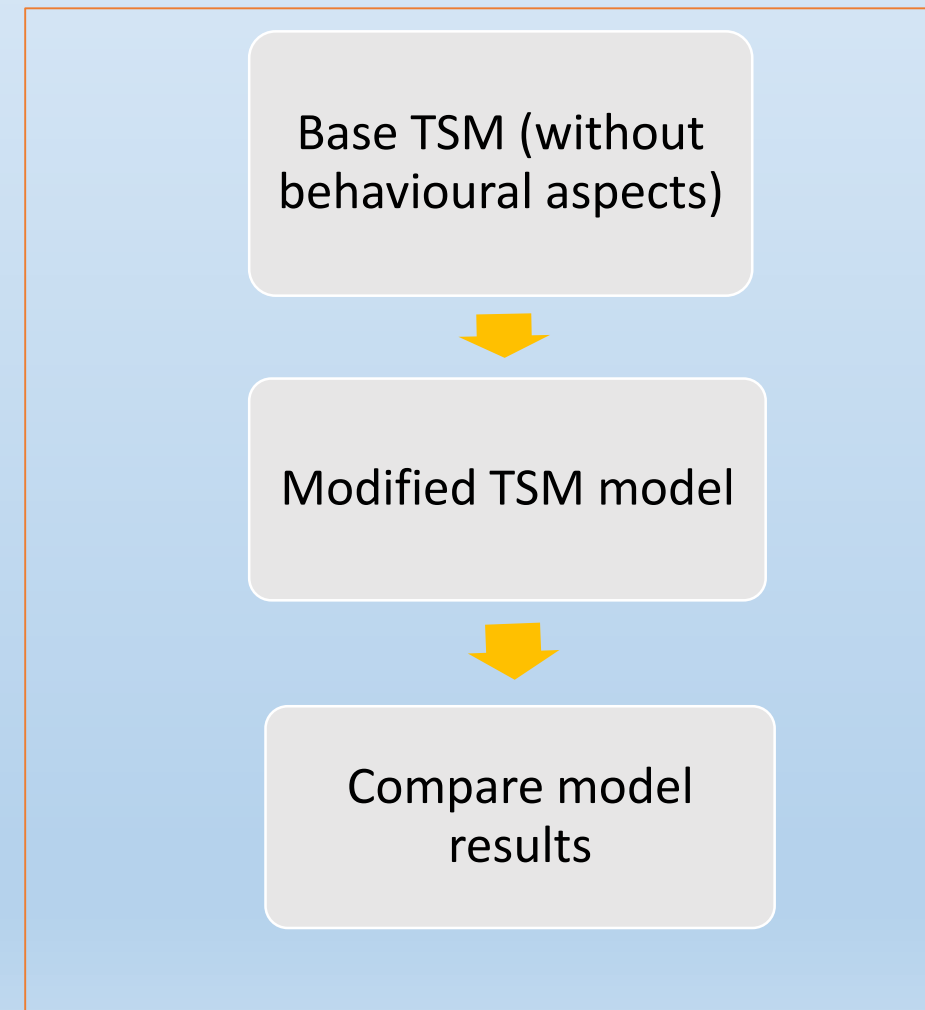**Modification of the proposed model for volcanic evacuation behaviour**

Methodology: research framework

Behavioural model

Traffic simulation model

Factor identification → Model development → Pilot questionnaire development

↓

Revised model ← Data analysis using SPSS ← Undertaking pilot survey

↓

Final questionnaire survey → Data analysis using SEM → Evaluations and recommendations

Base TSM (without behavioural aspects)

↓

Modified TSM model

↓

Compare model results

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Proposed model
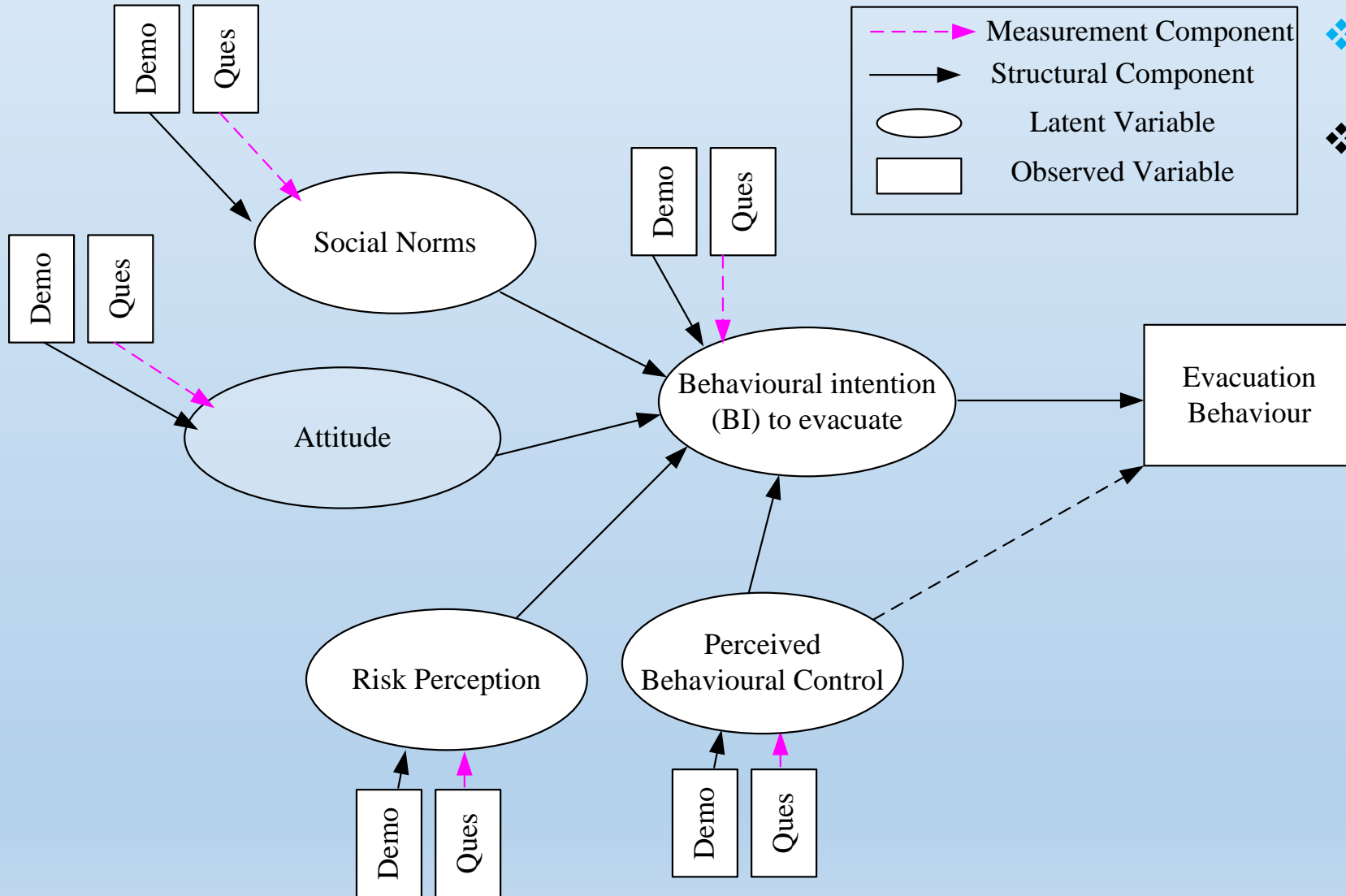
Pilot survey

❖ *Conducted in the Department of Civil and Environmental Engineering of University of Auckland*

❖ *The questionnaires mailed to the faculties, staffs and students*

❖ *Considers those who are living and working in the CBD*

❖ *Total number of responses 80, Only 53 completed*

❖ *Sample size 53 ,analysed in excel for descriptive statistics*

❖ *Latent variables factor analysis*

Evacuation behaviour

❖ *Almost 70% will wait for evacuation orders*

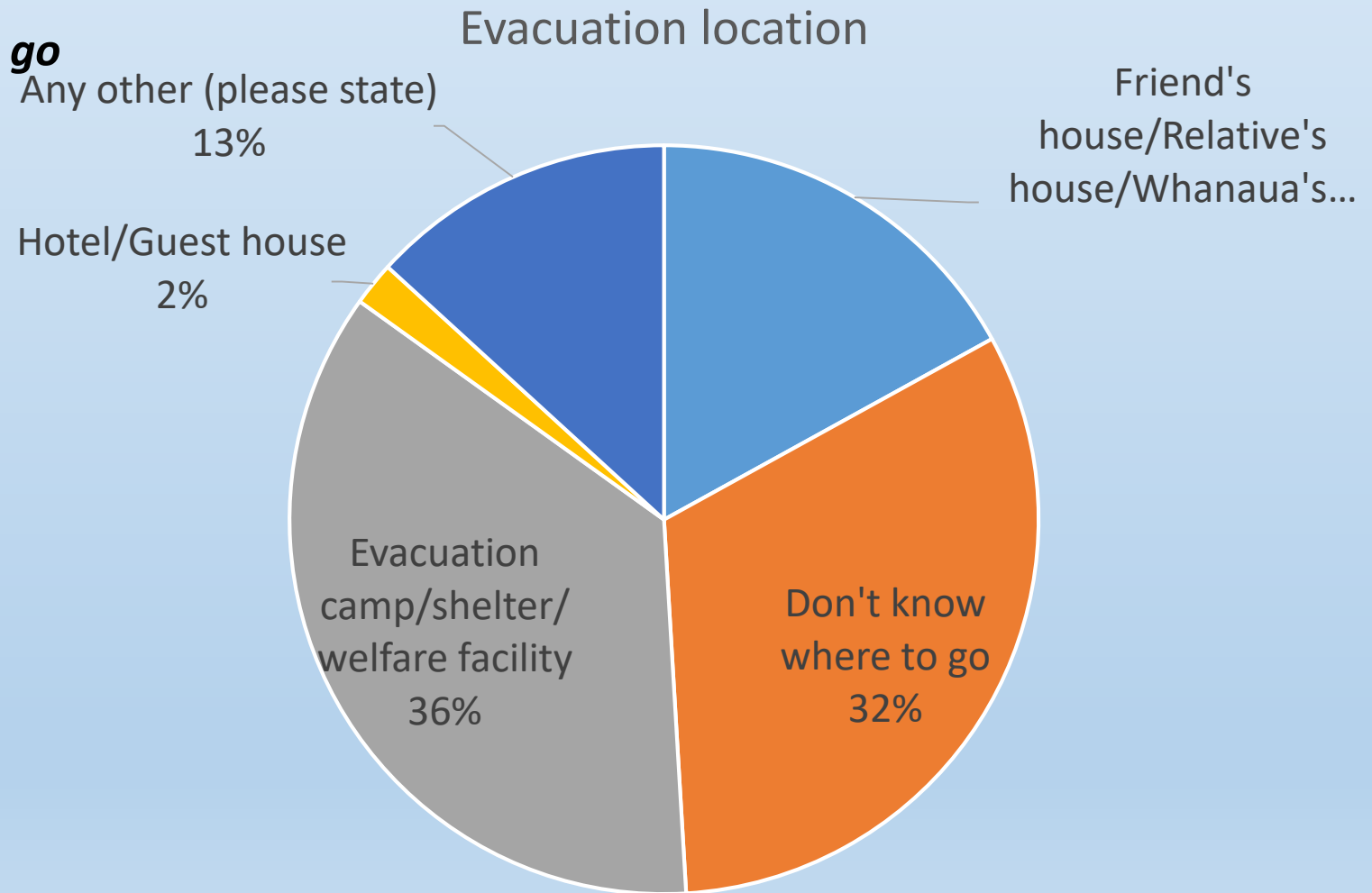❖ *51% of them will evacuate within 2 hours and 24% of them within in next 2 hours*

Evacuation time

12-24 hours after warning 6%

24-48 hours after warning 5%

4-12 hours after warning 14%

0-2 hours after warning 51%

2-4 hours after warning 24%

Where will you look for information on updates regarding the volcano?

Percentage

Radio & TV	Newspaper	Internet	Research Institute	Police...	University	Civil...
66%	13%	89%	11%	19%	28%	42%

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Evacuation behaviour

❖ *35% ranked **one for the step to look for information***

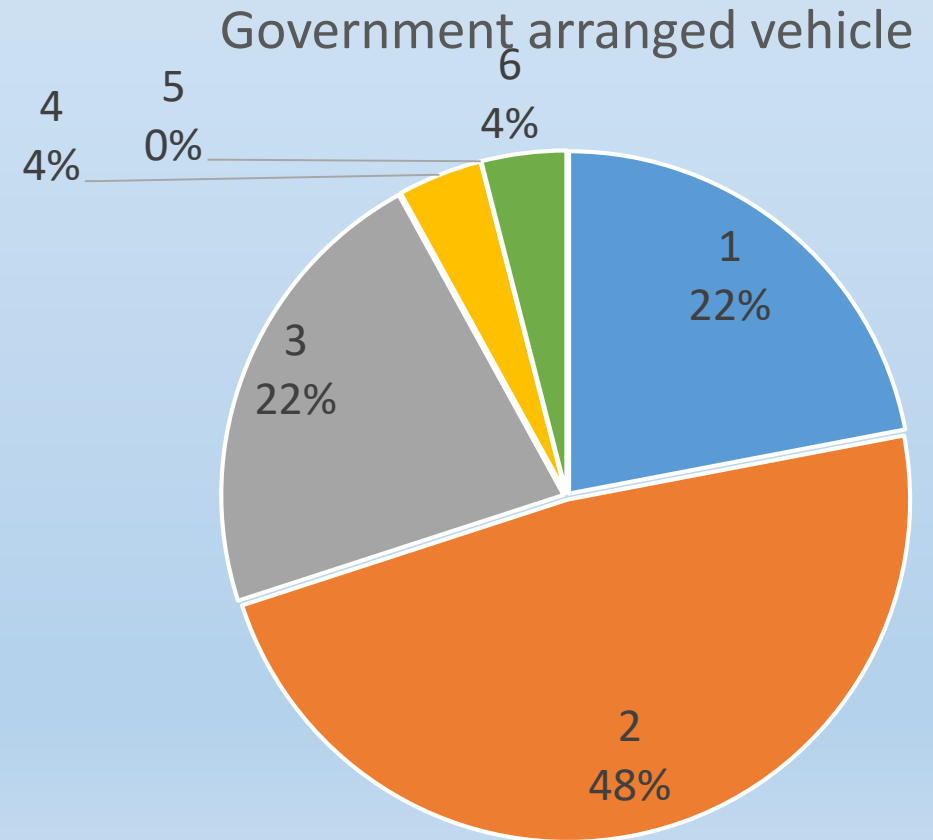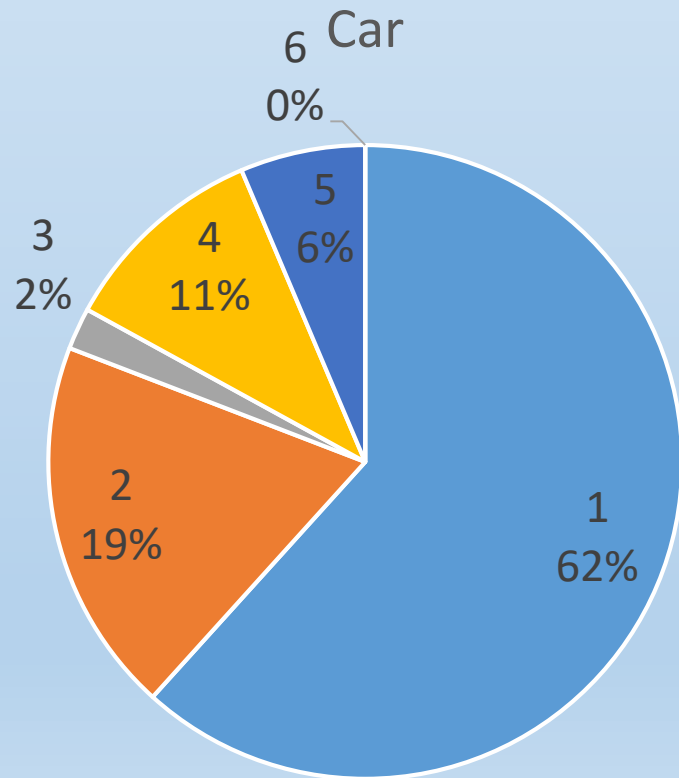❖ *To collect children was ranked second*

❖ *Collect partner was ranked third*
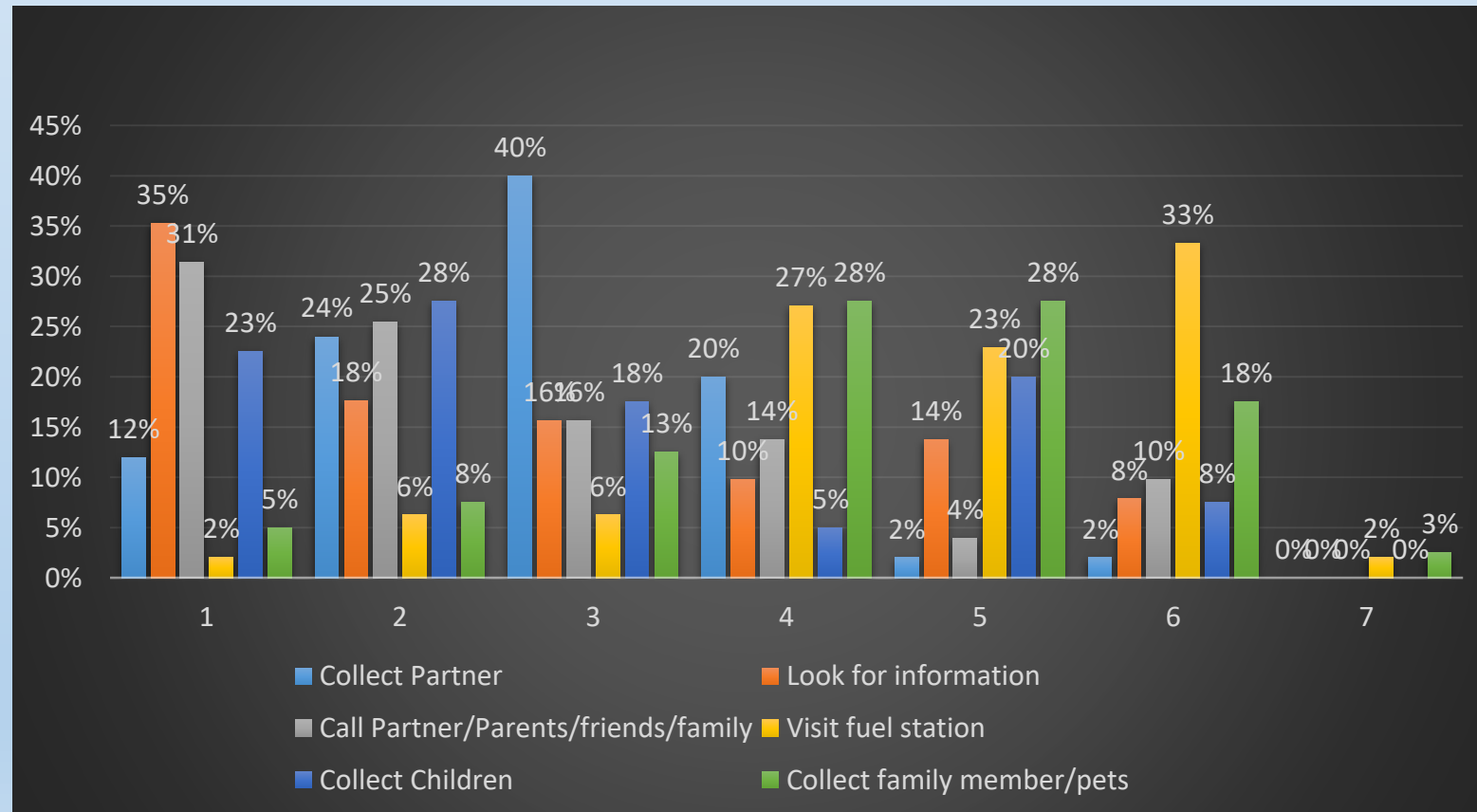
"Where will you go if you had to evacuate?"

❖ Almost *40 % of the respondents answered that they will go to evacuation camp/shelter/welfare facility*

❖ *32% of them don't know where to go*

Evacuation location

- Any other (please state) 13%
- Hotel/Guest house 2%
- Friend's house/Relative's house/Whanaua's…
- Evacuation camp/shelter/welfare facility 36%
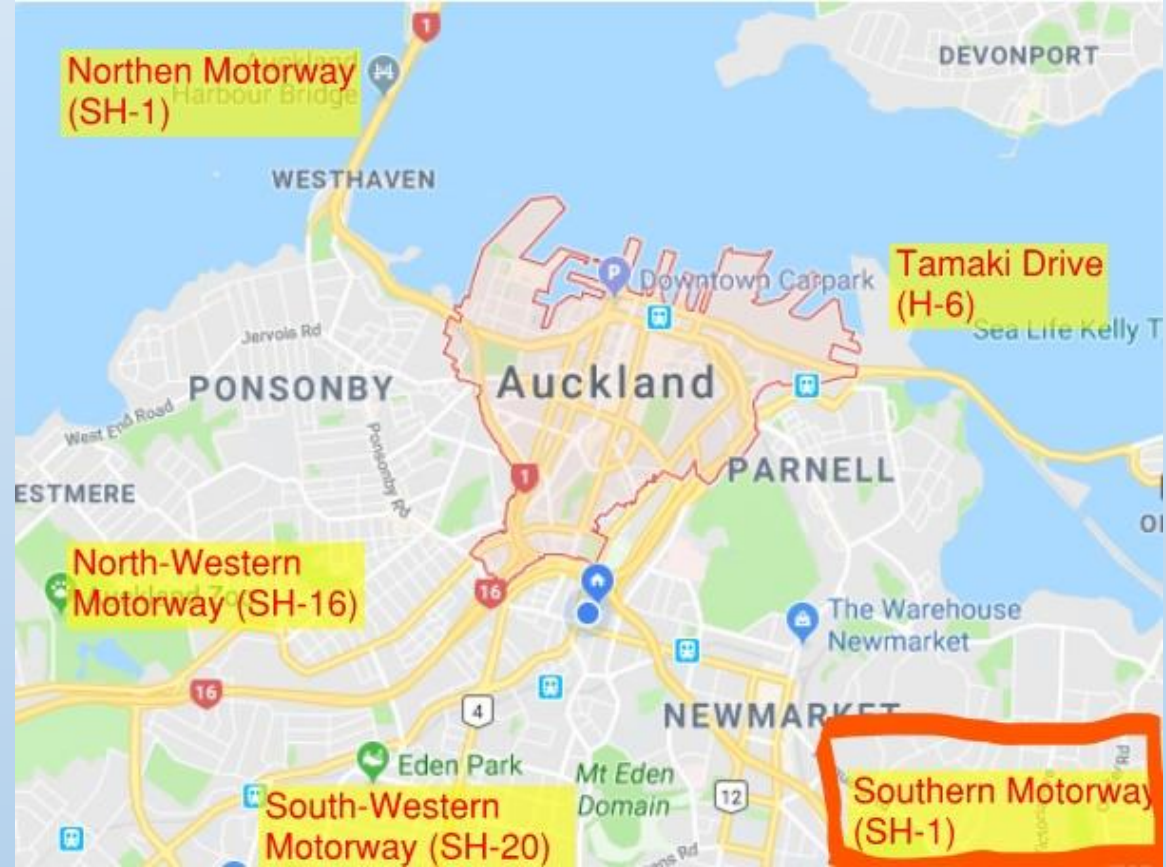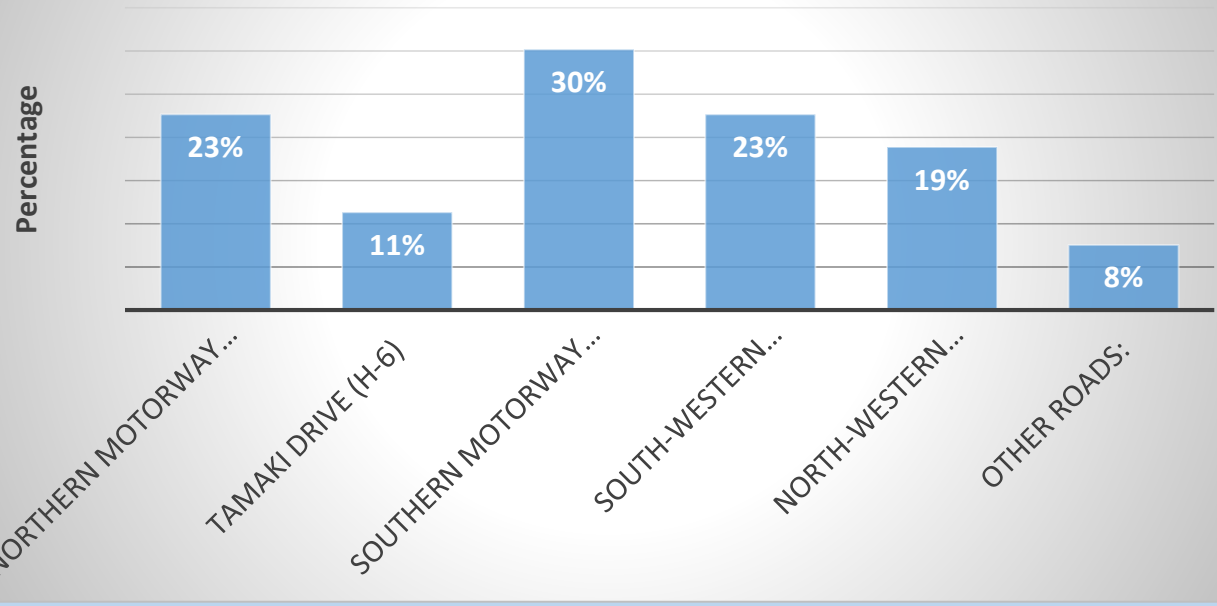- Don't know where to go 32%

Mode choice for evacuation

- ❖ Almost 60% ranked car as 1
- ❖ Government arranged vehicle was ranked second
- ❖ Three fourth don't have offline google map in their phone
- ❖ 60% will be driving during evacuation

Car pie chart: 1 62%, 2 19%, 3 2%, 4 11%, 5 6%, 6 0%

Government arranged vehicle pie chart: 1 22%, 2 48%, 3 22%, 4 4%, 5 0%, 6 4%

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Route choice for evacuation
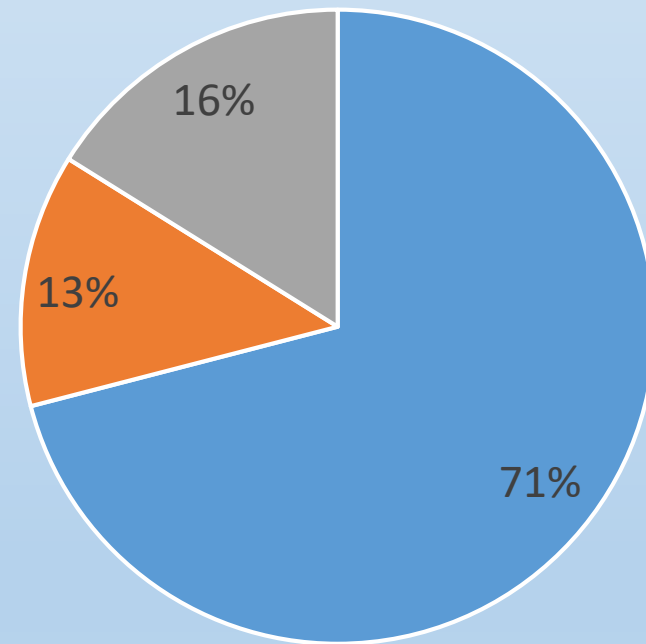
Trust on authorities

❖ *Information from the government was trusted most*

■ I will follow a designated evacuation route provided by authorities.

■ I will use familiar routes to evacuate.

■ I will follow the routes suggested in an automated navigation system.

16%

13%

71%

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Factor analysis (latent variables)

❖ *Method used to find the potential factors that effects the evacuation behaviour*

❖ *Also helps to identify whether the indicators are properly explaining the respective factor*

❖ *Here SoNo_1 denotes one of the questions relating to the social norms*
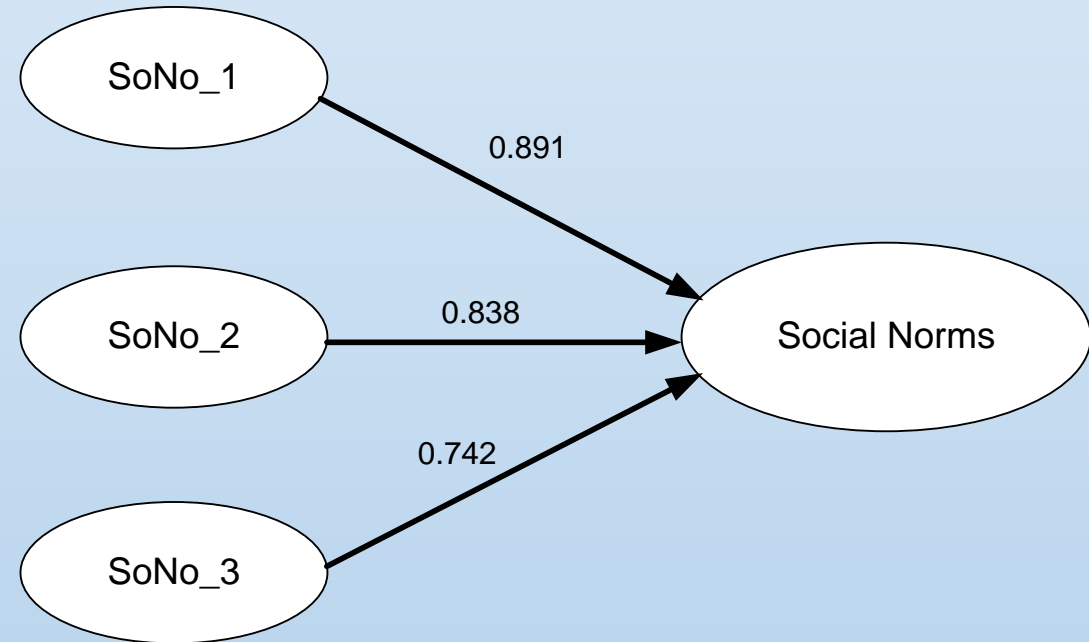
What next?

❖ *Revise the questionnaire as per pilot survey results and the suggestion given by Auckland Council*

❖ *Conduct the Final survey*

❖ *Analyse (Structure equation modelling) the proposed model and come up with the most influential variable which affect the evacuation behaviour*

❖ *Perform the simulation modelling considering with and without behavioural aspect*

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Thank You

Research output

S.N.	Activities	Date
1	Attended Matauranga Maori Workshop by QuakeCORE	30.07.2018
2	Attended QuakeCORE annual meeting	03.09.2018 to 06.09.2018
3	Poster presentation at Devora forum	26.10.2018
4	Attended "Volcanic crisis evacuation decision-making workshop" by Devora	17.12.2018
5	A day training workshop on AIMSUN	26.02.2019

S.N.	Activities	Remarks
1	Malik, L., Tiwari, G., Thakur, S., Kumar, A. (2019). Assessment of freight vehicle characteristics and impact of future policy interventions on their emissions in Delhi. Transport research part D, 67, 610-627.	Published
2	Chen, Z., Hart, R.T.J., Ranjitkar, R., Afzal, M., Thakur, S., Costello, S.B. Resilience of urban road networks: a case study of Auckland. 26th ITS World Congress	Submitted
3	Thakur, S., Gandhi, S., Tiwari, G. Impact of Socio-Psychological Variables on Public Transportation Mode Choice: Case Study Delhi Metro Rail. Travel behaviour and Society	Submitted
4	Thakur, S., Ranjitkar, P., Chohwdhury, S., Rashidi, S. Understanding Evacuation Behaviour under Volcanic Eruption: A Case Study of Auckland, New Zealand. Natural Hazards	In progress

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