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# Climate Change & Home Location Preferences in Flood Prone Areas of Bojonegoro Regency

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**Abstract**

Climate change has already happened in Indonesia; as strong evidence of the climatic events is flooding that frequently happened. Flooding frequencies in Bengawan Solo River Side Buffer of Bojonegoro Regency are relatively high, about 16 flooding events in 2010. Because of the flooding, government of Bojonegoro Regency built levees for flood protection. About 1.100 houses were built in Bengawan Solo River Side Buffer which is vulnerable to flooding every year, outside the protected area and the space between houses and the river is about 1 to 5 meters in average. The interesting part of this phenomenon is that people decide to choose their home locations outside the protected area, and this happens from generation to generation. The research questions are formulated as: (1) How is the vulnerability in the flood prone area? (2) What is the most influencing factor of the home location decision making in the flood prone areas? The method to answer the first research question was the vulnerability index and the second research question was answered with Structural Equation Model (SEM). Vulnerability analysis showed that Jetak hamlet, Klangon hamlet, LedokWetan and LedokKulon and Banjarejo hamlet are high vulnerability areas. Some factors that influenced the decision to choose home location in the flood prone areas in low vulnerability are shell, especially in the disaster evacuation path (X22). For the medium vulnerability type, the most influence variable is society focused on law and administration (X16). In high vulnerability, the regression model explains that the most influential parameter from the society variable is the membership and activity of the inhabitants in social organizations (X11).


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## 1. Introduction

Most coastal and river oriented cities in Asia, including Indonesia, are threatened by climate change. This is indicated by high frequency of hazard of climatic events, such as flooding, intensive storms, rising sea level, and storm surges, which, in turn, may result in large loses of life and infrastructure, as well as damage to national and regional economies [1]. Bojonegoro is one of the river-oriented regencies in East Java, Indonesia that are threatened by climate change. One of Bengawan Solo river basin subsystems is in Bojonegoro regency. The frequency of flooding in the area is relatively high; in 2010, there were 16 flooding events; it made the area become flood prone area [2]. The real threat of climate change is felt by society as routine floods occur every rainy season. The tendency in recent years is that the community perceived the impact of these issues increasingly by its intensity and frequency. It is also caused by changes in rainfall patterns. Based on the research of Naylor [3], this is the result of global climate change. Changed rainfall patterns are characterized by the delay of rainy season, while the end of the rainy season occurs sooner. On the other hand, although the rainy season is shorter, the intensity is very high. This will affect areas, such as river-based Bojonegoro district. This will threaten the existence of the settlements that are outside of the protected area.

From the early 70's, the government built levees along the river to protect the city from the flood. However, in advance, in the 70s and 80s, with the urbanization growth, especially in Bojonegoro District, people decided to open the levees to make access and to live in the riverside buffer outside the protected area. Now, the area is developed into settlements with 1,100 houses and about 1,300 families in the flood prone area (Fig. 1 and Fig.2). The density trend of the settlement has been increasing for the past 10 years. The settlement is equipped with infrastructures, such as streets, electricity, water, and public facilities (health and education facilities); some were provided independently by the community and some were by the government. Bojonegoro Spatial Planning Document (RTRW) 2011-2031 stated that this area is a vulnerable area and it is a high controlled area [4]. However, the law enforcement in the regency is weak so that the planning document is not well implemented; thus, the government needs to find a solution to this problem immediately. To find the solution, the government needs to recognize the reason of why the inhabitants in the flood prone area decided to live in the area.

Fig. 1 The Settlement in the flood prone area and the condition when the flood happened (2010)

The existence of social tie among individuals in the research area might drive them to keep staying in the area, which is categorized as the flood prone area. A collective action might make inhabitants have ability to live within this circumstance for a long period. In rainy season, they will work together to prevent and protect their living environment from the flood disaster voluntarily. Even more, some residents renovate their house in the shape of low-rise house in order to adapt in flooding condition, and their neighbors for the previous house or even for the new one follow it. These circumstances might illustrate that decision-making process to choose house location is a representative of: (i) human behavior which is embedded in networks of interpersonal relationships [5] and (ii) the choice of individuals which are determined by the influence from others as well as by reaction to the constraints and opportunities imposed by social system [6]. For such reason, this research developed a hypothesis that a household with better community ties may have higher influence in decision making for choosing home location in the flood prone area.

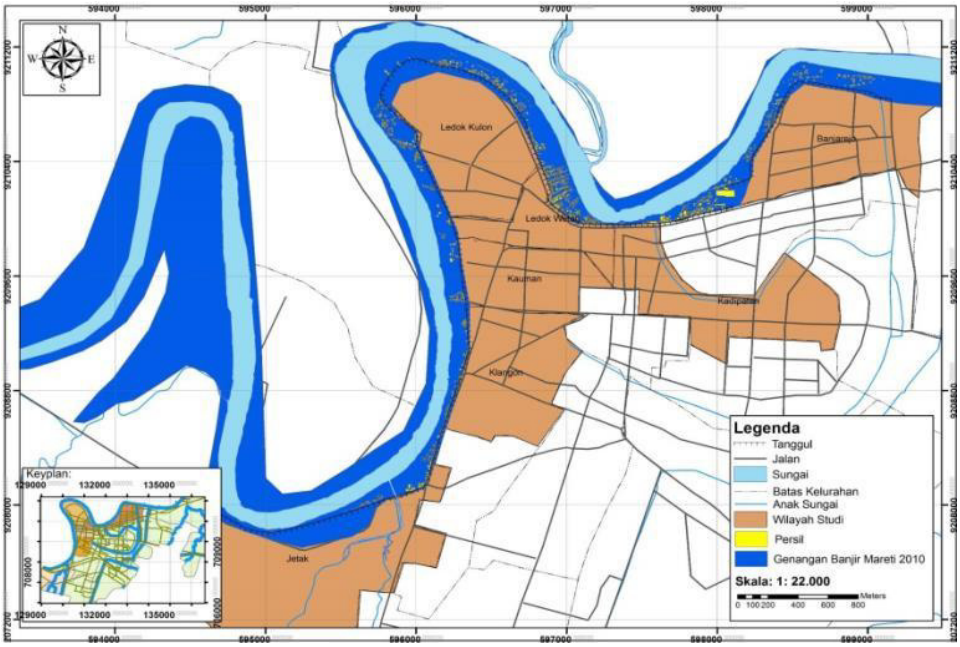


Fig. 2 Map of the flood prone area and the settlement developed in front of the levee.

A lot of government policies are not suitable with the needs of the society; thus, the policies or programs cannot be implemented successfully. This might be caused by inappropriate formulation of policy and planning program that are not based on the needs and social cultural considerations. Therefore, it is indispensable to dig deeper on how decision-making for choosing home location is made by the inhabitants in the research area.

Previous research in the Bojonegoro Regency, especially in Bojonegoro District (Kecamatan), has been done by Ratna in 2009. Basically, the research was focused on the flooding problem of the area. She studied the influence of development of land use pattern with the run off debit; the result of this research emphasized that there was a correlation between the land use change and the runoff debit [7]. This research was on the development of the previous research, focusing on social aspect of the home location preference.

The topic of climate change and social aspect has been established by some researchers. Adger highlighted that social vulnerability was important to study because social aspect is largely underemphasized in assessments of the impacts of climate change and climate extremes [8]. Vulnerability was defined in his research as the exposure of individuals or collective groups to livelihood stress as a result of the impacts of such environmental change. It was constituted by individual and collective aspects which could be disaggregated but are linked through the political economy of markets and institutions. Adger developed the social aspect more profound in the social collective action, and its connection to climate change adaptation [9]. Future changes in climate pose significant challenges for society and, not the least, how to adapt IN observed and potential future impacts of these changes best to which the world is already committed. Adaptation is a dynamic social process: the ability of societies to adapt is determined, in part, by the ability to act collectively. From Adger's research, the main focus was on social vulnerability and social collective action; this research was to enrich the knowledge of reconstructing how the pattern of decision making process of the inhabitants to live in the climate change prone area of Bojonegoro District was.

Based on the identification of the problem and the previous research, there were three main research questions as follow:

- How is the vulnerability in the flood prone area?
- What is the most influencing factor of the home location decision making in the flood prone areas?

## 2. Methodology

Vulnerability analysis methods are used to analyze areas vulnerability by finding the Overall Vulnerability Index areas based on the result of physical vulnerability index, social vulnerability index, economic vulnerability index, and infrastructure vulnerability index [10]. The parameters for physical vulnerability index were geology, topography, erosion and flood frequency. Observed parameters for social vulnerability index were population density, age group, education level, building density, and health level. Economic vulnerability index was measured from level of income, occupation, poverty, and jobless parameters. The parameters for infrastructure vulnerability index were public facilities, and transportation networks.

$$Vul_i^{\,o} = \frac{Vul_i^{\,phy} + Vul_i^{\,soc} + Vul_i^{\,Eco} + Vul_i^{\,Inf}}{4} \quad (1)$$

$Vul_i^{o}$ = Total Areas Vulnerability Index
$Vul_i^{phy}$ = Physical Vulnerability Index
$Vul_i^{soc}$ = Social Vulnerability Index
$Vul_i^{Eco}$ = Economic Vulnerability Index
$Vul_i^{Inf}$ = Infrastructure Vulnerability Index

The methodology for the second research questions was structural equation modeling (SEM) which was a collection of statistical techniques that allowed a set of relationships between one or more independent variables (IVs), either continuous or discrete, and one or more dependent variables (DVs), either continuous or discrete to be examined. Both IVs and DVs could be either factors or measured variables. Structural equation modeling was also referred to as causal modeling, causal analysis, simultaneous equation modeling, analysis of covariance structures, path analysis, or confirmatory factor analysis [11].

Employing the SEM would construct a decision-making for home location model of the inhabitants in the flood prone area of Bojonegoro district based on the five elements of Ekistics Theory developed by Doxiadis in 1964 [12] as the independent variables (X). The first element was nature covering geologic Resources (X1), topography resource (X2), soil resource (X3), water resource (x4), and climate (X5). The second element was man that consisted of biological feeds (X6), sensation and perception (X7), emotional feeds (X8), and moral values (X9). The third element was society encompassing population composition (X10), social organization (X11), and cultural patterns (X12), economic developments (X13), education (X14), health (X15), and law and administration (X16). The fourth element was shell covering housing (X17), community services (X18), shopping centers and markets (X19), recreational facilities (X20), small scale household industry (X21), and transportation services connected with disaster evacuation path. Lastly, the fifth element was network encompassing water supply (X23), power supply (X24), transportation systems (X25), communication systems (X26), sewerage and drainage (X27), and solid waste (X28). The dependent variables (Y) were also adopted from Doxiadis 5 Settlement Principles [12].

## 3. Field Survey Design

The research area covered six villages and 1,100 houses. From the first research question, it would define three types of vulnerability areas/hamlets as high, medium, and low hamlets. In this sense, this research would group the samples based on the three types of hamlets. Also, the size of samples was narrowed with some criteria, such as: (a) representative respondents in the flood prone area which were outside of the protected area; (b) the length of stay and the age of the houses in one century in 25 years periods; also, (c) the representative respondents were the heads of household that could be the husband or the wife in order to describe the role of gender on how decision-making for home location was made in the household level. By using 5% degree of error, the size of sample was about 294 households.

The survey design for this research was conducted in two steps of field surveys; first survey was observational survey to understand the situation of the study area and to develop attribute data through community profiling and asset mapping. The second survey was planned to build the model for the second research questions which were

Structural Equation Model (SEM). As mentioned above, the sample size was 300 samples. The questionnaire was household questionnaire to understand structural social capital and housing characteristic. This questionnaire was basically developed from the Doxiadis's Ekistics [12] which was nature, man, society, shell and network. From the SEM Model, we could conclude what was the most influencing element for home location decision, whether man or society elements which were bigger among other elements for each vulnerability typologies. The research framework can be observed as follows (Fig. 3).

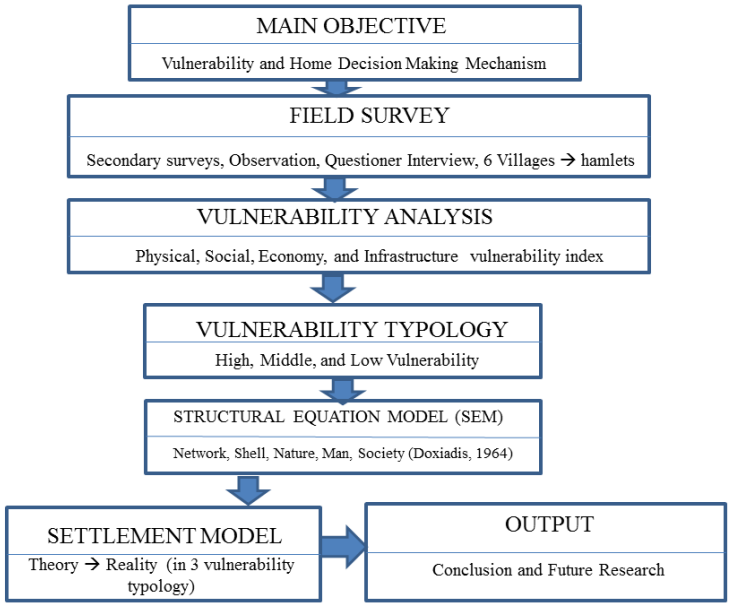


Fig. 3 Research framework.

## 4. Vulnerability

Vulnerability analysis showed that 12 hamlets in Jetak, Klangon, Ledok Wetan, Ledok Kulon and Banjarejo Village were high vulnerability areas. Medium vulnerability hamlets were 12 hamlets in Jetak, Kauman, LedokWetan, Ledok Kulon and Banjarejo Village. The low vulnerability hamlets were in 9 hamlets in Klangon, Kauman, and Banjarejo Village

Table 1. Total sampel of the respondent based on Vulnerability Index Clasification

| Vulnerability | Kelurahan(Village) | RT/RW (Hamlets) | Sample |
|---|---|---|---|
| High | Jetak | RW 1 RT 1, RT 2, RT 3 | |
| | Klangon | RW 2 RT 8 | |
| | Ledok Wetan | RW 1 RT 2, RW 1 RT 4 , RW RT 6, RW1 RT 7 | 119 |
| | Ledok Kulon | RW 3 RT 5, RW 4 RT 2, RW 4 RT 3 | |
| | Banjarejo | RW 1 RT 3 | |
| Medium | Jetak | RW 1RT 4, RW 1 RT 5 | |
| | Ledok Wetan | RW 1 RT 1, RW 1 RT 3 | |
| | Ledok Kulon | RW 1 RT 1, RW 2 RT 5, RW 3 RT 1, RW 3 RT 2, RW 4 RT 4 | 112 |
| | Banjarejo | RW 1 RT6 , RW 1 RT 7 | |
| | Kauman | RW 2 RT 11 | |
| Low | Klangon | RW 1 RT 1 | |
| | Ledok Wetan | RW 2 RT 10 | 69 |
| | Banjarejo | RW 1 RT 1 RT 2, and RT 5, RW 2 RT 9, RT 22, and RT 23, | |
| | Kauman | RW 2 RT 10 | |
| Total | | | 300 |

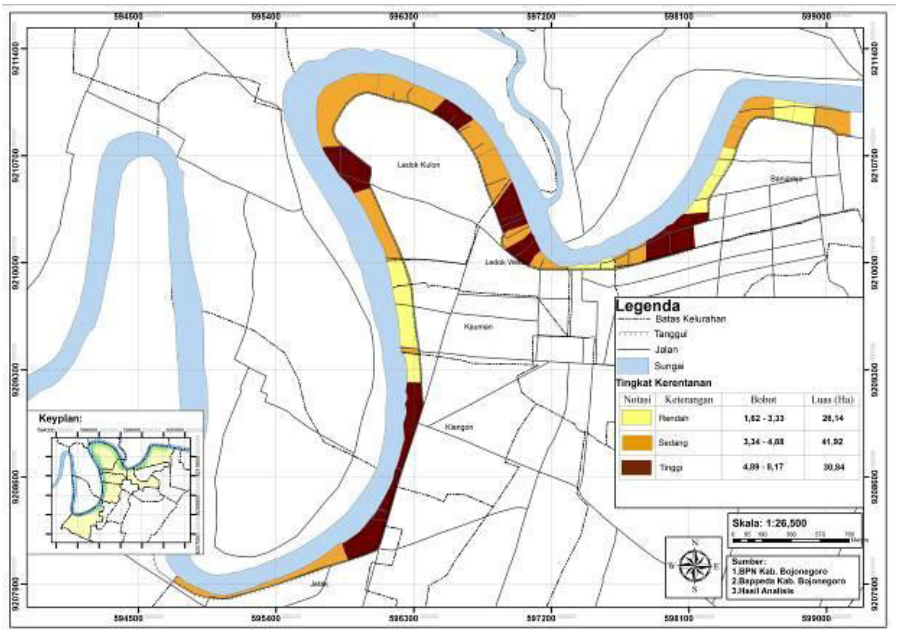


Fig. 4 Map of the vulnerability area (low, medium and high)

## 5. Structural Equation Model (SEM)

### *5.1. Low Vulnerability Type*

The medium vulnerability type, SEM estimation, can be viewed in Fig. 4 and the regression model is shown below

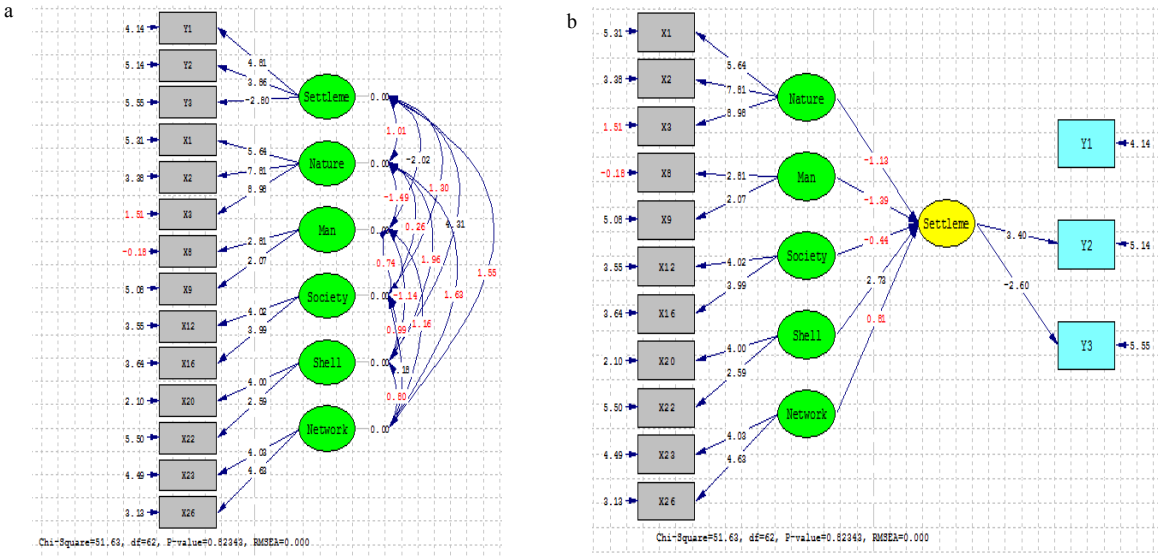


Fig. 5 (a) Confirmatory factor analysis and (b) Structural model for low vulnerability settlement type

Settlement = - 0.36*Nature - 0.35*Man - 0.27*Society + 1.01*Shell + 0.52*Network, Errorvar.= -0.17 , $R^2$ = 1.17

The goodness of fit statistics of this model is moderate (52.9 %); based on 17 indicators, only 9 of them determined that this model was fit enough. Based on above equation, the influences among parameters were: (a) minimization of the effort required for achievement of man's actual and potential contacts (Y2) was the strongest influence on settlement compared to Y1 and Y3, even though the value was negative; (b) Soil parameter (X3) was stronger than topography (X2) in influencing the nature variable; (c) Sensation and perception (X7) parameter was more influencing to Man variable than moral value (X9); (d) Law and administration (X16) parameter was stronger than cultural pattern parameter (12) in influencing the Society Variable; (e) Disaster evacuation path parameter (X22) had better influence to shell variable than facility parameter (X18). The X24 parameter or power supply parameter had better influence on network variable compared to communication system parameter (X26).

For the whole model, shell variable still had the highest influence to the settlement, followed by network, nature, man, and society. The variables that connected and were proportional with settlement aspect were shell and network. Meanwhile, other variables (man, nature, and society) had negative contribution to the settlement model.

### *5.2. Medium Vulnerability Type*

The medium vulnerability type, SEM estimation, can be viewed in Fig. 5 and the regression model is shown below.

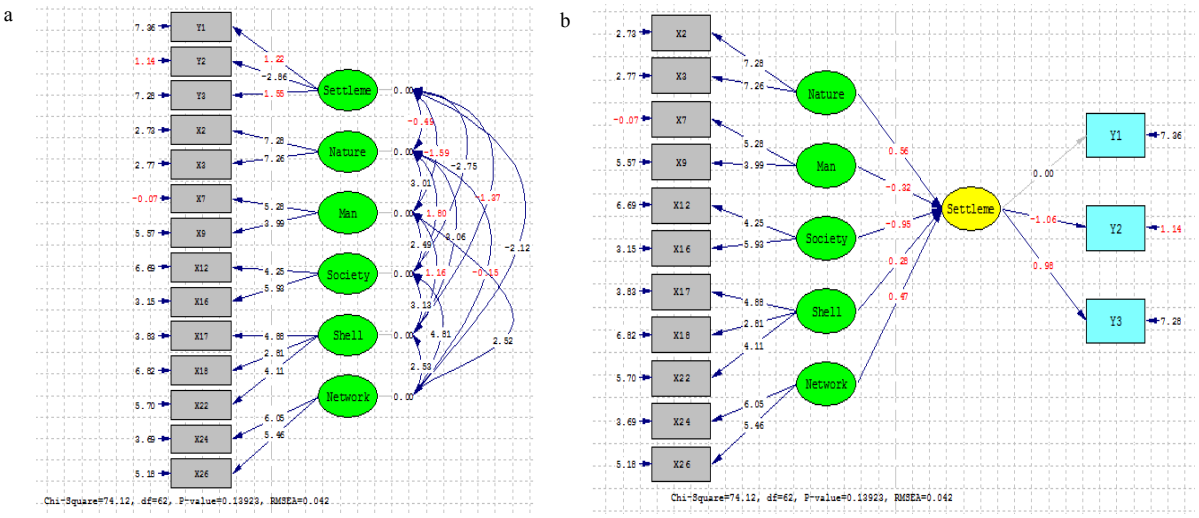


Fig. 6 (a) Confirmatory factor analysis and (b) Structural model for medium vulnerability settlement type

Settlement = 0.15*Nature - 0.055*Man - 0.95*Society + 0.082*Shell + 0.23*Network, Errorvar.= 0.41 , $R^2$ = 0.59

The most influencing variables for the settlements (dependent variable to independent variable) were network, nature, shell, man and, the last, society. The strongest interdependent relationships to the settlement variable were society, followed by network, and then nature, shell, and man. For the whole model, the society variable was the highest even though the value was negative. The variables that had positive contribution to the settlement aspect were nature, shell and network. For the fitness of the model, based on 17 fitness indicators, 9 of them were determined that the model was strong enough, so the fitness of the model was moderate (52.9 %).

### *5.3. High Vulnerability Type*

The High vulnerability type, SEM estimation, can be viewed in Fig. 7 and the regression model is shown below:

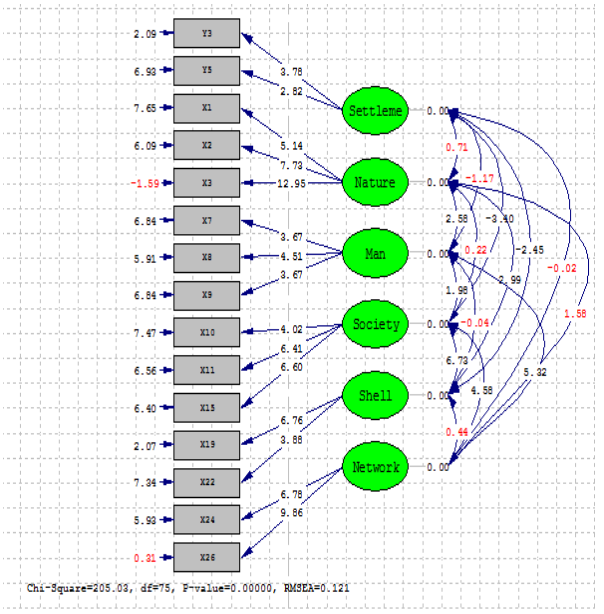


Fig. 7 Confirmatory factor analysis for high vulnerability settlement type

Settlement = - 1.19*Nature + 0.11*Man - 5.43*Society + 4.22*Shell + 2.75*Network, Errorvar.= -0.74 , $R^2$ = 1.74

For the high vulnerability type, the most influential variables for the settlement condition were shell, and then network variable, man, nature, and, the last one, society. The strongest interdependent relationships to the settlement variable were shell, and then network, man, nature, and society. For the whole model, the society variable to shell variable were the highest relationships.

The structural model for the high vulnerability type of area was not perfectly formed, because from 17 indices of the fit model test, only 3 of them were succeeded or suitable with the requirement of the model. The statistic model was the society that had no any other options, except for living in the flood prone area. In addition, the inhabitants had high resilience that was recorded in the questionnaire that they had no other choices except to adapt to the flooding events. Although, the structural model was not perfect, the regression model explained that the most influential parameter from the society variable in high vulnerability area/inhabitants was the membership and activity of inhabitant's in social organizations (X11), followed by population density and composition (X10) and health (X15).

## 6. Conclusion

The result of vulnerability analysis showed the typology of the vulnerability as the high vulnerability: 10 hamlets, in 30.84 Ha; Medium: 13 hamlets in the area of 41.92 Ha; and, low vulnerability in 8 hamlets within 26.14 Ha.

Model regression was in the classification of vulnerability (high, medium and low vulnerability); the inhabitants had different priorities, hopes and important variables that influenced the formation of settlement among the Doxiadis' variable. For the low vulnerability, the regression model explained that the most influencing variable was shell, especially in disaster evacuation path parameter (X22). For the medium vulnerability type, the most influencing variable was society focusing on law and administration (X16), followed by parameter X12 (cultural

parameter). In high vulnerability, the regression model explained that the most influential parameter from the society variable in high vulnerability area/inhabitants was the membership and activity of inhabitant's in social organizations (X11), followed by population density and composition (X10) and health (X15).

In the future research, this unique results might need further development or further investigation, especially in the high vulnerability settlement type that is most influenced by inhabitant's social organization membership (X11) under society variable. The membership and activity of inhabitant's in social organizations is one of the valuable findings in the research area. The approach that is suitable with the specific characteristic is Social Network Analysis (SNA), so that it can be valuable to understand the unique findings that contribute to flood prone area management.

## 7. Acknowledgement

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