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Where does flood resilience grow? the flood environmental management and socioeconomic configurations of the smart environment model

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Abstract. The most common natural hazard in the world, flooding often damages Indonesia's economy and claims many lives and properties. This article explores the significance of flood environmental management and socioeconomic configurations to flood resilience. The Smart Environment Model (SEM) helps understand the flow of the theoretical framework of flood reliance growth. Methodology in this research uses the quantitative method with independent sample two tests to analyze different patterns of flood experience in Malang City. The Multinomial Logistic Regression statistical analysis is used to evaluate causal models in Smart Environment Model. The Smart Environment Model provides a framework for methodically analyzing flood learning from various events (socioeconomic and smart environment) to demonstrate how to apply the SEM model and as an initial attempt to explore the question, of the linking between environmental flood management and flood resilience. These two environments are characterized by contrasting levels of flood resistance. There are differences between these two village flood resistance, Glintung Village and Sukun Village. The result shows that the SEM model has factors that are socio-economics, smart learning environment, and ecological path which have a significant impact on flood environment management. On the other hand, external factors including mitigation and preparation, have a significant in flood resilience that have subsequently in flood environmental management patterns. The linking flood environmental management and Socioeconomic to nurture flood resilience in the Face of Climate Change.

1. Introduction

Flooding was the most frequent natural hazard in the world. It frequently results in fatalities and significant property losses, and economic damage in Indonesia. The economic damage expected from

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floods will affect households differently across income levels [13]. In the social-ecological resilience literature, it is widely stated that natural shocks can lead into learning process. Learning process is an inherent environmental dynamics that play an essential social-ecological resilience [9]. On the other hand, intelligent environments are becoming a reality in our society. The number of intelligent devices which integrated into these spaces is overgrowing. This article describes how the relationship between the ability of a smart person and a competent learning environment as a component of flood environmental management, and flood resilience.

Flood management and flood resilience are very important to establish a safe, comfortable, and sustainable city in economic, social, and environmental terms. Malang City is one of the cities in Indonesia that has a level of comfort and is relatively safe compare to other cities. However, Malang City has regular floods at several points, during the rainy season. Standart operational procedure of mitigation is already implemented. Unfortunately, the mitigation procedure was not running optimally. Therefore, a smart environment is needed which is the formation of a livable city and environment through various facilities that can provide comfort and convenience to the community especially to face the threat of disasters in the future.

Innovative applications of Smart Environment Model (SEM) should be implemented to connect environmental ecological management with the behaviour of local community. At first, the existing research on flood resilience considered as idea of learning. Then,we describe the concept of flood resilience before elaborating it on the SEM model. We apply the Smart Enviroment Model to examine the learning process in two different location. The examine will theoretically show that diverse in an environmental floodgate management strategies can affect flood resistance in various ways. Finally, a justification of the connection between fostering flood resilience and flood environmental management as a shield against climate change and environmental flood control.

2. Methods

2.1 Material and Method

An alternative strategy for managing natural disasters was adaptive flood environmental management [9]. It was a systematic process of improving management policies and practices by learning from the outcomes of management strategies that have already been implemented [17]. The existing research indicates there is a connection between learning and adaptation. First, learning will increase knowledge, which leads to an improvement in flexibility [23]. While, adaptability is enhance by the accumulation and testing of knowledge through learning [5]. Second, learning is a crucial process for maintaining the system capability to evolve. While, adaptability necessitates learning ability. Learning represent smart people and Adaptability represent smart environment. An essential element of adaptability or a smart environment is the capacity to learn from experience [8]. Despite currently community has flood-adaptive strategies, it will lack of adaptability if it does not keep changing flood-adaptive indicator in response to flood danger.

Transformability defined as the potential to modify flood management and other systems (smart people, smart environment, and ecological evaluation) to promote flood resilience. It is necessary for a community that lacks flood resilience. There are diverse definition of flood resilience. Flood resilience is the ability to use flood control facilities, such as levees, floodwalls, dams, piped drainage networks, and pumping stations, as well as temporary emergency flood-fighting measures, to prevent flood occurs in an area that is naturally prone to flooding [9]. Research by Morrison et al., 2018 and Dieperink et al., 2018 makes a clear case of flood resilience depends on flood risk management. According to Sorensen et al. [3], flood resilience refers to the capacity to prepare for, respond to, reorganize, and learn from floods. Additionally, Zevenbergen et al. [24] defines flood resilience as the capacity to cope with the danger, recover from it, and quickly restructure after it.

2.2 Data Collection

The quantitative methodology with independent two-sample test is used for explain different patterns of flood experience in Malang city. Multinomial logistic regression is used for evaluate causal models in Smart Environment Model (SEM). In an initial attempt to investigate the relationship between flood environmental management and flood resilience, the Smart Environment Model (SEM) serves as a framework to understand learning process and adaptability from various flood experiences. SEM model also serves as an analytical framework to discuss the learning processes in two different environments. Levels of flood resistance distinguish between these two environments, i.e: (1) Glintung Village, a well-protected environment, where is a high flood resistance; and (2) Sukun Village, there is no protection and low flood resistance (Regional Disaster Management Regency of Malang City/Badan Penanggulangan Bencana Daerah, 2021).

The data obtained from the study were analyze with SPSS software. The number of respondent is 30 respondents. The nominal dependent variable of the study was the level of flood management and level of flood resistance. The level of flood management is based on mitigation, preparation, response, and recovery. While, the level of flood resistance is based on flood ability, recoverability, adaptability, and transformability. The description of the variables was organized in Table 1:

TABLE 1. The description of variables in the flood management

Variables	Alternatives	n	Marginal Percentage
Flood management	1: Very low flood management	2	6.7%
	2: Low flood management	7	23.3%
	3: Medium flood management	6	20.0%
	4: High flood management	8	26.7%
	5: Very high flood management	7	23.3%
Education	Elementary School	1	3.3%
	Junior High School	4	13.3%
	Senior High School	21	70.0%
	College	4	13.3%
Social learning	No	6	20.0%
	Yes	24	80.0%
learning opportunity	No	17	56.7%
	Yes	13	43.3%
information	No	9	30.0%
	Yes	21	70.0%
social capital	No	9	30.0%
	Yes	21	70.0%
policy barriers	No	10	33.3%
	Yes	20	66.7%
flood regime	No	11	36.7%
	Yes	19	63.3%
flood impact	No	13	43.3%
	Yes	17	56.7%
location	Low flood resistance	15	50.0%
	High flood resistance	15	50.0%

TABLE 2. The description of variables in flood resilience

Variables	Alternatives	n	Marginal Percentage
flood resilience	Low flood resilience	5	16.7%
	Medium flood resilience	12	40.0%
	High flood resilience	8	26.7%
	Very high flood resilience	5	16.7%
mitigation	Yes	11	36.7%

	No	19	63.3%
preparation	Yes	12	40.0%
	No	18	60.0%
response	Yes	15	50.0%
	No	15	50.0%
recovery	Yes	11	36.7%
	No	19	63.3%

2.3 Multinomial Logistic Regression Model

The multinomial logistic regression model is an extension of the binomial logistic distribution for the category and is used when the dependent variables are more than two discrete, non-ordered categories with nominal features. Therefore, following the creation of the multinomial regression model, the parameters are utilized to forecast the likelihood of an event occurring in comparison to the reference category. In this scenario, the study sought to determine the effect of changes in the independent variables listed above on the probability of the variable in Equation (1) denoted as:

$$P(Y = j/X1, X2, :::, Xk) = P(Y = j/K); j = 0, 1, :::, J \quad (1)$$

Response probabilities were modeled in Equations (2) and (3) as in the multinomial case:

$$P\ (Y = j/X) = \frac{\exp(X\beta_j)}{1+\sum_{h=1}^{j}\exp(X\beta_h)} = pj\ (X, \beta); J = 1, \dots, J \quad (2)$$

$$P\ (Y = 0/X) = \frac{1}{1+\sum_{h=1}^{j}\exp(X\beta_h)} = po\ (X, \beta) \quad (3)$$

Equation describes the use of maximum likelihood to estimate multinomial logit models, where the logarithm of the likelihood function typically yields consistent and asymptotically normal estimators (4).

$$I(\beta) = \sum_{i=1}^{n}\sum_{j=0}^{j} 1\ [Yi = j] \log[pj\ (X_{i,}, \beta] \quad (4)$$

3. Results and Discussion

There are three results from this study i.e.: flood management, flood resilience, and correlation between flood management and resilience. The results of the study is described as follows:

3.1 Multinomial Logistic Regression for Flood Environment Management

The chi-squared ratio test for the fitted model data got a score of 70.370 ($p = 0.000$), suggesting a satisfactory model fit. Additionally, acceptable results for the pseudo R-squared (Cox and Snell: 0.891, Nagelkerke: 0.952). Because our logistic multinomial model accurately classified 86.7% of the existing observations and can be counted on to project future estimations. Table 3 displays the likelihood ratio tests for the model's effects a partial, whose small p-values demonstrate the significant relation of the model's variables.

TABLE 3. The power classification of flood management

Observed	Predicted				
	low flood management	medium flood management	high flood management	very high flood management	Percent Correct
low flood management	7	0	2	0	77.8%
medium flood management	0	5	1	0	83.3%
high flood management	0	0	8	0	100.0%
Very high flood management	0	0	1	6	85.7%
Overall Percentage	23.3%	16.7%	40.0%	20.0%	86.7%

TABLE 4. Likelihood ratio tests

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	65.781	107.817	5.781	.000	0	.
education	79.519	117.352	25.519	19.739	3	.000
Social learning	60.827	98.660	6.827	1.046	3	.790
learning_opportunity	66.511	104.343	12.	6.730	3	.051
information	83.944	121.776	29.944	24.163	3	.000
social_capital	77.990	115.823	23.990	18.210	3	.000
policy_barriers	79.192	117.024	25.192	19.411	3	.000
flood_regime	67.882	105.714	13.882	8.101	3	.044
flood_impact	72.679	110.512	18.679	12.899	3	.005
location	63.600	101.432	9.600	3.819	3	.002

3.2 Influencing factors

3.2.1 Education

Regarding the likelihood ratio test, the education variable has a positive significance to flood management. The completion of the educational level was relevant for the perceptions of the country's preparedness it human capital (smart people) for natural hazards like flooding. Education is an individual learning that occurs when an individual transforms flood experience into flood-related knowledge [19]. According to the notion of experiential learning, knowledge is acquired through four stages: tangible experience, reflective observation, abstract conceptualization, and active experimentation [9].

3.2.2 Social learning

The result of the social learning variable has not significant to flood management. The discussion in the previous literature, which is an expanding body of empirical literature that addresses case studies in individual and comparative settings, centers on the relative significance of various contextual elements in shaping the process and consequences of social learning. Medema et al. [12] and Pahl-Wostl ([18] contend that the governance framework in which learning processes are integrated has a significant impact on such processes. The relevant organizational and legal framework, as well as the social and cultural context, are all part of the governance system. Learning can take place at several levels of agent interaction because social learning can be thought of as a multiscale process. The macro-level is the social level of the governing framework. The actor-network level is the meso-level, or organized stakeholder groups.

3.2.3 Learning opportunity
The opportunity to participate directly in a flood, to be in the floodwater, to clean up after a flood, and to take action to control a flood are examples of learning opportunities. Shorter psychological distances or greater trust can both help to foster the exchange of flood-related knowledge within the community, which is a learning opportunity [10]. Flood frequency affects the learning opportunity by determining the likelihood of practicing flood environmental management. Since intensive training is required to withstand the flooding, higher flood frequency is advantageous for learning. According to Brilly and Polic, residents whose areas often flood have better knowledge about floods than those who live in rarely flooded areas, who may simply ignore the threat of flooding.

3.2.4 Information
The ability to put flood-related knowledge into practice is hampered by a variety of obstacles. The availability of knowledge and resources is one hurdle. Lack of a flood warning system could result in delayed and ineffective action if individuals are aware of the risk of flooding. It has been observed in some cases that those who are not receive a warning prior to a flood frequently neglect to relocate their belongings to safer regions and as a result sustain bigger flood losses than those who did [19]. Thus, the information dimension becomes important for preparing and mitigating when heavy rains occur which have the potential to cause floods and landslides. The government can give information in the form of an alarm sound or the sound of a fire car that used as a symbol when a flood occurs.

3.2.5 Social capital
Social networks such as: social norms, and trust are all components of social capital that can influence both individual and group behaviour. On the other hand, "*social capital*" refers to connectivity-based trust standards. Social interactions, networks, and affiliations that produce shared knowledge, mutual trust, social norms, and unwritten rules are known as social capital. Social capital also refers to informal institutions and organizations. According to a study, those living in a neighbourhood with low social capital were less willing to work together with their neighbours and recovered more slowly than those are living in a neighbourhood with high social capital [4].

3.2.6 Policy barriers
Policy barriers variable has positive and significant to flood management. The policy barriers in Glintung Village area enforce every citizen to have plants if they want to process document letter in the Rukun Warga (*RW).* This policy obstacle will indirectly make the people in Glintung Village area care about their environment. Path dependence can limit any new flood management action due to the propensity of the prior policies of a certain direction to restrict the development of future policies in the same direction (Pierson, 2000). Path dependency can also lead to public expectations that the government will continue to implement the same flood management strategy, which can limit the use of new flood-related knowledge [22].

3.2.7 Flood regime and flood impact
Flood impact and flood regime are factors that affect flood experience. The effects of a flood on a person or a society could be beneficial, bothersome, or disastrous. Additionally, different flood regimes could provide various flood experiences. The term "*flood regime*" describes various aspects of flooding, including its frequency, diversity, magnitude, timing, length, rate of change, etc. For instance, experiencing lengthy flooding frequently differs greatly from experiencing flash flooding infrequently.

3.2.8 Location
The samples used in this study originated from two unique background areas: high flood environmental management and low flood environmental management. Flood control infrastructure that fulfills safety design criteria and a well-protected environment safeguard people. Such a scenario is widespread; in fact, most significant cities throughout the world are well-protected, making floods much less common than they would have been otherwise. It is well recognized that a lack of knowledge of flood hazards

can be induced by overconfidence in flood control infrastructure [11]. While it may appear uncomfortable, an unprotected and regularly flooded environment is advantageous for learning. Because a centralized mitigation solution, such as flood control infrastructure, property-level actions must be taken to survive. It implies a greater desire to learn about flood mitigation. In the unprotected Sukun Village, local society often believe that they are completely responsible for flood protection, as opposed to the government. Furthermore, floods occur naturally and far more frequently in vulnerable areas than in well-protected areas. This means more flood experiences and, as a result, more learning opportunities. However, because of flood adaptation techniques, the majority of floods experienced are harmless.

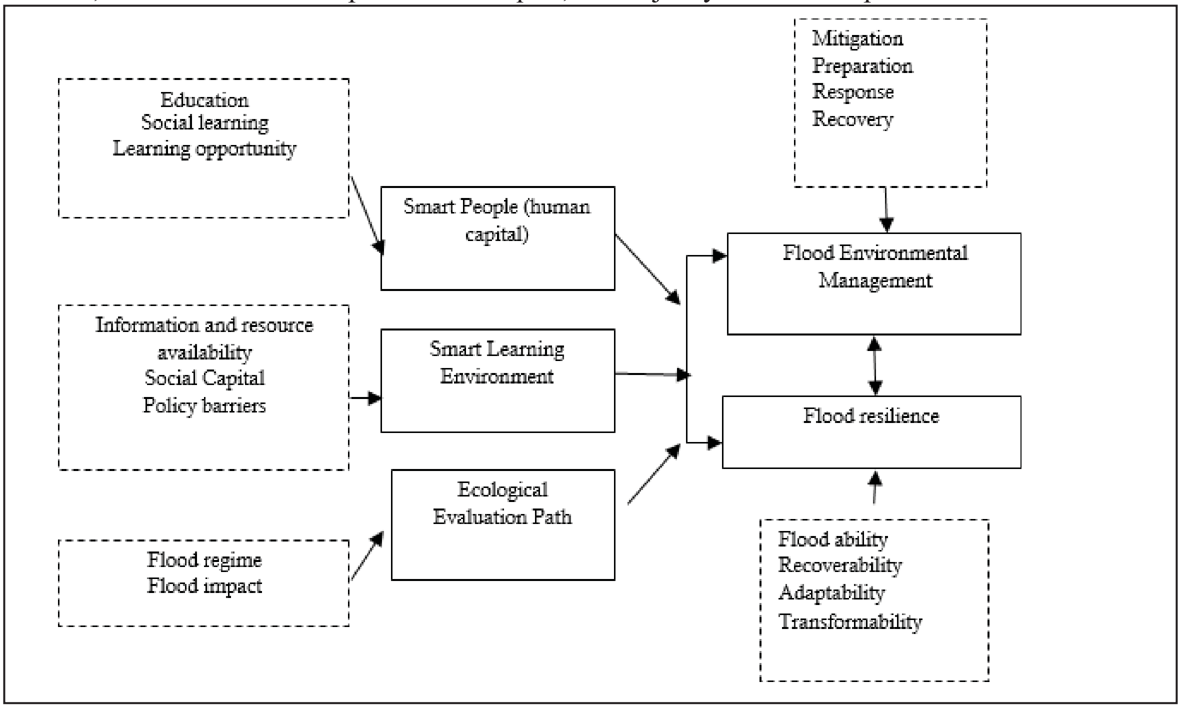

FIGURE 1. The smart environment model (SEM)

3.3 Multinomial Logistic Regression for Flood Resilience

TABLE 5. The power classification of flood resilience

Observed	Predicted				
	Low flood resistance	Medium flood resistance	High flood resistance	Very high flood resistance	Percent Correct
Low flood resilience	3	2	0	0	60.0%
Medium flood resilience	0	12	0	0	100.0%
High flood resilience	0	0	8	0	100.0%
Very high flood resilience	0	2	3	0	0.0%
Overall Percentage	10.0%	53.3%	36.7%	0.0%	76.7%

TABLE 6. Likelihood ratio tests of flood resilience

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	37.687	58.705	7.687[a]	.000	0	.
mitigation	47.530	64.344	23.530	15.842	3	.001

preparation	62.785	79.600	38.785	31.098	3	.000
response	38.118	54.933	14.118	6.431	3	.092
recovery	36.531	53.345	12.531	4.843	3	.184

3.3.1 Towards flood Resilience

According to the preliminary study presented above, various flood experience patterns resulting from various contexts can have various effects on flood resilience through external factors (mitigation, preparation, response, and recovery). The terms "mitigation," "preparation," "response," and "recovery" all refer to different types of actions that can be taken to minimize the effects of flooding. Mitigation refers to long-term solutions, while preparation, response, and recovery refer to immediate actions that can be taken to minimize the effects of flooding when they are anticipated to be unworkable. Knowledge about floods may also lead to changes that are not directly related to flooding control. Additionally, it might lead to other institutional, social, or economic changes [9]. Flood mitigation that is based on learning encourages civic engagement to boost learning motivation. In the industrialized world, it has long been assumed that the government bears primary responsibility for flood control [16]. The idea of flood risk management has been used to acknowledge the significance of shared responsibility between the government and citizens [6]. The perception of one's own duty might enhance people's willingness to conduct flood mitigation and preparation measures, learning-based flood mitigation focuses more on citizens' responsibilities [15].

3.4 The Correlation of Flood Environmental Management and Flood Resilience

Based on Table 7, Four types were identified by the spearman correlation's findings. The association between "mitigation" and flood capacity comes first. The relationship between "Preparation" and recovery comes in second. The "Response" variable, which has the potential to recover and flood, is the third. Lastly, transformability with adaptation. As previously argued, it is still widely accepted that flooding must be avoided in the first place for flood ability, despite significant conceptual changes in flood management. People are always learning by doing as they are obliged to make preparations for every flood. Each flood experience adds to the knowledge they already have about preparedness and reaction because their past understanding of flood prevention is dominated by property-level measures. Flood mitigation and adaptation also produce flood-related knowledge that is challenging to learn in an environment with adequate protection.

TABLE 7. The correlations the flood management and flood resilience

		mitigation	preparation	response	recovery	flood ability	recoverability	adaptability
mitigation	Correl. coev	1.000	-.198	.346	-.005	.709**	-.198	.010
preparation	Correl. coev	-.198	1.000	.272	.367*	-.089	.306	.123
response	Correl. coev	.346	.272	1.000	.484**	.364*	.000	.000
recovery	Correl. coev	-.005	.367*	.484**	1.000	.106	.085	-.302
flood ability	Correl. coev	.709**	-.089	.364*	.106	1.000	.059	-.066
recoverability	Correl. coev	-.198	.306	.000	.085	.059	1.000	.123
adaptability	Correl. coev	.010	.123	.000	-.302	-.066	.123	1.000
transformability	Correl. coev	.196	-.144	.000	-.245	.154	.000	.373*

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed).

4. Conclusion

The Smart Environment Model (SEM) builds forth the theoretical connections between intelligent individuals (human capital), a smart learning environment, and an ecological approach to managing the flood environment. The learning process of smart people, a smart environment, ecology and how it influences flood environmental management and flood resilience may be systematically examined using this as an analytical framework. To assess the learning processes under various flood mitigation plans with varying levels of flood resistance and to understand their possible effects on flood resilience, empirical investigations using the SEM model might be helpful. In order to determine whether the learning process is consistent, it would also be crucial to research various cities or towns with comparable levels of flood resilience. Researchers could describe each case's flood experience in terms of flood regime and flood impact before looking at the contributing factors (education, learning opportunity, information, social capital, and policy barrier). In the future research, the association among flood resistance, flood ability, recoverability, adaptability, and transformability could be investigated further.

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