



Abstract



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Introduction

Due to climate change, floods have become more frequent and intense over the years. Residents with different backgrounds and perceptions have been reacting differently. More responses have been implemented, such as strategies, administrative or technical measures. Among them, evacuation is regarded as a vital last-resort measure to protect lives and their properties.

The **goals** of this study is...

- i) to compile the state-of-the-art of the knowledge on human decision-making in evacuation process and
- ii) to categorize the approaches that consider human decision-making within a modelling framework.

Methodology

This study reviewed one hundred papers on human decision-making in the evacuation process. Two reference search methods were used to find relevant papers on the topic: general searching and snowball searching method. These papers were then categorized into three groups based on their relevance to the topic.

Keyword: flood human behaviour model

1. General searching method

- Find as much related literature as possible.
- Filter - Include all keywords instead of just one
- Numbers - Top 50 rankings and top 50 with the most citations
- Tool - Google Scholar, Scopus and Semantic Scholar

2. Snowball searching method

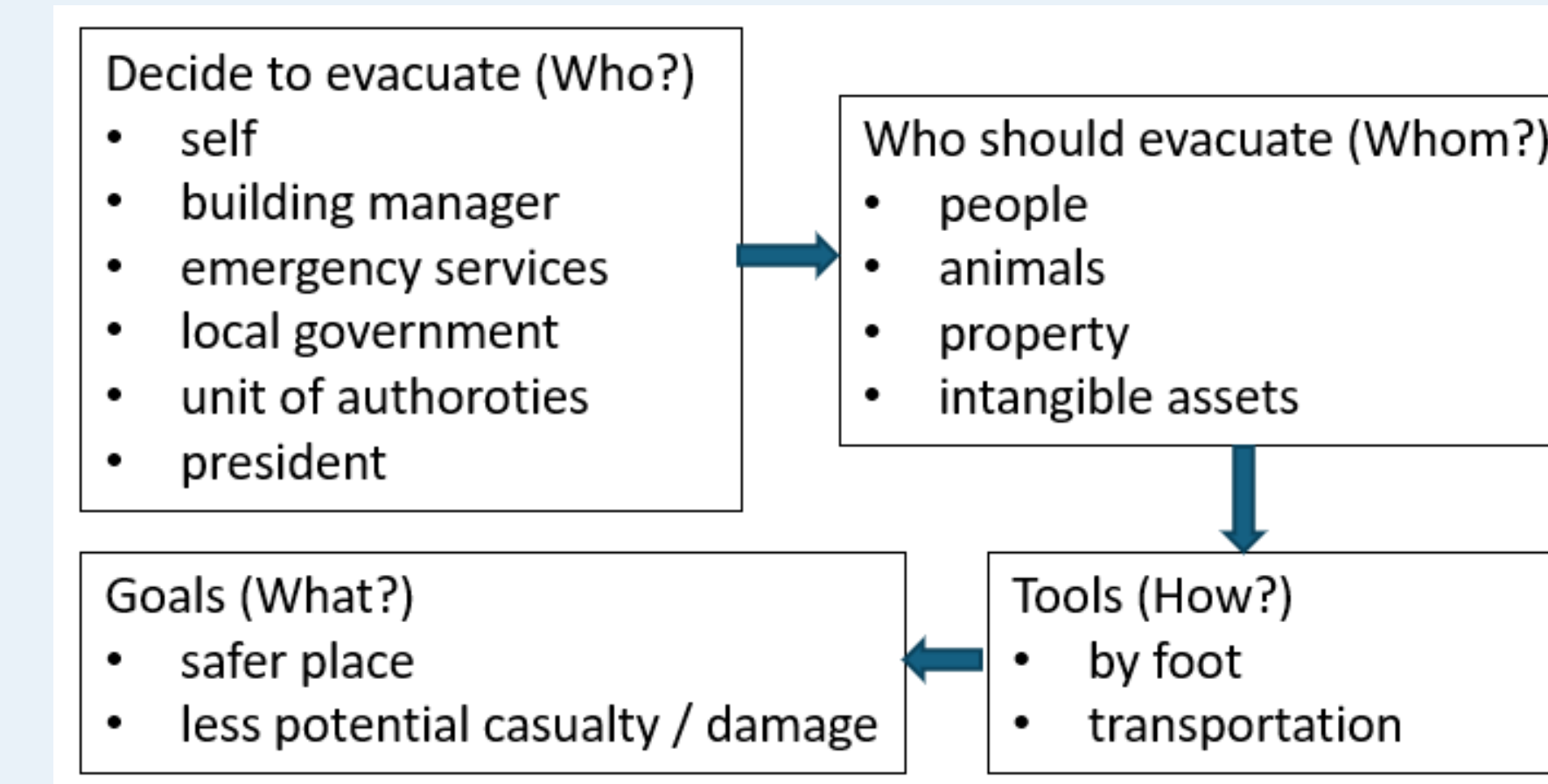
- Find the most relevant paper, and then expand to other related references, including *past* and *future* ones.
- Tool - Google Scholar, Elicit and Research Rabbit
- Initial paper - Simonovic, S. P., & Ahmad, S. (2005). Computer-based model for flood evacuation emergency planning. *Natural Hazards*, 34(1), 25-51.

References

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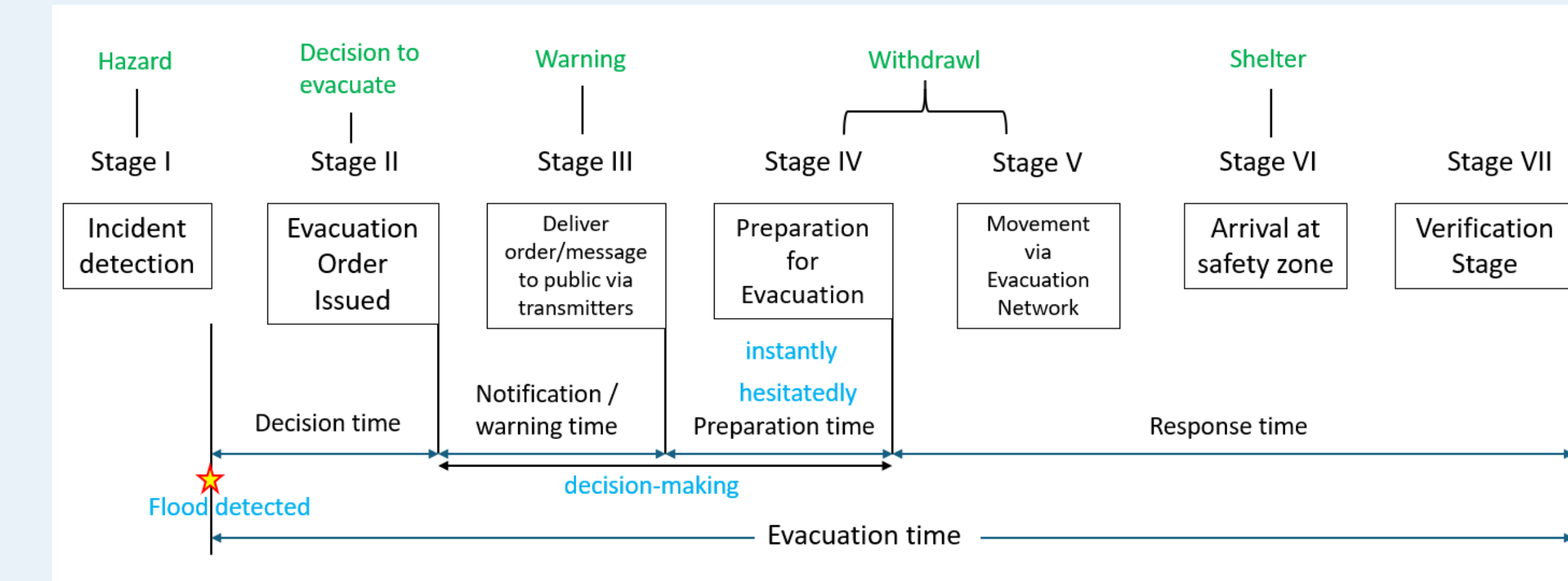
Evacuation Process

Literatures from the third category indicated the components and the stages of the evacuation process in face of floods. This study organized these points mentioned in the papers into the flow chart and incorporated the phases of evacuation into the modelling perspective.



Key components of the evacuation process in general:

Figure 1: Stakeholders, tools, and destinations in the evacuation process (Thomas E., 1969; E.I. Quarantelli, 1980, 1990; Ralph B. Leonard, 1991)



Incorporated flood evacuation process in modelling aspect (based on Stepanov et al., 2009)

Figure 2: Flood evacuation process from the perspective of modelling (Emergency Management Australia, 2005; Alexander Stepanov et al., 2009; add author's opinion)

Results

• Factors why people choose to evacuate

In most cases, the residents have to decide whether the evacuation is necessary and worth the cost of retreat. This decision depends on various psychological, social, and contextual factors, mostly based on risk perceptions. The three frequently discussed factors are:

- **Flood memory** – the last flood experience
- **Trust in government** – credibility of the authorities (e.g. warning alerts)
- **Risk perception** – how people think and assess floods

Table 1: Factors of flood risk perceptions (Ewa Lechowska, 2018, 2021; Zhiqiang Wang et al., 2018; add author's opinion)

Nature of factors	Factors
Informational	Awareness (knowledge), Indirect experience (media)
Cognitive	Worry, Direct experience (flood memory)
Behavioral	Preparedness (e.g. PMT by Birkholz Sharon et al., 2014)
Socio-economical and demographical	age, gender, education, professional status (employed / unemployed), occupation, disability , incomes, household size, home ownership
Geographical (physical)	location , hazard proximity, type of building, length of residence
Contextual	culture, religion, history, political system, trust in government , social bonds, public protection measures

• Frameworks of modeling approaches

Depending on their features and time evolution, three types of modeling methods are listed: a simple mathematical model, System Dynamics ("SD", Simonovic et al., 2000) and Agent-Based Modeling ("ABM", Dawson et al., 2011). Their characteristics are:

A mathematical model	<ul style="list-style-type: none"> • based on equations and functions that describe the general state of human behaviour • Aspect of merely residents or merely within government
System Dynamics	<ul style="list-style-type: none"> • a dynamic model that converts the responses into a gaming format for policy analysis • based on feedback loops and 'what-if' paradigm that capture dynamic interactions among different factors • Aspect of merely residents
Agent-Based Modeling	<ul style="list-style-type: none"> • an interactive dynamic model that consists of rule-based behavioural agents and environment in order to simulate the overall system • Aspect of both residents and the government or either one

Within the ABM framework, three approaches are used to simulate the decision-making process in evacuation: Threshold, Database and Event tree.

	Threshold	Database	Event Tree
Concept	(one's opinion) v.s. (flood risk-tolerance threshold)	combine with the database to give attributes to agents	use event tree to perform the decision of every steps
Features	<ul style="list-style-type: none"> • simulates agent's opinion dynamic as a stochastic process • quantify the factors • factors could be differentiated 	<ul style="list-style-type: none"> • foundations of surveys etc. • assumption of human behaviour scenarios • fixed process of when and how agents respond 	<ul style="list-style-type: none"> • usage of the decision tree with each step of probabilities • could combine with the theory (e.g. PMT) to present each step
Instance or Implemented model	Opinion Dynamics Model (ODM)	ESCAPE (BENS) or Cognitive behaviour model (PECS)	Decision tree of the threat or coping appraisal
Reference	Erhu Du et al. (2017)	Franck Taillandier et al. (2021)	T. O'Shea et al. (2020)

Conclusion and Future Works

- For simulating the scenario of decision-making process and analyzing the influence of single factors, the "Threshold" modeling approach using ABM is the suitable method for next phase of this research.
- For future works, results from the modeling (ABM) will be overlaid on the inundation map, comparing the flood evacuation process, especially decision-making process, between case study in Germany and Taiwan.

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