Valuing the Economic Impact of Flood Mitigation in Central Java, Indonesia

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ABSTRACT

Objective – This research aims to map and identify the areas vulnerable to flood in Central Java Province, Indonesia, using Geography Information System (GIS) and value the economic impact on flood mitigation using Contingent Valuation Methods (CVM).

Methodology/Technique – The data regarding geographical, demographical, socio-economic, and topographical condition collected from local governments in Central Java Province, Meteorology and Geophysics Board, the Statistical Bureau, and Planning and Development Boar.

Findings – Spatial analysis with GIS provides evidence that Surakarta, Sragen, and Sukoharjo districts are more vulnerable to flood than other districts in Central Java Province. This evidence points the need to conduct a thorough study on these areas.

Novelty – This research contributes to empirical study, methodology, and policy implications.

Type of Paper: Empirical

Keywords: Spatial Analysis; Flood Impact; Local Wisdom; Economic Valuation; Willingness to Pay.

JEL Classification: C21, Q51, Q54.

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1. Introduction

Indonesia has a number of areas that are vulnerable to flood. Water debit is rising in several rivers during the rainy season. It may lead to harvest failures in rice fields, as well as damage the pattern of planting season and irrigation system, which in turn will negatively affect national supply of rice; the main component of Indonesian food (Khomsan, Riyadi & Marliyati, 2013).

The statistic shows that flood occurred in just over half of total districts in Central Java Province, including Banyumas, Brebes, Kebumen, Cilacap, Purworejo, Demak, Semarang, and Groboganin the last ten years. However, this study will focus on mapping the areas vulnerable to flood in Boyolali, Sukoharjo, Sragen, and Surakarta using Geography Information System (GIS).

Communities that have the sound management of resources can mitigate the impacts of the flood. The mitigation measures are more effective when performed at the community level, which directly experiences

the risk of loss caused by the flood. To determine the willingness to pay (WTP) for flood mitigation, we include local wisdom in the analysis. The result of WTP estimation is affected by the residential location and the risk of losses caused by the flood. Besides that, we put special concern for demographic factors, as attitude and community behavior are found to affect people's WTP (Clarke & Wallsten, 2003).

2. Research Method

2.1. Mapping of Flood Vulnerable Areas

To map the areas vulnerable to flood, the data regarding geographical, demographical, socio-economic, and topographical condition are needed. The data regarding geographical condition contains the information regarding surface levels, green areas, catchment areas, rivers, waterfalls, land morphology, and land use. These data are collected from local governments in Central Java Province, Meteorology and Geophysics Board, the Statistical Bureau, and Planning and Development Board.

GIS is employed to determine the characteristics of regions vulnerable to flood. GIS transforms raw data into usable information through integration of several different data, analysis of the data, and provide a final result for decision-making (Tian, 1996) in Kuncoro (2002). Kuncoro (2002) states that some of the departments in Indonesia use GIS for different purposes. For example, the Department of Mining uses GIS to build a more efficient stock-procedure and to determine soil stock (East Asian Executive Reports, 1996).

2.2. Valuating the impact of flood with socio-economic variables and local wisdom

Local wisdom is considered as an important variable in the valuation the impact of the flood. Local wisdom can be defined as activities using cognitive aspect to act toward objects or events in their spatial perspective. Wisdom can be defined as a deep understanding and realization of people, things, events, or situations, which will result in the ability to apply the perceptions, judgments, and actions that come along with this understanding. The word 'local' is often defined as limited interactions in a limited system in an area and involves a relationship between environment and people.

2.3. Data

The primary data needed are a direct and indirect loss to show the impact of the flood in the areas vulnerable to flood. The data are gathered using surveys and direct interview with selected respondents using a questionnaire.

We collect secondary data from government institutions that have authority in handling flood and its mitigation. The institutions are the Regional Environmental Impact Control Board, the Statistical Board, the National Disaster Coordination Board, and the Regional Planning and Development Board. The secondary data comprise of the population of municipals and regencies, the characteristics of vulnerable areas, and socio-economy data in Central Java Province.

To collect secondary data regarding loss calculation caused by flood we employ literature review method. The primary data needed are collected from the samples that are selected using the strategic random sample (Scheaffer, Mendenhall Ott & Gerow, 2011). Sample selection is performed by dividing the houses in the studied areas into several blocks and then researchers select the samples randomly from each block. The number of samples needed for the analysis is determined based on Watson, Ballingsley, Croft and Hundsberger. (1993) formula:

$$ n = \frac{4Z_{\frac{1}{2\alpha}}^2 p(1-p)}{(\omega)^2} $$

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Notes:

ω	= tolerance of error from population mean on left limit (L) and right limit (R), so ω = L+ R
q	= residual of proportion (1-p)
p	= proportion of prospected samples
$Z_{1/2\alpha}$	= coefficient of confident
n	= sample size

2.4. Analysis Tools

Flood loss is computed using Contingent Valuation Method (CVM). This method is performed through a direct survey to determine respondent's WTP and Willingness to Accept (WTA). Compared to indirect method, CVM has two benefits. First, CVM can be used to calculate the direct and indirect value of environment simultaneously. Secondly, respondent's answers toward the WTP and WTA items reflect someone's value in flood mitigation. (Lee, 1999).

In this study, we proposed the following model: WTP = f (*socio-economy, flood risk, local wisdom*)

$$WTP_i = \alpha_0 \sum_{l=1}^{11} \beta_i X_{i1} + \beta_i X_{i2} + \cdots + \beta_n X_{in} + \varepsilon$$

Notes:

a. Dependent variable:

   WTPmit = willingness to pay for flood mitigation

b. Independent variables:

   Socio-economic: education (EDUC), income (INC), family size (FAM), and land ownership (OWN), and
   Local wisdom: Personal saving from non-agriculture income (DMIT1), Storing part of agriculture products and sell it periodically (DMIT2), Informal loans
   Flood risk: Flood losses (LOSS)
   (DMIT3), and Diversification (DMIT4). These variables are dummy variables.

The regression function is as follows:

$$LWTPmit = \beta_0 + \beta_1 LINC + \beta_2 LOWN + \beta_3 LLOSS\,AGE + \beta_4 FAM + \beta_5 EDUC + \beta_6 DWIL1 + \beta_7 DWIL2 + \beta_8 DWIL3 + \beta_9 DMIT1 + \beta_{10} DMIT2 + \beta_{11} DMIT3 + \beta_{12} DMIT4 + \varepsilon$$

3. Result

3.1. Mapping of Flood Areas

Mapping of flood areas using GIS was performed to identify the areas vulnerable to flood in Central Java Province. The area lies along the catchment area of Bengawan Solo River. Bengawan Solo River is one of the major rivers in Java Island, flowing across East Java Province and Central Java, crossing three municipalities and17 regencies. The river is about 19.778 km^2 wide, which is around 12% of total Java Island's width. The areas along the river bank are vulnerable to flood.

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Bengawan Solo River flows in tropical area, with dry season stated in May and ended in October, while the wet season started in November and ended in April. The average humidity level is 80% and the average monthly temperature is 26.7°C (Public Work Department, 2008).

Vulnerable parts in Central Java Province in the northern areas are Pekalongan, Brebes, Kendal, Tegal, Kudus, Pemalang, Semarang, Batang, Demak, Blora, and Pati, while in the south are Banyumas, Cilacap, Kebumen, Magelang, and Purwokerto, and as shown in Figure 1.
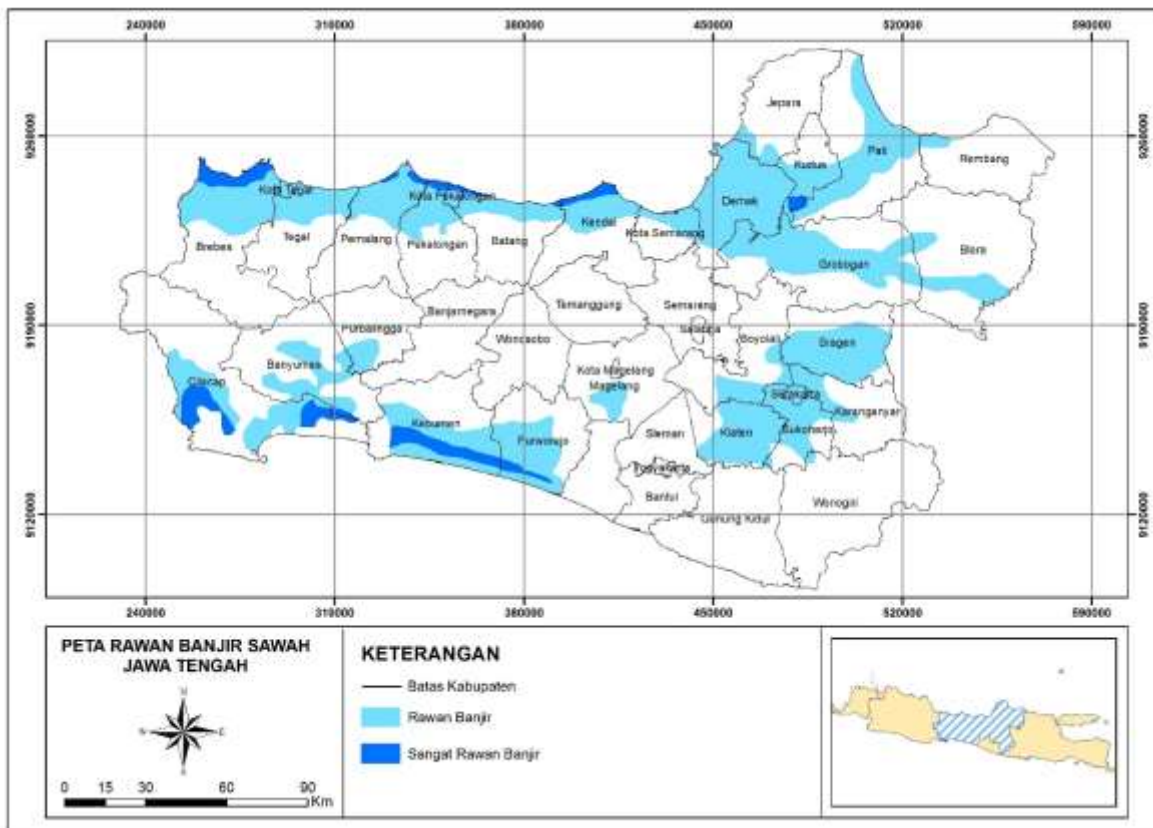

Figure 1. Map of Areas Vulnerable to Flood in Central Java Province

This study focused on the middle area, which comprises of Surakarta, Sragen, and Sukoharjo. These areas have higher risk compared to the other areas, as can be seen in Figure 2.
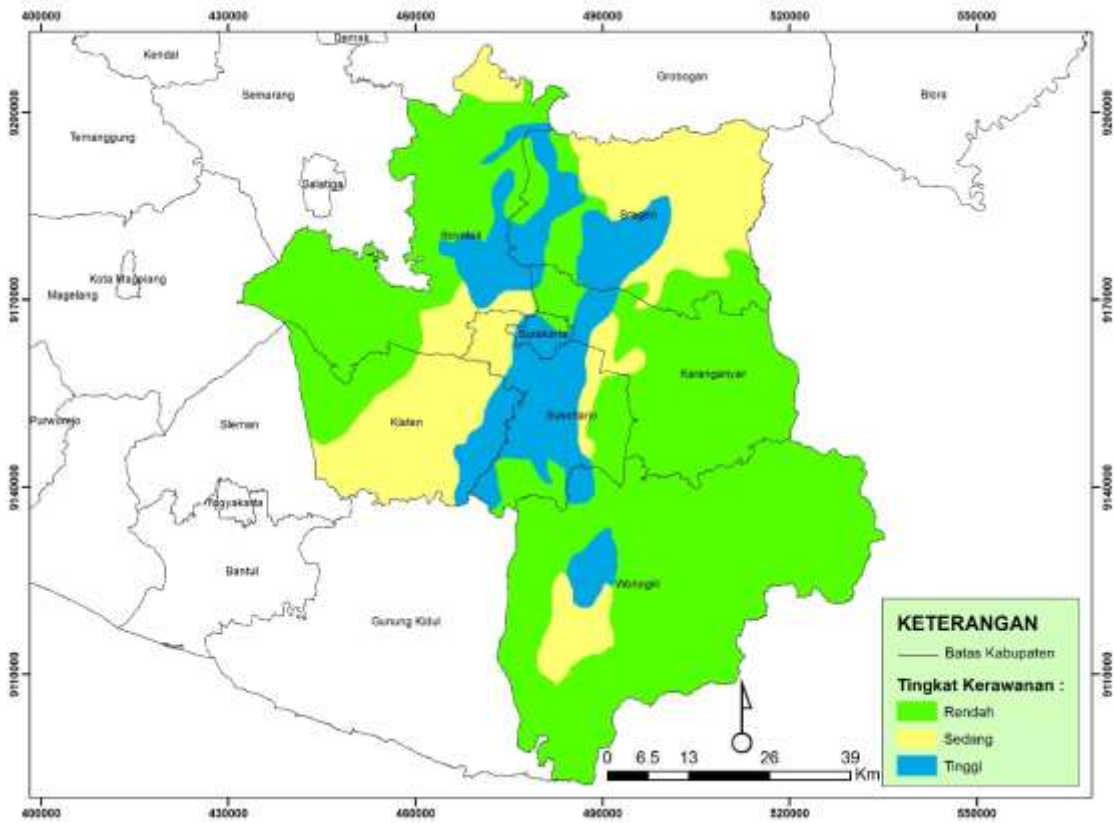
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Figure 2. Map of Study Area: Sragen, Sukoharjo, Surakarta

3.2. Willingness to Pay (WTP)

We proposed the following formula to assess the effect of WTP:

WTP = f (*flood risk, socio-economy*, *local wisdom*)

The model shows the result of the economic valuation as:

$$LWTPmit = 2.72 - 0.091LINC - 0.194LOWN + 0.58LLOSS - 0.004FAM + 0.013EDUC - 0.402DWIL1 - \\ - 2.668DWIL2 - 2.735DWIL3 + 0.143DMIT1 + 0.011DMIT2 + 0.074DMIT3 - 0.059DMIT4$$

Table 1. Results of WTP for Flood Mitigation

Variable	Explanation	
LINC	Income	- 0.091* (-2.374446)
LLOSS	Flood loss	0.587* (11.21098)
LOWN	Land owner	- 0.194* (-5.804150)
EDUC	Education	0.013* (1.947245)
FAM	Family size	- 0.004*

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		(-0.328495)
DWIL3	Surakarta Area	- 2.735* (-15.68592)
DWIL1	Sragen Area	- 0.402* (-2.561292)
DWIL2	Sukoharjo Area	- 2.668* (-13.79895)
DMIT2	Storing part of agriculture products and sell it periodically (dummy)	0.011** (6.1165)
DMIT1	Private saving from non-agriculture income (dummy)	0.143** (7.81370)
DMIT4	Diversification (dummy)	- 0.059** (-3.07879)
DMIT3	Informal loans (dummy)	0.074** (4.13895)
Constant		2.535 (5.908552)
Adjusted R^2		0.832509
F statistic		125.2613
Classical Assumption Test	Multi collinearity	-
	Heteroscedasticity	Hetero

**significant on α=10%, *significant on α=5%, = t statistic

The analysis results show that all independent variables affect the WTP for flood mitigation. The adjusted R-Squared (0.832509) indicates that 83% variations of the dependent variable (WTP) are caused by the variations in the independent variables, while the remaining 17% variation is caused by other variables outside the model.

Income level, land ownership, education level, and family size negatively affect the WTP. This means that the increase in income level, education level, landownership, and family size will cause a decrease in WTP. The reason for this is because people have low awareness on flood mitigation and they believe that it is government's responsibility to mitigate the risk of flood.

The study conducted by Lai and Hsieh (2007), Morone and Ozdemir (2006) and Suryanto, Cahyadin and Raharjo (2011) conclude that income has a positive influence on WTP. The loss also has the positive effect on WTP. People awareness will increase when they experienced losses caused by the flood. The other variable that positively affects WTP is the level of education. This means that if farmers have higher education level they will have broader experience and insight regarding mitigation measures. This finding is in line with the finding from Saptutyningsih & Suryanto (2008), Morone & Ozdemir (2006). Respondent's residence is found to cause the difference in WTP. Respondents who live in Sragen display different WTP from the respondents who live in Sukoharjo and Surakarta. This difference might be caused by the difference infrequency of flood occurrence in the area.

Local wisdom shows the significant statistical effect on WTP. Storing part of harvesting products and sell it periodically, Personal saving from non-agriculture income, and informal loans indicate a positive effect on WTP.

4. Discussion

Mitigation for the areas vulnerable to flood is important. Local wisdom should be considered as one of mitigation strategies. Community empowerment and local wisdom are needed in creating more effective mitigation scheme for the flood. Storing part of harvesting products and sell it periodically is the local

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wisdom for mitigation preferred by most farmers. However, this measure cannot guarantee farmers' welfare when the flood strikes. The farmers need to develop a more secure mitigation strategy such as disaster insurance. In deciding the alternatives for flood mitigation, Benefit-Cost Analysis can be used by the government. The government also needs to manage and adjust their policy scenario for the flood to the community needs.

5. Conclusion

Sukoharjo, Sragen, and Surakarta are the districts vulnerable to flood in Central Java Province. Sragen and Sukoharjo have a significantly wider agriculture area than Surakarta in which most its area is covered with housing area, thus reducing the potential agricultural loss. The family size, level of education, income, landownership, flood area, flood loss, and local wisdom affect the WTP for mitigation. Local wisdom measures were taken by the farmers including storing part of agriculture products and sell it periodically, private saving from non-agriculture income, diversification of crops, and informal loans.

Acknowledgement

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Valuing the Economics Impact

by Suryanto Suryanto

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Novelty – This research contributes to empirical study, methodology, and policy implications.
Type of Paper: Empirical

Keywords: Spatial Analysis; Flood Impact; Local Wisdom; Economic Valuation; Willingness to Pay.
JEL Classification: C21, Q51, Q54.

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2. Research Method

2.1. Mapping of Flood Vulnerable Areas

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2.4. Analysis Tools

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3. Result

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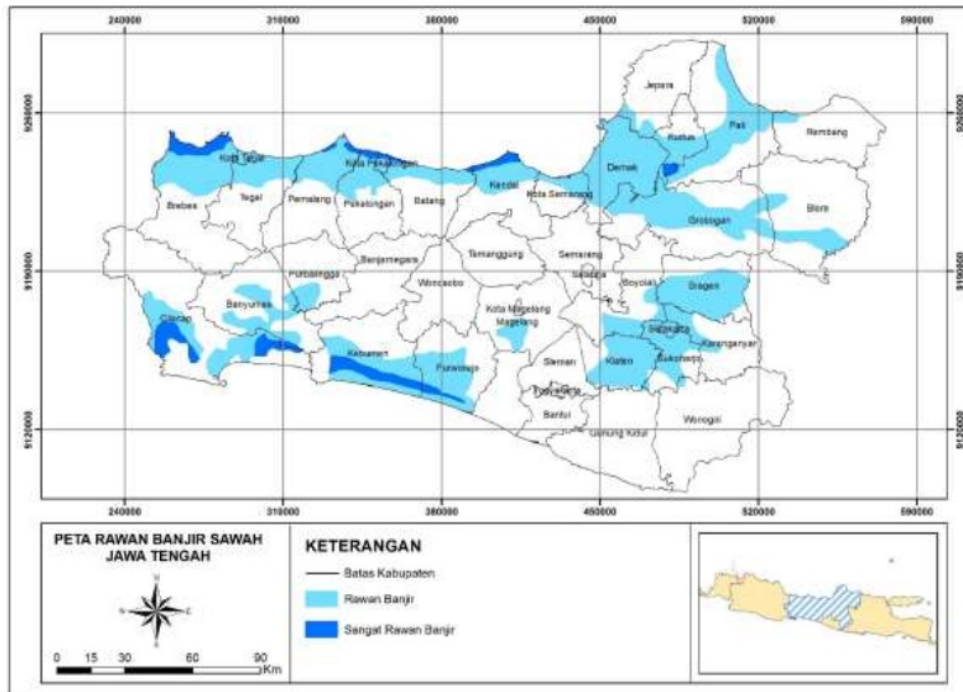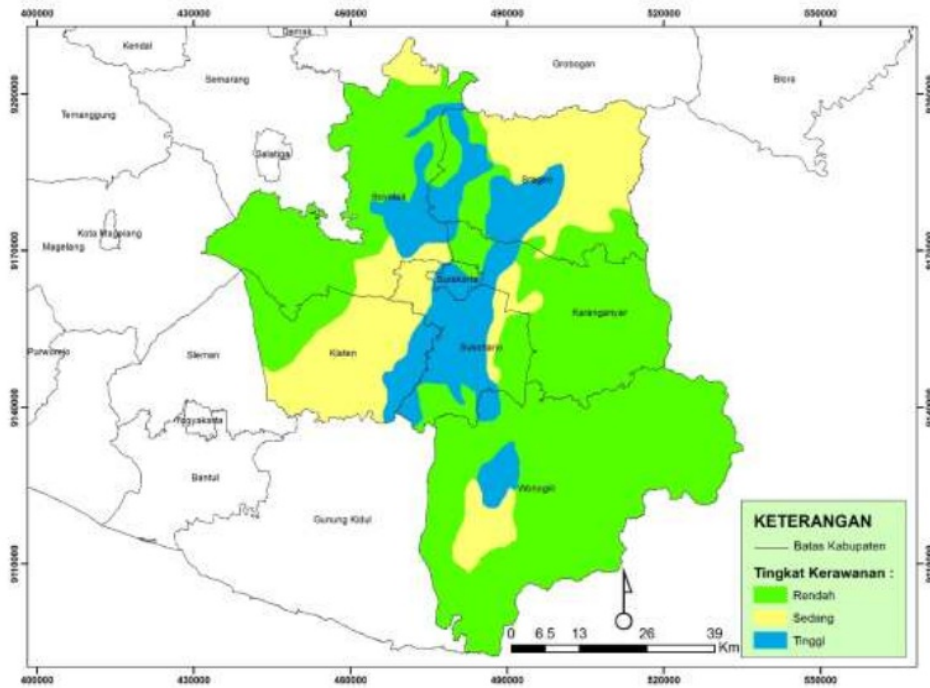

Figure 1. Map of Areas Vulnerable to Flood in Central Java Province

This study focused on the middle area, which comprises of Surakarta, Sragen, and Sukoharjo. These areas have higher risk compared to the other areas, as can be seen in Figure 2.

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Figure 2. Map of Study Area: Sragen, Sukoharjo, Surakarta

3.2. Willingness to Pay (WTP)

We proposed the following formula to assess the effect of WTP:

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The model shows the result of the economic valuation as:

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Local wisdom shows the significant statistical effect on WTP. Storing part of harvesting products and sell it periodically, Personal saving from non-agriculture income, and informal loans indicate a positive effect on WTP.

4. Discussion

Mitigation for the areas vulnerable to flood is important. Local wisdom should be considered as one of mitigation strategies. Community empowerment and local wisdom are needed in creating more effective mitigation scheme for the flood. Storing part of harvesting products and sell it periodically is the local

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Valuing the Economics Impact

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(artikel)

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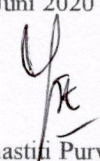- ☐ Jurnal Ilmiah Nasional/Nasional terindeks di DOAJ, CABI, COPERNICUS**

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