# HEDONIC PRICE APPROACH OF FLOOD EFFECT ON AGRICULTURAL LAND

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## Abstract

The natural disasters that took place in many parts of Indonesia in the last 10 years have caused an enormous losses, including agricultural sector. The objective of this paper is to estimate the magnitude of the influence of flood disaster on land price changes in Yogyakarta, using a hedonic price approach. The sample are is choosen from the vulnerable flood area mapped by Geographical Information Systems (GIS), from which farmers and land owner are selected as the respondents. The paper finds the evidence of a high level of flood stream coefficient, indicating that the flood significantly reduces the land price. The average of household's marginal willingness to pay for the decrease in flood stream level is estimated to be Rp 2.175.

**Keywords:**A gricultural land, marginal willingness to pay (MWTP), hedonic price
**JEL classification numbers:** Q15, Q19

## Abstrak

Bencana alam yang terjadi di berbagai daerah Indonesia dalam kurun 10 tahun terakhir telah menyebabkan kerugian yang besar di berbagai sektor ekonomi, termasuk sektor pertanian. Tujuan dari makalah ini adalah untuk memperkirakan besarnya pengaruh bencana banjir pada perubahan harga tanah di Yogyakarta, dengan menggunakan pendekatan harga *hedonis*. Sampel dipilih dari daerah rawan banjir yang dipetakan oleh Sistem Informasi Geografis. Responden yang dipilih adalah petani dan pemilik tanah. Makalah ini menemukan bukti tingginya koefisien aliran banjir, menunjukkan bahwa banjir secara signifikan mengurangi harga tanah. Rata-rata kesediaan marjinal rumah tangga untuk membayar upaya demi mengurangi tingkat banjir sungai diperkirakan bernilai Rp 2,175.

**Keywords:** Tanah pertanian, keinginan marjinak untuk membayar, harga hedonis
**JEL classification numbers:** Q15, Q19

## INTRODUCTION

Disaster risk is influenced by three factors which are the level of vulnerability, danger, and community capacity. The danger can be minimized if the vulnerability level can be reduced and the community capacity level can be increased. In flood subscription area, the awareness of public on mitigating the risk might enable to minimize the loss. In contrast, the low awareness would cause a very detrimental disaster effect.

The natural disasters might affect the sustainability of development processes. The direct impact is the destruction

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of economic assets including stock of capital, infrastructure, natural resources, and human being. The disasters can also affect government budget. Hofman and Brukoff (2006) states that when the disaster occurred then the government are faced by two urgent financings which are the operating fund and reconstruction fund. In its 1999 report, the United Nations Economic Commission for Latin America and the Caribbean estimated the impact of the direct loss of 25 major disasters occurred during a specific time period. The investigation shows that there have been serious damages caused by the impact of disasters in several states.

Several studies have been conducted to assess the impact of natural disaster. The use of a hedonic price method to perform valuation has become a long debate especially since the study conducted by Ridker and Hennings in 1967. The debate is on the identification of functional forms which eventually shifts to a simple functional form

The hedonic price method estimates demand and price of goods without traditional economic markets. This method is used to examine its constituent characteristics, and to estimate the value of each characteristic. In the case of land, which is a heterogeneous bundle of goods, researchers have used hedonic price to assess the implicit prices for characteristics associated with various properties, such as structural components, environmental factors, public services, and urban form.

Kulon Progo is one of the regencies in Yogyakarta Special Region (Yogyakrta here after) in which the flood reached 1,944 hectares and the number of inundated houses were 129 units. The data indicates that the substantial losses were mainly in the form of physical damage to homes, lands, farms and forests (Table 1).

Many studies on flood disaster have been done using various methods of analysis such as, Cost and Benefit Analysis, econometrics, Geographic Information System, Data Envelope Analysis, and hedonic price. Table 2 presents some summary of previous related studies. Dai et al. (2003) mention that high rainfall will increase the risk of landslides, slope instability as well as landslides risk of vegetations. It is stressed out that landslides is associated with rainfall levels. Meanwhile Parson et al. (2004) use GIS to change the mitigation plans. Cowell and Zeng (2003) also use GIS as a modeling-prone area due to weather changes.

The GIS method has been widely used to identify areas of potential disasters. Wood and Good (2004) use GIS to identify vulnerabilities at airports and seaports by the earthquake and tsunami. Rashed (2003) measures the environmental context of social insecurity by the earthquake. Zerger (2002) uses GIS to examine the risk disaster model and Cowell and Zeng (2003) integrate the theory of uncertainty by as a modeling-prone area due to weather changes.

**Table 1:** Damage and Casualties of Flood in Yogyakart Special Region Over the Last 10 Years

| District/city | Victims | Damages | | |
|---|---|---|---|---|
| | | Houses (units) | Land (ha) | Garden/forest (ha) |
| Yogyakarta | - | - | - | - |
| Bantul | - | 6 | 39 | 200 |
| Gunung Kidul | - | 1 | - | - |
| Kulon Progo | 103 | 129 | 1944 | 100 |
| Sleman | 2 | 1 | - | - |

Source: Data of Information and Business Indonesia, DIY 2009

The purposes of this study are to map flood area especially the agricultural land in Yogyakarta Special Region and analyzes factors that influence agricultural land price in the flood area. Based on the prone area map, the paper will make the economic valuation of loss suffered from flood in the most vulnerable area by using a hedonic price method. This study also aimed to evaluate how far the effects of the flood on land prices are concerned.

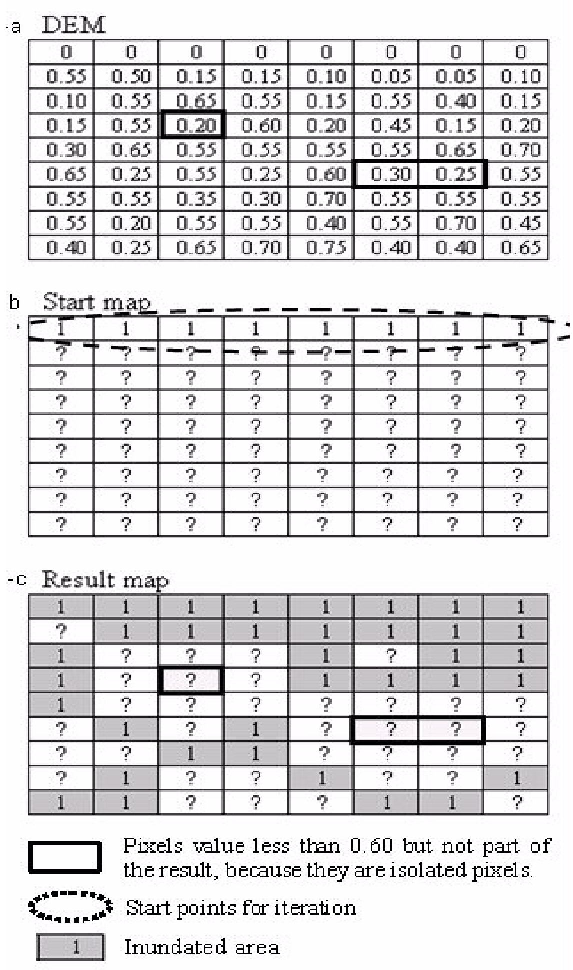
## METHODS

### Geographic Information System

To identify the flood prone area in Yogyakarta, this paper uses the Geographical Information Systems (GIS). To construct the flood modeling, this paper uses neighborhood model operation with an iterative method. This method is adopted from Marfai (2003) model in the case of flood modeling study in Semarang.

An iteration method is a mathematical model using the calculation result of iteration as input for subsequent calculations. The calculation is done in the form of raster spatial data. Raster data is represented with a square shape with a certain values. For example, if one zooms in an image on a computer, the image will be difficult to be recognized. The appearance of existing will be only in the form of boxes that have different colors. The color indicates a value. In the field of cartography, raster data is often encountered in remote sensing image. In addition, raster data is also widely used to represent the height of a place which is represented by a DEM (Digital Elevation Model). In DEM, elevation values will be represented somewhere in each picture box, or often referred to as pixels (picture element). The value of each pixel represents the value of altitude on the earth surface.

Figure 1 depicts the illustration of neighborhood operations and iteration procedures. In this study, DEM is used to predict flood inundation caused by river overflow. Water propagation will be modeled by iterative calculations. Iterative calculation using the value of DEM is to identify the nearest neighbor pixels. Nearest neighbor pixels will be recognized as inundation areas based on the scenario. In the scenario of flood inundation as high as 1 meter high, the iteration process will stop at the DEM pixels that is worth 1 meter higher than the initial surface water.




Source: Marfai, 2003

**Figure 1:** Neighborhood Operations

The data calculation in Geographical Information System applications is hdone with the help of ILWIS 3.4, ArcView 3.3, and ArcGIS 9.3 software packages, including a Point Interpolation Altitude, Vector

Data to raster conversion, and the Iteration Technique-Neighborhood Analysis

## Flood Vulnerability Index Scoring Model

The emphasis of this second method is to identify flood areas based on several factors that are owned by the region or study area. The data analysis techniques with this method is similar to the first method. The variables used in this method is not only based on the high scenario puddle and altitude regions, but by using the basic data (Table 2), one can map to identify regions most catastrophic floods potential.

These basic data which carry out layers of various parameters can indicate the potential for flood. In addition, by scoring and weighting of these parameters, one can get the index of vulnerability to flood. Flood-prone areas can be identified according to the scores and weights that have been made in which

Vulnerability = Σ(x weighting score) (1)

This formula enables cross-mapping on the basis of the data (Figure 2).

**Table 2:** Basic Data for Mapping PotentialF lood Areas

| No | Type of data | Sources | Scale | Year |
|---|---|---|---|---|
| 1. | Land Use | Bakosurtanal | 1:25.000 | 2001 |
| 2. | Administrative Boundaries | Bakosurtanal | 1:25.000 | 2001 |
| 3. | Topographic | Bakosurtanal | 1:25.000 | 2001 |
| 4. | Landform | Bapeda DIY | 1:250.000 | 2007 |
| 5. | Infiltration | Bapeda DIY | 1:250.000 | 2007 |
| 6. | Soil texture | Bapeda DIY | 1:250.000 | 2007 |
| 7. | Slope | Bapeda DIY | 1:250.000 | 2007 |
| 8. | Flood events | BPSDA-PU | 1:250.000 | 2007 |

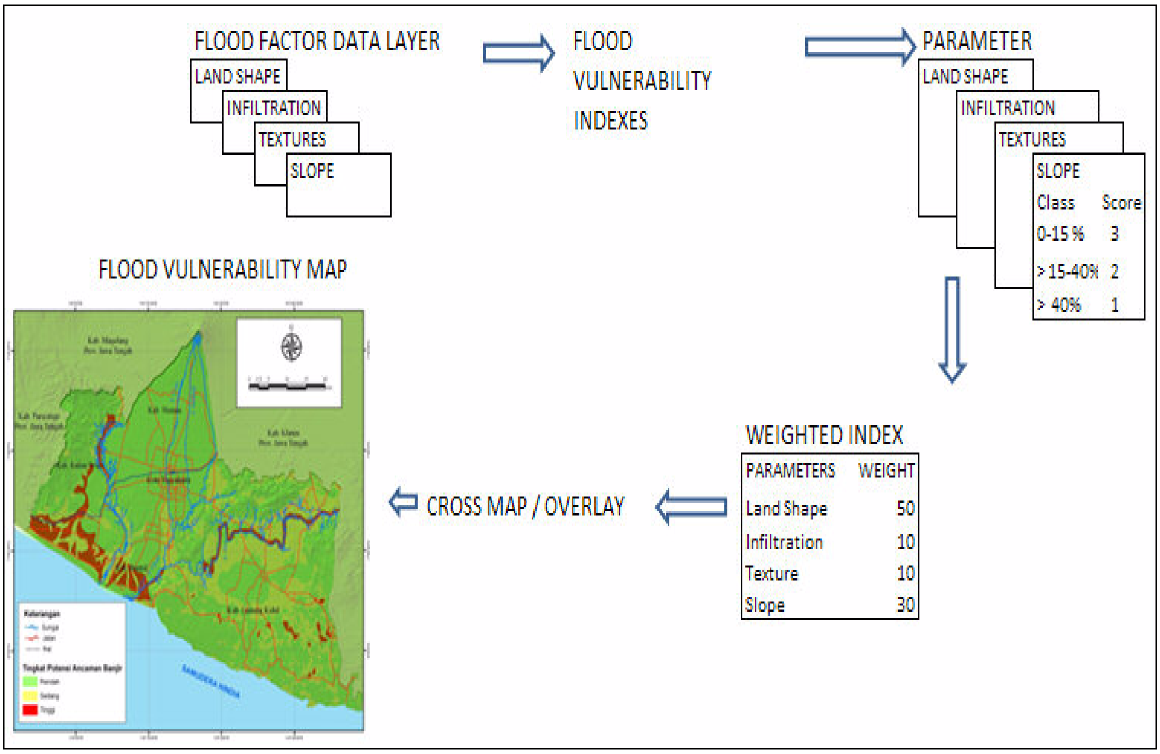



**Figure 2:** Chart of Flood Vulnerability Index Scoring Method

**Hedonic Price Model**

This study uses two hedonic price models. The models use variables related to land prices. The model is

$$LP = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_5 x_5 + u \quad (2)$$

where,

$LP$ is Land price

$x1$ is Vector of property (land) characteristics

$x_2$ is Vector of neighborhood characteristics

$x_3$ is Vector of flood risk characteristics

$x_4$ is Vector society awareness

$x_5$ is Vector socioeconomic characteristics

$e,u$ is standard error

The data is needed to conduct mapping of the flood prone areas including 1) Map of Yogyakarta using RBI scale 1:25.000; 2) Geological Map scale 1:100,000; 3) Data of height point of Yogyakarta Special Region; 4) Information of road; 5) Information of River; 6) Information of land use; 7) Data of flood inundation in Yogyakarta Special Region; and 8) Data of River Flow.

The other type of data for economic valuation is the primary data resulted from the respondents, which are previously taken by the mean of distributed questionnaire. This paper applies a strategic random sampling method to get the sample from which the primary data are obtained. The respondents consists of agricultural land owners in the research location. The steps for collecting data are focus group discussion, pre-test, and final survey

**RESULTS DISCUSSION**

The flood in the province of Yogyakarta was concentrated in Kulonprogo Regency. The areas prone to flood is those located in southern county district of Kulonprogo i.e. Temon, Wates, and Panjatan. This can be observed from the height of the low area (00-10 m above sea level). Kulonprogo Regency along with Oyo River are also considered as sensitive areas. Although it is not widespreaded, but the area along the Oyo River must be alert to the flood hazard.

Results from the tentative mapping of flood inundation by using iteration method is cross checked by the flood inundation data published of Board of Water Resource Management of Opak-Progo Oyo River. The result indicates that there are some areas prone to the flood. However, the are cannot be included as areas prone to flood by the iteration method. As the example is the flood caused by the overflow of Opak River soaking about 10 hectares of paddy fields and 12 hectares of grounds. The inability of the iteration method to map the flood is caused by the lack of the stretcher on the height data in a high detailed scale. Iteration methods heavily rely on data which is represented by the DEM altitude (Digital Elevation Model). The more detailed the elevation data is used as input, the more detailed the flood mapping that will be produced. DEM generated in this study cannot represent micro relief thus it cannot represent the localized flood.

Most of the residential population occupies with clumped pattern. The characteristics of lowland areas tend to be flat and it facilitate the population to exploit the land for settlement. Based on field observations in Temon, Panjatan, and Wates Districts, the location of densely residential and clustered are in village centers. In Temon District, population are clustered in the Glagah and Kedundang Villages. Population in the Panjatan District are clustered in Tayuban and Wates Villages. Wates District which is the capital of Kulonprogo Regency has the highest concentration of population located in Wates Village and Village Dam.

Mapping using Flood Vulnerability Index Scoring Method produces vulnerable area among other areas in south of Kulonprogo Regency area such as the Temon, Panjatan, and Wates Districts. There is also identified areas other than Kulonprogo regency that is areas along the River Oyo of Bantul Regency.

Vulnerability to flood risk in each zone are varied and divided into four levels of vulnerability scenarios. The scenarios are water height 25 cm, 50 cm, 100 cm and 150 cm. Based on observations the most vulnerable area are the settlements and rice field area. In the scenario of 25 cm flood inundation, Plumbon and Kalidengen are the area the most prone to flood risk. The characteristics in these two regions are also mostly rice fields and un-irrigated land. In the scenario of 50 cm, flood inundation begin to overflow into areas around Kalidengen and Plumbon which are mostly rice field and un-irrigated land. Inundation scenarios of 100 cm and 150 cm will reach Sogan region, eastern Kuwaru and western Palihan.

From the analysis results it can be seen that the most vulnerable area in Temon District is the irrigated fields. While that of for Wates and Panjatan District are the moor and garden. From the analysis of population density level and settlement it can be noted that flood in settlements will reach 34 hectares.

Of the two methods of analysis, it can be concluded that the highest flood-prone areas in the region Yogyakarta Special Region is Kulonprogo Regency especially in the three districts are Temon, Wates, and the Panjatan Districts. So the primary data are collected from these districts. Table 3 provides and overview the descriptive statistic of the variables used in the analysis.

**Table 3:** Description andS ummary statistics of Land Price -Related Variables

| Variables | Description of Variables | Mean | Standard deviation |
|---|---|---|---|
| Land Characteristics | | | |
| *PRICE* | Price of land (000 rupiah) | 28803.9216 | 31.4891 |
| *COST* | Cost of production (000 rupiah) | 738.2367 | 922.8187 |
| *YIELD* | Amount of harvest (000 rupiah) | 2859.8024 | 216.8515 |
| *OWNER* | Ownership status | 1.09 | 0.41 |
| Neighborhood Characteristics | | | |
| *D_HEALTH* | Distance to health center (m) | 731.6832 | 964.3029 |
| *D_SCHOOL* | Distance to elementary school (m) | 1.3887 | 1.237 |
| *D_HALTE* | Distance to bus stop (m) | 10.9314 | 49.1691 |
| *D_HDRAIN* | Distance to drainage (m) | 166.9706 | 286.5472 |
| *D_DRAIN* | Distance of drainage (m) | 50.5051 | 114.1397 |
| Flood Risk Characteristics | | | |
| *PERCEPT* | Perception of Flood | 0.8235 | 1.0187 |
| *LONG* | Time period of flood inundation (days) | 8.1078 | 8.6102 |
| *FAILED* | Failed of harvest | 0.5588 | 0.5372 |
| *LOSS* | Losses caused by flood | 542549.02 | 295292.05 |
| *HEIGHT* | Height level of flood inundation (cm) | 82.6471 | 61.8748 |
| Socioeconomic Characteris tics | | | |
| *AGE* | Age of respondent | 51.2941 | 12.9833 |
| *SEX* | Sex (male or female) | 0.7451 | 0.4379 |
| *EDUCATE* | Education level | 3.5392 | 1.663 |
| *CHILD* | Number of children (person) | 1.1373 | 1.2745 |
| *INCOME* | Income level per month | 1.2059 | 0.4942 |

**Source:** Data processed

The price of land in the area of the sample are still a reasonable price. Mostly the land is owned by the farmers. The average yield for one-time harvesting is 2.86 million rupiah. Characteristics of neighborhood variables are the distance of the area with the health, educational, and bus stop facilities, the distance to the nearest river, and the distance from drainage. On average, the distance of land to health facilities is 731 meters and the distance to education facilities is 1.38 km. The location of the observed land is not too far away to rivers and drains i.e. 166 meters and 49 meters, respectively. Length of flood inundation is approximately eight days with the 542,549.00 IDR crop losses.

The socioeconomic characteristics of respondents can be reflected by age, sex, educational level, number of children, and income level. In general the education level of respondents is graduates of Junior Secondary School (SMP) and the level of their average income is less than one million rupiah per month. The number of children is also relatively low at one child.

Hedonic price method has been used to study natural disasters. The underlying assumption of the revealed preference are based on housing market prices in which the purchase option of a house is based on structural characteristics, as well as characteristics associated with the location of the agricultural land. Each of these characteristics has a value and these values are added into the transaction price that is being observed.

**Table 4:** Hedonic Valuation of Marginal Willingness to Pay for Flood Mitigation Related to Land Value in Kulon Progo Regency

| Variable | Full Model | Fit Model |
|---|---|---|
| Constant | 10.637 (4.768) | 11.273 (23.632) |
| *OWNER* | .147(.738) | |
| *LAREA* | -.283(-1.334) | -.196(-2.297)** |
| *LNCOST* | .089 (.504) | -.164 (-2.302)** |
| *LNYIELD* | -.014 (-.316) | |
| *D_HEALTH* | -.000 (.838) | -.000 (1.235)* |
| *D_SCHOOL* | -.010 (-.157) | |
| *D_BUSSTOP* | -.001 (-.511) | -.380 (-2.785)** |
| *D_HDRAIN* | .000 (.683) | |
| *D_DRAIN* | .000 (.145) | |
| *PERCEPT* | -.027 (-.352) | |
| *LONG* | .007 (.698) | |
| *FAILED* | -.307 (-1.860) | -.376 (-20.725)*** |
| *LOSS* | -.000 (.688) | |
| *AGE* | -.004 (-.561) | |
| *SEX* | -.002 (-.359) | |
| *EDUCATE* | .035 (.647) | |
| *CHILD* | .059 (.865) | |
| *INCOME* | .081 (.451) | |
| *HEIGHT* | -.005 (-2.560) | -.004 (-2.735)** |
| No. Observation | 102 | 102 |
| Adjusted $R^2$ | .051 | .151 |

Note: ***, **, * indicates significant at 1%, 5%, 10% levels of significance, respectively.
Source: Data estimation

Column (3) of Table 4 indicates that the production cost has a negative effect on land prices. The higher the production cost is, the lower the price of land. It indicates that the land buyers will consider cost as one of factors to decide the price of land. Higher production cost will reduce their future profit.

Distance to the center of education and bus stops negatively affect the price of land. Further from the health services and the bus stop will lower the price of land. Meanwhile, crop failures affect the price of land. This can be ascertained that the success of land to produce crops would affect price of those land. Inundation height also has a negative effect on prices of land. This is because the prospective buyer of land would have to consider the risk of any loss due to flood inundation. Therefore, the higher of flood inundation, the lower the price of those land.

The result shows that all coefficients are significantly different from zero. All coefficients have expected sign and their magnitudes are comfortably reasonable. The marginal implicit prices of land characteristics are not constant due to the nonlinearity of the hedonic function. The marginal implicit price of the variable of interest, HEIGHT, is calculated by differentiating the hedonic price function with respect to HEIGHT. Therefore, for a given household, each unit increment in height of flood inundation results an estimated decrease in land unit value as –0.004 times land unit value divided by the associated height level. For example, a household whose land unit's value 12.500.000,00 IDR with associated level of height at 50 centimeters will suffer a marginal damage of 1.000,00 IDR. The same household's marginal benefit of a unit decrease in height level of flood inundation is equivalently 1.000,00 IDR. In other words, this particular household is expected to be willing to pay no more than 1.000,00 IDR to avoid the damage to their land associated with a one unit increase in height level of flood inundation.

Denoting the size of the sample by $N$, the sample's average MWTP is calculated as the average of marginal damages as follows:

$$MWTP = \sum \left( \frac{\delta p}{\delta HEIGHT} \right) \left( \frac{p_i}{HEIGHT} \right) \quad (3)$$

Thus, if the sample is fairly representative of Kulon Progo Regency, an average household should be willing to pay about 1.100.00 IDR for a unit decrease in height level of flood inundation. While an average household should be willing to pay about 2.175,00 IDR for a unit decrease in height level of flood inundation. Needless to say, the benefit is capitalized in the property, and the associated MWTP is not to be thought of as a payment per some unit of time, but rather as a lump sum payment for moving from the status quo to a lower level of flood inundation.

There are several variables that theoretically affect the price of land. However for the following flood-prone areas such variables are not significantly affected. This is possible because people underestimate of the risks caused by flood. Moreover, socioeconomic variables that do not affect the price of property and land might because the perception of the community that think the flood was a common. Therefore, the marginal WTP of their flood mitigation of the impact was quite low.

## CONCLUSION

Using a Geographical Information Systems (GIS) approach, the flood was concentrated in Kulon Progo Regency of the Province of Yogyakarta Special Region. Areas prone to flood located in southern county of Kulon Progo Regency i.e. Temon, Wates, and Panjatan Districts. These area experiencing severe flood every year need a special treatment such as by optimizing channels of existing water. Many channels of water are not optimally functioned. It also required an evaluation about the volume of water that does not fit into drains or causing flood.

The serious attention is required to cope the floods in the future. It related to the increasing population while it not accompanied by the improving environmental carrying capacity. The decreasing environmental carrying capacity cause higher vulnerability to flood.

The results of this study indicates that the hedonic price method can be applied in flood case of Kulon Progo Regency. It is to obtain the estimates of marginal damage to property value caused by flood. The significance of height level of flood inundation shows that flood is indeed depressing the property and land value. The average marginal willingness to pay (MWTP) for a unit decreasing in height of flood level inundation is estimated at a reasonable amount of 2,175.00 IDR.

Based on the low measure of MWTP and no influence of socioeconomic variables, it is necessary to socialize the awareness of disaster risk to communities. This is intended to increase awareness of disaster risks so that the impact caused by flood disasters can be minimized in the future.

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