Journal of Tropical Resources and Sustainable Science
Website : http://journal.umk.edu.my/index.php/jtrss/
eISSN : 2462-2389
Vol: 13, Issue 1, 2025, 149-156
DOI: 10.47253/jtrss.v13i1.1457

RESEARCH ARTICLE

A theoretical review of flood and its social-economic impacts

Lee Bak Yeo[1]*, Nor Hamizah Abdul Hamid[1], Nurul Izzati Othmani[1], Noorliyana Ramlee[1], Wan Saiful Nizam Wan Mohamad[1], Ramly Hasan[2] and Syahidah Amni Mohamed[2]

[1]Sustainability, Urban Design and Wellbeing Research Group, Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, 16300 Bachok, Kelantan, Malaysia.
[2]Architectural Heritage and Cultural Studies Research Group, Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, 16300 Bachok, Kelantan, Malaysia.

ARTICLE HISTORY
Received : 6 November 2024
Accepted : 11 December 2024
Online : 30 June 2025

KEYWORDS
behavioral-psychology,
framework,
flood,
theories,
social-economic impacts

☒ *** CORRESPONDING AUTHOR**
LAr. Dr. Yeo Lee Bak
Sustainability Urban Design and Wellbeing Research Group, Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, 16300 Bachok, Kelantan, Malaysia
Email: yeoleebak@umk.edu.my

ABSTRACT

Environmental problems such as floods were happening annually and contributing to the displacement of people, loss of money, and casualties. The study employed a quantitative review of approximately 60 journals, newspapers, and government reports using Google Search Engine. Eventually, 49 were analysed based on relevancy in theme, context, theories and models. It was found that critical focus areas are urban planning, hazard management, climate change, and sustainability. While studying risk factors and perception, hazard assessment and uncertainty analysis are still lacking. Many approaches to flood risk management revolve around flood protection, infrastructure development, monitoring, and forecasting. The oversight of the social dimensions of floods, particularly the public's perception of risk, still needs attention. Nine theories and models related to social and human dimensions were reviewed to formulate a conceptual framework which is fundamentally based on Behavioural Decision Theory (BDT), Protective Action Decision Model (PADM), Rational Actor Paradigm (RAP), Expectancy-Valence Models (EVM), Circumplex Model of Affect (CMA), and agent-based modelling. This framework encompasses the creation of a flood map using agent-based modelling while examining the decision-making environment, including certainty, uncertainty, and risk, along with their implications, such as assessing emotional states and economic losses. The framework would help us understand the people's ways of life in flooding areas, which recovery efforts and raising awareness could be implemented effectively. Ultimately, the findings of this study can assist stakeholders, planners, and decision-makers in creating more effective policies and guidelines that consider the human and social dimensions of enhancing community resilience.

1. INTRODUCTION

The world population has increased from 3.032 to 7.762 billion from 1960 to 2020, a remarkable increment of more than twice the population over the past 60 years (The World Bank, 2020). The increasing population has changed the characteristics of the Earth's surface. The flourishing of the built-up structures and the construction of impervious materials have altered the characteristics of the land, thus contributing to numerous environmental problems (Yang et al., 2021). Environmental problems related to inappropriate town and city planning are well reported, which include flooding, soil erosion and threatened local ecosystems (Yeo et al., 2016). In scientific communities, physical-based modelling has been long established to monitor storms, rainfall-runoff, water level and flow, and global atmospheric and ocean phenomena (Liang et al., 1994; Costabile et al., 2013; Costabile & Macchione, 2015; Xia et al., 2017). Such modelling often required various hydro-geomorphological monitoring datasets, requiring complex computational simulation, making it hard to predict short-term events (Nayak et al., 2005). Some of the examples of physical-based modelling include rainfall-runoff modelling (Peel & McMahon, 2020), groundwater modelling (Chiang, 2005) and flood modelling (Guo et al., 2021). On the other hand, data-driven modelling also has a long history in predicting flood events such as genetic programming and neural network models (Makkeasorn et al., 2008), decision trees-based machine learning models (Khosravi et al., 2018), random forest-based machine learning models (Wang et al., 2015), multilayer perceptron (Widiasari & Nugroho, 2017); support vector machine (Tehrany et al., 2015); artificial neural networks (Lekkas et al., 2004), and neuro-fuzzy inference system (Shu, & Ouarda, 2008). Despite various approaches or modelling techniques that have been examined, the flooding situation still has not improved, particularly in Southeast Asia. For instance, Lechowska (2022) posits that oversight of the social dimensions of floods still lacks attention, particularly on public perception of risk.

According to Chen et al. (2020), Vietnam and Thailand have been paying relatively more attention to studying the impacts of floods. Countries such as China and Malaysia are also severely impacted by floods due to cyclones and other factors (refer to Figure 1). Malaysia in the Southeast Asia region has suffered from extreme flood events in these past few years. One of the heaviest rainfalls was reported by the Environment and Water Ministry on 19 December 2021, which contributed to widespread flooding in many states in Malaysia. It was considered one-in-a-100-year heavy rainfall (The Straits Times, 2021). There are a total of 5235 high-risk areas and 4795 flood-prone areas listed by the Malaysian Fire and Rescue Department, with Kelantan, Pahang, Johor, Selangor, Sabah and Sarawak listed as hotspots for flooding due to heavy rainfall forecast (Bernama, 2022). In December 2022, a severe flood caused the displacement of 66,718 people in five states, including Kelantan, Terengganu, Pahang, Johor, and Perak (The Straits Times, 2022). The erratic flooding due to climate change caused Malaysia to lose RM6.1 billion, equivalent to 0.4% of the national gross domestic product (GDP) at a nominal price (The Edge Markets, 2022). Based on a recent review by Zulkepli & Mohd Idris (2022), studies related to flood events in Kelantan can be categorised into four themes: factor of flood, impact of flood, flood mitigation and resilience, and flood vulnerability. The factors contributing to floods and their impact, mitigation, and resilience strategies are the most common topics examined. Meanwhile, there are relatively few studies on vulnerability in buildings. Hence, it is essential to consider both the people and their living environment, especially in social and environmental dimensions.

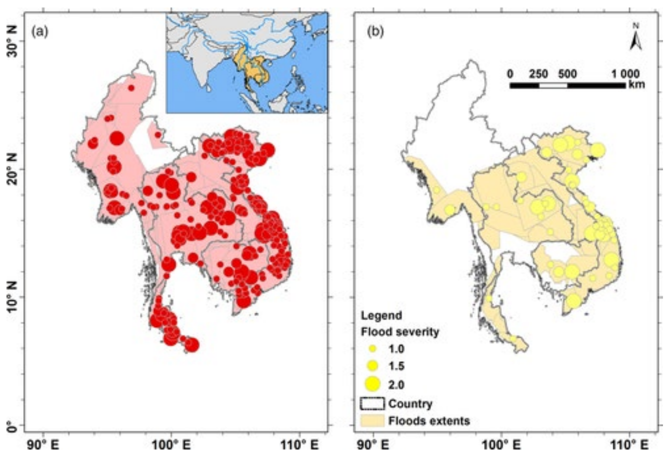

Figure 1: Flood by all causes (a) and tropical cyclone-induced flood from 1985-2018. Source: Chen et al. (2020).

Kelantan, a state in Malaysia, has a long history of grappling with flooding. However, the catastrophic flood 2014 stands out as one of the worst in a century. The unprecedented surge in December 2014, exacerbated by continuous rains from the 14th to the 19th of December, resulted in widespread destruction and numerous casualties. The impact was staggering, with an estimated loss of about 2.8 billion ringgits (Yahaya et al., 2015). A study by Chan et al. (2016) conducted during the 2014 flood in Kelantan revealed that households could suffer losses of almost RM 3945 for house damage, RM 5250.66 for property losses, and RM 23427.09 for vehicle damages. The devastating effects of the flood have significantly affected the community, particularly families and individuals who have suffered substantial financial losses.

After a flood event, victims struggle to rebuild their properties and receive aid. Some prefer to collect and fix items to save money, while others choose to rebuild their lives independently (Nurumal et al., 2017). First, based on the problem highlighted above, there is a need to assess the social aspect of flooding, for example, the public's understanding of risk and the perceived likelihood of a hazard and its consequences. Secondly, understanding the decisions made by an individual during the chain of flooding events. The decision can be categorised into three aspects: i) a decision made under certainty, for instance, knowing the fact that the flood is going to hit soon through past experiences and news reported in media; ii) a decision under uncertainty, for instance, does not have any idea on the flooding event and its repercussion which potentially causing a massive loss in assets and degraded health, and iii) decision under risk, for instance, knowing the flood occurrence but not taking it seriously and not making all the preventive measures. Thirdly, based on their decision, each household's loss of assets and recovery expenditure can be estimated to reflect better the actual situation and damage done. Hence, formulating a psychological-behavioural framework to assess psychological and financial implications based on the decision-making environment is mandatory.

2. MATERIALS AND METHODS

The study employed a quantitative review of approximately 60 journals, newspapers, and government reports using Google Search (https://www.google.com.my/) and Google Scholar (https://scholar.google.com/). Eventually, 49 were used based on relevancy in theme, context, theories and models (refer to Figure 2). Regarding the theme, critical focus areas, risk and perception were discussed. In terms of context, countries that were given the least attention were reported. Lastly, theories and models of flood on human behaviour were reviewed to form a conceptual framework.

Google search engine was used because some of the government reports (i.e., Department of Statistics Malaysia and The World Bank) and newspapers (i.e., Bernama, New Straits Times, and The Edge Markets) are not accessible in Google Scholar. For the journal articles, we have elicited peer-reviewed journals from the fields of psychology (environment of decision-making and emotional states), behavioural economics (estimating loss), geoinformatics (flood map), and disaster management (environment of decision-making- preparedness, response, recovery, mitigation). Most of the literature and information were selected from the 2000s to 2024 to ensure recency of knowledge, except for the theoretical underpinnings explained in Section 4. Initially, literature about flood trends was reviewed based on co-occurrence analysis data. Second, adapting theories and models related to the flood was discussed. Lastly, a conceptual framework was developed to examine the flood's social-economic implications.

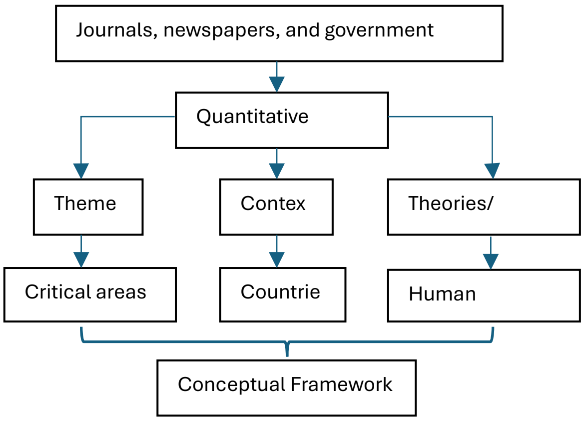

Figure 2: Methodological flow for literature selection.

3. RESULT AND DISCUSSION

3.1 The trend of research

The co-occurrence analysis by Prashar et al. (2024) on urban flood resilience, using the Scopus database, reveals strong interconnections among terms such as floods, climate change, urban planning, vulnerability, resilience, and risk assessment (refer to Figure 3). The thematic analysis highlights critical focus areas of urban planning, hazard management, climate change, and sustainability. It also indicates that risk factors and perception, hazard assessment, and uncertainty analysis are among the least considered aspects. Additionally, the study notes that countries like the United Kingdom, the United States, the Netherlands, and China are more actively involved in addressing flood resilience. Meanwhile, Southeast Asia countries like Malaysia, Thailand, and Indonesia are giving less attention.

According to Lechowska (2022), many approaches to flood risk management (FRM) predominantly revolve around physical flood protection, encompassing infrastructure development, monitoring, and forecasting. The oversight of the social dimensions of floods, particularly the public's perception of risk, is still lacking attention. By overlooking risk perception, which involves evaluating the public's perceived likelihood of a hazard and its negative consequences, the current approaches miss out on an essential aspect of comprehensive flood risk management.

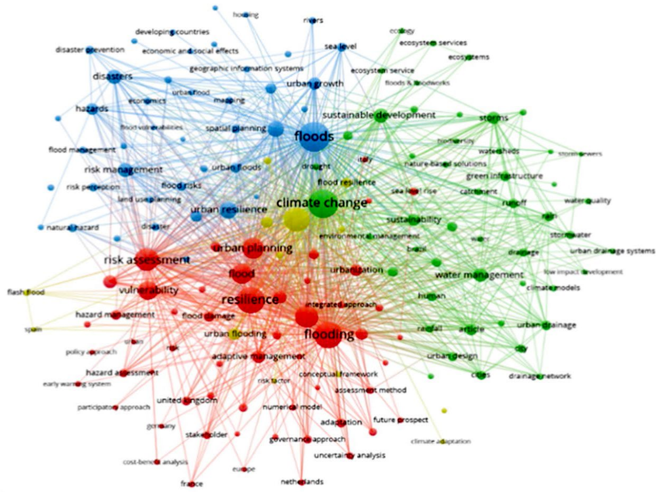

Figure 3: VOSviewer's co-occurrence analysis based on themes. Source: Prashar et al. (2024).

Climate change is expected to result in a higher frequency of natural disasters, especially weather-related issues. Floods are the most common natural hazards, and their effects are becoming more severe. Recent studies have demonstrated the effectiveness of green infrastructure (GI) techniques in reducing stormwater runoff and improving water quality. A recent review study by Nazarpour et al. (2023) reveals that GI water volume reduction rates for bio-retention are 50–98% and 11–71% for field and laboratory experiments. Green infrastructure is increasingly being integrated into more extensive stormwater management strategies; for example, River Torrens Linear Park in Adelaide, Australia, was designed to mitigate riverine floods, transform neglected waterways into attractive landscapes, and help protect and preserve the aquatic species within river systems (Ibrahim et al., 2020). Despite the valuable advantages that GI could offer, applying GI for flood mitigation is relatively new and is progressing slowly in many developing countries. Therefore, it is essential to emphasise the significance of disaster preparedness in order to mitigate risks effectively.

Preparedness encompasses a range of proactive measures to prevent or minimise potential hazards' impacts. It includes conducting thorough hazard identification and mapping, performing vulnerability analyses, and conducting

eISSN Number: 2462-2389

comprehensive risk assessments to develop robust preparedness strategies. Effective preparedness initiatives are pivotal in reducing vulnerability, enhancing mitigation efforts, facilitating prompt and efficient disaster responses, shortening the recovery period post-disaster, and ultimately bolstering community resilience. Behavioural change strategies are often used to determine how protective actions can be taken based on the outcome of this process (Ejeta et al., 2015). Therefore, it is crucial to determine whether a particular theory can forecast the preparedness needed for various types of hazards.

Previous research has examined the reasons behind the vulnerability of flood-prone areas. For instance, the difficulties encountered by flood victims, how residents and authorities anticipate, mobilise resources, adapt and respond to the disasters, as well as recommendations for improving resilience to future floods and preventing future disasters in urban areas (Safiah et al., 2020; Karki, 2020). However, most studies use qualitative approaches such as focus group discussion or interview methods to derive the results. Thus affecting the generalisation of the findings. This study proposes quantitative measures via agent-based modelling for a more convincing statistical study. Agent-based modelling creates computer simulations that imitate real-world systems of interacting units like people or animals. In each simulation, agents represent units with their attributes, rules, and goals and can interact with other agents and the environment. By observing how the agents adapt, we can understand complex phenomena like social networks or epidemics (Wilensky & Rand, 2015). A conceptual framework is produced to assess the relationship of agent-based modelling, theories and its parameters in Section 5.

3.2 Adaptation of theories and models

Many studies related to floods have mainly focused on hazards and risks. It is challenging to assess the vulnerability of exposed assets influenced by human behaviour and its loss-reducing measures. Conventional flood risk projections assume a static vulnerability, which may lead to an inaccurate representation of future flood risk. For instance, Haer et al. (2017) posit that extensive literature has delved into how individuals prepare for flood events using survey data on flood preparedness and risk perception. However, it is essential to note that survey data alone does not elucidate how individual behaviour impacts current flood risk or how individual adaptation decisions may mitigate flood damage as flooding has happened more frequently over time. Thus, behavioural-related decision theory has been adapted to understand this complex phenomenon.

Multiple models, theories, and frameworks have been put forward in flood research and the exploration of human conduct in disaster readiness and risk evaluation (Ejeta, 2015; Altarawneh et al., 2018). Among these are the Protective Action Decision Model (PADM), affective and cognitive routes path model (ACR), Expectancy-Valence Models (EVM), Protective Motivation Theory (PMT), Vested Interest Theory (VIT), Rational Action Paradigm (RAP), and Social Cognitive Theory (SCT): self-efficacy and outcome expectancies, Behavioural Decision Theory (BDT), and Circumplex Model of Affect (CMA).

The PADM explains the decision-making process in response to environmental hazards and disasters. It draws from research on how people react to a situation, integrating information from social and environmental cues. The model identifies three core perceptions: general perceptions, perceptions of protective actions, and stakeholder perceptions. These perceptions are fundamental in deciding how to respond to an imminent or long-term threat. It is important to note that the PADM shows how variables are linked in sequences of cause and effect. It is crucial to note that the PADM predicts specific variables that should form causal chains. For instance, hazard proximity may lead to individual hazard experience, such experience may lead to risk perception, and the perception may infer hazard adjustment adoption (Lindell & Perry, 2012).

The ACR model is a path model that elucidates the mechanisms in two parallel routes, affective and cognitive, from perceptions to behaviour when responding to risk. According to Terpstra (2011), the affective route encompasses the "emotions linked to prior experiences/trust in flood protection → perceived dread → intention to prepare. Emotions play a vital role in evaluating risks. The cognitive route involves the "trust → perceived likelihood → intention to prepare." The model also emphasises the importance of risk communication strategies in both routes to motivate disaster preparedness behaviour.

The EVM outline perceptual processes crucial for decision-making, including risk identification and appraisal, preventive action search, assessment, and implementation. Perceiving risk involves assessing a threat's severity and probability for starting risk reduction and motivating individuals to act. Risk-reducing responses depend on two categories of attributes: hazard-related and resource-related. Hazard-related attributes assess the effectiveness of the response to the hazard, while resource-related attributes consider the necessary resources such as finances, time, knowledge, personnel, and social collaboration (Becker et al., 2014).

SCT examines the connections between self-efficacy, outcome expectations, and behaviours (Bandura, 1977). Evidence shows that outcome expectations significantly shape self-efficacy. Researchers need to define how self-efficacy and outcome expectations relate when studying self-efficacy. It is also essential to define self-efficacy clearly, which matches the researcher's theory. Suppose the theory suggests that outcome expectations influence capability (self-efficacy) beliefs. In that case, researchers need to ensure participants consider expected outcomes in their self-efficacy assessments (William, 2010).

The PMT elucidates how individuals' concerns about adverse outcomes and the efficacy of their responses influence their behavioural adjustments (Rogers, 1975). Initially, the theory was used to comprehend people's reactions to health threats. The PMT is increasingly employed in the environmental context to explain the adoption of pro-environmental behaviours. It explains that an individual faced with environmental dangers is likelier to look for information that helps them gauge their risk and assess the different coping responses (Li et al., 2023).

The VIT suggests that the emotional importance of an attitude object influences the connections between attitudes, intentions, and responses to danger. Objects that are seen as having a significant personal impact are considered vested. The theory proposes that attitudes toward highly vested objects are closely linked to behaviour, and research has provided evidence. For example, using VIT in assessing communication about environmental risks may help create messages encouraging people to effectively address emerging environmental risks (De Dominicis et al., 2014).

The RAP suggests that people are willing to take on significantly more risk for activities they choose to do than activities they are forced to do because of the perceived benefits. Several factors play a role in evaluating risks, including how specific and severe the risk is, whether its effects on public health can be reversed, how well-understood the risk is, whether it is chosen freely or forced upon individuals if there are compensations for taking the risk or incentives for mitigating it, the perceived advantages of the risky behaviour, how the risks and benefits compare to other options, and how trustworthy the person making decisions about the risk is perceived to be (Zhai & Ikeda, 2008).

BDT is a psychological framework (refer to Figure 4) that elucidates the decision-making process in complex and uncertain scenarios. This theory suggests that individuals employ cognitive strategies, heuristics, and biases to streamline decision-making, thereby minimising the time and cognitive effort required (Takemura, 2021). The theory delineates three distinct categories of decision-making:

1. Decision-making under certainty explains situations where the outcome of selecting an alternative is known with certainty.
2. Decision-making under risk explains scenarios where the outcome of selecting an alternative carries a known probability.
3. Decision-making under uncertainty explains situations in which the probability of the outcome of selecting an alternative is not known.

Decision-making under uncertainty has two main categories: ambiguity and ignorance. Ambiguity occurs when the conditions and results are known, but the probabilities of these conditions and results are unknown. Ignorance happens when the elements of the set of states or results are unknown, leading to situations where the possibilities and consequences of adopting a social policy are also unknown.

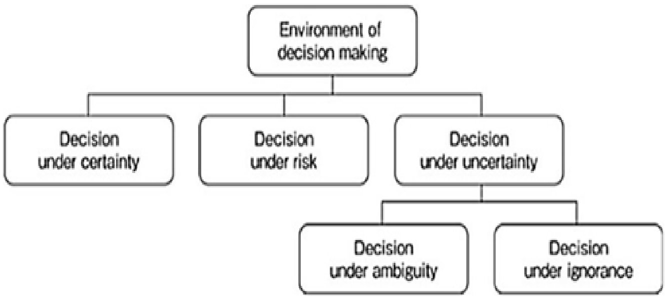

Figure 4: A framework showing BDT. Source: Takemura (2021).

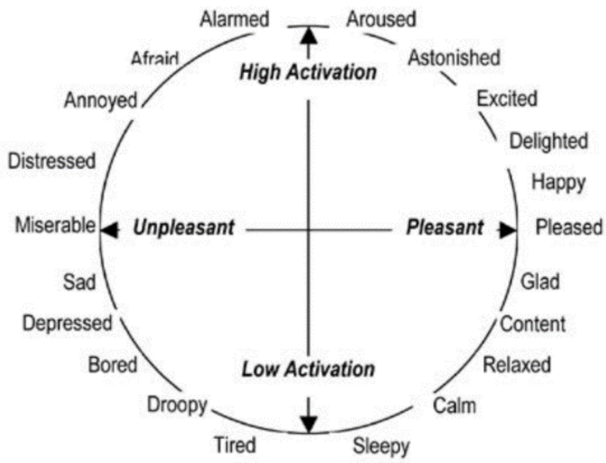

Figure 5: Circumplex model of affect. Source: Russell (1980, 2003)

The CMA, developed by Russell (1980) in 1980 and updated in 2003 (Russell, 2003), proposes that all emotional states can be described using two dimensions: valence and arousal (see Figure 5). Valence describes how pleasant or unpleasant an emotion is, while arousal refers to how intense or calm an emotion is. In this model, emotions are represented as points on a circular space where similar emotions are located close to each other while contrasting emotions are opposite. For instance, happy and sad are opposite emotions in the valence dimension, while tense and sleepy are opposite emotions in the arousal dimension. The model also distinguishes between core affect, the primary feeling at any moment, and prototypical emotion episodes, which are more complex and specific emotional experiences.

The study utilised Takemura's theoretical framework (2021) and Russell's circumplex model of affects (2003) to gain a comprehensive insight into decision-making environments. These theories offer a nuanced understanding of decisions made under various conditions, such as certainty, risk, and uncertainty, and also consider the impact of known and unknown outcome expectations on self-efficacy judgments. Additionally, the study integrated the PADM to explore how hazard proximity leads to hazard experience, which influences risk perception and subsequent hazard adjustment adoption. Moreover, the RAP was linked to decisions made under certainty and risk, shedding light on people's varying willingness to take risks for activities they choose to undertake versus those they are compelled to do due to perceived benefits. The study also highlighted the direct association between decision-making under risk and the EVM, which involves the evaluation of threat severity and likelihood. While the ACR model and VIT were not considered for this study, it is essential to note that ACR holds significance in understanding how individuals integrate emotions and reasoning for responding to risks.

3.3 Conceptualising Psychological-behavioural Framework

A conceptual framework (Figure 6) is designed based on theoretical underpinnings, such as BDT, PADM, RAP, EVM, CMA, and agent-based modelling. The framework shows the process of preparing a flood map based on agent-based modelling, which integrates a selected site's environmental and social data, such as land use/ land cover (LULC), topography, climatic data and demographic profile.

The flood map that considers environmental and social data allows us to identify potential flooding zones and vulnerable and risky areas using a geographical information system. Therefore, it is easier for us to identify the areas affected by floods or rising water levels. Environmental data includes remote sensing data, climate data and field observation data. In contrast, social data includes data from statistics departments and is gathered in the survey questionnaires (i.e., gender, income, age, and educational background).

The framework also demonstrates the predictive action of a person who experiences flood may adjust their acts based on the environment of decision-making theory. The environment in which decisions are made is the set of conditions that influence the process and outcome of making a choice. There are three primary types of decision-making environments: certainty, uncertainty, and risk. In a particular environment, the decision maker has all the relevant information available and can predict the consequences of each alternative. In an uncertain environment, the decision maker has incomplete, insufficient, or unreliable information and cannot estimate the probabilities of different outcomes. In a risky environment, the decision maker has some information but faces some uncertainty and must assess the likelihood of various scenarios. Different decision-making environments require different strategies and tools to cope with the challenges and opportunities they present.

Lastly, the framework explains the implications that can be measured based on psychological and emotional states and de facto economic loss. The psychological and emotional states can be assessed in terms of both positive and negative. Positive emotions include pleased, delighted, calm, and aroused. Negative emotions include misery, depression, fear, and tiredness. The economic loss explicates household loss, e.g., property damage, repairing, cleaning, and replacing damaged goods. The framework also shows the indirect impact on psychological emotional states, whether due to economic loss or decision-making

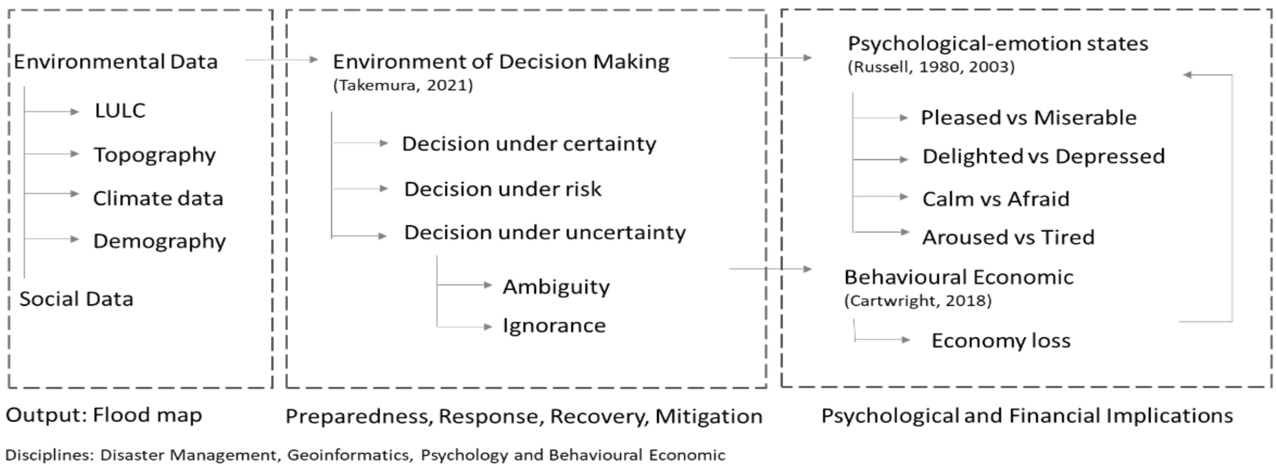

Figure 6: Psychological-behavioural framework to assess psychological and financial implications based on the decision-making environment.

4. CONCLUSION

The novelty of this research is mainly in presenting the behavioural-psychological patterns of the people affected by the flood. The theoretical contribution of this study is. First, we have proposed a novel integrated framework based on behavioural decision theory (BDT), Protective Action Decision Model (PADM), Rational Actor Paradigm (RAP), expectancy-valence models (EVM), circumplex model of affect (CMA), and agent-based modelling. To produce this framework, we have integrated theories and concepts from the field of psychology (environment of decision-making and emotional states), behavioural economics (estimating loss), geoinformatics (flood map), and disaster management (embedded in the environment of decision-making-preparedness, response, recovery, mitigation), which offer a holistic understanding of the human dimensions of flooding. It can help enhance risk communication, encourage proactive behaviours, reduce vulnerability, and enhance resilience. This framework generally shows how people react and what impacts it would bring based on their decisions. It may also help to estimate the actual loss for each household. For instance, we might anticipate that those who make uncertain decisions (not preparing or not bothering) will suffer a more significant loss in terms of money and escalated negative emotions. This framework helps inform how a person prepares, responds and reacts during a flooding event, which would lessen or worsen the condition; thereby, the people will be more aware and alert during the flooding season and remain resilient. Practically, it may help the stakeholders raise awareness or impart knowledge on floods to the people. Meanwhile, planners and decision-makers can comprehend actual human behaviour rather than relying on assumptions. Thus, interventions can be taken to reduce loss in social-economic aspects. Lastly, future studies can provide relevant case studies, especially in the east coast regions of Peninsular Malaysia, based on the conceptual framework developed.

REFERENCES

Altarawneh, L., Mackee, J., & Gajendran, T. (2018). The influence of cognitive and affective risk perceptions on flood preparedness intentions: A dual-process approach. Procedia Engineering, p. 212, 1203–1210.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioural change. Psychological Review, 84, 191-215. https://psycnet.apa.org/doi/10.1037/0033-295X.84.2.191

Becker, G., Aerts, J. C., & Huitema, D. (2014). Influence of flood risk perception and other factors on risk-reducing behaviour: a survey of municipalities along the R hine. Journal of Flood Risk Management, 7(1), 16-30. https://doi.org/10.1111/jfr3.12025

Bernama (2022, Dec 14). Kelantan, Pahang, Johor, Selangor listed as flood spots. Bernama. Retrieved from: https://www.bernama.com/en/general/news_disaster.php?id=2147824.

Chan, N. W., Ku Ruhana, K. M., & Mohd Zaini, A. K. (2016). Assessing Different Types of Flood Losses in Kelantan State in Malaysia during the December 2014 Flood. Proceedings of 1st International Conference on Society, Space, & Environment, 2016, 8–15.

Chen, A., Giese, M., & Chen, D. (2020). Flood impact on Mainland Southeast Asia between 1985 and 2018—The role of tropical cyclones. Journal of Flood Risk Management, 13(2), e12598.

Costabile, P., Costanzo, C., & Macchione, F. (2013). A storm event watershed model for surface runoff based on 2D fully dynamic wave equations. Hydrological processes, 27(4), 554-569.

Costabile, P., & Macchione, F. (2015). Enhancing river model set-up for 2-D dynamic flood modelling. Environmental Modelling & Software, 67, 89-107.

Chiang, W. H. (2005). 3D-Groundwater modeling with PMWIN: a simulation system for modeling groundwater flow and transport processes. Springer Science & Business Media.

De Dominicis, S., Crano, W. D., Ganucci Cancellieri, U., Mosco, B., Bonnes, M., Hohman, Z., & Bonaiuto, M. (2014). Vested interest and environmental risk communication: Improving willingness to cope with impending disasters. Journal of Applied Social Psychology, 44(5), 364-374. https://doi.org/10.1111/jasp.12229

Ejeta, L. T., Ardalan, A., & Paton, D. (2015). Application of behavioral theories to disaster and emergency health preparedness: A systematic review. PLoS currents, 7.

Guo, K., Guan, M., & Yu, D. (2021). Urban surface water flood modelling–a comprehensive review of current models and future challenges. Hydrology and Earth System Sciences, 25(5), 2843-2860.

Haer, T., Botzen, W. W., de Moel, H., & Aerts, J. C. (2017). Integrating household risk mitigation behavior in flood risk analysis: an agent-based model approach. Risk Analysis, 37(10), 1977-1992. https://doi.org/10.1111/risa.12740

Hung, H. C. (2009). The attitude towards flood insurance purchase when respondents' preferences are uncertain: a fuzzy approach. Journal of Risk Research, 12(2), 239-258.

Ibrahim, A., Bartsch, K., & Sharifi, E. (2020). Green infrastructure needs green governance: Lessons from Australia's largest integrated stormwater management project, the River Torrens Linear Park. Journal of Cleaner Production, 261, 121202.

Karki, T. K. (2020). Flood resilience in Malaysian cities: a case study of two towns in Johor state. International journal of disaster resilience in the built environment, 11(3), 329-342.

Khosravi, K., Pham, B.T., Chapi, K., Shirzadi, A., Shahabi, H., Revhaug, I., Prakash, I. and Bui, D.T. (2018). A comparative assessment of decision trees algorithms for flash flood susceptibility modeling at Haraz watershed, northern Iran. Science of the Total Environment, 627, pp.744-755.

Lekkas, D. F., Onof, C., Lee, M. J., & Baltas, E. A. (2004). Application of artificial neural networks for flood forecasting. Global Nest Journal, 6(3), 205-211. https://doi.org/10.30955/gnj.000305

Lechowska, E. (2022). Approaches in research on flood risk perception and their importance in flood risk management: a review. Nat Hazards 111, 2343–2378. https://doi.org/10.1007/s11069-021-05140-7

Liang, X., Lettenmaier, D. P., Wood, E. F., & Burges, S. J. (1994). A simple hydrologically based model of land surface water and energy fluxes for general circulation models. Journal of Geophysical Research: Atmospheres, 99(D7), 14415-14428.

Li, J., Qin, P., Quan, Y., & Tan-Soo, J. S. (2023). Using Protection Motivation Theory to examine information-seeking behaviors on climate change. Global Environmental Change, 81, 102698.

Lindell, M. K., & Perry, R. W. (2012). The protective action decision model: Theoretical modifications and additional evidence. Risk Analysis: An International Journal, 32(4), 616-632.

Makkeasorn, A., Chang, N. B., & Zhou, X. (2008). Short-term streamflow forecasting with global climate change implications–A comparative study between genetic programming and neural network models. Journal of Hydrology, 352(3-4), 336-354.

Nayak, P. C., Sudheer, K. P., Rangan, D. M., & Ramasastri, K. S. (2005). Short-term flood forecasting with a neurofuzzy model. Water Resources Research, 41(4).

Nazarpour, S., Gnecco, I., & Palla, A. (2023). Evaluating the Effectiveness of Bioretention Cells for Urban Stormwater Management: A Systematic Review. Water, 15(5), 913.

Nurumal, M. S., Aung, K. T., & Yusoff, N. S. M. (2017). Community experiences at the aftermath of flood disaster based on cultural context. Journal of Advanced Research in Social and Behavioural Sciences, 8(1), 89-96.

Peel, M. C., & McMahon, T. A. (2020). Historical development of rainfall-runoff modeling. Wiley Interdisciplinary Reviews: Water, 7(5), e1471. https://doi.org/10.1002/wat2.1471

Prashar, N., Lakra, H. S., Kaur, H., & Shaw, R. (2024). Urban flood resilience: mapping knowledge, trends and structure through bibliometric analysis. Environment, Development and Sustainability, 26(4), 8235-8265.

Russell, J. A. (1980). A circumplex model of affect. Journal of personality and social psychology, 39(6), 1161.

Russell, J. A. (2003). Core affect and the psychological construction of emotion. Psychological review, 110(1), 145.

Safiah Yusmah, M. Y., Bracken, L. J., Sahdan, Z., Norhaslina, H., Melasutra, M. D., Ghaffarianhoseini, A., ...& Shereen Farisha, A. S. (2020). Understanding urban flood vulnerability and resilience: a case study of Kuantan,Pahang, Malaysia. Natural Hazards, 101, 551-571.

Shu, C., & Ouarda, T. B. (2008). Regional flood frequency analysis at ungauged sites using the adaptive neuro-fuzzy inference system. Journal of Hydrology, 349(1-2), 31-43.

Takemura, K. (2021). Behavioral decision theory. Springer Singapore.

Tehrany, M. S., Pradhan, B., Mansor, S., & Ahmad, N. (2015). Flood susceptibility assessment using GIS-based support vector machine model with different kernel types. Catena, 125, 91-101.

Terpstra, T. (2011). Emotions, trust, and perceived risk: Affective and cognitive routes to flood preparedness behavior. Risk Analysis: An International Journal, 31(10), 1658-1675.

The Edge Markets (2022, Nov 24). Flooding caused overall losses of RM6.1b last year-DOSM. The Edge Markets. Retrieved from: https://www.theedgemarkets.com/article/flooding-caused-overall-losses-rm61b-last-year-%E2%80%94-dosm

The Straits Times (2021, Dec 20). Peninsular Malaysia hit by '1-in-100-year' rainfall, govt says amid severe flooding. The Straits Times. Retrieved from: https://www.straitstimes.com/asia/se-asia/malaysia-pm-ismail-mobilises-armed-forces-to-assist-with-flooding-more-rains-expected.

The Straits Times (2022, Dec 20). Flooding in Malaysia displaces over 66,000, 5 deaths reported. The Straits Times. Retrieved from: https://www.straitstimes.com/asia/se-asia/flooding-in-malaysia-displaces-over-56000-5-deaths-reported

The World Bank (2020). Population in the World. Retrieved from: https://datacommons.org/place/Earth?utm_medium=explore&mprop=count&popt=Person&hl=en

Wang, Z., Lai, C., Chen, X., Yang, B., Zhao, S., & Bai, X. (2015). Flood hazard risk assessment model based on random forest. Journal of Hydrology, 527, 1130-1141.

Widiasari, I. R., & Nugroho, L. E. (2017). Deep learning multilayer perceptron (MLP) for flood prediction model using wireless sensor network based hydrology time series data mining. In 2017 International Conference on Innovative and Creative Information Technology (ICITech) (pp. 1-5). IEEE.

Williams, D. M. (2010). Outcome expectancy and self-efficacy: Theoretical implications of an unresolved contradiction. Personality and Social Psychology Review, 14(4), 417-425.

Wilensky, U., & Rand, W. (2015). An introduction to agent-based modeling: modeling natural, social, and engineered complex systems with NetLogo. MIT Press.

Xia, X., Liang, Q., Ming, X., & Hou, J. (2017). An efficient and stable hydrodynamic model with novel source term discretization schemes for overland flow and flood simulations. Water Resources Research, 53(5), 3730-3759.

Yang, Q., Huang, X., Yang, J., & Liu, Y. (2021). The relationship between land surface temperature and artificial impervious surface fraction in 682 global cities: spatiotemporal variations and drivers. Environmental Research Letters, 16(2), 024032.

Yahaya, N. S., Lim, C.-S., Jamaluddin, U. A., & Pereira, J. J. (2015). The December 2014 flood in Kelantan: A post-event perspective. Warta Geologi, 41(3), 54–57.

Yeo, L. B., Said, I., Saito, K., & Ling, G. H. T. (2016). Conceptual framework of ecosystem services in landscape planning, Malaysia. International Journal of Built Environment and Sustainability, 3(3).

Zhai, G., & Ikeda, S. (2008). Empirical analysis of Japanese flood risk acceptability within multi-risk context. Natural Hazards and Earth System Sciences, 8(5), 1049-1066.

Zulkepli, N. A., & Mohd Idris, N. D. (2022). Identifying the research of flooding in Kelantan, Malaysia: A review. International Journal of Mechanical Engineering, 7(4), 430.

