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RESEARCH PAPER

Probit Modeling of Indonesian Economic and Social Factors to The Interest in Purchasing Flood-Impacted Insurance Products

Yulial Hikmah[1]*, Vindaniar Yuristamanda[2], Ira Rosianal Hikmah[3] & Karin Amelia Safitri[4]

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ABSTRACT
For tropical countries such as Indonesia, flooding is generally caused by high rainfall above normal. Almost all cities in Indonesia experience flooding every year, including DKI Jakarta, the capital city of Indonesia. Based on data from the National Disaster Management Agency (BNPB) in 2020, East Jakarta is a city that is prone to flooding. Because there are so many losses caused by flooding, it is necessary to have a disaster mitigation effort to minimize the possible risk of flooding. One risk mitigation due to natural disasters is buying insurance products. However, not all people buy flood-impacted insurance products because of their economic and social factors. This research aims to create a model with Probit Regression Model to determine the factors that influence Indonesian's interest in buying flood-impacted insurance products. The results show that eight (8) factors significantly affect Indonesia's interest in purchasing flood-impacted insurance products, namely X1 (Contract/Lease and Family Owned), X2 (Married), X4 (Age of the Head of the Household), X7 (Has experienced a flood), X8 (Frequency of flood experience), X9 (flood height), and X15 (Total Property Loss due to flooding). In the end, this research calculated the level of model accuracy and obtained 84.3%.

KEYWORDS: *Flood; Risk mitigation; Insurance; Probit regression model.*

1. Introduction

Every year, natural disasters occur worldwide. According to the international disaster database, the number of natural disasters and the losses arising from these events have increased significantly in the last decades [1]. Natural disasters, such as earthquakes, tsunamis, floods, hurricanes, and volcanic eruptions, caused tremendous harm in the past and continue to threaten infrastructure and the lives of millions of people each year [2]. Flood is a disaster threat with high risk in Indonesia, especially property and infrastructure, and is a serious threat to the community's economy. Floods can be caused by static natural conditions (such as geography, topography, and river channel geometry), dynamic natural events (such as high rainfall, damming from the sea/tidal on the main river, land subsidence, and pentangular due to sedimentation), and activities dynamic human activities such as inappropriate use of floodplain land (establishing settlements on riverbanks, lack of flood control infrastructure, land subsidence and sea-level rise due to global warming) [3].

In general, the impact of flooding can be direct or indirect. Direct effects are relatively easier to predict than indirect impacts [4]. It is important to be prepared for an incident, such as floods [5]. Disaster management can be defined as the discipline of avoiding and dealing with risks [6]. Based on the Flood Disaster Risk Study, there are ten priority provinces to focus on for flood disaster management activities, one of which is DKI Jakarta Province [3]. Geomorphologically, most of the Jakarta area is formed by fluvial processes and is located in the northern part of Java Island. This condition causes the DKI

* **Corresponding author:** ***Yulial Hikmah***
yulialhikmah47@ui.ac.id

1. *Vocational Education Program, Universitas Indonesia, Depok, Indonesia.*
2. *Vocational Education Program, Universitas Indonesia, Depok, Indonesia.*
3. *Politeknik Siber dan Sandi Negara, Bogor, Indonesia.*
4. *Vocational Education Program, Universitas Indonesia, Depok, Indonesia.*

Jakarta area to be prone to hydro-meteorological hazards, especially floods. Based on these conditions, it shows that DKI Jakarta Province is an area that has a high threat of flooding [7]. The flood disaster in early 2020 was one of the most significant floods in Jakarta [8]. The Meteorology, Climatology, and Geophysics Agency (BMKG) recorded extreme rains that occurred evenly in Jakarta and its surroundings on December 31, 2019, and January 1, 2020. The highest rainfall reached 377 mm per day, higher than the record for the highest rainfall. In February 2015, 367 mm per day (Kompas, January 3, 2020) [9]. This condition is exacerbated by Jakarta's location, a lowland prone to flooding. According to Sakethi (2010), the area of DKI Jakarta below sea level is 40% of the total land area [10], [11].

Economic losses from floods and landslides were enormous, ranging from direct losses such as damage to houses and damaged or lost items due to flooding to motorbikes and cars submerged in water [9]. One alternative effort to provide funds (economic problems) due to flooding is participating in flood loss insurance [12]. One of the insurance losses due to flooding is property insurance, a type of protection for property assets such as houses, apartments, and offices. The goal is to anticipate financial losses due to unexpected events on our property. These unexpected events can be catastrophic. However, not everyone buys flood impact insurance products due to economic and social factors. This study aims to determine the social and economic factors that influence the interest of the Indonesian people to buy flood-impacted insurance products. Various methods can determine the factors that influence the community's interest, especially those who experience flooding and are affected by floods, to buy property insurance products due to flooding, a linear regression model. In addition, other models can be used, and of course, some conditions must be met to determine the model to be selected. One of the statistical probability models can be used when the dependent variable has two categories: the probit model [13]. Furthermore, this research uses the probit regression model to find the factors influencing Indonesian people to purchase flood-impacted insurance products.

2. Literature Review

2.1. Risk and insurance

Risk is the uncertainty of loss. The uncertainty can be about time, place, and to whom the event occurred, while the loss in question must be valued in money. According to Naron, 2008 in a book published by the Financial Services Authority (OJK), there are three risk components, namely: [14]

1. *Risk has an element of uncertainty*
2. *The risk of causing an implication of loss*
3. *Risk arises due to one or more reasons*

Risk cannot be eliminated but can be shared, managed, and significantly reduced with the help of insurance [15]. Insurance can legally be defined as an agreement between two parties, namely the insurer (insurance company) and the insured (individual or business entity). Insurers bind themselves to provide compensation to the insured in an event or disaster guaranteed by the policy. The insured pays a sum of money to the insurer called the premium. Based on the type, insurance is divided into two groups, namely: [14]

1. *Life Insurance is insurance with the object of coverage in the form of a person, and the insured is a person's life.*
2. *General Insurance provides guarantees against losses that occur in property, both movable and immovable property, and provides legal liability guarantees to third parties who suffer losses.*

The types of insurance in Indonesia, among others: [14], [16]

1. *Life Insurance. This type of insurance provides financial benefits to the insured upon his death.*
2. *Health Insurance. Health insurance is an insurance product that handles the insured's health problems due to an illness and bears the cost of the treatment process.*
3. *Vehicle insurance. This insurance, which is the most popular in Indonesia, is a type of car insurance that focuses on dependents for injury to others or against damage to other people's vehicles caused by the insured. Based on the OJK, this coverage can be extended to additional risks, one of which is the risk of flooding.*
4. *Home and Property Ownership Insurance. As an asset that is considered quite valuable, usually, homeowners will protect themselves and their assets which can be a house or personal property, with a home and property owners insurance. This insurance provides protection against loss or damage that may occur to certain personal belongings of the insured.*

2.2 Probit regression

The probit regression model is also known as the

nonlinear regression model. The probit regression model analyses the relationship between a dependent variable (response variable) and several independent variables (predictor variables), where the response variable is dichotomous qualitative data. In the probit regression model, the response variables can be 0 to state the non-existence of a characteristic and 1 to express the existence of a characteristic [17]. In a scenario where the outcome variable is dichotomous, probit regression models are the frequently used statistical methods for predicting the outcome variable based on independent variables.

In general, the probit regression model can be expressed as follows: [18]

$$\pi_i = \Phi(z_i) = \Phi(\beta_0 + \beta_1 x_{i1} + \cdots + \beta_p x_{ip} + \varepsilon_i) \quad (1)$$

where Φ represents the cumulative distribution of the standard normal. Since the probit model is related to the cumulative function of the Standard Normal Distribution, to get an expectation of the probit value (z_i), the inverse of the standard normal cumulative distribution function can be obtained: [18]

$$z_i = \Phi^{-1}(\pi_i) = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_p x_{ip} + \varepsilon_i \quad (2)$$

with $i = 1, \ldots, n$. Estimating the $\boldsymbol{\beta}$ parameter in the probit regression model can use the Maximum Likelihood Estimation (MLE) method.

2.3. Confusion matrix and evaluation measurement

The confusion matrix tests to estimate true and false objects [19]. According to Han and Kamber, the Confusion matrix can be interpreted to analyze whether the classifier recognizes tuples from different classes. True Positive (TP) and True Negative (TN) values provide information when classifying data as correct. In contrast, False Positive (FP) and False Negative (FN) provide information when the classifier is wrong in categorizing data [20], [21].

One measure that can be used to measure model evaluation is the level of accuracy. The formula for the level of accuracy can be calculated based on the results of the confusion matrix as follows: [22]

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (3)$$

According to Rosandy, the diagnostic value levels are: [23]

a. *Accuracy range value 0.90 – 1.00 = excellent classification*
b. *Accuracy range value 0.80 – 0.90 = good classification*
c. *Accuracy range value 0.70 – 0.80 = fair classification*
d. *Accuracy range value 0.60 – 0.70 = poor classification*
e. *Accuracy range value 0.50 – 0.60 = failure*

This research also calculates PPV (Positive Predictive Value), the proportion with positive test results, and NPV (Negative Predictive Value), the ratio of cases with negative tests. The following are the results of PPV and NPV calculations: [24]

$$PPV = \frac{TP}{TP+FP} \quad (4)$$

$$NPV = \frac{TN}{TN+FN} \quad (5)$$

3. Methodology/Materials

3.1. Research samples

The population in this study is the population of Indonesia. This study uses a non-probability purposive sampling technique, which is a sampling technique with certain considerations [25]. The BNPB (National Disaster Management Agency) report shows that East Jakarta City was the worst affected by floods [26], [27]. Furthermore, the Head of the BNPB Disaster Data, Information and Communication Center, Agus Wibowo, said eight sub-districts in East Jakarta with the highest number of flood victims, namely 752 families (2476 people) [28], [29]. Due to limited time, cost, and resources, this research selected several Neighborhood Units that did and are still experiencing flooding in early 2020. The distribution of the selected respondents can be seen in Table 1.

Tab. 1. Distribution of sample data for research

District	Sub-Distric	The Number of Samples
Duren Sawit	Pondok Bambu	10
Jatinegara	Bidara Cina	25
	Kampung Melayu	22
	Rawa Bunga	10
Kramat Jati	Cawang	25
	Cililitan	10

Makasar	Cipinang Melayu	18
Pulo Gadung	Pisangan Timur	20
Total		140

3.2. Method of collecting data

The number of research samples was 140 families. Data were collected through interviews and also by filling out online questionnaires. The reason for conducting interviews is that several questions must be given directly to see the truth and validity of the respondent's answers. However, even though it was completed with an interview, this research still complies with the health protocol (covid-19 pandemic). The data collection process through interviews and online filling can be seen in Figure 1 and Figure 2.

Fig. 1. Online questionnaire display

Fig. 2. Survey documentation

3.3. Research questionnaire

The questionnaire is a data collection technique that gives respondents a set of questions or written statements to answer [30]. To find out the factors that influence the interest of the Indonesian population to buy property insurance products due to floods, the researchers formulated several questions which were research variables and were built using Google Form (online questionnaire). Research variables are everything the researcher determines to be studied to obtain information [30]. Nineteen questions become independent variables in this study, while the dependent variable is the respondent's interest in buying flood impact insurance products (Y). The list of questionnaire questions can be seen in Table 2.

Tab. 2. Questionnaire questions

No	Questions	Variables
1	Respondent's interest in buying flood impact insurance products (No, Yes)	Y
2	Respondents' House Status (Contract/Lease, Family-Owned, Private)	X1
3	Respondents' Marital Status (Single, Married, Divorced)	X2
4	Last Education Level of Householder Head (No School, Primary School, Junior High School, Senior High School, D3, Bachelor Degree, Master/Doctoral)	X3

5	Age of Householder Head	X4
6	Monthly Income Type (in Rupiah) (Low, Moderate, High)	X5
7	Average Monthly Expenses	X6
8	Flood Experienced (Ever, Never)	X7
9	How many times have you experienced floods?	X8
10	Flood Height (cm)	X9
11	How long does the flood until it recedes (days)?	X10
12	Have you ever been evacuated? (Yes, No)	X11
13	How many times do you evacuate each year?	X12
14	Is your house near a river? (Yes, No)	X13
15	Has a flood ever caused damage to your property? (Yes, No)	X14
16	How much is property damage loss due to flooding (in IDR)?	Z15
17	Do you know about insurance? (Yes, No)	X16
18	Do you agree with the following statement: Insurance is one way to minimize losses from loss or damage to valuable objects due to flooding? (Yes, No)	X17
19	Did you know that insurance products can be purchased to cover the losses you will receive from flooding each year? (Yes, No)	X18
20	Do you know about property all-risk insurance? (Yes, No)	X19

3.4. Data analysis method

One of the analytical methods to obtain the factors that influence the interest of the Indonesian population to buy flood impact insurance products is modeling. To predict a problem, the general model is a linear regression model. Probit regression can be considered a particular linear regression case when the predicted is categorical. Probit Regression is a statistical model that estimates the probability of an event occurring. The dependent variable code in this study is 0 for not interested and 1 for interested in buying flood impact insurance products. After the model is formed, it is evaluated. This study measures the results of the evaluation of the probit regression model based on the level of accuracy, PPV, and NPV. The three measurements can be calculated after obtaining the confusion matrix first. This study uses IBM SPSS Statistics 21 software for probit regression analysis and Microsoft Excel to calculate the level of accuracy, PPV, and NPV.

4. Results and Findings

Based on 140 research samples, it can be seen in the description of the respondents' answers. Respondents' reports related to Variable X1 (respondent's homeownership status) and Variable X2 (marital status) can be seen in Figures 3 and 4.

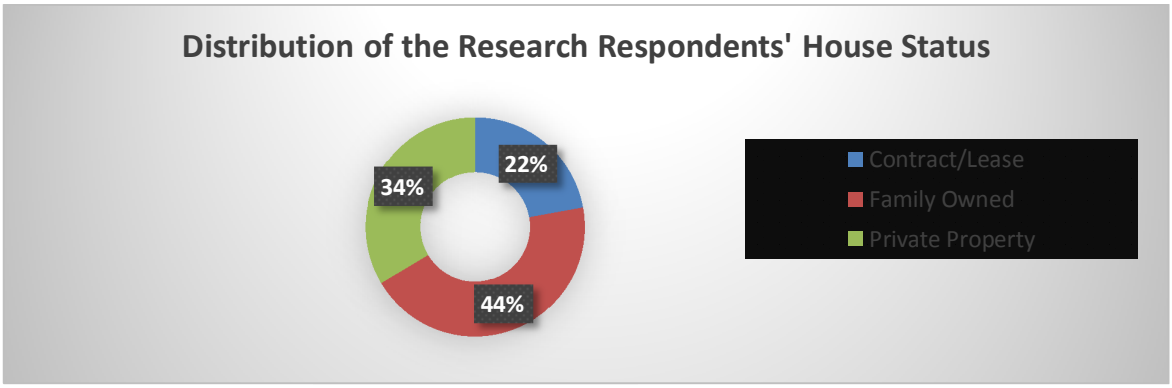

Fig. 3. Distribution of the research respondents' house status

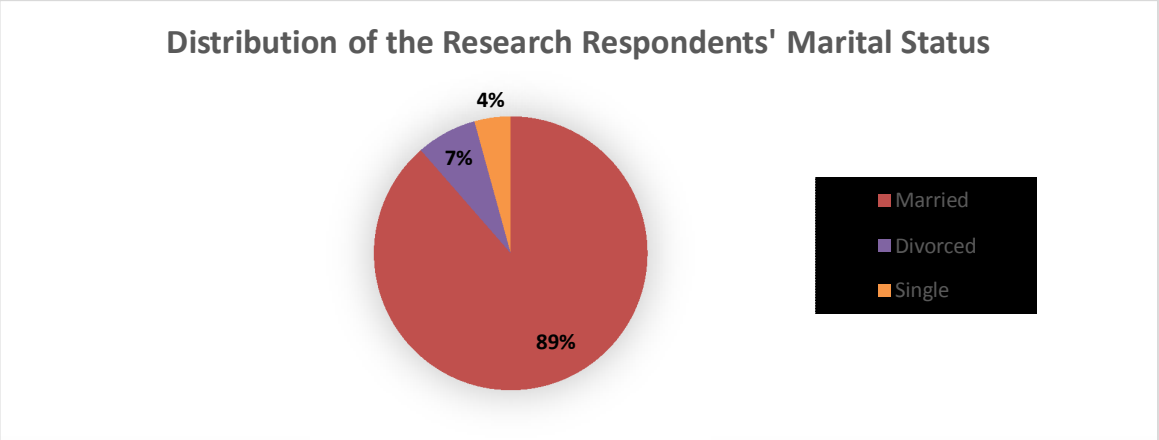

Fig. 4. Distribution of the research respondents' marital status

Based on Figure 3, most of the homeownership status of the research respondents is family-owned, followed by private property. However, the figure is still quite prominent; 22% of the respondent's homeownership status is a rental/contract. In addition, Figure 4 shows that most research respondents are married (89%).
Furthermore, the respondent's description of the age of the head of the household and his wife (data on the wife's age is specifically for those who are married) can be seen in Table 3. The variable used is only the age of the head of the household (X4). In contrast, the wife's age of the head of the family is not included as a research variable, considering that not all research respondents are married. Therefore, to reduce errors in modeling, the wife of the head of the household was excluded from the study. The average age of the head of the household and his wife can be seen in Table 3.

Tab. 3. The average age of the research respondents

Householder	Wife of Householder
47 years	41 years

In addition, Figure 5 shows the distribution of monthly income groups, where the low-income category is 0 to IDR 4,000,000. The moderate-income class is in the range of IDR 4,000,001 to IDR 8,000,000, and the high-income category is more than IDR 8,000,000. It can be seen that the majority of respondents have low incomes. Based on Figure 6, it was found that 99.3% of research respondents had experienced floods, and 94.3% of respondents experienced floods last year (2019). The result shows that the research sample follows the target, namely the research sample, the majority of which have been and are still experiencing flooding. The experience of evacuation can be seen in Figure 7. Based on Figure 7, 69% of respondents have been evacuated due to flooding. However, the remaining 31% of respondents stayed in their homes and waited for the flood to recede. Furthermore, Figure 8 shows the percentage of evacuation frequency each year. There are still more than 12% of respondents who evacuated more than four times each year. Next will be seen the description of research respondents regarding the impact of floods they have experienced. The effect of flooding on property or valuables damage can be seen in Figure 9.

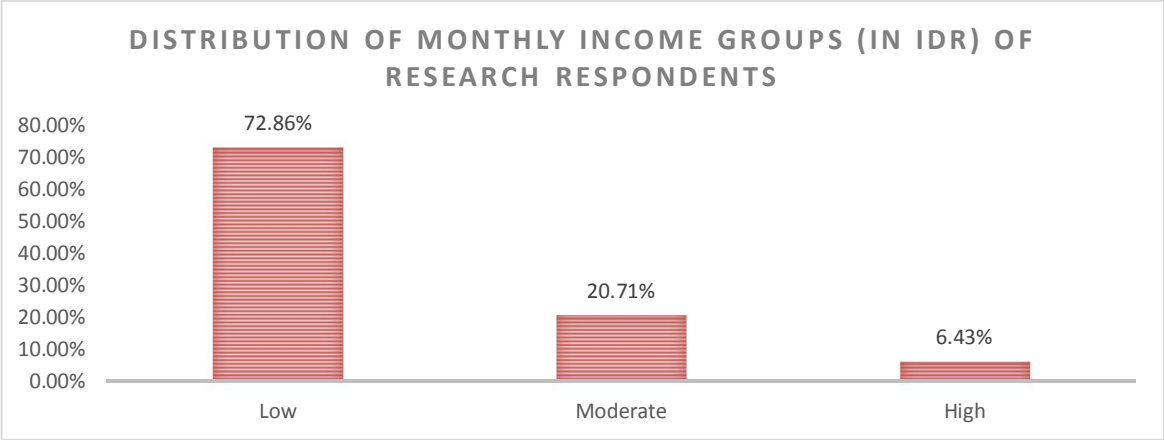

Fig. 5. Distribution of monthly income groups (in IDR) of research respondents.

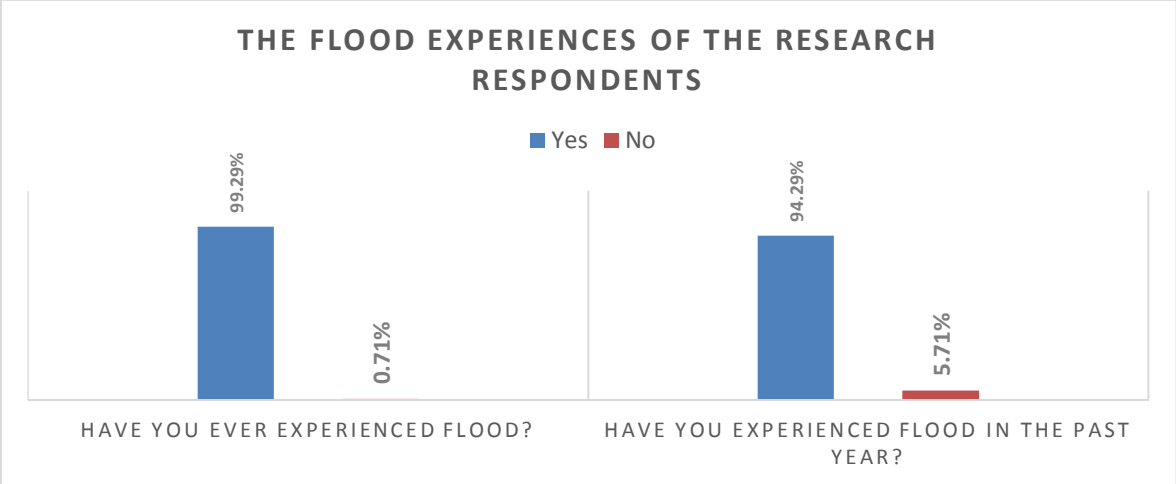

Fig. 6. The flood experiences of the research respondents.

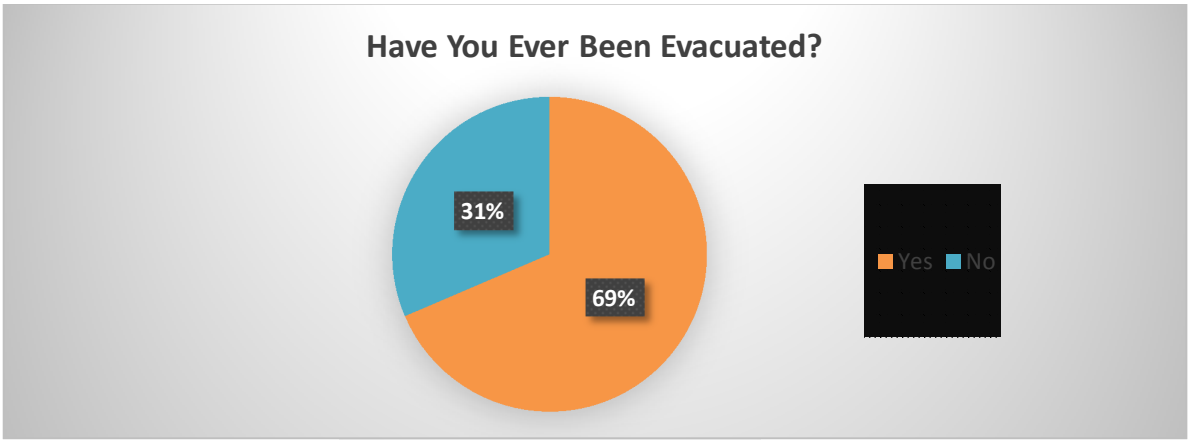

Fig. 7. Distribution of respondents who have been evacuated.

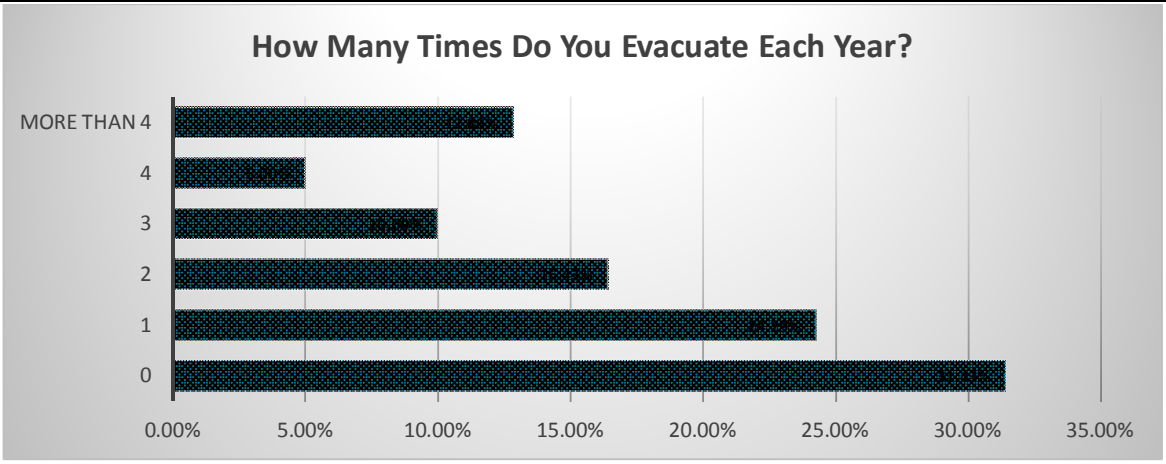

Fig. 8. Distribution of respondents who are always evacuated.

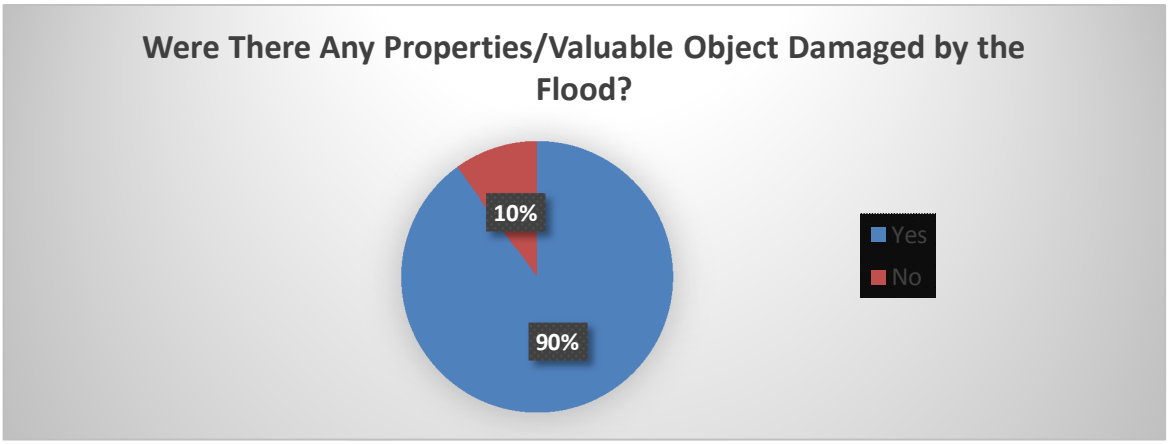

Fig. 9. Distribution of property/valuable objects damaged by the flood.

Next in this research is to form a probit regression model—formation of this model using the SPSS tool. Based on 19 variables used in this research, there are 7 Continuous Variables and 12 Discrete Variables whose categories are adjusted and written in the previous section. Therefore, 32 regression coefficients (including intercepts) are obtained that must be estimated. Before getting parameter estimates along with conclusions about which factors affect respondents' interest in buying flood impact insurance products, several tests will be carried out, namely model suitability testing can be seen in Table 4, simultaneous parameter testing can be seen in Table 5, and parameter estimates along with Partial parameter testing can be seen in Table 6.

Tab. 4. The goodness of fit testing in this research

	Chi-Square Pearson	Sig.
Model	114.488	0.862

Tab. 5. Simultaneous parameter testing in this research

Model	-2 Log-Likelihood	Chi-Square	df	Sig.
Intercept Only	121.772			
Final	75.76	46.012	27	0.013

Based on Table 4, it can be seen that the p-value in the model suitability test is 0.862 > α=10%. Using a significant level of 10%, the formed probit regression model is appropriate or suitable to explain the study's dependent variable. Furthermore, from Table 5, it is obtained that p-value = 0.013 < α=10%, then with a significant level of 10%, there is at least one significant parameter (a factor that significantly influences interest in purchasing insurance products affected

by floods). Table 6 shows that with a significance level of 10%, there are eight (8) significant regression coefficients, namely X1 (Contract/Lease and Family Owned), X2 (Married), X4 (Age of the Head of the Household), X7 (Has experienced a flood), X8 (Frequency of flood experience), X9 (flood height), and X15 (Total Property Loss due to flooding).

Tab. 6. Parameter estimation

		Estimate	Sig.
Threshold	[Y = Not Interested]	5.205	.935
	X4	-.020	.056
	X6	3.806E-08	.720
	X7 (Ever)	2.691	.000
	X8	.301	.029
	X9	.004	.080
	X10	.097	.384
	X11 (Yes)	.350	.563
	X12	-.241	.186
Location	X13	-.812	.291
	X14	.130	.802
	X15	1.380E-07	.047
	X16	.107	.788
	X17	.207	.615
	X18	.423	.284
	X19	.411	.455
	[X1= Contract/Lease]	-.905	.025
	[X1= Family Owned]	.285	.056
	[X1=Private]	0[a]	
	[X2= Single]	.450	.188
	[X2=Married]	-.896	.052
	[X2=Divorced]	0[a]	
	[X3= No School]	-4.285	.946
	[X3= Primary]	-2.415	.994
	[X3=Junior]	2.344	.971
	[X3=Senior]	2.865	.964
	[X3=Diploma]	1.083	.986
	[X3=Bachelor]	2.044	.974
	[X3=Master/Doctoral]	0[a]	
	[X5= Low]	-.382	.824
	[X5= Moderate]	-.027	.987
	[X5= High]	0[a]	

Based on Table 6, we can see that contracted/leased houses reduce interest in purchasing insurance products. One of the reasons is economic factors that have to meet daily life, including paying rent so that it is not enough to buy insurance products due to flooding. Meanwhile, self-owned houses increase interest in purchasing insurance products. The reason is that apart from not having to spend money to pay rent, there is also a sense of ownership of the house they live in to keep it safe and comfortable. If there is a disaster such as a flood, it will not cause big losses. Another variable that influences is marital status. Married respondents are less interested in buying products when compared to unmarried respondents. One of the reasons is the burden of dependents who are married and have dependents such as husband/wife and children to support. Another variable that influences is the age of the head of the family. The older the age of the head of the family, the less interested. Some of the reasons are because they don't know what insurance is, because they are old (lack knowledge about insurance) or because there are more dependents. After all, children are getting older and have a lot of costs needed while age will approach retirement.

Variables of experience of flooding, including flood frequency and water level during floods,

also affect interest in purchasing insurance products due to flooding. Respondents who have experienced floods are more interested in buying insurance products than respondents who have never experienced floods. In addition, it was also found that the more frequent floods and the higher the water level during the flood, the more interested in buying insurance products due to flooding. The last factor is the total loss due to flooding. The greater the loss received, the higher the respondent's interest in buying insurance products. Overall, from several research variables related to social and economic conditions, the most influential variables are the frequency of experiencing flooding, rental housing, total losses due to flooding, and marital status.

Next is to create a confusion matrix and calculate the level of accuracy, PPV, and NPV. The confusion matrix of this study can be seen in Table 7. Based on Table 7, TP, FP, FN, and TN values are 3, 8, 14, and 115, respectively.

Tab. 7. Parameter estimation

		Predicted Class	
		Interest	Not Interest
Actual Class	Interest	3	14
	Not Interest	8	115

The following is the result of calculating the level of accuracy:

$$Accuracy = \frac{118}{140} = 84.3\%$$

Therefore, the probit regression model is accurate in the good classification category. The following are the results of PPV and NPV calculations:

$$PPV = \frac{3}{11} = 27.3\%$$
$$NPV = \frac{115}{129} = 89.1\%$$

5. Conclusion

In this study, with a significance level of 10%, the probit regression model obtained was appropriate, and the independent variables explained the dependent variable well. In addition, it was also found that eight factors influence the interest in purchasing insurance products due to flooding, namely X1 (Contract/Lease and Family Owned), X2 (Married), X4 (Age of the Head of the Household), X7 (Has experienced a flood), X8 (Frequency of flood experience), X9 (flood height), and X15 (Total Property Loss due to flooding). The probit regression model is then evaluated based on its level of accuracy. The result shows that accuracy is very good, namely 84.3%. In addition, this study also obtained PPV and NPV measures which were valued at 27.3% and 89.1%, respectively. PPV in this study is low value because most of the research sample is not interested in buying insurance products due to flooding. Suggestions that can be given in this study are increasing the number of research samples interested in purchasing insurance products due to flooding. Using the probit model that has been built, it is obtained that contracted/leased houses reduce interest in buying insurance products. Meanwhile, self-owned houses increase interest in purchasing insurance products. Another variable that influences is marital status. Married respondents are less interested in buying products when compared to unmarried respondents. Another factor that influences is the age of the head of the family. The older the age of the head of the family, the less interested. Variables of experience of flooding, including flood frequency and water level during floods, also affect interest in purchasing insurance products due to flooding. Respondents who have experienced floods are more interested in buying insurance products than respondents who have never experienced floods. In addition, it was also found that the more frequent floods and the higher the water level during the flood, the more interested in buying insurance products due to flooding. The last factor is the total loss due to flooding. The greater the loss received, the higher the respondent's interest in buying insurance products.

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