



**BUKTI KORESPONDENSI**  
**INTERNATIONAL JOURNAL OF BUSINESS AND**  
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Do Social-Economy Vulnerability Index and Poverty Index Have  
Correlation? Study in Bengawan Solo Watershed

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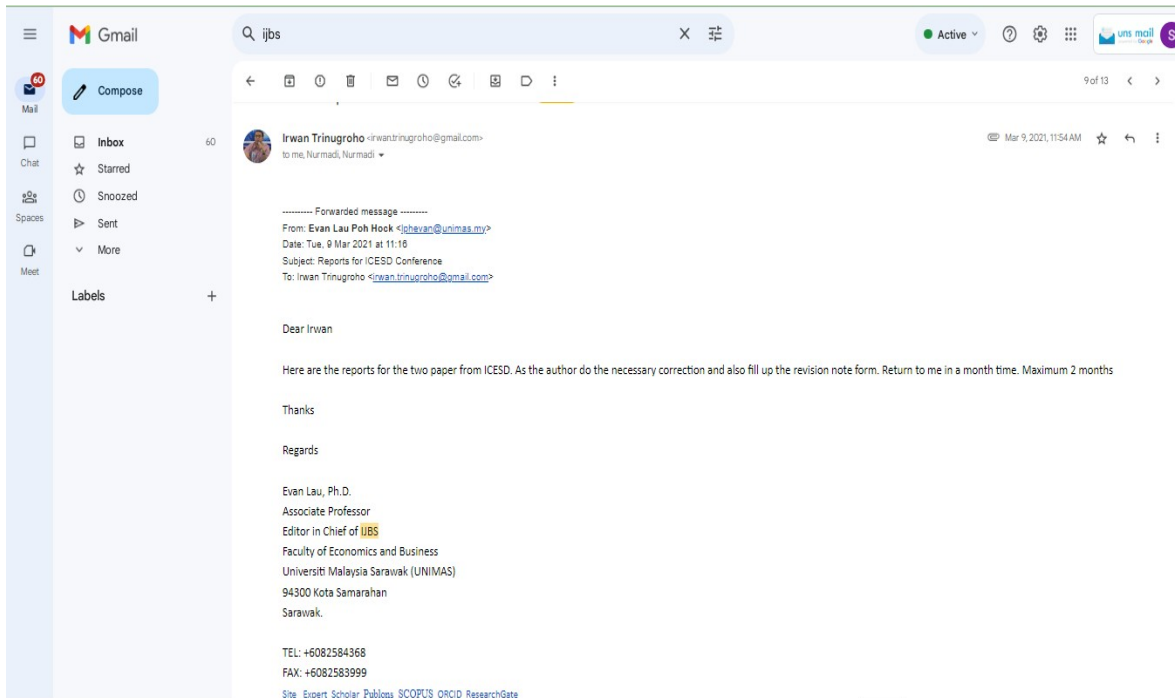
Penulis: Suryanto\*, Ratih Kumalasari, Danur C. Guritno, Nugroho Saputro, Sabar Marniyati

\*Correspondence Author

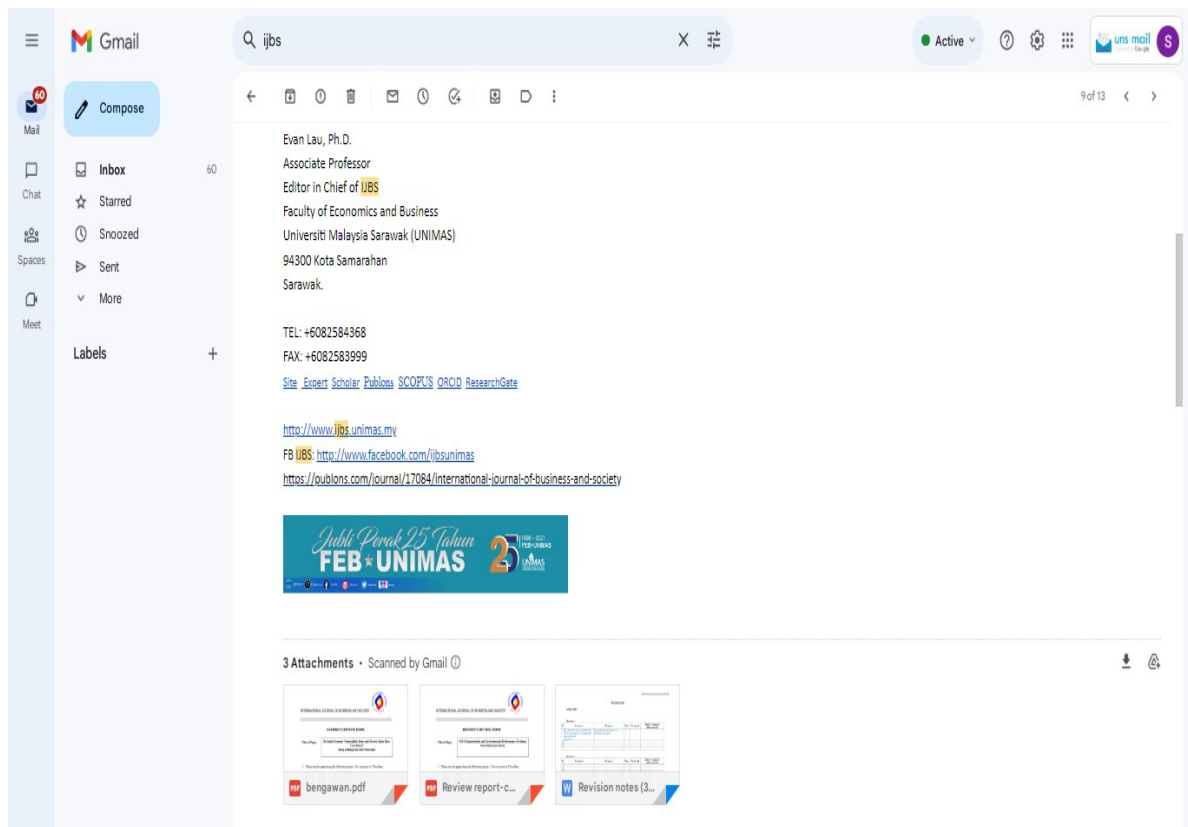
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9.	Lampiran-lampiran		10

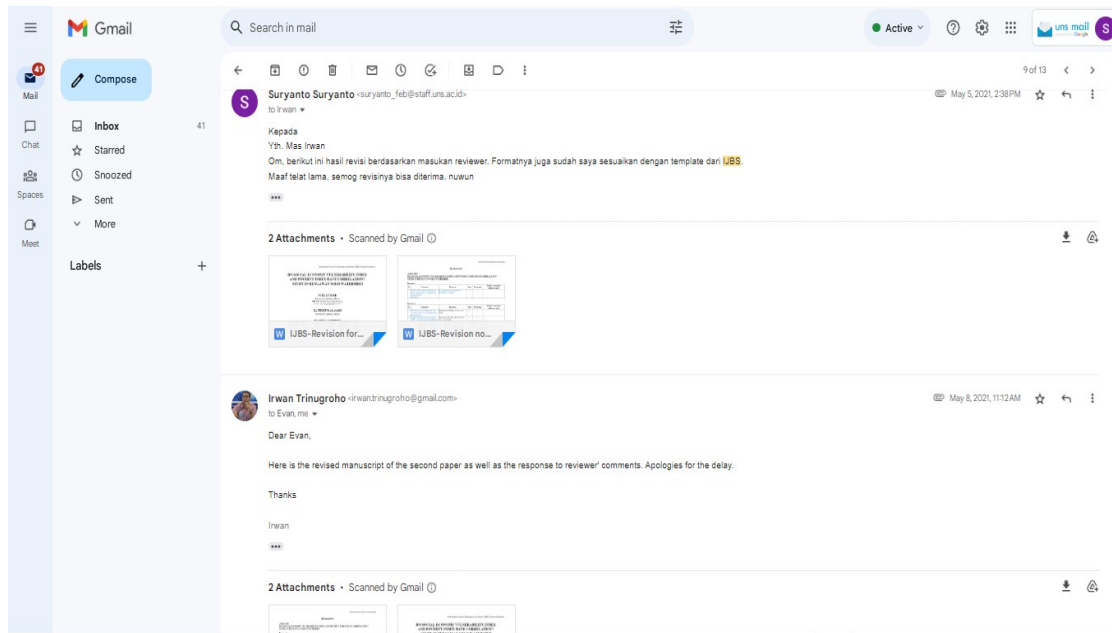
# 1. Bukti korespondensi awal dengan editor tanggal 9 Maret 2021



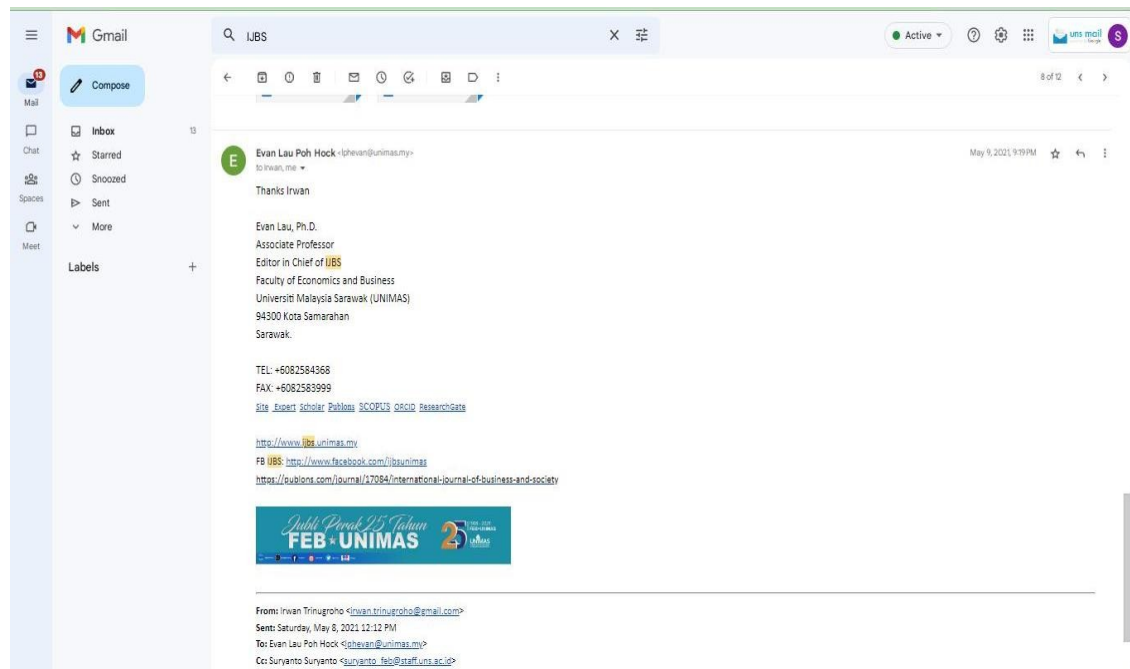
## Attachment Revisi 1 (9Maret 2021)



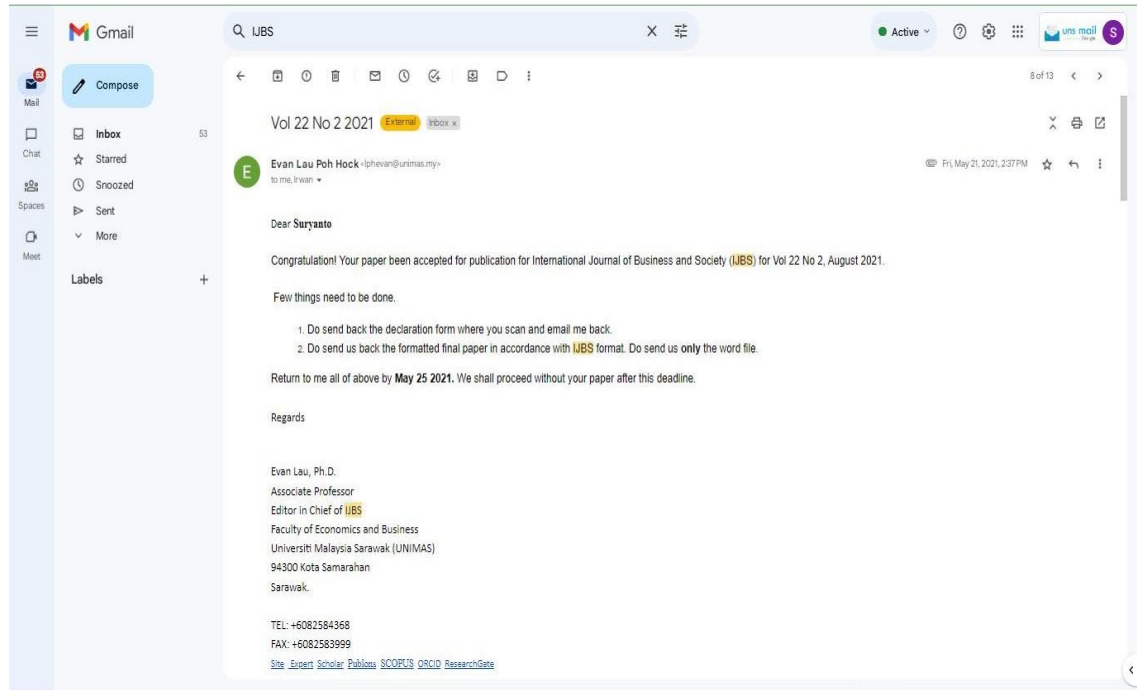
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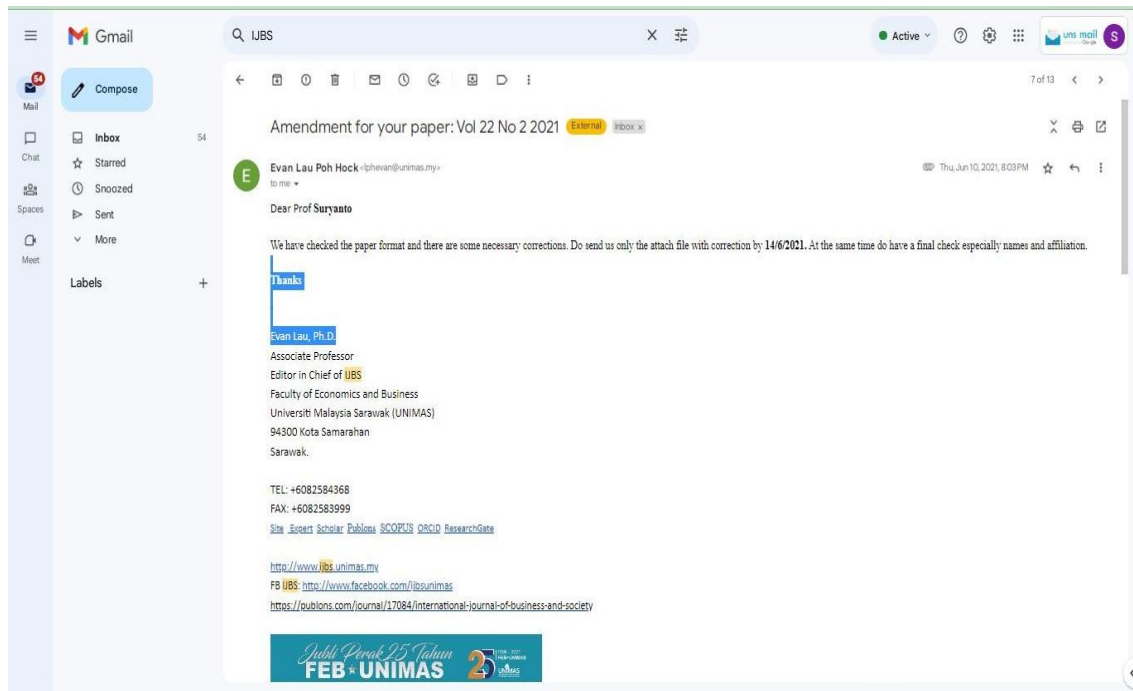
### 3. Bukti korespondensi dengan Editor (9 Mei 2021)



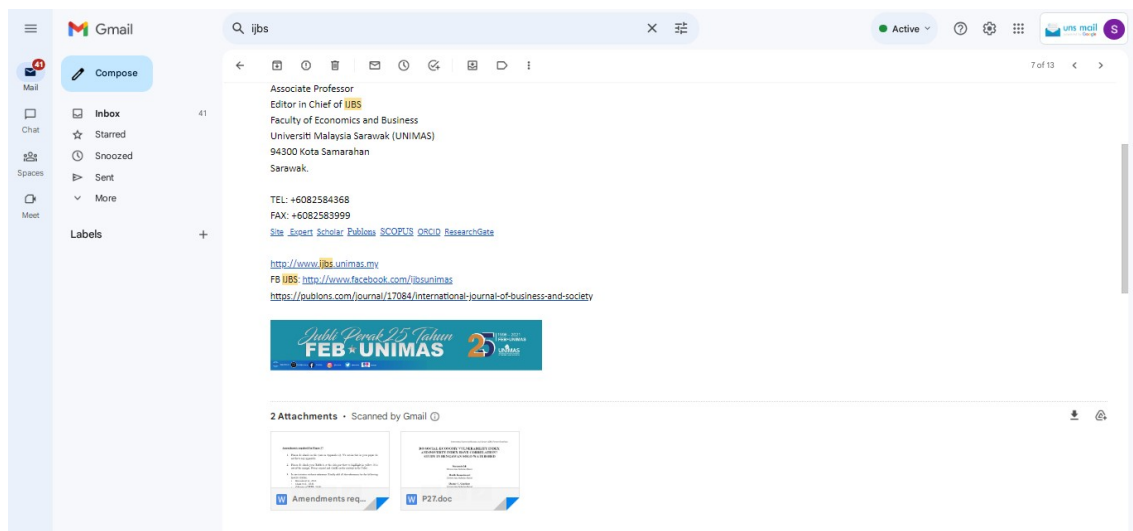
#### 4. Bukti Korespondensi dengan Editor: Letter of Accepted (21 Mei 2021)



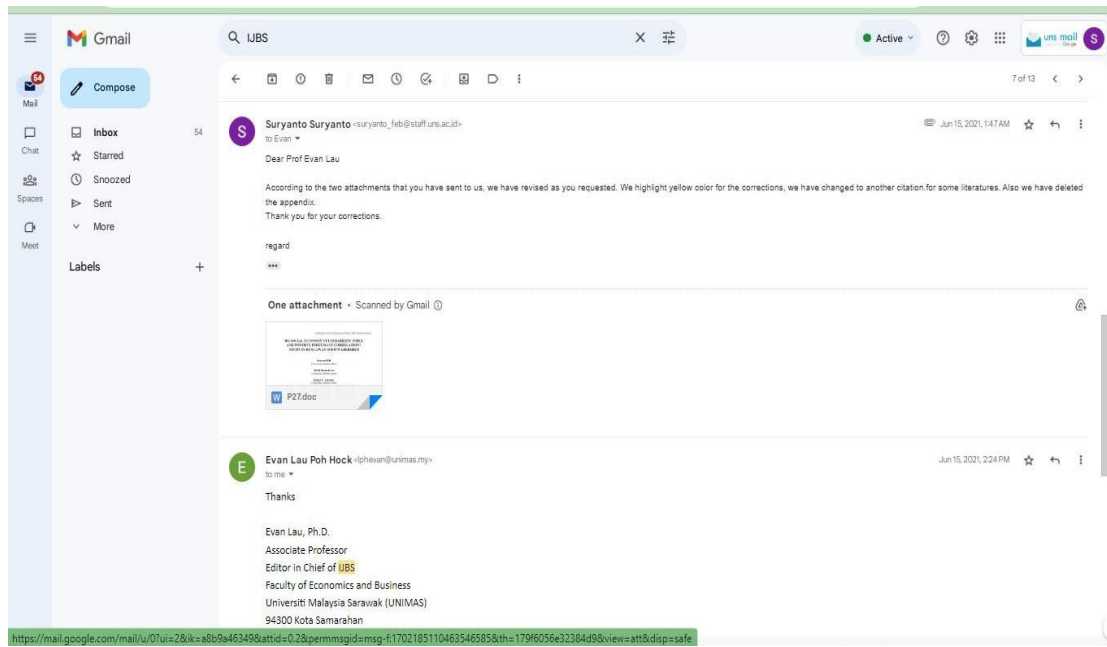
## 5. Bukti Korespondensi dengan Editor: Format Check (10 Juni 2021)



## Attachment Revisi 2 (10 Juni 2021)

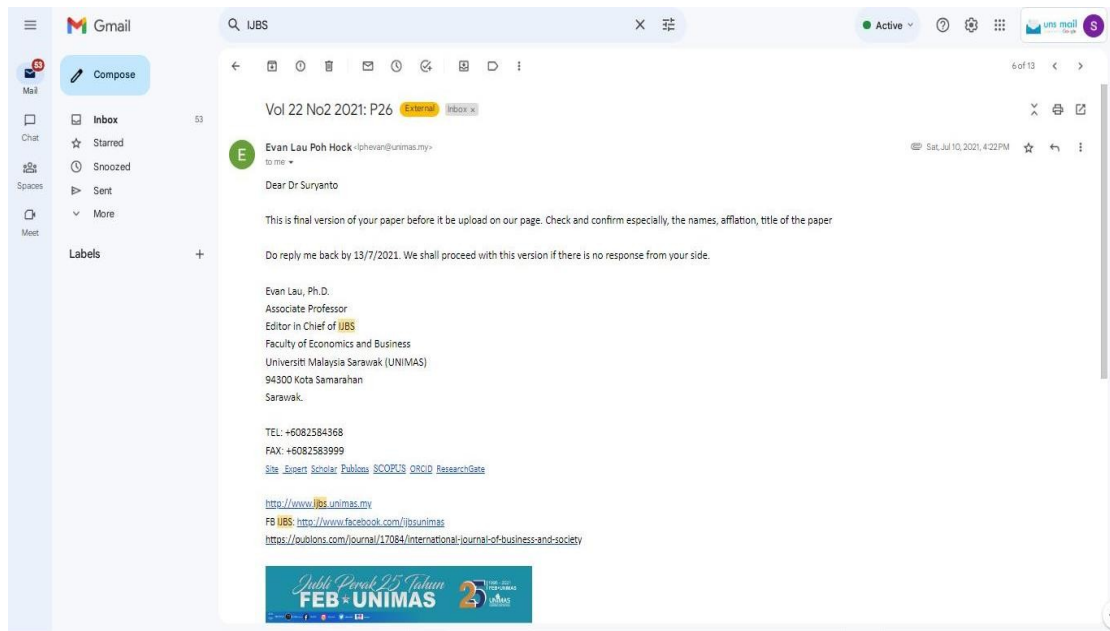


## 6. Bukti Korespondensi dengan Editor: mengirimkan hasil review format (15 Juni 2021)

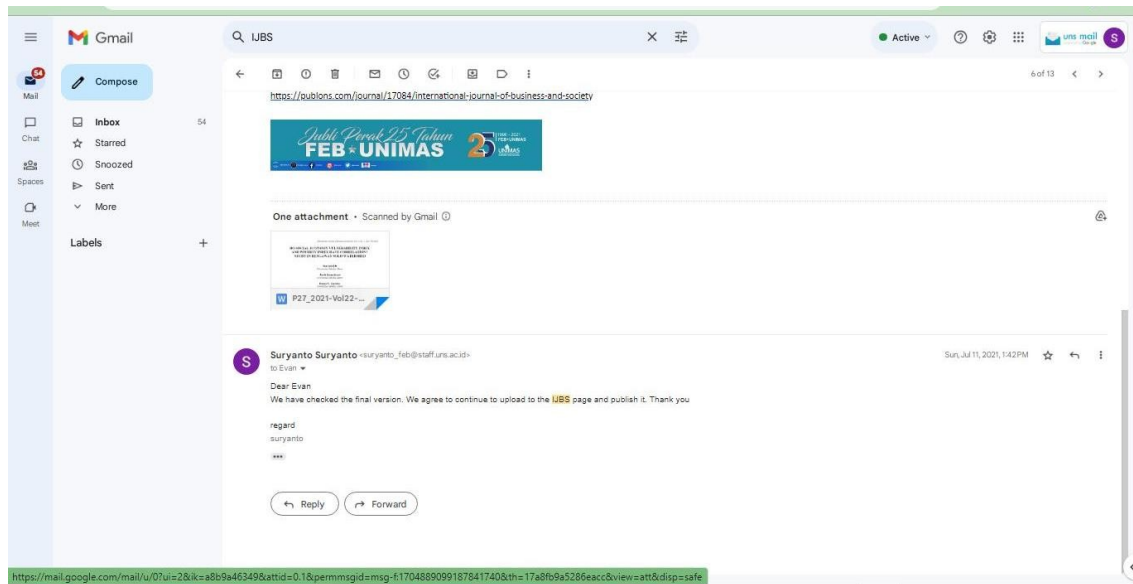




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## 8. Bukti Korespondensi siap publikasi (11 Juli 2021)



## LAMPIRAN-LAMPIRAN

1. Draf Artikel (9 Maret 2021)

### **Do Social-Economy Vulnerability Index and Poverty Index Have Correlation? Study in Bengawan Solo Watershed**

**Suryanto; Kumalasari, Ratih; Guritno, Danur C.**

Faculty of Economics and Business, Universitas Sebelas Maret, Indonesia

Suryanto\_feb@staff.uns.ac.id

#### **ABSTRACT**

The components to measure of disaster risk (i.e flood) are level of hazard, vulnerability of individual/community, and capacity of individual/community. Research related to vulnerability is based on the level of probability of a region experiencing a disaster, while vulnerability is based on conditions where individual/community cannot cope with disasters. The aim of the study was to measure the level of vulnerability of the socio-economic and institutional society. This research tried to explain the level of sosial vulnerability among the communities in upper Bengawan Solo wathershed. SoVI makes more appropriate parameters for measuring social vulnerability than relying only on partial socioeconomic data. The data generated from relevan institution, such as Central Bureau of Statistic (Badan Pusat Statistik–BPS), Social Service Institution (Dinas Sosial), National Population and Family Planning Board. Data needed such as socio-economic community, demography, age, family structure, village-city, education, and unemployment rate. We find the data from the related agencies. The first step analysis is to adapt the measurement of vulnerability (SoVI) that has been developed. After the measurement of the SoVI is carried out then it is classified relatively between districts (Sragen, Sukoharjo, Wonogiri, and Karanganyar) in the upstream Bengawan Solo Watershed. The results show that the regency with the highest SoVI score is Sragen, followed by Wonogiri and Sukoharjo, and the lowest is Karanganyar. Meanwhile, Sragen has the highest scores in social-economy components score such as age, gender, rural/urban, occupation, and family structure. It implies that when disasters attack to Sragen, their community will be more suffering potentially.

**Keywords:** social economy, community, vulnerability, risk

\*) The research is part of the output of the research grants of Higher Education 2017-2018

## ABSTRAK

Komponen pengukuran risiko bencana termasuk banjir adalah kerawanan terhadap suatu bahaya, kerentanan individu atau masyarakat, dan kapasitas individu atau masyarakat. Penelitian terkait kerawanan mendasarkan pada tingkat probabilitas suatu wilayah mengalami suatu bencana, sedangkan kerentanan mendasarkan pada kondisi di mana individu/masyarakat tidak bisa mengatasi bencana. Tujuan penelitian mengukur tingkat kerentanan masyarakat secara sosial ekonomi dan kelembagaan. Penelitian ini bersifat deskriptif, langkah pertama mengadaptasi pengukuran kerentanan atau *social vulnerability index* (SoVI) yang pernah dikembangkan. SoVI menjadikan parameter yang lebih tepat untuk mengukur tingkat kerentanan social disbanding hanya mengandalkan data social ekonomi secara parsial. Data yang dibutuhkan seperti misalnya sosial ekonomi masyarakat, demografi, usia, struktur keluarga, desa-kota, pendidikan, dan tingkat pengangguran. Sumber data diperoleh dari instansi yang berkaitan dengan data yang diperlukan. Setelah pengukuran SoVI dilakukan kemudian diklasifikasikan secara relatif di antara kabupaten-kabupaten (Sragen, Sukoharjo, Wonogiri, dan Karanganyar) di wilayah Daerah Aliran Sungai Bengawan Solo bagian hulu. Hasil penelitian dapat digunakan untuk melengkapi informasi mitigasi kebencanaan di daerah yang rawan bencana. Hasil penelitian menunjukkan di antara wilayah di DAS Bengawan Solo bagian hulu, ternyata Karanganyar adalah wilayah yang relatif tidak rentan, sedangkan wilayah yang rentan yaitu Sragen. Dua kabupaten yang memiliki tingkat kerentanan yang sama yaitu Wonogiri dan Sukoharjo. Sragen berdasarkan hasil penghitungan SoVi diketahui memiliki kerentanan terutama pada komponen usia, kependudukan, pekerjaan, susunan keluarga, jenis kelamin, dan desa/kota.

**Kata kunci:** sosial ekonomi, masyarakat, kerentanan, risk.

## 1. Introduction

Disaster is a phenomenon that occurs as a result of the combination of hazard components that can affect the condition of the surrounding environment and how the level of vulnerability and ability of an area to manage threats (Oxfam, 2012 in Hapsoro, 2015). The flood that re-occurred every year in several regencies passed through Bengawan Solo River, and it leads to socio-economic vulnerability in those regency. Vulnerability can be defined as a weakness to anticipate the potential for something that has a risk. Lawal & Arokoyu (2015) stated that vulnerability is a loss of life or properties as the result of a natural disaster. Meanwhile, Suryanto (2017) stated a vulnerable area to the natural disaster is often socially more vulnerable compared to the areas that less prone to natural disasters. Research from Widiarto & Kingma, (2014) also reported that impact of vulnerability to flood can disrupt the development and economic growth in Sragen. Furthermore, according to Miyan (2015) and Lawal & Arokoyu (2015), vulnerability consists of two categories, namely biophysical and social vulnerability. Biophysical vulnerability can cause food insecurity, drought, flood, bad weather, etc, meanwhile social vulnerability leads them to suffer from disease, loss of property, etc.

One of the factor that causing the flood in several areas is climate change. Climate change is the change in climate variable, especially air temperature and rain intensity that occur gradually around 50 to 100 years (Kifli, Mulyo, & Sugiyarto, 2015); (Hettiarachchi, Wasko, & Sharma, 2018). In the time of disaster, there will be many aspects get hampered such as socio-economic aspect. An area that often faced natural disasters such as flood usually has its socio-economic effects in the life of people that are affected compared to other areas. The disruption in the social-economy condition in an area can increase the vulnerability of the area.

A high level of vulnerability will affect poverty. One of the most affected group is farming. For farmers, the land is an earning asset which can generate revenue (Giyarsih et al., 2011). Therefore, when their farmland is flooded, they cannot cultivate their crops which reduce their revenue. There is a correlation between the population's vulnerability to poverty and their residence ecosystem, thus the level of poverty will differ from each agro-ecosystem (Giyarsih et al., 2011). The more vulnerable community will find it more difficult to fulfill their basic needs compared to the society that is not vulnerable.

The previous studies on vulnerability show mixed results. Research conducted by Lawal & Arokoyu, (2015) examined social vulnerability in Sub-Sahara area especially West Africa. Another research by Setyaningrum & Giyarsih (2012) examine the socio-economic vulnerability of communities that live around the Kali Code riverbank in Yogyakarta towards Merapi Mountain sediments flood. Meanwhile, Shirley, Cutter, and Borruf et al., (2003) examined the vulnerability related to the social life of the communities.

Social vulnerability is measured using various method in the previous researches. SoVI has introduced by Shirley, Cutter, and Borruf., (2003), they developed SoVI to identify and

mapping the level social vulnerability in Mississippi Delta Region. This model has been adapted and adjusted depend on local characteristics aspects. Research by Lawal & Arokoyu, (2015) and use the Social Vulnerability Index method in measuring the vulnerability. However, they add SIG to map the level of vulnerability of each area discussed in their research. Setyaningrum and Giyarsih (2012) use weighting method for each vulnerability component.

Another research on vulnerability is conducted by Shah, Dulal, Johnson, & Baptiste, (2013), which analyze farmers' vulnerability toward climate change. The method used is the Livelihood Vulnerability Index (LVI) method. Razafindrabe, et al. (2009) in contrast, examined the resilience of a region toward disasters that occur as an effect of climate change on the Asian coastal area. The method was the Climate Disaster Resilience Index (CDRI).

This research aims to examine the social vulnerability, describe the socio-economic condition, mapping social vulnerability comparison, and the basis of consideration for the development policy of Bengawan Solo watershed area, which covers for the regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen. The main benefit of the study is decision maker have accurate or precision to priorate the community who suffered by the disaster.

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Using the index of social vulnerability (SoVI), a study of social vulnerability by Lawal and Arokoyu (2015) indicates that Ondo and Ekiti have LGAs more vulnerable than other countries in the region. While research by Shirley et al., (2003) establish several spatial patterns in SoVI calculation, in which the most vulnerable regency located in East Metropolitan area, South Texas, and Mississippi Delta area. Another research conducted by Setyaningrum & Giyarsih, (2012) found that the vulnerability level of the community that resides around Kali Code Riverbank is low and more affected by the economics factor. Research conducted by

Shah et al., (2013) found that Narvia is more vulnerable than Caroni, especially in socio-demographics, health condition and water availability, natural disaster, and climate variability. Razafindrabe et al., (2009) suggest that the type of vulnerability in each area varies. Thus, a policy that should be taken for the area will be different.

According to BPS (2018), Central Java has 7 Regency/Municipality that passes through Bengawan Solo River, thus become the part of its watershed. However, Surakarta, as one of the municipality, have a small agricultural sector in the wetland rice production area with only 36 hectares and production of 230 ton (2018). The other regions such as Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency, and Sragen Regency have broader of square land. agricultural sector is one of the components in assessing social vulnerability, thus the areas used in this research are Wonogiri, Sukoharjo, Karanganyar, and Sragen Regency.

## **2. The Methods**

This research describes the socio-economic living, the level of social vulnerability, the comparison mapping of social vulnerability as a basis of consideration for the development policy of Bengawan Solo watershed area. The Social Vulnerability Index (SoVI) is performed to measure the vulnerability level in each regency. After the SoVI score is obtained, a Geographical Information System (Sistem Informasi Geografi – SIG) will be conducted to describe the most vulnerable regency.

The research took place on the areas located around Bengawan Solo watershed with the developed agricultural sector. Therefore, the four regencies which located in Bengawan Solo River watershed are chosen for this study namely, the Regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen.

This research use secondary data generated from other institutions or organizations related to this study. This data will be used to examine the social vulnerability level of the society in Bengawan Solo River watershed area. The secondary data are obtained from the Central Bureau of Statistic (Badan Pusat Statistik–BPS), Social Service Institution (Dinas Social-DinSos), One-door Integrated Investment and Licensing Offices (Dinas Penanaman Modal dan Perijinan Terpadu Satu Pintu–DPMPTSP), Population and Family Planning Bureau (Badan Kependudukan dan Keluarga Berencana Nasional), General Election Commission (Komisi Pemilihan Umum–KPU), and Financial and Regional Assets Management Office (Dinas Pengelolaan Pendapatan Keuangan dan Aset–DPPKA), which located in the Regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen.

Interview is a data collection technique that conducted by asking the employees directly in related institutions. The data obtained from the interview is used in this research. Observation is a technique conducted by directly observing and recording systematically in the research locations in order to understand the actual condition of the locations. Literature study

is a data collection method in which the researcher collect data from books, scientific journals, and reports of related institutions.

The SoVI score for each regency will be calculated using Microsoft Excel and SPSS 16 based on secondary data collected. The results will be discussed descriptively. SIG will be used to illustrate the area that is more vulnerable than others.

**Social Vulnerability Index (SoVI) Analysis:** a method that will generate the social vulnerability score for each area in this research. Therefore, in order to provide the score that will be used in the SoVI calculation, the z-score of each sub-component should be computed previously, using the following formula:

$$z = \frac{x - \mu}{\sigma}$$

Note:

z = z-score

x = base value

$\mu$  = the average value

$\sigma$  = standard deviation

After the z-score is computed, which mean the standard value for each sub-component is obtained, a varimax rotation method is used to know the correlation between a sub-components with another sub-component. The aim of varimax rotation is to test whether the factor score of each component is overlapping with other components. Based on the Rotated Component Matrix in the varimax rotation output, if there is more than one component that has a score above 0.50 then the component is overlapping with other components, thus the component should be eliminated.

After the overlapping components are eliminated, the next step is to decide whether the remaining components represent more than 50 percent of the total components before elimination. If the remaining component represents more than 50 percent than the total component, the SoVI score computation can be continued.

The remaining components that represent the total component are scored. The scoring is conducted by categorizing the z-score into the classes that have had prepared. The class is prepared based on Sturges formula, as follow:

$K = 1 + 3.3 \log n$ , with n, is the size of data

Range = highest score – the lowest score

Class length = Range/K

After the class is prepared, the z-score of each component is classified into the class. Moreover, each sub-component is analyzed whether it increases or decreases the vulnerability. The next step is by adding up all the sub-components, which represent the SoVI score. This score will be used to prepare the vulnerability map. The area with the highest SoVI score is the



area with the highest level of social vulnerability, vice versa. The classification of vulnerability level is based on the class. In this research, the classification is divided into three classes, namely, low, medium, and high vulnerability. The classification of vulnerability classes use a relative scale; the same method used for the scoring (Appendix 2).

**Table 1. The Indicator and Sub-indicator of *Social Vulnerability Index (SoVI)***

<b>Indicator</b>	<b>Sub-indicator</b>	<b>Sub-indicator explanation</b>
Social-economy status	Percapita income	The income earned by e person in a spesific year
	The dependency ratio of government to general allocation fund.	The Amount of General Allocation Funds in Regency/City income balance funds
	The number of votes in the presidential election	The number of voters who voted in the 2014 presidential election
	The percentage of family welfare	The number of household having more total income than regional minimum wage.
	The percentage of people live under poverty line	The number of poor people
Age	The number of households that own car	The number of households that own car
	Average age	The average age of population in a regency/city
	The number of elderly	The number of population over 65 years old
Property	The number of toddler	The number of children under 5 years old
	The rental cost of occupied housing	Average rental cost housing paid by community
	The number of Building Permit (IMB)	The number of building permit that issued by government
	The number of companies	The number of companies in regency/city
	Company productivity	The average value of company productivity
Health	GRDP Agriculture	Agricultural sector contribution to Regency / City income
	The number of doctors	The number of doctors, nurse, and midwife.
	The number of people living in nursing homes.	The number of people living in nursing homes.
Demography	The number of health facilities.	The number of health facilities such as hospital and health center.
	The percentage of population change	The comparison of population changes from the previous year
	Birth rate	Number of births in a Regency /

	Population density	City in 1 year The average of population density in district/ city.
Education	The number of high school graduate	The number of residents who have a high school certificate
Sex	The number of female	The number of female citizenship
Unemployment	The number of unemployment	The number of unemployed workforce
Rural/urban area	Land used by farmers	The amount of land used for agriculture
	The number of farmers	The number of residents who work as farmers
	The population of urban area	The number of residents living in urban areas
Social dependence	Social dependence Number of BPJS Health users	Number of residents using BPJS Health facilities
Number of people with special needs		The number of people who have physical, and mental limitations
Renter	The percentage of renter	The number of people who rent house
Job	Working workforce	The number of workforce employed
	The number of working female	The number of female work force employed
	The number of worker in agriculture, fishery, and forestry (primary industry)	The number of people whose livelihoods work in the agriculture, fisheries, mining and forestry sectors
	The number of residents working in the transportation, communication and other public facilities sectors	The number of residents working in the transportation, communication and other public facilities sectors
	Number of people working in the public service sector (services)	Number of residents whose livelihoods work in the public service sector (services)
Family structure	The number of Indonesian Migrant Workers (TKI)	The number of Indonesian Migrant Workers (TKI)
	The average number of family member	The average member in one family.
	Women as head of the family	Population of women who act as heads of families (do not have husbands)

Source: modified from Shirley, Cutter, and Borruf., (2003)

**Socio-Economics Description:** this analysis is conducted to describe the socio-economic condition of the communities that reside in the Bengawan Solo River watershed area. The socio-economic description is conducted using descriptive statistic method. The data used in this analysis is the result of z-score in the SoVI assessment. Each main component will be used to compare the vulnerability in each area, which will simplify the description of the socio-economic condition.

**The Analysis Using Geographical Information System (SIG):** SIG will be conducted to describe the most vulnerable regency among the four regency, based on the SoVI score. This part explains how the research is conducted, research design, data collecting techniques, instrument development, and data analysis techniques.

**Table 2. Summary of Research Method**

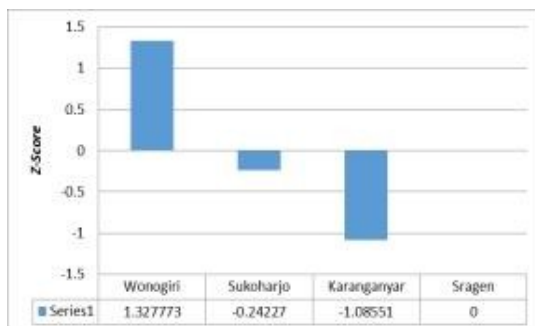
Research Objective	Analysis Tools	Data	Result
Social Vulnerability of the community that live at Bengawan Solo River watershed area	Social Vulnerability Index (SoVI)	Secondary Data	Social Vulnerability Index
Mapping of the most vulnerable area at the Bengawan Solo River watershed areas	Geographical Information System (SIG)	Secondary Data	Social Vulnerability Map

Source: research method (2017)

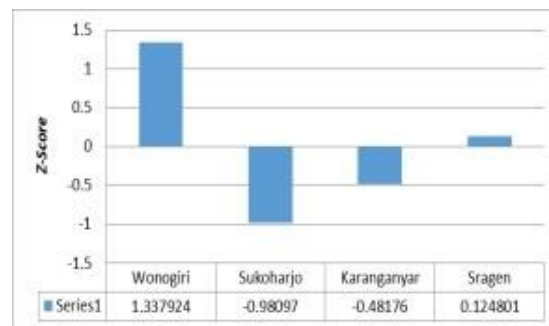
### 3. Result and Discussion

#### Social-Economic Description

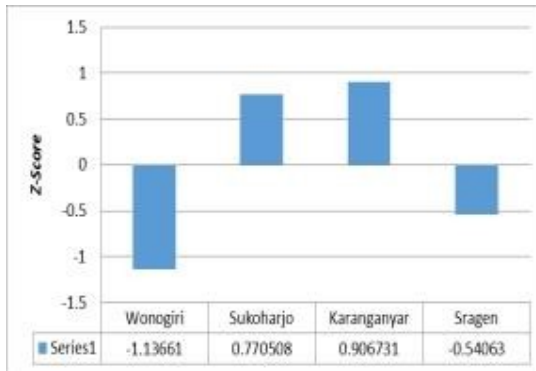
This analysis is performed to understand the social-economy life in Bengawan Solo watershed. Descriptive statistic is utilized to explain the social-economy description. The data employed are from z-score calculation in the process of SoVI scoring. Each main component will be explained the comparison in each area. Thus, it will be able to see the description of social-economy (Appendix 2). Some picture below represent each component of SoVI variable.



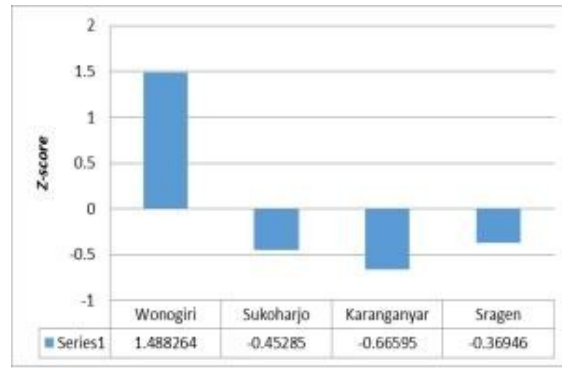
Source: Central Bureau of Statistics  
**Figure 1. Dependence of Transfer Allocation Fund (DAU)**



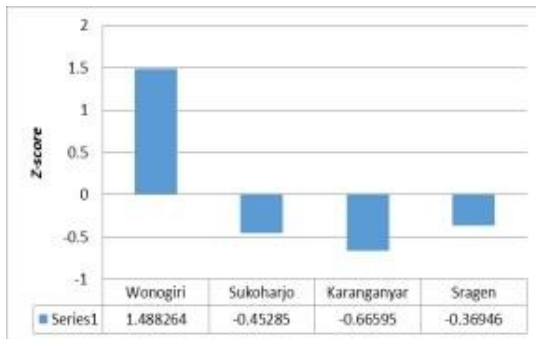
Source: Central Bureau of Statistics  
**Figure 2. The Number of Citizens Older than 65 Years**



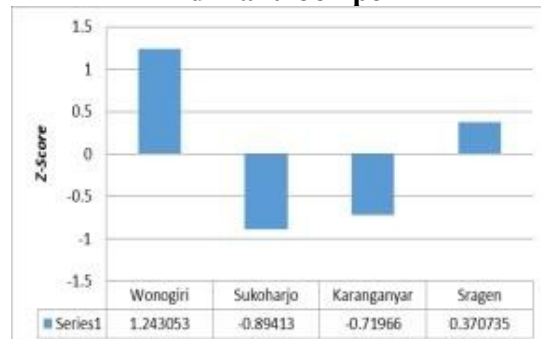
Source: Central Bureau of Statistics  
**Figure 3. Jumlah Perusahaan**



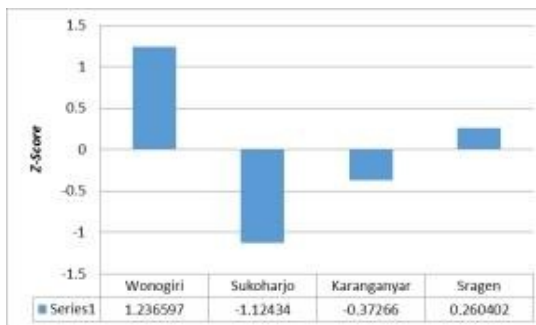
Source: Central Bureau of Statistics  
**Figure 4. Jumlah Penduduk yang Tinggal di Panti Jompo**



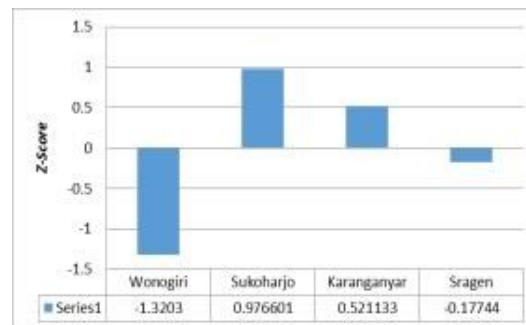
Source: Central Bureau of Statistics  
**Figure 5. Birth Rate**



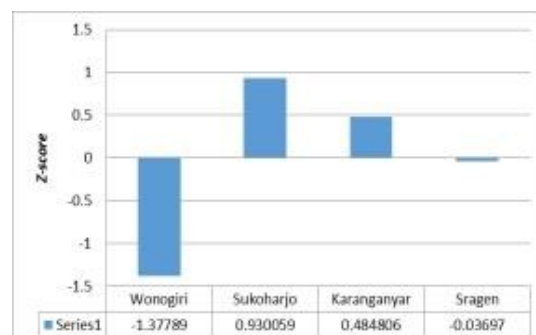
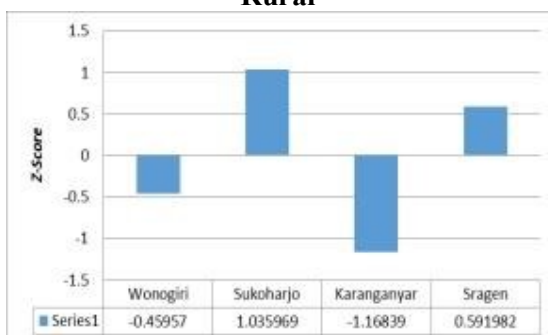
Source: Central Bureau of Statistics  
**Figure 6. Proportion of Citizens Living in Rural/Urban**



Source: Central Bureau of Statistics  
**Figure 7. The Number of Farmers in Rural**



Source: Central Bureau of Statistics  
**Figure 8. Percentage of Women**



Source: Central Bureau of Statistics  
**Figure 9. Woman as Head of Household**

Source: Central Bureau of Statistics  
**Figure 10. Health Insurance Members**

In Figure 1, the highest regional dependence on DAU is Wonogiri Regency with a z-score of 1.328, Sragen Regency with a z-score of 0, Sukoharjo Regency with a z-score of -0.242, and the lowest score is Karanganyar Regency with a z-score of -1.086. . Figure 1 explains that the highest socioeconomic status score is Sragen Regency with a score of 3, Wonogiri Regency and Sukoharjo Regency have the same score, namely 2, and the lowest score is Karanganyar Regency with a score of 1. The more scores of the components of socioeconomic status obtained indicate the area increasingly vulnerable. One of the sub-components of socio-economic status is dependence on DAU. The greater the General Allocation Fund (DAU) received by a region indicates that the dependence of a region in meeting its needs is still very high. The following is a graph of the dependence of Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency on the General Allocation Fund (DAU).

Figure 2 explains that the highest age component is in Wonogiri and Sragen districts with a score of 8, Sukoharjo and Karanganyar districts also have the same score, namely 7. The more scores you get in the age component, the higher the SoVI score of the area. An area with a larger number of people with an average age means that the area has a greater potential for vulnerability than an area with a small average age. The highest limit for a person's productivity is at the age of 65 years. In figure 2, the more age a person is, the less distance it will be from the age of 65, which means that someone's chance to be productive is less than the younger one. The regency with the highest average age was Wonogiri Regency with a z-score of 1.337924, then Sragen Regency with a z-score of 0.124801, followed by Karanganyar Regency with a z-score of -0.48176, and the lowest was Sukoharjo Regency with z- score of -0.98097.

Figure 3 explains the property score shows that the less property score in an area means that the area is more vulnerable than other areas. Wonogiri Regency has the highest score among the other 4 districts, namely -6, Sragen Regency with a score of -7, Sukoharjo Regency with a score of -8 and Karanganyar Regency with the lowest score, namely -9. One of the sub-components in property is the number of companies. An area with many operating companies indicates that the area is quite developed. Furthermore, people who work for companies have a lower vulnerability. This possibility is caused when working in a community company has a fixed salary that can be used to meet their needs. In figure 3, the district with the highest number of companies is Karanganyar Regency with a z-score of 0.906731, then Sukoharjo Regency with a z-score of 0.770508, Sragen Regency with a z-score of -0.54063, and the number of companies is the least located in Wonogiri Regency with a z-score of -1.13661. The less z-score of the number of companies in an area, the less the number of companies in the area, and this can increase the social vulnerability score.

Figure 4 explains the regional health component score which has the lowest score is

Sragen Regency with a score of -1, the other three districts namely Wonogiri Regency, Sukoharjo Regency and Karanganyar Regency each have the same score, namely 0. The greater the score of an area will increase the vulnerability score. social area. One of the sub-components in the health component is the number of people living in nursing homes. The nursing home used in this study is a nursing home that is managed by the government, so that the greater the number of people in the nursing home, the more the costs will be borne by the government. In figure 4, when the z-score in an area is higher, it will increase the social vulnerability in that area. The highest z-score was in Wonogiri Regency with a score of 1.488, Sragen Regency with a z-score of -0.369, Sukoharjo Regency with a z-score of -0.452, and the lowest was Karanganyar Regency with a z-score of -0.666. The greater the z-score of the number of people living in nursing homes, indicating that the area is more vulnerable than other areas. The highest score for the population component was Karanganyar Regency with a score of 6, Sukoharjo Regency and Sragen Regency with the same score, namely 5, and Wonogiri Regency with the lowest score of 4. The higher the population component score will increase the SoVI score obtained by the region.

In figure 5, the higher the z-score, the higher the SoVI score in that area. The following is a graph of the birth rates from Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency.

After obtaining the SoVI score for each regency, in order to classify the regency into different level of vulnerability (low, medium, and high vulnerability), vulnerability classes are made. The calculation for classes' setup is as follow:

Data quantity: 4

$$K = 1 + 3.3 \log n$$

$$K = 1 + 3.3 (\log 4)$$

$$K = 1 + 3.3 (0.6)$$

$$K = 1 + 1.98$$

$$K = 2.98 \text{ rounded up into } 3$$

$$\text{Range} = 30-22$$

$$= 8$$

$$\text{Interval} = 8/4$$

$$= 2.6 \text{ rounded up, to } 3$$

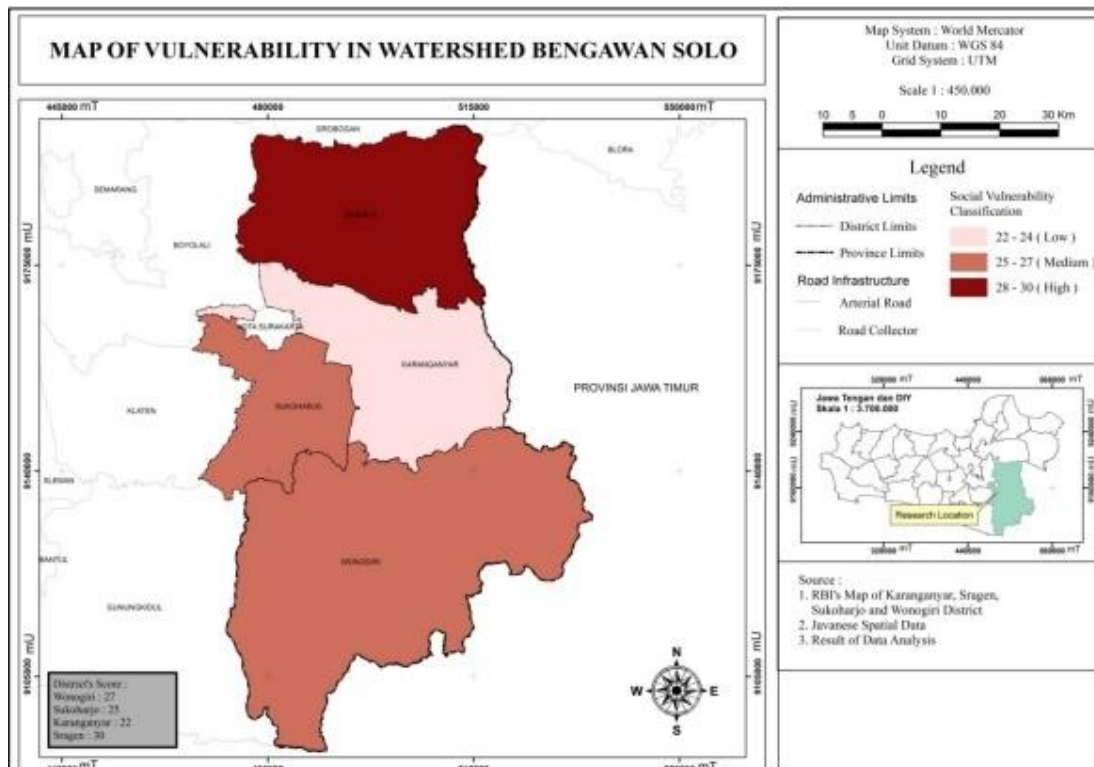
The classes set:

$$1 \text{ (low vulnerability)} = 22 \text{ up to } 24$$

$$2 \text{ (medium vulnerability)} = 25 \text{ up to } 27$$

**Map of Vulnerability using SIG:** This research relied on SIG to illustrate the level of vulnerability of each area. The vulnerability map of Wonogiri, Sukoharjo, Karanganyar, and Sragen Regency is presented in Figure 1.

Based on Figure 1, the area depicted with dark red color is the area with higher vulnerability, compared to the area with light color. Figure 1 illustrates that the area with the highest vulnerability level is Sragen Regency. Sukoharjo and Wonogiri Regency are the area with medium vulnerability, while Karanganyar Regency is the area with the lowest vulnerability level. The level of vulnerability is affected by the city/village and occupancy component. This result is in line with the research conducted by Widiarto & Kingma, (2014) and Setyaningrum & Giyarsih, 2012). concluded that the floods in Sragen would have been impacted to the farmer households. Further, Setyaningrum and Giyarsih (2012) the vulnerability of the community around Kali Code riverbank is affected by economic sector.



Source: Kumalasari (2017)

**Figure 11. The Map of Social Vulnerability in the Bengawan Solo Watershed Area**

### Socio-Economic Effect

Natural disasters will actually have an impact on the condition of areas that have high vulnerability to the occurrence of these disasters, this refers to the upstream part of the Bengawan Solo river (Sragen Regency, Sukoharjo Regency, Wonogiri Regency, Karanganyar Regency). The impact of an area's vulnerability to flooding can disrupt economic development and growth, as well as social vulnerability (Widiarto and Kingma, 2014, Rawal and Arokoyu, 2015).

**Table 3. Socioeconomic Performance Indicator Relates SoVI Score**

Regency	Socioeconomic Performance Indicator			
	SoVI	P0*	P2*	HDI*
Sragen	30	15.48	0.63	70.34
Sukoharjo	25	9.52	0.26	73.88
Wonogiri	27	13.66	0.51	66.84
Karanganyar	22	12.97	0.47	73.41

Notes: \*average index (2010-2018); P<sub>0</sub>: Poverty Index (%); P<sub>2</sub>: Poverty Severity Index

Source: Central Bureau Statistic (Data Processed)

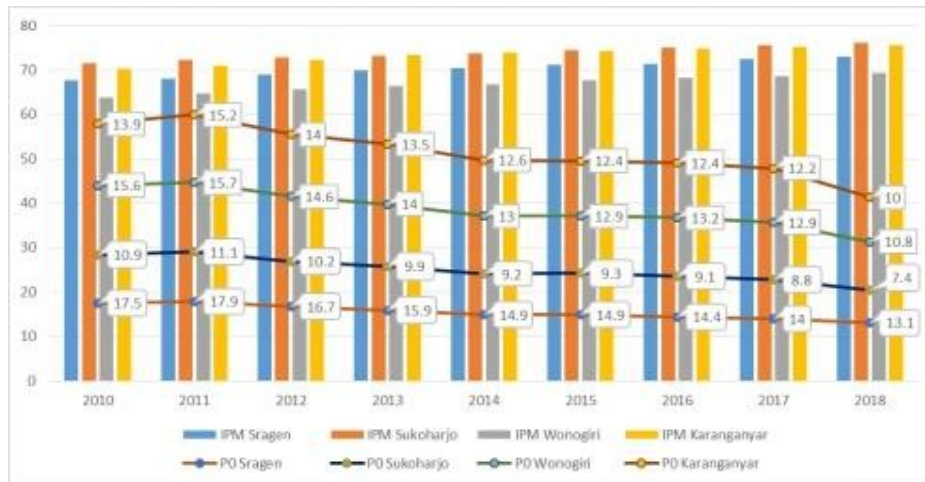
According to Giyarsih et al (2011), there are many aspects that are hampered when a disaster occurs, one of which is the socio-economic aspect. An area that often faces natural disasters such as floods usually has a socio-economic effect on people's lives compared to another area that is not affected. Disruption to the socio-economic conditions in an area can increase the vulnerability of the area and a high level of vulnerability will affect poverty. Vulnerability itself is a condition or a consequence of circumstances (physical, social, economic and environmental) that affect disaster prevention and management efforts (Bakornas, 2009).

Sragen regency which has high vulnerability to disasters has a high percentage of poverty and poverty severity index or expenditure disparity among residents, on the other hand, regions with lower SoVI scores than Sragen regency have lower poverty levels and lower disparities (Table 4). ). Social and economic vulnerability is the cause and effect of the large loss of flood disasters and the economic level of the community (high percentage of poverty and high poverty severity) makes people in disaster-prone areas have lower economic vulnerability because economically high areas are considered capable of protecting their lives (Hapsoro and Buchori, 2015).

Disasters (floods) have a tendency to influence cultural factors, livelihoods, and reasoning at the local socio-economic scope. Economic losses due to flooding can be directly observed (for example damaged houses or destroyed business sectors) which have an impact on output losses (unable to produce) and will later create poverty as a result of adjusting the changing structural conditions of society (Artiani, 2011; Kumulawati, 2015).



**Table 4.HDI and Poverty Index in the Upper Bengawan Solo River Basin 2010-2018  
(in Percent)**



Notes: P<sub>o</sub>= Poverty Index; IPM: Indeks Pembangunan Manusia/*Human Development Index* (HDI)

Source: Central Bureau Statistic (Data Processed)

If there is a flood in the upstream area of the Bengawan Solo river, the possibility of economic loss is very high. The economic loss of floods is a trend and extreme projections related to water (floods) that cause economic and life damage, where flood events can be expensive, such as in Central and Eastern Europe in 2013 which caused a loss of 15 billion Euros (Jonkman and Kelman, 2005; Kunreuther and Michel-working, 2007; United Nations International Strategy for Disaster Reduction Secretariat, 2009; Munich Re 2014 in Carrera, 2014).

The trend of poverty reduction and increase in HDI (2010-2018) which contradicts the SoVI measurement shows that the index is valid (Table 4.1). Based on SoVI, Sragen, which has a high level of vulnerability (Table 4), is the area with the highest poverty but in a decreasing trend, as well as HDI which continues to increase from year to year. The trend of reducing poverty and increasing HDI also occurs in other upstream areas of the Bengawan Solo river, meaning that there are efforts to prevent and mitigate disasters (floods). The increase in HDI is an indicator in the economic development of the community which continues to improve which will also have an impact on reducing poverty, so that people with high economies are able to protect their lives or be able to rise in the event of a natural disaster.

#### **4. Conclusion**

This research aims to discover the description of the socio-economic condition, the level of social vulnerability, and to map the comparison of social vulnerability of Bengawan Solo watershed area with the developed agricultural sector.

The Social Vulnerability Index (SoVI) calculation revealed that the area with the highest vulnerability is Sragen Regency followed by Wonogiri and Sukoharjo Regency, and Karanganyar Regency with the lowest vulnerability. Furthermore, the result of socio-economic description based on all the 10 components, Sragen Regency is the most vulnerable area with the highest score on socio-economic status, age, gender, village/city, occupancy, and family structure. Meanwhile, the other three regencies have the relatively the same result in each component.

The result of vulnerability map analysis based on SIG showed that the area with the highest vulnerability is Sragen Regency followed by Wonogiri and Sukoharjo Regency with medium vulnerability, and Karanganyar Regency with the lowest vulnerability. The map also shows that the areas, that geographically adjacent and have a different administration, have a vulnerability level with insignificant difference.

The implication of this study is that local governments can reduce the level of social vulnerability by paying attention to some SoVI indicators. Reducing the level of social vulnerability will directly reduce the risk of increasing poverty, income disparities, and increased government spending. Local governments can allocate budgets to develop strategies to reduce disaster damage by providing provision to communities in vulnerable areas to be more responsive to disasters.

#### **Acknowledgement**

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**Appendix 1**  
**Z-score Calculation**

No	Vulnerability Indicators	Vulnerability sub indicators	Z-score Wonogiri	Z-score Sukoharjo	Z-score Karanganyar	Z-Score Sragen
1.	<b>Social economy status</b>	Income per capita	-1,08193	-0,60816	0,970273	0,719817
		Dependency of local Government budget to Government Transfer	1,327773	-0,24227	-1,08551	0
		The number of voters in presidential election	0,204791	-0,94758	1,315928	-0,57314
		The number of pre prosperous families	-0,3723	-0,48966	-0,62971	1,491673
		Percentage of poverty	0,24659	-1,26452	-0,13217	1,150098
		Percentage of the families who owned a car/cars	-0,90629	1,393346	-0,48705	0
2.	<b>Age</b>	Average age population	1,337924	-0,98097	-0,48176	0,124801
		Percentage of elderly	1,431226	-0,71987	-0,65598	-0,05537
		Percentage of toddler.	-1,45732	0,372632	0,815363	0,269328
3.	<b>Property</b>	Cost of house rent	-1,16498	1,270834	-0,15831	0,052451
		The number of building permit (IMB)	-0,77135	1,277286	0,315175	-0,82111
		The number of companies	-1,13661	0,770508	0,906731	-0,54063
		Companies productivity	-1,23932	-0,118	1,192953	0,16437
		Agriculture Contribution to Regional GDP	-0,4988	-0,50112	1,499999	-0,50008
4.	<b>Health</b>	The numbers of doctors	-1,01234	1,300775	-0,49175	0,203312
		The number of population who live in nursing home	1,488264	-0,45285	-0,66595	-0,36946
		The number of health facilities	1,34901	-0,96358	-0,49055	0,105118
5.	<b>Demography</b>	Percentage of population growth	-0,92299	0,714312	1,003248	-0,79457

		Birth rate	-1,23556	-0,18352	0,244338	1,174741
		Density of population	-1,04483	1,345666	0,011225	-0,31206
6.	<b>Education</b>	The number of graduate of high school	-0,95026	1,382189	-0,43193	0
7.	<b>Sex</b>	The number of female	1,243053	-0,89413	-0,71966	0,370735
8.	<b>Unemployment</b>	The number of unemployment	-0,97624	0,540743	-0,69322	1,128716
9.	<b>Rural/Urban</b>	proportion of agricultural land that is cultivated and not cultivated	-1,24929	0,883326	-0,3611	0,727064
		Percentage of farmer population in rural.	1,236597	-1,12434	-0,37266	0,260402
		Percentage of urban population.	-1,00575	1,28686	0,242162	-0,52327
10.	<b>Social Dependency</b>	The number of member of Health Insurance	-1,37789	0,930059	0,484806	-0,03697
11.	<b>Population of disability</b>		1,480113	-0,61417	-0,26396	-0,60199
12.	<b>Renters</b>	The number of house renters	-0,8838	1,431888	-0,17813	-0,36996
13.	<b>Occupation</b>	Percentage of work force in population	1,197157	-0,83906	0,452883	-0,81098
		Percentage women in work force	-0,72679	1,453005	-0,58317	-0,14304
		The number of worker in Primary Sector (Agriculture, mining, fisheries, and forestry)	1,259848	-1,10918	-0,36786	0,217197
		Percentage worker in transportation, communication, and public facilities.	-0,75701	1,449134	-0,55514	-0,13698
		Percentage worker in public services.	-1,3203	0,976601	0,521133	-0,17744
		The number of migrant worker	-0,93638	-0,43808	-0,01517	1,389625
14.	<b>Family Structure</b>	The average member in a household	-0,76075	0	-0,65207	1,412821
		The percentage women who is the head of household	-0,45957	1,035969	-1,16839	0,591982

**Appendix 2**  
**Main Component Score, Sub-Component, and SoVI Score**

No	Vulnerability Indicator	Vulnerability Sub-Indicator	+/-	Wonogiri		Sukoharjo		Karanganyar		Sragen	
				SC Score	MC Score	SC Score	MC Score	SC Score	MC Score	SC Score	MC Score
1.	<b>Social-economy status</b>	The local Government dependence on DAU (government transfers)	+	3	2	2	2	2	1	2	3
		The number of votes in the presidential election	-	-3		-2		-3		-2	
		The number of pre-prosperous families	+	2		2		2		3	
2.	<b>Age</b>	The average age	+	3	8	2	7	2	7	3	8
		The percentage of elderly	+	3		2		2		2	
		The percentage of children under 5 years	+	2		3		3		3	
3.	<b>Property</b>	The number of building permit (IMB)	-	-2	-6	-3	-8	-3	-9	-2	-7
		The number of companies	-	-2		-3		-3		-2	
		Companies productivity	-	-2		-2		-3		-3	
4.	<b>Health</b>	The number of people living in nursing homes	+	3	0	2	0	2	0	2	-1
		The number of health facilities	-	-3		-2		-2		-3	

5.	<b>Demography</b>	The percentage of population change	+	2	4	3	5	3	6	2	5
		Birth rate	+	2		2		3		3	
6.	<b>Sex</b>	The percentage of female	+	3	3	2	2	2	2	3	3
7.	<b>Rural/Urban</b>	The percentage of farmer population in rural area	+	3	5	2	5	2	5	3	5
		The percentage of population in urban area	+	2		3		3		2	
8.	<b>Social dependence</b>	BPJS users	+	2	2	3	3	3	3	2	2
9.	<b>Occupation</b>	The number of people working in the agriculture, fisheries, mining, and forestry sectors (primary industry)	+	3	5	2	4	2	3	3	5
		The percentage of people working in the fields of transportation, communication, and other public facilities.	+	2		3		2		2	
		The percentage of people working in the field of	-	2		3		3		2	



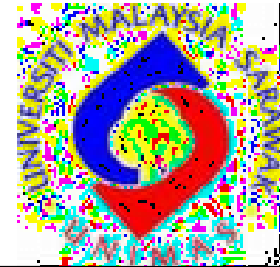
		public services.									
		The number of Indonesian Migrants Workers (TKI)	+	2		2		2		3	
10	<b>Family Structure</b>	The average member in a household	+	2	4	2	5	2	4	3	6
		The percentage women who is the head of household	+								
	<b>SoVI score</b>				<b>27</b>		<b>25</b>		<b>22</b>		<b>30</b>

SC=Sub Component, MC=Main Components

Source : Secondary data (processed)

2. Hasil Review 1 (9 Maret 2021)

INTERNATIONAL JOURNAL OF BUSINESS AND SOCIETY



## REFEREE'S REVIEW FORM

**Title of Paper**                      **Do Social-Economy Vulnerability Index and Poverty Index Have Correlation?  
Study in Bengawan Solo Watershed**

1. Please rate the paper along the following criteria. 1 for very poor to 5 Excellent

No	Criteria	1	2	3	4	5	N/A
1	Appropriateness of Title and Abstract			X			
2	Relevance to Business and Society				X		
3	Structure of the work			X			
4	Appropriateness of research method			X			
5	Elaboration of prior knowledge/research			X			
6	Discussion and Conclusions			X			
7	Content is scientifically accurate				X		
8	Contribution to Body of Knowledge				X		
9	Implication for Society, Industry, or Policy Maker				X		
10	Reference list, Adequate, and Correctly Cited				X		
11	Reference list, cited good and reputable journals			X			

2. Please tick only one of the following and provide comments/reasons below as requested.

- a) The work is publishable in its present form.
- b) The work is publishable with minor changes suggested below.
- c) The work is publishable with major changes suggested below.      X
- d) The work is not publishable in its present form.

3. Please provide detailed comments/reasons below.
  1. The need to study the Bengawan Solo watershed area is not well explained in the introduction.
  2. *Using the index of social vulnerability (SoVI), a study of social vulnerability by Lawal and Arokoyu (2015) indicates that Ondo and Ekiti have LGAs more vulnerable than other countries in the region. It is not clear Ondo, Ekiti and LGA meant, it should be further explained.*
  3. The indicators should be explained further and provide proper citations.
  4. *Interview is a data collection technique that conducted by asking the employees directly in related institutions. The data obtained from the interview is used in this research. Observation is a technique conducted by directly observing and recording systematically in the research locations in order to understand the actual condition of the locations. Literature study is a data collection method in which the researcher collect data from books, scientific journals, and reports of related institutions - so the study adopt mixed method? Do clearly defined this part.*
  5. Put forward the explanation of the Sturges formula.
  6. No appendix 2.
  7. Results - the series 1 - should be more specific on that. What does it represent, SOVI?
  8. Figure 11 - it is not originally from this research, why? It would be good to generate one from this research and compare with those from the earlier study.
  9. Table 3 - from the analysis or from the data available in governmental level?
  10. Table 4 - the presentation is not clear. Might be good to have different presentation tables or chart so that the percentage is clearly defined.
  11. Put forward the implication for this study, how the local government would be of benefit?

3. Lampiran Bukti Konfirmasi submit revisi pertama, respon pada reviewer, dan artikel yang di resubmit (9 Mei 2021)

**Article title:  
DO SOCIAL-ECONOMY VULNERABILITY  
INDEX AND POVERTY INDEX HAVE  
CORRELATION?  
STUDY IN BENGAWAN SOLO WATERSHED**

**Reviewer 1**

No	Comments	Responses	Page	Paragraph	Editors' comment (office use only)
1	<i>Eg. The authors need to explain more on how the equation (2) is specifically derived from the equation (1).</i>	<i>Eg. Explanations for Equation (2) derivation were added.</i>	3	2	

**Reviewer 2**

No	Comments	Responses	Page	Paragraph	Editors' comments (office use only)
1	<i>The need to study the Bengawan Solo watershed area is not well explained in the introduction.</i>	<i>Explanations for Begawan solo were added</i>	1	1	
2	<i>Using the index of social vulnerability (SoVI), a study of social vulnerability by Lawal and Arokoyu (2015) indicates that Ondo and Ekiti have LGAs more vulnerable than other countries in the region. It is not clear Ondo, Ekiti and LGA meant, it should be further explained.</i>	<i>Explanations for Ondo, Ekiti and LGA meant were added</i>	4	6	
3	<i>The indicators should be explained further and provide proper citations.</i>	<i>Explanation for indicators in SoVI has been added to the paper based on Shirley, Cutter, and Borruf, (2003). page 6.</i>	6	2	
4	<i>Methodology</i>	<i>We have added the explanation in methodology the steps for analysis.</i>	6	6	
5	<i>Put forward the explanation of the Sturgess formula.</i>	<i>We have added the explanation for sturgess formula</i>	5	5	
6	<i>No appendix 2.</i>	<i>Appendix 2 is needed for showing the result of SoVI analysis (last steps).</i>	9	1	

7	<i>Results - the series 1 - should be more specific on that. What does it represent, SOVI?</i>	<i>The social-economic description represent the indicators that used in SoVI</i>	9	1	
		<i>analysis.</i>			
8	<i>Figure 11 - it is not originally from this research, why? It would be good to generate one from this research and compare with those from the earlier study.</i>	<i>Figure 11- it is originally based on our result in Bengawan Solo watershed. The study discussed with earlier study but limited on poverty index. Because calculation with SoVI method has not conducted before.</i>	14	2	
9	<i>Table 3 -from the analysis or from the data available in governmental level?</i>	<i>The data is processed, which is taken from data published by the government and compared with the Sovi index</i>	15	1	
10	<i>Table 4 - the presentation is not clear. Might be good to have different presentation tables or chart so that the percentage is clearly defined.</i>	<i>the table has been changed</i>	15	3	
11	<i>Put forward the implication for this study, how the local government would be of benefit?</i>	<i>The implication for government was added.</i>	15	last	

## Hasil Revisi

# DO SOCIAL-ECONOMY VULNERABILITY INDEX AND POVERTY INDEX HAVE CORRELATION? STUDY IN BENGAWAN SOLO WATERSHED

**SURYANTO** ❁

*University Sebelas Maret  
FEB UNS, Jalan Ir.Sutami 36A Surakarta  
Email: suryanto\_feb@staff.uns.ac.id*

**RATIH KUMALASARI**

*University Sebelas Maret*

**DANUR C. GURITNO**

*University Sebelas Maret*

## ABSTRACT

The components to measure of disaster risk (i.e flood) are level of hazard, vulnerability of individual/community, and capacity of individual/community. Research related to vulnerability is based on the level of probability of a region experiencing a disaster, while vulnerability is based on conditions where individual/community cannot cope with disasters.

The aim of the study was to measure the level of vulnerability of the socio-economic and institutional society. This research tried to explain the level of social vulnerability among the communities in upper Bengawan Solo watershed. SoVI makes more appropriate parameters for measuring social vulnerability than relying only on partial socioeconomic data.

The data generated from relevant institution, such as Central Bureau of Statistic (Badan Pusat Statistik–BPS), Social Service Institution (Dinas Sosial), National Population and Family Planning Board. Data needed such as socio-economic community, demography, age, family structure, village-city, education, and unemployment rate. We find the data from the related agencies. The first step analysis is to adapt the measurement of vulnerability (SoVI) that has been developed. After the measurement of the SoVI is carried out then it is classified relatively between districts (Sragen, Sukoharjo, Wonogiri, and Karanganyar) in the upstream Bengawan Solo Watershed.

The results show highest SoVI total score (the most vulnerability) is Sragen Regency, followed by Wonogiri and Sukoharjo, and the lowest is Karanganyar. Meanwhile, Sragen has the highest scores in social-economy components score such as age, gender, rural/urban, occupation, and family structure. It implies that when disasters attack to Sragen, their community will be more suffering potentially.

**Keywords:** social economy, community, vulnerability, risk

\*) The research is part of the output of the research grants of Higher Education 2017-2018

**Keywords:** leave one blank line after the abstract and write the keywords.

## 1. INTRODUCTION

Disaster is a phenomenon that occurs as a result of the impact of hazards and vulnerabilities simultaneously that can affect environmental conditions or areas in managing threats (Oxfam, 2012 in Hapsoro & Buchori, 2015). Floods that occur every year in several districts or regencies that pass through the river cause socio-economic vulnerability in these districts or regencies

Societies that have a high dependency on natural resources are very vulnerable to changes in rainfall (Boissière et al., 2013; Lintner et al., 2012 in Auliyani & Wahyuningrum (2020)). Societies in Java island especially some parts of regencies in Bengawan Solo Watershed are often experienced by floods. According to National Board for Disaster Management (BNPB) in 2015, Java Island is the most frequently exposed by the flood. Societies in Java Island suffered physical losses of up to USD 4,502 million and drought with a loss of up to USD 3,899 million (Amri et al., 2016).

The Bengawan Solo is the largest watershed and longest river flow on the island of Java, Indonesia. This river has a length of 548.53 km with a watershed area of 16,100 km<sup>2</sup> and crosses two provinces, namely Central Java and East Java. Its area covering ± 12% of the entire island of Java. Bengawan Solo has a problem of drought and seawater intrusion during the rainy season in several areas where floods often occur and vice versa in the dry season which results in considerable loss of property and human life (Ministry of PUPR, 2010). Therefore, studies on vulnerability in the Bengawan Solo watershed are needed to prevent greater material and non-material losses related to natural disasters.

According to BPS (2018), Central Java has seven regencies/municipalities that are passed by the Bengawan Solo River. Among the seven regencies/municipalities, Surakarta is an area that does not have large agricultural land. Surakarta as a municipality has a small contribution from agricultural sector. Surakarta has farmland for rice production area only 36 hectares and produces 230 tons per year (2018). Meanwhile, other areas such as in Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency, and Sragen Regency have broader agricultural land areas. The impact of climate change, especially flooding in the agricultural sector, triggers the increased social vulnerability. In this research, the areas to be studied are Wonogiri, Sukoharjo, Karanganyar, and Sragen regencies.

Climate change has been believed as one of the factors that causing the flood in several areas. Climate change is the change in climate variables, especially air temperature and rain intensity that occur gradually around 50 to 100 years (Kifli, Mulyo, & Sugiyarto, 2015); (Hettiarachchi, Wasko, & Sharma, 2018). When the disaster struck to society, there will be many aspects that get hampered such as the socio-economic aspect. Areas that frequently faced natural disasters such as floods usually have to bear the negative impacts in socio-economic life than other areas. The disruption in the social-economy condition in an area can increase the vulnerability of the area.

One of the most affected groups is the agriculture sector. For farmers, the land is an earning asset that can generate revenue (Giyarsih et al., 2011). Therefore, when their farmland is flooded, they cannot cultivate their crops which reduces their revenue. There is a correlation between the population's vulnerability to poverty and their residence ecosystem, thus the level of poverty will differ from each agro-ecosystem (Giyarsih et al., 2011). The vulnerable society will harder to cover their basic needs compared to the less vulnerable society. However, the vulnerability can also be caused by the socioeconomic conditions of the community. One of the factors causing vulnerability is poverty. People who are in poor condition will tend to be vulnerable. This means that the factors of vulnerability and poverty are thought to have a positive relationship.

Measurement of social vulnerability has been carried out using several approaches, for example, the Social Vulnerability Index, the Livelihood Vulnerability Index, or the Climate Disaster Resilience Index. All measurement models rely on relative comparisons between regions in a single study. Meanwhile, the poverty indicators show individual conditions and do not show collective conditions. This study aims to find out whether the vulnerability has a relationship with the poverty index. If poverty has a relationship with vulnerability, then SoVI in the Bengawan Solo watershed can be predicted from the poverty level. Research areas in Bengawan Solo watershed covers for the regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen.

## 2. LITERATURE REVIEW

Disaster Risk Management (DRM) could not be success without concern to improve the capability of society. DRM will need to address not only the physical aspect, but also the economic and social factors which influence the greater society and reinforce the impact of hazardous events (White and Howe, 2002). A better preparation and precisely calculation of risk is an important and long overdue addition to the hazard mitigation planning and implementation processes (Tate, 2013) especially in the context of climate change adaptation and disaster risk reduction strategies.

Social vulnerability is measured using various method in the previous researches. SoVI has introduced by Shirley, Cutter, and Boruff., (2003), they developed SoVI to identify and mapping the level social vulnerability in Mississippi Delta Region. This model has been adapted and adjusted depend on local characteristics aspects. Research by Lawal & Arokoyu, (2015) and use the Social Vulnerability Index method in measuring the vulnerability.

Vulnerability can be defined as a weakness to anticipate the potential for something that has a risk. Lawal & Arokoyu (2015) stated that vulnerability is a loss of life or properties as the result of a natural disaster. Furthermore, according to Miyan (2015) and Lawal & Arokoyu (2015), vulnerability consists of two categories, namely biophysical and social vulnerability. Biophysical vulnerability can cause food insecurity, drought, flood, bad weather, etc, meanwhile social vulnerability leads them to suffer from disease, loss of property, etc. They conducted research to measure social vulnerability in Sub-Sahara area especially West Africa. They found that the impact of disasters tends to be more devastating in developing countries as a result of the interaction between population growth, land pressure, economic growth, technological innovation, social expectations, and growing interdependence. They also resulted the differentiation of the social vulnerability score among Local Government Areas (LGA) by Social Vulnerability Index.

Implementation of the index of social vulnerability (SoVI) has been conducted by Lawal and Arokoyu (2015) used a sample of Nigeria's Southwest Zone, which consists of six states, namely Ekiti, Lagos, Ogun, Ondo, Osun and Oyo and this region have a total of 137 local government areas (LGA), the result indicates that Ondo and Ekiti have LGAs are more vulnerable than other countries in the region. While research by Shirley et al., (2003) establish several spatial patterns in SoVI calculation, in which the most vulnerable regency located in East Metropolitan area, South Texas, and Mississippi Delta area. Another research conducted by Setyaningrum & Giyarsih, (2012) found that the vulnerability level of the community that resides around Kali Code Riverbank is low and more affected by the economic factor. They conclude that social and economic vulnerability with societies perception have negative correlation. It will impact to high loss potential toward societies.

Meanwhile, Suryanto (2017) supported the finding from Setyaningsih & Giyarsih (2012), in his research tried to valuate the negative impact of flood in Surakarta city. He stated a vulnerable area to the natural disaster is often socially vulnerable more compared to the areas that less prone to natural disasters. Research from Widiarto & Kingma, (2014) also reported that impact of vulnerability to flood can disrupt the development and economic growth in Sragen.

Another research on vulnerability is conducted by Shah, Dulal, Johnson, & Baptiste, (2013), which analyze farmers' vulnerability toward climate change. The method used is different from SoVI method, they tried to estimate with another approach. They used the Livelihood Vulnerability Index (LVI) method. Razafindrabe, et al. (2009) in contrast, examined the resilience of a region toward disasters that occur as an effect of climate change on the Asian coastal area. The method was the Climate Disaster Resilience Index (CDRI). Research conducted by Shah et al., (2013) found that Narvia is more vulnerable than Caroni, especially in socio-demographics, health condition and water availability, natural disaster, and climate variability. Razafindrabe et al., (2009) suggest that the type of vulnerability in each area varies. Thus, a policy that should be taken for the area will be different.

Almost all SoVI or LVI measurements rely on data which is then compared between regions. This measurement relies on relative sizes and contains weaknesses if several areas used have almost the same level of vulnerability.

## 3. METHODOLOGY

Bengawan Solo Watershed through 17 regencies/municipalities in two provinces, Central Java and East Java. There two steps to analysis the data, first step is calculation of social vulnerability index and second step is Geographical Information System. In SoVI method we describes the socio-economic living, the level of social vulnerability, the comparison mapping of social vulnerability as a basis of consideration for the development policy of Bengawan Solo watershed area. The Social Vulnerability Index (SoVI) has been developing to measure the vulnerability level in each regency. After the SoVI score is obtained, a Geographical Information System conducted



to describe the most vulnerable regency.

The research took place on the areas located around Bengawan Solo watershed with the developed agricultural sector. Therefore, the four regencies which located in Bengawan Solo River watershed are chosen for this study namely: Wonogiri, Sukoharjo, Karanganyar, and Sragen. Four regencies has known as main supplier for rice to Java island people, especially in Central Java Province.

SoVI approach relied on secondary data, that has been generated from other institutions or organizations related to this study. This data will be used to examine the social vulnerability level of the society in Bengawan Solo River watershed area. The secondary data are obtained from the Central Bureau of Statistic (Badan Pusat Statistik–BPS), Social Service Office (Dinas Social-DinSos), One-door Integrated Investment and Licensing Offices (Dinas Penanaman Modal dan Perijinan Terpadu Satu Pintu–DPMPTSP), Population and Family Planning Bureau (Badan Kependudukan dan Keluarga Berencana Nasional), General Election Commission (Komisi Pemilihan Umum–KPU), and Financial and Regional Assets Management Office (Dinas Pengelolaan Pendapatan Keuangan dan Aset–DPPKA), which located in the Regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen.

The SoVI score for each regency calculated using Microsoft Excel and SPSS 16 based on estimating for each regency. The results discussed descriptively to get socio-economic conditions for each regency. GIS method used to figure out the level of vulnerability among four regencies. By the GIS approach, it makes easier for us to analyse data on vulnerability.

**Social Vulnerability Index (SoVI) Analysis:** a method that will generate the social vulnerability score for each area in this research. Therefore, in order to provide the score that will be used in the SoVI calculation, the z-score of each sub-component should be computed previously, Z-score is needed because the size and data units used in the analysis are different. The socioeconomic measurement differs from the measurement for age and property. The Z-score accommodates the different unit measurements into comparable unit among regions. The Z-score calculated using the following formula:

$$z = \frac{x - \mu}{\sigma}$$

Note:

z = z-score

x = base value

$\mu$  = the average value

$\sigma$  = standard deviation

After the z-score is computed, which mean the standard value for each sub-component is obtained, a varimax rotation method is used to know the correlation between a sub-components with another sub-component. The aim of varimax rotation is to test whether the factor score of each component is overlapping with other components. Based on the Rotated Component Matrix in the varimax rotation output, if there is more than one component that has a score above 0.50 then the component is overlapping with other components, thus the component should be eliminated.

After the overlapping components are eliminated, the next step is to decide whether the remaining components represent more than 50 percent of the total components before elimination. If the remaining component represents more than 50 percent than the total component, the SoVI score computation can be continued.

The remaining components that represent the total component are scored. The scoring is conducted by categorizing the z-score into the classes or groups that have had prepared. The groups is calculated based on Sturges Formula and it is needed to determine how many groups of vulnerabilities can be created based on the data. The classification of vulnerable groups is determined in a range based on the calculation results. For example, the category is vulnerable if the SoVi score is above 70. The class determination of the Sturges model can be determined based on a formula,

Number of Class =  $1 + 3.3 \log n$ , with n, is the number of n data

Range = highest score – the lowest score

Class length = Range/K

After the class has prepared, the z-score of each component is classified into the class. Moreover, each sub-component is analyzed whether it increases or decreases the vulnerability. The next step is by adding up all the sub-components, which represent the SoVI score. This score will be used to prepare the vulnerability map. The area with the highest SoVI score is the area with the highest level of social vulnerability, vice versa. The classification of vulnerability level is based on the class. In this research, the classification is divided into three classes, namely, low, medium, and high vulnerability. The classification of vulnerability classes use a relative scale; the same method used for the scoring (Appendix 2).

The explanation of social vulnerability indicators refers to Shirley, Cutter, and Borruf, (2003), (Kusenbach, Simms, & Tobin, 2010), Lee, (2014), and McEntire, (2012) of social-economic status are used to describe the level of a region's macroeconomy. The number of votes in the presidential election illustrates the awareness of the economic preference of candidates. The higher the regional domestic regional gross, the higher the capacity of an area to overcome the risk of flooding.

Age indicator shows the age composition of the population of an area. If more and more of the population is elderly, it shows that the population is more vulnerable. With almost the same explanation, it also occurs in the health indicator. The higher the number of doctors in an area, the lower the level of vulnerability faced.

The property indicator shows the level of dependence of the GDRP on the agricultural sector. If the contribution of the agricultural sector is high, the regency will have a high dependence on the agricultural sector. Meanwhile the agricultural sector is very dependent on the climate. Conversely, the region has a low vulnerability if the dependence on the agricultural sector is low.

The other SoVI indicators are sex, demography, and social dependence. Sex is an indicator that shows the proportion of the sex of the population. Meanwhile, demography reflects the level of population density and social dependence shows the proportion of the population who has participated in the BPJS insurance program. The proportion of the population that is dominated by women is considered to have a higher vulnerability. Meanwhile, a high level of population density is considered to have a higher level of vulnerability.

**Table 1. The Indicator and Sub-indicator of Social Vulnerability Index (SoVI)**

<b>Indicator</b>	<b>Sub-indicator</b>	<b>Sub-indicator explanation</b>
Social-economy status	Percapita income	The income earned by e person in a spesific year
	The dependency ratio of government to general allocation fund.	The Amount of General Allocation Funds in Regency/City income balance funds
	The number of votes in the presidential election	The number of voters who voted inthe 2014 presidential election
	The percentage of family welfare	The number of household having more total income than regional minimum wage.
	The percentage of people live under poverty line	The number of poor people
Age	The number of households that own car	The number of households that own car
	Average age	The average age of population in a regency/city
	The number of elderly	The number of population over 65 years old
Property	The number of toddler	The number of children under 5 yearsold
	The rental cost of occupied housing	Average rental cost housing paid by community
	The number of Building Permit (IMB)	The number of building permit that issued by government
	The number of companies	The number of companies in regency/city
	Company productivity	The average value of company productivity
Health	GRDP Agriculture	Agricultural sector contribution to Regency / City income
	The number of doctors	The number of doctors, nurse, and midwife.
	The number of people living in nursing homes.	The number of people living in nursing homes.

	The number of health facilities.	The number of health facilities such as hospital and health center.
Demography	The percentage of population change Birth rate  Population density	The comparison of population changes from the previous year Number of births in a Regency / City in 1 year  The average of population density in district/ city.
Education	The number of high school graduate	The number of residents who have a high school certificate
Sex	The number of female	The number of female citizenship
Unemployment	The number of unemployment	The number of unemployed workforce
Rural/urban area	Land used by farmers  The number of farmers  The population of urban area	The amount of land used for agriculture  The number of residents who work as farmers  The number of residents living in urban areas
Social dependence	Social dependence Number of BPJS Health users	Number of residents using BPJS Health facilities
	Number of people with special needs	The number of people who have physical, and mental limitations
Renter Job	The percentage of renter Working workforce The number of working female  The number of worker in agriculture, fishery, and forestry (primary industry) The number of residents working in the transportation, communication and other public facilities sectors Number of people working in the public service sector (services)	The number of people who rent house The number of workforce employed The number of female work force employed  The number of people whose livelihoods work in the agriculture, fisheries, mining and forestry sectors The number of residents working in the transportation, communication and other public facilities sectors  Number of residents whose livelihoods work in the public servicesector (services)
Family structure	The number of Indonesian Migrant Workers (TKI) The average number of family member Women as head of the family	The number of Indonesian Migrant Workers (TKI) The average member in one family.  Population of women who act asheads of families (do not have husbands)

Source: modified from Shirley, Cutter, and Borruf, (2003)

**Socio-Economics Description:** this analysis is conducted to describe the socio-economic condition of the communities that reside in the Bengawan Solo River watershed area. The socio-economic description is conducted using descriptive statistic method. The data used in this analysis is the result of z-score in the SoVI assessment. Each main component will be used to compare the vulnerability in each area, which will simplify the description of the socio-economic condition.

**The Analysis Using Geographical Information System (GIS):** GIS will be conducted to describe the most vulnerable regency among the four regency, based on the SoVI score.

This part explains how the research is conducted, research deGISn, data collecting techniques, instrument development, and data analysis techniques.

**Table 2. Summary of Research Method**

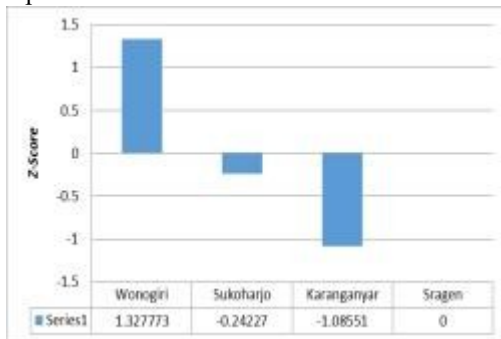
Research Objective	Analysis Tools	Data	Result
Social Vulnerability of the community that live at Bengawan Solo River watershed area	Social Vulnerability Index (SoVI)	Secondary Data	Social Vulnerability Index
Mapping of the most vulnerable area at the Bengawan Solo River watershed areas	Geographical Information System (GIS)	Secondary Data	Social Vulnerability Map

Source: research method (2017)

**4. Result and Discussion**

**4.1. Social-Economic Description**

This analysis is performed to understand the social-economy life in Bengawan Solo watershed. Descriptive statistic is utilized to explain the social-economy description. The data employed are from z-score calculation in the process of SoVI scoring (see on Appendix 1). Each main component will be explained the comparison in each area. Thus, it will be able to see the description of social-economy (see on Appendix 2). Some figures below represent each component of SoVI variable.



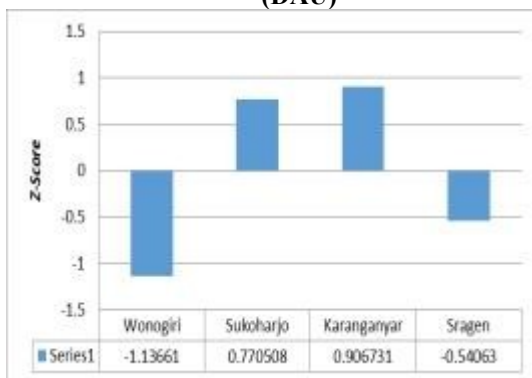
Source: Central Bureau of Statistics

**Figure 1. Dependence of Transfer Allocation Fund (DAU)**



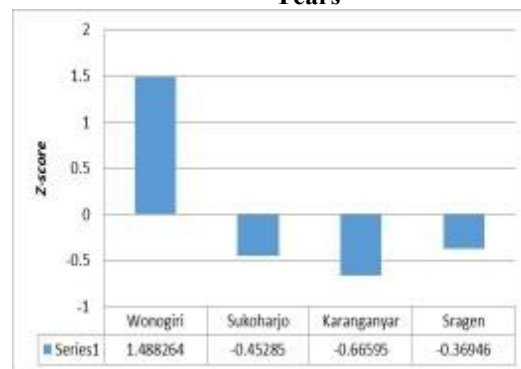
Source: Central Bureau of Statistics

**Figure 2. The Number of Citizens Older than 65 Years**



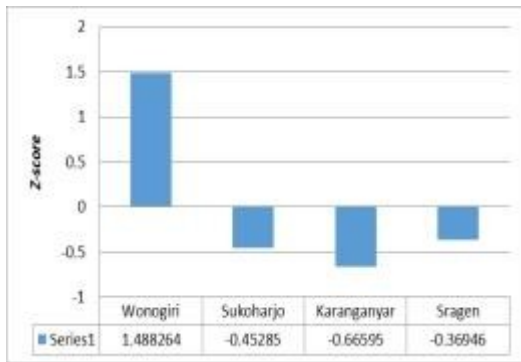
Source: Central Bureau of Statistics

**Figure 3. Jumlah Perusahaan**

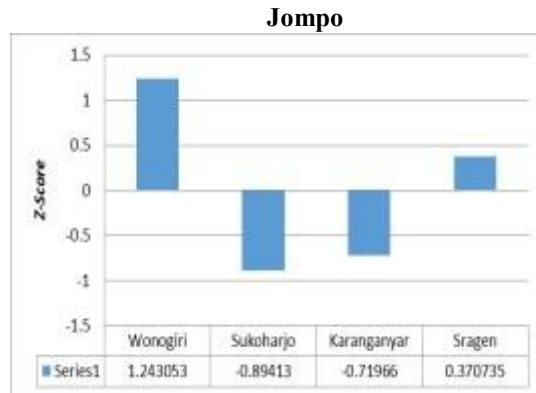


Source: Central Bureau of Statistics

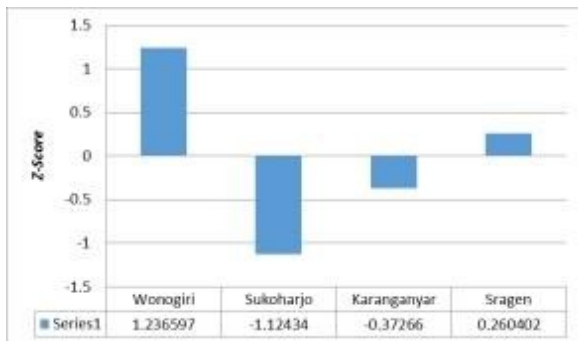
**Figure 4. Jumlah Penduduk yang Tinggal di Pantai**



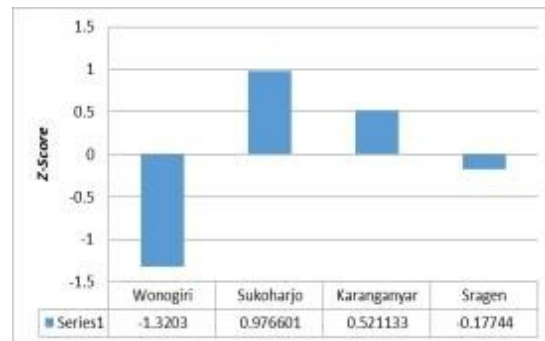
Source: Central Bureau of Statistics  
**Figure 5. Birth Rate**



Source: Central Bureau of Statistics  
**Figure 6. Proportion of Citizens Living in Rural/Urban**



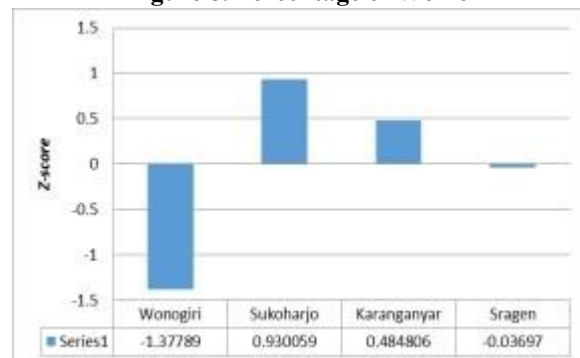
Source: Central Bureau of Statistics  
**Figure 7. The Number of Farmers in Rural**



Source: Central Bureau of Statistics  
**Figure 8. Percentage of Women**



Source: Central Bureau of Statistics  
**Figure 9. Woman as Head of Household**



Source: Central Bureau of Statistics  
**Figure 10. Health Insurance Members**

In Figure 1, the highest regional dependence on DAU is Wonogiri Regency with a z-score of 1.328, Sragen Regency with a z-score of 0, Sukoharjo Regency with a z-score of -0.242, and the lowest score is Karanganyar Regency with a z-score of -1.086. Figure 1 explains that the highest socio-economic status score is Sragen Regency with a score of 3, Wonogiri Regency and Sukoharjo Regency have the same score, namely 2, and the lowest score is Karanganyar Regency with a score of 1. The more scores of the components of socioeconomic status obtained indicate the area increasingly vulnerable. One of the sub-components of socio-economic status is dependence on DAU. The greater the General Allocation Fund (DAU) received by a region indicates that the dependence of a region in meeting its needs is still very high. The following is a graph of the dependence of Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency on the General Allocation Fund (DAU).

Figure 2 explains that the highest age component is in Wonogiri and Sragen districts with a score of 8,

Sukoharjo and Karanganyar regencies also have the same score, namely 7. The more scores you get in the age component, the more SoVI scores are obtained in the area. An area with a larger number of people with an average age means that the area has a greater potential for vulnerability than an area with a small average age. The highest limit for a person's productivity is at the age of 65 years. In figure 2, the more age a person is, the less distance it will be from the age of 65, which means that someone's chance to be productive is less than the younger one. The district with the highest average age was Wonogiri Regency with a z-score of 1.338 then Sragen Regency with a z-score of 0.125, followed by Karanganyar Regency with a z-score of -0.482, and the lowest was Sukoharjo Regency with z-score of -0.981.

**Figure 3** explains the property score shows that the less property score in an area indicates that the area is more vulnerable than other areas. Wonogiri Regency has the highest score among the other 4 districts, namely -6, Sragen Regency with a score of -7, Sukoharjo Regency with a score of -8 and Karanganyar Regency with the lowest score, namely -9. One of the sub-components in property is the number of companies. An area with many operating companies indicates that the area is quite advanced. Furthermore, people who work for companies have a lower vulnerability. This possibility is caused when working in a community company has a fixed salary that can be used to meet their needs. **In figure 3**, the district with the highest number of companies is Karanganyar Regency with a z-score of 0.907, then Sukoharjo Regency with a z-score of 0.770508, Sragen Regency with a z-score of -0.54063, and the number of companies is the least located in Wonogiri Regency with a z-score of -1.13661. The less z-score of the number of companies in an area, the less the number of companies in the area, and can increase the social vulnerability score.

**Figure 4** explains the regional health component score which has the lowest score is Sragen Regency with a score of -1, the other three districts namely Wonogiri Regency, Sukoharjo Regency and Karanganyar Regency each have the same score, namely 0. The greater the score of an area will increase the vulnerability score. social area. One of the sub-components in the health component is the number of people living in nursing homes. The nursing home used in this study is a nursing home that is managed by the government, so that the greater the number of people in the nursing home, it means that the costs borne by the government will increase. **In figure 4**, when the z-score in an area is getting higher, it will increase the social vulnerability in that area. The highest z-score was in Wonogiri Regency with a score of 1.488, Sragen Regency with a z-score of -0.369, Sukoharjo Regency with a z-score of -0.452, and the lowest was Karanganyar Regency with a z-score of -0.666. The greater the z-score of the number of people living in nursing homes, indicating that the area is more vulnerable than other areas. The highest score for the population component was Karanganyar Regency with a score of 6, Sukoharjo Regency and Sragen Regency with the same score, namely 5, and Wonogiri Regency with the lowest score of 4. The higher the population component score will increase the SoVI score obtained by the region.

**In figure 5**, the higher the z-score, the higher the SoVI score in that area. The following is a graph of the birth rates from Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency. The picture shows that Wonogiri Regency is an area that has the highest z-score, namely 1.49, Sragen Regency has a z-score of -0.37, Sukoharjo Regency has a z-score of -0.45, and the lowest is Karanganyar Regency with z-score of -0.67. The more basic z-score value of a region's birth rate, the higher the SoVI score of that area. Wonogiri Regency and Sragen Regency have the same gender component score, namely 3, Sukoharjo Regency and Karanganyar Regency both have a score of 2. The more gender component scores that are owned by an area will increase the SoVI score of the area.

**Figure 6**, explains that Wonogiri Regency has the highest z-score with a z-score of 1.24. The regency with the second highest z-score was Sragen Regency with a z-score of 0.37, Karanganyar Regency with a z-score of -0.72, and the lowest was Sukoharjo Regency with a z-score of -0.89. The scores for the rural / urban component of the four districts have the same score, namely 5. **In figure 6**, the more scores the rural / urban component has in an area, the more it will increase the area's SoVI score. The number of people living in villages and in cities will affect the level of social vulnerability of the community. The more people who live in villages and in cities will both increase their vulnerability.

**Figure 7**, explains the sub-components that exist in the rural / urban component, one of which is the number of farmers in rural areas. The more people who work as farmers in the village will increase their vulnerability. This is because farmers are jobs that depend on resources, so that when the resources are disturbed, the farmers' lives will also be disturbed. The following is a graph of the number of rural farmers from Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency, and Sragen Regency. **In figure 7**, the z-score for the sub-component of the number of farmers in rural areas is Wonogiri Regency with a z-score of 1.24, then Sragen Regency with a z-score of 0.26, Karanganyar Regency with a z-score of -0.37, and the lowest is Sukoharjo Regency with a z-score of -1.12. The z-score value of the sub-component of the number of farmers in rural areas will increase the social vulnerability score in the area. Sragen Regency has the highest score for the work component with a score of 6, Wonogiri Regency has the second highest score with a score of 5, Sukoharjo Regency has a score of 4, and Karanganyar Regency has the

lowest score, namely 3. The greater the score of the work component of an area, the higher the total SoVI score for that area.

In **Figure 8** it is known that the work sub-component measured is the percentage of people working in the service sector. The service sector is a sector of employment with a low level of vulnerability compared to other sectors. This is because the service sector is not too dependent on existing natural resources. Based on the results of the Z score analysis, it is known that Sukoharjo Regency has the highest Z-score for the proportion of people working in the service sector with a Z-score of 0.98, then Karanganyar Regency with a z-score of 0.52, Sragen Regency with a Z-score of -0, 18, and the lowest is Wonogiri Regency with a z-score of -1.32. The higher the Z-score for the percent of people working in the service sector, the lower the social vulnerability score for the area.

**Figure 9** shows that the district with the z-score of the number of women who act as head of the family (without husbands) is Sukoharjo Regency with a z-score of 1.04, Sragen Regency with a z-score of 0.59, Wonogiri Regency with a z-score of - 0.46, and the lowest is Karanganyar Regency with a z-score of -1.17. The higher the z-score value for the number of women who act as family heads (without husbands), the higher the SoVI score for that area. Women who have the role of family head will be more vulnerable than families with male family heads. In earning a living, men are usually stronger, especially the head of the family is the responsibility of men, so that men will be more able to be responsible for their families than female heads of families. The following is a graph of the number of women who act as heads of families (without husbands) in Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency. One measure of family structure is the number of women who have the role of head of the family. Based on the results of the analysis, it is known that Sragen Regency has a score of 6, Sukoharjo Regency with a score of 5, Wonogiri Regency and Karanganyar Regency both have a score of 4. The higher the score for the family structure owned by an area, the higher the SoVI score for that area.

**Figure 10** describes the conditions of social dependence between districts. Sukoharjo Regency and Karanganyar Regency both have the same social dependency component score, namely 3. Wonogiri Regency and Sragen Regency also have the same score, namely 2. The more scores of the social dependency components obtained, the higher the SoVI score of the area. One of the sub-components in social dependence is the number of BPJS Kesehatan users in the area. The more people who participate in health insurance will increase the dependence of the community on the government. The following is a graph of BPJS Kesehatan users in Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency: the highest z-score for BPJS Kesehatan users is Sukoharjo Regency with a z-score of 0.930059, Karanganyar Regency with a z-score of 0.484806. Sragen Regency with a z-score of -0.03697, and Wonogiri Regency with a z-score of -1.37789. The higher the z-score value of BPJS Kesehatan users in an area, the higher the SoVI score of that area.

After obtaining the SoVI score for each regency, in order to classify the regency into different level of vulnerability (low, medium, and high vulnerability), vulnerability classes are made. The calculation for classes' setup is as follow:

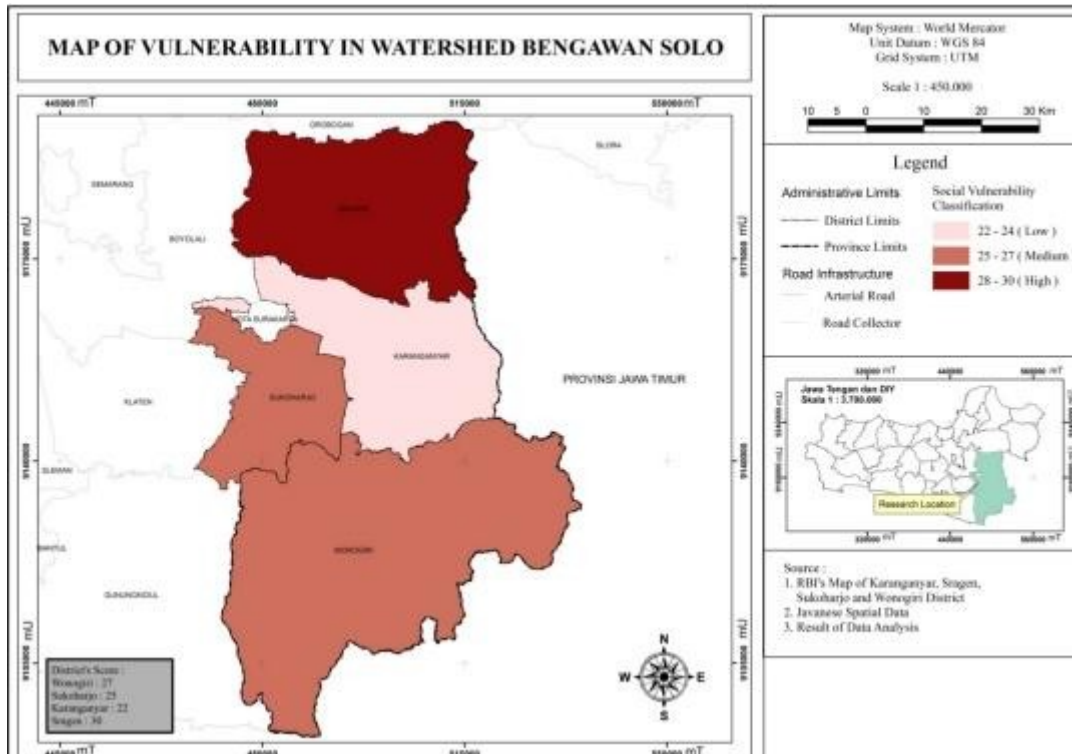
Data quantity: 4  
 $K = 1 + 3.3 \log n$   
 $K = 1 + 3.3 (\log 4)$   
 $K = 1 + 3.3 (0.6)$   
 $K = 1 + 1.98$   
 $K = 2.98$  rounded up into 3  
Range = 30-22  
= 8  
Interval =  $8/4$   
= 2.6 rounded up, to 3  
The classes set:  
1 (low vulnerability) = 22 up to 24  
2 (medium vulnerability) = 25 up to 27

#### 4.2. Map of Vulnerability using GIS

This research relied on GIS to illustrate the level of vulnerability of each area. The vulnerability map of Wonogiri, Sukoharjo, Karanganyar, and Sragen Regency is presented in Figure 11. Based on Figure 11, the area depicted with dark red color is the area with higher vulnerability, compared to the area with light color. Figure 1 illustrates that the area with the highest vulnerability level is Sragen Regency. Sukoharjo and Wonogiri Regency are the area with medium vulnerability, while Karanganyar Regency is the area with the lowest vulnerability level. The

level of vulnerability is affected by the city/village and occupancy component. This result is in line with the research conducted by Widiarto & Kingma, (2014) and Setyaningrum & Giyarsih, (2012), concluded that the floods in Sragen would have been impacted to the farmer households. Further, Setyaningrum and Giyarsih (2012) the vulnerability of the community around Kali Code riverbank is affected by economic sector.

**Figure 11.** The Map of Social Vulnerability in the Bengawan Solo Watershed Area



Source: Data processing

#### 4.2.3. Socio-Economic Effect

Natural disasters will actually have an impact on the condition of areas that have high vulnerability to the occurrence of these disasters, this refers to the upstream part of the Bengawan Solo river (Sragen Regency, Sukoharjo Regency, Wonogiri Regency, Karanganyar Regency). The impact of an area's vulnerability to flooding can disrupt economic development and growth, as well as social vulnerability (Widiarto and Kingma, 2014, Rawal and Arokoyu, 2015).

**Table 3. Socioeconomic Performance Indicator Relates SoVI Score**

Regency	Socioeconomic Performance Indicator			
	SoVI	P0*	P2*	HDI*
Sragen	30	15.48	0.63	70.34
Sukoharjo	25	9.52	0.26	73.88
Wonogiri	27	13.66	0.51	66.84
Karanganyar	22	12.97	0.47	73.41

Notes: \*average index (2010-2018); P<sub>0</sub>: Poverty Index (%); P<sub>2</sub>: Poverty Severity Index

Source: Central Bureau Statistic, (Data Processed)

Referring to Giyarsih et al (2011), there are many aspects that are hampered when a disaster occurs, one of which is the socio-economic aspect. An area that often faces natural disasters such as floods usually has a socio-economic effect on people's lives compared to another area that is not affected. Disruption to the socio-economic



conditions in an area can increase the vulnerability of the area and a high level of vulnerability will affect poverty. Vulnerability itself is a condition or a consequence of circumstances (physical, social, economic, and environmental) that affects disaster prevention and management efforts (Bakornas, 2009).

Sragen regency which has high vulnerability to disasters has a high percentage of poverty and poverty severity index or expenditure disparity among residents, on the other hand, regions with lower SoVI scores than Sragen regency have lower poverty levels and lower disparities (Table 4). Social and economic vulnerability is the cause and effect of the large loss of flood disasters and the economic level of the community (high percentage of poverty and high poverty severity) makes people in disaster-prone areas have lower economic vulnerability because economically high areas are considered capable of protecting their lives (Hapsoro and Buchori, 2015).

Disasters (floods) have a tendency to influence cultural factors, livelihoods, and reasoning at the local socio-economic scope. Economic losses due to flooding can be directly observed (for example damaged houses or destroyed business sectors) which have an impact on output losses (unable to produce) and will later create poverty as a result of adjusting the changing structural conditions of society (Artiani, 2011; Kumulawati, 2015).

**Table 4. Human Development Index dan Poverty Index in Upper Bengawan Solo Watershed, 2010-2018 (in Percent)**

	Regency	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>HD I</b>	Sragen	67.67	68.12	68.91	69.95	70.52	71.1	71.43	72.4	72.96
	Sukoharjo	71.53	72.34	72.81	73.22	73.76	74.53	75.06	75.56	76.07
	Wonogiri	63.9	64.75	65.75	66.4	66.77	67.76	68.23	68.66	69.37
	Karanganyar	70.31	71	72.26	73.33	73.89	74.26	74.9	75.22	75.54
<b>P<sub>0</sub></b>	Sragen	17.5	17.9	16.7	15.9	14.9	14.9	14.4	14	13.1
	Sukoharjo	10.9	11.1	10.2	9.9	9.2	9.3	9.1	8.8	7.4
	Wonogiri	15.6	15.7	14.6	14	13	12.9	13.2	12.9	10.8
	Karanganyar	13.9	15.2	14	13.5	12.6	12.4	12.4	12.2	10

Notes: P<sub>0</sub>= Poverty Index; HDI: Human Development Index

Source: Central Bureau Statistic (Data Processed)

If there is a flood in the upstream area of the Bengawan Solo river, the possibility of economic loss is very high. The economic loss of floods is a trend and extreme projections related to water (floods) that cause economic and life damage, where flood events can be expensive, such as in Central and Eastern Europe in 2013 which caused losses of 15 billion Euros (Jonkman and Kelman, 2005; Kunreuther and Michel-working, 2007; United Nations International Strategy for Disaster Reduction Secretariat, 2009; Munich Re 2014 in Carrera, 2014).

The trend of poverty reduction and increase in HDI (2010-2018) which contradicts the SoVI measurement shows that the index is valid (Table 4). Based on SoVI, Sragen, which has a high level of vulnerability (Table 4), is the area with the highest poverty but in a decreasing trend, as well as HDI which continues to increase from year to year. The trend of reducing poverty and increasing HDI also occurs in other upstream areas of the Bengawan Solo river, meaning that there are efforts to prevent and mitigate disasters (floods). The increase in HDI is an indicator in the economic development of the community which continues to improve which also has an impact on reducing poverty, so that people with high economies are able to protect their lives or be able to rise up in the event of a natural disaster.

## 5. CONCLUSION

The Social Vulnerability Index (SoVI) calculation revealed that the area with the highest vulnerability is Sragen Regency followed by Wonogiri and Sukoharjo Regency, and Karanganyar Regency with the lowest vulnerability. Furthermore, the result of socio-economic description based on all the 10 components, Sragen Regency is the most vulnerable area with the highest score on socio-economic status, age, gender, village/city, occupancy, and family structure. Meanwhile, the other three regencies have the relatively the same result in each component.

The result of vulnerability map analysis based on GIS showed that the area with the highest vulnerability is Sragen Regency followed by Wonogiri and Sukoharjo Regency with medium vulnerability, and Karanganyar Regency with the lowest vulnerability. The map also shows that the areas, that geographically adjacent and have a different

administration, have a vulnerability level with GIS insignificant difference.

The implication of this study is that local governments can reduce the level of social vulnerability by paying attention to some SoVI indicators. Reducing the level of social vulnerability will directly reduce the risk of increasing poverty, income disparities, and increased government spending. Local governments can allocate budgets to develop strategies to reduce disaster damage by providing provision to communities in vulnerable areas to be more responsive to disasters.

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Faculty of Economics & Business, Universiti Malaysia Sarawak  
94300 Kota Samarahan, Sarawak, Malaysia.

Tel: +60 82 584368 Fax: +60 82 583999 Email: [editorjbs@unimas.my](mailto:editorjbs@unimas.my)  
<http://www.ijbs.unimas.my>

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SURYANTO

Universitas Sebelas Maret,  
Jalan Ir. Sutami 36A, Surakarta,  
Indonesia 57126

SURYANTO

We are pleased to inform that your paper entitled “***DO SOCIAL-ECONOMY VULNERABILITY INDEX AND POVERTY INDEX HAVE CORRELATION? STUDY IN BENGAWAN SOLO WATERSHED***” has been accepted for publication and will publish in the International Journal of Business and Society (IJBS). It is my pleasure to indicate that the paper will be scheduled for the publication in Vol. 22, No 2, August (2021) of the journal.

Thank you for considering this journal and we look forward to receiving future articles from you.

Sincerely yours,

Evan Lau, Ph.D.

**Editor in Chief**

***International Journal of Business and Society (IJBS)***

## 6. **Lampiran hasil revisi format Amendement P27 (10 Juni 2021)**

### **DO SOCIAL-ECONOMY VULNERABILITY INDEX AND POVERTY INDEX HAVE CORRELATION? STUDY IN BENGAWAN SOLO WATERSHED**

**Suryanto**✪

*Universitas Sebelas Maret*

**Ratih Kumalasari**

*Universitas Sebelas Maret*

**Danur C. Guritno**

*Universitas Sebelas Maret*

**Nugroho Saputro**

*Center for Fintech and Banking, Universitas Sebelas Maret*

**Sabar Marniyati**

*Universitas Surakarta*

#### **ABSTRACT**

The components to measure of disaster risk (i.e flood) are level of hazard, vulnerability of individual/community, and capacity of individual/community. Research related to vulnerability is based on the level of probability of a region experiencing a disaster, while vulnerability is based on conditions where individual/community cannot cope with disasters. The aim of the study was to measure the level of vulnerability of the socio-economic and institutional society. This research tried to explain the level of social vulnerability among the communities in upper Bengawan Solo watershed. SoVI makes more appropriate parameters for measuring social vulnerability than relying only on partial socioeconomic data. The data generated from relevant institution, such as Central Bureau of Statistic (Badan Pusat Statistik–BPS), Social Service Institution (Dinas Sosial), National Population and Family Planning Board. Data needed such as socio-economic community, demography, age, family structure, village-city, education, and unemployment rate. We find the data from the related agencies. The first step analysis is to adapt the measurement of vulnerability (SoVI) that has been developed. After the measurement of the SoVI is carried out then it is classified relatively between districts (Sragen, Sukoharjo, Wonogiri, and Karanganyar) in the upstream Bengawan Solo Watershed. The results show highest SoVI total score (the most vulnerability) is Sragen Regency, followed by Wonogiri and Sukoharjo, and the lowest is Karanganyar. Meanwhile, Sragen has the highest scores in social-economy components score such as age, gender, rural/urban, occupation, and family structure. It implies that when disasters attack to Sragen, their community will be more suffering potentially.

**Keywords:** social economy, community, vulnerability, risk

## 1. INTRODUCTION

Disaster is a phenomenon that occurs as a result of the impact of hazards and vulnerabilities simultaneously that can affect environmental conditions or areas in managing threats (Oxfam, 2012 in Hapsoro & Buchori, 2015). Floods that occur every year in several districts or regencies that pass through the river cause socio-economic vulnerability in these districts or regencies.

Societies that have a high dependency on natural resources are very vulnerable to changes in rainfall (Boissiere, Locatelli, & Sheil, 2013); Lintner et al., 2012 in Auliyani & Wahyuningrum, 2020). Societies in Java island especially some parts of regencies in Bengawan Solo Watershed are often experienced by floods. According to National Board for Disaster Management (BNPB) in 2015, Java Island is the most frequently exposed by the flood. Societies in Java Island suffered physical losses of up to USD 4,502 million and drought with a loss of up to USD 3,899 million (Amri et al., 2016).

The Bengawan Solo is one of the largest watershed and longest river flow on the island of Java, Indonesia. This river has a length of 548.53 km with a watershed area of 16,100 km<sup>2</sup> and crosses two provinces, namely Central Java and East Java. Its area covering ± 12% of the entire island of Java. Bengawan Solo has a problem of drought and seawater intrusion during the rainy season in several areas where floods often occur and vice versa in the dry season which results in considerable loss of property and human life (Auliyani & Wahyuningrum, 2020). Therefore, studies on vulnerability in the Bengawan Solo watershed are needed to prevent greater material and non-material losses related to natural disasters.

According to Rusminah & Gravitian (2012) Central Java has seven regencies/municipalities that are passed by the Bengawan Solo River. Among the seven regencies/municipalities, Surakarta is an area that does not have large agricultural land. Surakarta as a municipality has a small contribution from agricultural sector. Surakarta has farmland for rice production area only 36 hectares and produces 230 tons per year (2018). Meanwhile, other areas such as in Wonogiri, Regency, Sukoharjo Regency, Karanganyar Regency, and Sragen Regency have broader agricultural land areas. The impact of climate change, especially flooding in the agricultural sector, triggers the increased social vulnerability. In this research, the areas to be studied are Wonogiri, Sukoharjo, Karanganyar, and Sragen regencies.

Climate change has been believed as one of the factors that causing the flood in several areas. Climate change is the change in climate variables, especially air temperature and rain intensity that occur gradually around 50 to 100 years (Runtunuwu & Syahbuddin, 2007); (Hettiarachchi, Wasko, & Sharma, 2018). When the disaster struck to society, there will be many aspects that get hampered such as the socio-economic aspect. Areas that frequently faced natural disasters such as floods usually have to bear the negative impacts in socio-economic life than other areas. The disruption in the social-economy condition in an area can increase the vulnerability of the area.

One of the most affected groups is the agriculture sector. For farmers, the land is an earning asset that can generate revenue (Surmaini, Runtunuwu, & Las, 2015); (Suryanto, Sutrisno, Gravitiani, & Susilowati, 2017). Therefore, when their farmland is flooded, they cannot cultivate their crops which reduces their revenue. There is a correlation between the population's vulnerability to poverty and their residence ecosystem, thus the level of poverty will differ from each agro-ecosystem (Ali & Erenstein, 2017). The vulnerable society will harder to cover their basic needs compared to the less vulnerable society. However, the vulnerability can also be caused by the socioeconomic conditions of the community. One of the factors causing vulnerability is poverty. People who are in poor condition will tend to be vulnerable. This means that the factors of vulnerability and poverty are thought to have a positive relationship.

Measurement of social vulnerability has been carried out using several approaches, for example, the Social Vulnerability Index, the Livelihood Vulnerability Index, or the Climate Disaster Resilience Index. All measurement models rely on relative comparisons between regions in a single study. Meanwhile, the poverty indicators show individual conditions and do not show collective conditions. This study aims to find out whether the vulnerability has a relationship with the poverty index. If poverty has a relationship with vulnerability, then SoVI in the Bengawan Solo watershed can be predicted from the poverty level. In this research we collect data from Bengawan Solo watershed covers for the regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen.

## 2. LITERATURE REVIEW

Disaster Risk Management (DRM) could not be success without concern to improve the capability of society. DRM will need to address not only the physical aspect, but also the economic and social factors which influence the greater society and reinforce the impact of hazardous events (Mcentire, 2012). A better preparation and precisely calculation of risk is an important and long overdue addition to the hazard mitigation planning and implementation processes (Opiyo, Wasonga, Nyangito, Schilling, & Munang, 2015);(Iglesias, Quiroga, Diz, & Garrote, 2011) especially in the context of climate change adaptation and disaster risk reduction strategies.

Social vulnerability is measured using various method in the previous researches. SoVI has introduced by Shirley, Cutter, and Boruff (2003), they developed SoVI to identify and mapping the level social vulnerability in Mississippi Delta Region. This model has been adapted and adjusted depend on local characteristics aspects. Research by Lawal & Arokoyu, (2015) and use the Social Vulnerability Index method in measuring the vulnerability.

Vulnerability can be defined as a weakness to anticipate the potential for something that has a risk. Lawal and Arokoyu (2015) stated that vulnerability is a loss of life or properties as the result of a natural disaster. Furthermore, according to Miyan (2015) and Lawal and Arokoyu (2015), vulnerability consists of two categories, namely biophysical and social vulnerability. Biophysical vulnerability can cause food insecurity, drought, flood, bad weather, etc, meanwhile social vulnerability leads them to suffer from disease, loss of property, etc. They conducted research to measure social vulnerability in Sub-Sahara area especially West Africa. They found that the impact of disasters tends to be more devastating in developing countries as a result of the interaction between population growth, land pressure, economic growth, technological innovation, social expectations, and growing interdependence. They also resulted the differentiation of the social vulnerability score among Local Government Areas (LGA) by Social Vulnerability Index.

Implementation of the index of social vulnerability (SoVI) has been conducted by Lawal and Arokoyu (2015). They used a sample of Nigeria's Southwest Zone, which consists of six states, namely Ekiti, Lagos, Ogun, Ondo, Osun and Oyo and this region has 137 local government areas (LGA). The result indicates that Ondo and Ekiti have LGAs are more vulnerable than other countries in the region. While research by Shirley et al. (2003) establish several spatial patterns in SoVI calculation, in which the most vulnerable regency located in East Metropolitan area, South Texas, and Mississippi Delta area. Another research conducted by Setyaningrum and Giyarsih (2012) found that the vulnerability level of the community that resides around Kali Code Riverbank is low and more affected by the economic factor. They conclude that social and economic vulnerability with people perception have negative correlation. It will impact to high loss potential toward societies.

Meanwhile, Suryanto (2017) supported the finding from (Setyaningrum & Giyarsih, 2012), in his research tried to evaluate the negative impact of flood in Surakarta city. He stated a vulnerable area to the natural disaster is often socially vulnerable more compared to the areas that less prone to natural disasters. Research from Widiarto and Kingma (2014) also reported that impact of vulnerability to flood can disrupt the development and economic growth in Sragen.

Another research on vulnerability is conducted by Shah, Dulal, Johnson, and Baptiste (2013), which analyze farmers' vulnerability toward climate change. The method used is different from SoVI score calculation, they tried to estimate with another approach. They used the Livelihood Vulnerability Index (LVI) method. Razafindrabe, Parvin, Surjan, Takeuchi, and Shaw (2009) in contrast, examined the resilience of a region toward disasters that occur as an effect of climate change on the Asian coastal area. The method was the Climate Disaster Resilience Index (CDRI). Research conducted by Shah et al. (2013) found that Narvia is more vulnerable than Caroni, especially in socio-demographics, health condition and water availability, natural disaster, and climate variability. Razafindrabe et al. (2009) suggest that the type of vulnerability in each area varies. Thus, a policy that recommend to be conducted for the area will be different.

Almost all SoVI or LVI measurements method rely on secondary data, which is then compared among regions. This measurement relies on relative sizes and contains weaknesses if several areas used have almost the same level of vulnerability.

## 3. METHODOLOGY

Bengawan Solo Watershed through 17 regencies/municipalities in two provinces, Central Java and East Java. There two steps to analysis the data, first step is calculation of social vulnerability index and second step is Geographical Information System. In SoVI approach we describe the socio-economic living, the level of social vulnerability, the comparison mapping of social vulnerability as a basis of consideration for the development policy of Bengawan Solo watershed area. The Social Vulnerability Index (SoVI) has been developing to measure the vulnerability level in each regency. After the SoVI score is obtained, a Geographical Information System conducted to describe the most vulnerable regency.

The research took place on the areas located around Bengawan Solo watershed with the developed agricultural sector. Therefore, the four regencies which located in Bengawan Solo River watershed are chosen for this study namely: Wonogiri, Sukoharjo, Karanganyar, and Sragen. Four regencies have known as main supplier for rice to Java island people, especially in Central Java Province.

SoVI approach relied on secondary data, that has been generated from other institutions or organizations related to this study. This data will be used to examine the social vulnerability level of the society in Bengawan Solo River watershed area. The secondary data are obtained from the Central Bureau of Statistic (Badan Pusat Statistik–BPS), Social Service Office (Dinas Social-DinSos), One-door Integrated Investment and Licensing Offices (Dinas Penanaman Modal dan Perijinan Terpadu Satu Pintu–DPMPSTP), Population and Family Planning Bureau (Badan Kependudukan dan Keluarga Berencana Nasional), General Election Commission (Komisi Pemilihan Umum–KPU), and Financial and Regional Assets Management Office (Dinas Pengelolaan Pendapatan Keuangan dan Aset–DPPKA), which located in the Regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen.

The SoVI score for each regency calculated using Microsoft Excel and SPSS 16 based on estimating for each regency. The results discussed descriptively to get socio-economic conditions for each regency. GIS method used to figure out the level of vulnerability among four regencies. By the GIS approach, it makes easier for us to analyse data on vulnerability.

**Social Vulnerability Index (SoVI) Analysis:** a method that will generate the social vulnerability score for each area in this research. Therefore, in order to provide the score that will be used in the SoVI calculation, the z-score of each sub-component should be computed previously, Z-score is needed because the size and data units used in the analysis are different. The socioeconomic measurement differs from the measurement for age and property. The Z-score accommodates the different unit measurements into comparable unit among regions. The Z-score calculated using the following formula:

$$z = \frac{x - \mu}{\sigma} \quad (1)$$

Note:

z = z-score

x = base value

μ = the average value

σ = standard deviation

After the z-score is computed, which mean the standard value for each sub-component is obtained, a varimax rotation method is used to know the correlation between a sub-components with another sub-component. The aim of varimax rotation is to test whether the factor score of each component is overlapping with other components. Based on the Rotated Component Matrix in the varimax rotation output, if there is more than one component that has a score above 0.50 then the component is overlapping with other components, thus the component should be eliminated.

After the overlapping components are eliminated, the next step is to decide whether the remaining components represent more than 50 percent of the total components before elimination. If the remaining component represents more than 50 percent than the total component, the SoVI score computation can be continued.

The remaining components that represent the total component are scored. The scoring is conducted by categorizing the z-score into the classes or groups that have had prepared. The groups is calculated based on Sturges Formula and it is needed to determine how many groups of vulnerabilities can be created based on the data. The classification of vulnerable groups is determined in a range based on the calculation results. For example, the category is vulnerable if the SoVi score is above 70. The class determination of the Sturges model can be determined based on a formula,



Number of Class =  $1 + 3.3 \log n$ , with  $n$ , is the number of  $n$  data  
 Range = highest score – the lowest score  
 Class length = Range/K

After the class has prepared, the z-score of each component is classified into the class. Moreover, each sub-component is analyzed whether it increases or decreases the vulnerability. The next step is by adding up all the sub-components, which represent the SoVI score. This score will be used to prepare the vulnerability map. The area with the highest SoVI score is the area with the highest level of social vulnerability, vice versa. The classification of vulnerability level is based on the class. In this research, the classification is divided into three classes, namely, low, medium, and high vulnerability. The classification of vulnerability classes use a relative scale; the same method used for the scoring of level vulnerability.

The explanation of social vulnerability indicators refers to Shirley et al. (2003), (Kusenbach, Simms, & Tobin, 2010), Lee (2014), and McEntire (2012) of social-economic status are used to describe the level of a region's macroeconomy. The number of votes in the presidential election illustrates the awareness of the economic preference of candidates. The higher the regional domestic regional gross, the higher the capacity of an area to overcome the risk of flooding.

Age indicator shows the age composition of the population of an area. If more and more of the population is elderly, it shows that the population is more vulnerable. With almost the same explanation, it also occurs in the health indicator. The higher the number of doctors in an area, the lower the level of vulnerability faced.

The property indicator shows the level of dependence of the GDRP on the agricultural sector. If the contribution of the agricultural sector is high, the regency will have a high dependence on the agricultural sector. Meanwhile the agricultural sector is very dependent on the climate. Conversely, the region has a low vulnerability if the dependence on the agricultural sector is low.

The other SoVI indicators are sex, demography, and social dependence. Sex is an indicator that shows the proportion of the sex of the population. Meanwhile, demography reflects the level of population density and social dependence shows the proportion of the population who has participated in the BPJS insurance program. The proportion of the population that is dominated by women is considered to have a higher vulnerability. Meanwhile, a high level of population density is considered to have a higher level of vulnerability.

**Table 1. The Indicator and Sub-indicator of Social Vulnerability Index (SoVI)**

Indicator	Sub-indicator	Sub-indicator explanation
Social-economy status	Percapita income	The income earned by e person in a spesific year.
	The dependency ratio of government to general allocation fund.	The Amount of General Allocation Funds in Regency/City income balance funds
	The number of votes in the presidential election	The number of voters who voted in the 2014 presidential election
	The percentage of family welfare	The number of household having more total income than regional minimum wage.
	The percentage of people live under poverty line	The number of poor people
Age	The number of households that own car	The number of households that own car
	Average age	The average age of population in a regency/city
	The number of elderly	The number of population over 65 years old
Property	The number of toddler	The number of children under 5 years old
	The rental cost of occupied housing	Average rental cost housing paid by community
	The number of Building Permit (IMB)	The number of building permit that issued by government
	The number of companies	The number of companies in regency/city
	Company productivity	The average value of company productivity

	GRDP Agriculture	Agricultural sector contribution to Regency / City income
Health	The number of doctors	The number of doctors, nurse, and midwife.
	The number of people living in nursing homes.	The number of people living in nursing homes.
	The number of health facilities.	The number of health facilities such as hospital and health center.
Demography	The percentage of population change	The comparison of population changes from the previous year
	Birth rate	Number of births in a Regency / City in 1 year
	Population density	The average of population density in district/ city.
Education	The number of high school graduate	The number of residents who have a high school certificate
Sex	The number of female	The number of female citizenship
Unemployment	The number of unemployment	The number of unemployed workforce
Rural/urban area	Land used by farmers	The amount of land used for agriculture
	The number of farmers	The number of residents who work as farmers
	The population of urban area	The number of residents living in urban areas
Social dependence	Social dependence Number of BPJS Health users	Number of residents using BPJS Health facilities
Number of people with special needs	The number of people who have physical, and mental limitations	
Renter		The percentage of renter
Job	Working workforce	The number of workforce employed
	The number of working female	The number of female work force employed
	The number of worker in agriculture, fishery, and forestry (primary industry)	The number of people whose livelihood work in the agriculture, fisheries, mining and forestry sectors
	The number of residents working in the transportation, communication and other public facilities sectors	The number of residents working in the transportation, communication and other public facilities sectors
	Number of people working in the public service sector (services)	Number of residents whose livelihood work in the public service sector (services)
	The number of Indonesian Migrant Workers (TKI)	The number of Indonesian Migrant Workers (TKI)
Family structure	The average number of family member	The average member in one family.
	Women as head of the family	Population of women who act as heads of families (do not have husbands)

Source: modified from Shirley, Cutter, and Borruf, (2003)

**Socio-Economics Description:** this analysis is conducted to describe the socio-economic condition of the communities that reside in the Bengawan Solo River watershed area. The socio-economic description is conducted using descriptive statistic method. The data used in this analysis is the result of z-score in the SoVI assessment. Each main component will be used to compare the vulnerability in each area, which will simplify the description of the socio-economic condition.

**The Analysis Using Geographical Information System (GIS):** GIS will be conducted to describe the most vulnerable regency among the four regency, based on the SoVI score.

This part explains how the research is conducted, research deGISn, data collecting techniques, instrument development, and data analysis techniques.

**Table 2. Summary of Research Method**

Research Objective	Analysis Tools	Data	Result
Social Vulnerability of the community that live at Bengawan Solo River watershed area	Social Vulnerability Index (SoVI)	Secondary Data	Social Vulnerability Index
Mapping of the most vulnerable area at the Bengawan Solo River watershed areas	Geographical Information System (GIS)	Secondary Data	Social Vulnerability Map

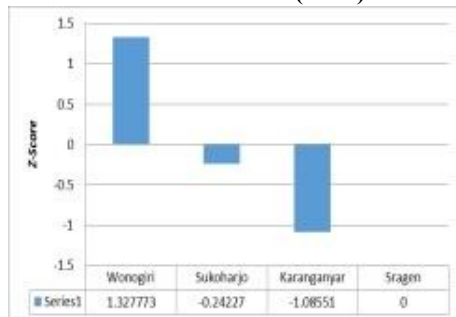
Source: research method (2017)

#### 4. RESULT AND DISCUSSION

##### 4.1 Social-Economic Description

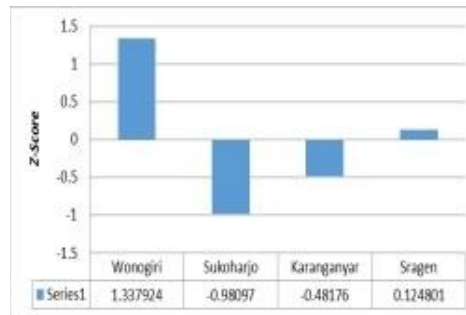
This analysis is performed to understand the social-economy life in Bengawan Solo watershed. Descriptive statistic is utilized to explain the social-economy description. The data employed are from z-score calculation in the process of SoVI scoring. Each main component will be explained the comparison in each area. Thus, it will be able to see the description of social-economy indicators (see on Table 1). Some figures below represent each component of SoVI variable.

**Figure 1. Dependence of Transfer Allocation Fund (DAU)**



Source: Central Bureau of Statistics

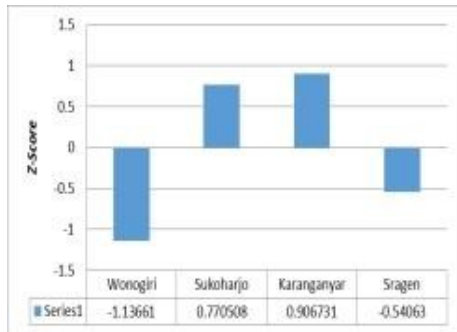
**Figure 2. The Number of Citizens Older than 65 Years**



Source: Central Bureau of Statistics

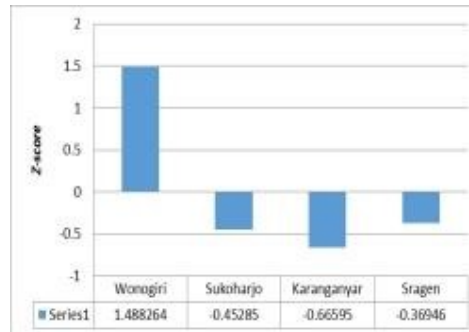
**Figure 3. The number of Firms**

**Figure 4. The number of people living in nursing homes**



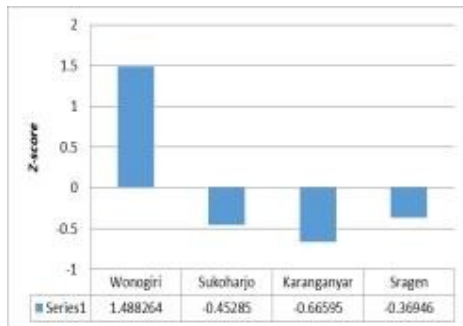
Source: Central Bureau of Statistics

**Figure 5. Birth Rate**



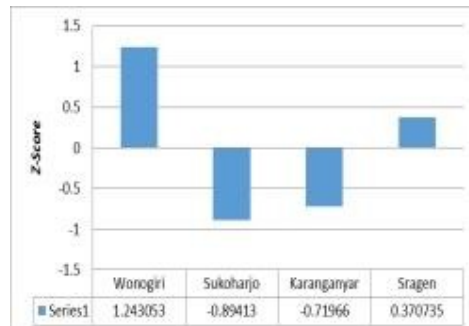
Source: Central Bureau of Statistics

**Figure 6. Proportion of Citizens Living in Rural/Urban**



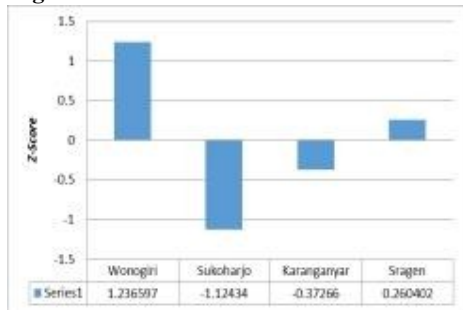
Source: Central Bureau of Statistics

**Figure 7. The Number of Farmers in Rural**



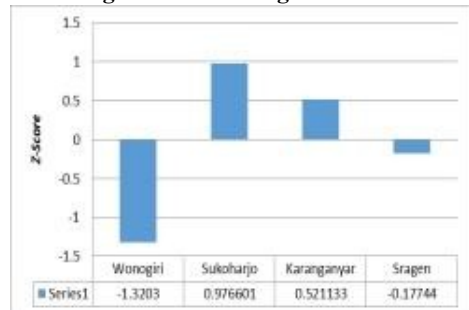
Source: Central Bureau of Statistics

**Figure 8. Percentage of Women**



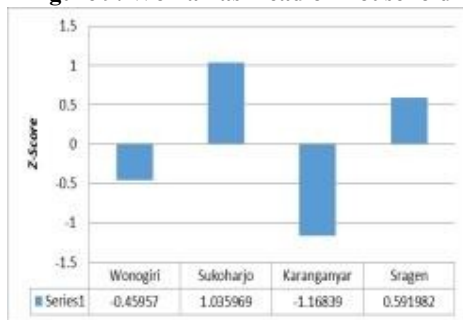
Source: Central Bureau of Statistics

**Figure 9. Woman as Head of Household**

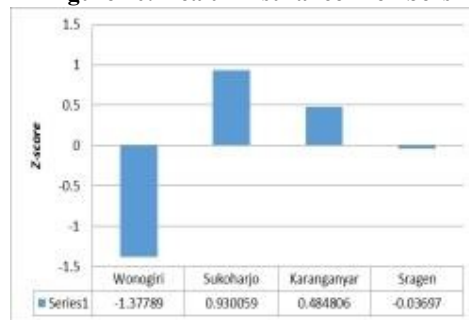


Source: Central Bureau of Statistics

**Figure 10. Health Insurance Members**



Source: Central Bureau of Statistics



Source: Central Bureau of Statistics

In Figure 1, the highest regional dependence on DAU is Wonogiri Regency with a z-score of 1.328, Sragen Regency with a z-score of 0, Sukoharjo Regency with a z-score of -0.242, and the lowest score is Karanganyar

Regency with a z-score of -1.086. Figure 1 explains that the highest socio-economic status score is Sragen Regency with a score of 3, Wonogiri Regency and Sukoharjo Regency have the same score, namely 2, and the lowest score is Karanganyar Regency with a score of 1. The more scores of the components of socioeconomic status obtained indicate the area increasingly vulnerable. One of the sub-components of socio-economic status is dependence on DAU. The greater the General Allocation Fund (DAU) received by a region indicates that the dependence of a region in meeting its needs is still very high. The following is a graph of the dependence of Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency on the General Allocation Fund (DAU).

**Figure 2** explains that the highest age component is in Wonogiri and Sragen districts with a score of 8, Sukoharjo and Karanganyar regencies also have the same score, namely 7. The more scores you get in the age component, the more SoVI scores are obtained in the area. An area with a larger number of people with an average age means that the area has a greater potential for vulnerability than an area with a small average age. The highest limit for a person's productivity is at the age of 65 years. In figure 2, the more age a person is, the less distance it will be from the age of 65, which means that someone's chance to be productive is less than the younger one. The district with the highest average age was Wonogiri Regency with a z-score of 1.338 then Sragen Regency with a z-score of 0.125, followed by Karanganyar Regency with a z-score of -0.482, and the lowest was Sukoharjo Regency with z-score of -0.981.

**Figure 3** explains the property score shows that the less property score in an area indicates that the area is more vulnerable than other areas. Wonogiri Regency has the highest score among the other 4 districts, namely -6, Sragen Regency with a score of -7, Sukoharjo Regency with a score of -8 and Karanganyar Regency with the lowest score, namely -9. One of the sub-components in property is the number of companies. An area with many operating companies indicates that the area is quite advanced. Furthermore, people who work for companies have a lower vulnerability. This possibility is caused when working in a community company has a fixed salary that can be used to meet their needs. **In figure 3**, the district with the highest number of companies is Karanganyar Regency with a z-score of 0.907, then Sukoharjo Regency with a z-score of 0.770508, Sragen Regency with a z-score of -0.54063, and the number of companies is the least located in Wonogiri Regency with a z-score of -1.13661. The less z-score of the number of companies in an area, the less the number of companies in the area, and can increase the social vulnerability score.

**Figure 4** explains the regional health component score which has the lowest score is Sragen Regency with a score of -1, the other three districts namely Wonogiri Regency, Sukoharjo Regency and Karanganyar Regency each have the same score, namely 0. The greater the score of an area will increase the vulnerability score. social area. One of the sub-components in the health component is the number of people living in nursing homes. The nursing home used in this study is a nursing home that is managed by the government, so that the greater the number of people in the nursing home, it means that the costs borne by the government will increase. **In figure 4**, when the z-score in an area is getting higher, it will increase the social vulnerability in that area. The highest z-score was in Wonogiri Regency with a score of 1.488, Sragen Regency with a z-score of -0.369, Sukoharjo Regency with a z-score of -0.452, and the lowest was Karanganyar Regency with a z-score of -0.666. The greater the z-score of the number of people living in nursing homes, indicating that the area is more vulnerable than other areas. The highest score for the population component was Karanganyar Regency with a score of 6, Sukoharjo Regency and Sragen Regency with the same score, namely 5, and Wonogiri Regency with the lowest score of 4. The higher the population component score will increase the SoVI score obtained by the region.

**In figure 5**, the higher the z-score, the higher the SoVI score in that area. The following is a graph of the birth rates from Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency. The picture shows that Wonogiri Regency is an area that has the highest z-score, namely 1.49, Sragen Regency has a z-score of -0.37, Sukoharjo Regency has a z-score of -0.45, and the lowest is Karanganyar Regency with z-score of -0.67. The more basic z-score value of a region's birth rate, the higher the SoVI score of that area. Wonogiri Regency and Sragen Regency have the same gender component score, namely 3, Sukoharjo Regency and Karanganyar Regency both have a score of 2. The more gender component scores that are owned by an area will increase the SoVI score of the area.

**Figure 6**, explains that Wonogiri Regency has the highest z-score with a z-score of 1.24. The regency with the second highest z-score was Sragen Regency with a z-score of 0.37, Karanganyar Regency with a z-score of -0.72, and the lowest was Sukoharjo Regency with a z-score of -0.89. The scores for the rural / urban component of the four districts have the same score, namely 5. **In figure 6**, the more scores the rural / urban component has in an area, the more it will increase the area's SoVI score. The number of people living in villages and in cities will affect the level of social vulnerability of the community. The more people who live in villages and in cities will

both increase their vulnerability.

**Figure 7**, explains the sub-components that exist in the rural / urban component, one of which is the number of farmers in rural areas. The more people who work as farmers in the village will increase their vulnerability. This is because farmers are jobs that depend on resources, so that when the resources are disturbed, the farmers' lives will also be disturbed. The following is a graph of the number of rural farmers from Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency, and Sragen Regency. In **figure 7**, the z-score for the sub-component of the number of farmers in rural areas is Wonogiri Regency with a z-score of 1.24, then Sragen Regency with a z-score of 0.26, Karanganyar Regency with a z-score of -0.37, and the lowest is Sukoharjo Regency with a z-score of -1.12. The z-score value of the sub-component of the number of farmers in rural areas will increase the social vulnerability score in the area. Sragen Regency has the highest score for the work component with a score of 6, Wonogiri Regency has the second highest score with a score of 5, Sukoharjo Regency has a score of 4, and Karanganyar Regency has the lowest score, namely 3. The greater the score of the work component of an area, the higher the total SoVI score for that area.

In **Figure 8** it is known that the work sub-component measured is the percentage of people working in the service sector. The service sector is a sector of employment with a low level of vulnerability compared to other sectors. This is because the service sector is not too dependent on existing natural resources. Based on the results of the Z score analysis, it is known that Sukoharjo Regency has the highest Z-score for the proportion of people working in the service sector with a Z-score of 0.98, then Karanganyar Regency with a z-score of 0.52, Sragen Regency with a Z-score of -0, 18, and the lowest is Wonogiri Regency with a z-score of -1.32. The higher the Z-score for the percent of people working in the service sector, the lower the social vulnerability score for the area.

**Figure 9** shows that the district with the z-score of the number of women who act as head of the family (without husbands) is Sukoharjo Regency with a z-score of 1.04, Sragen Regency with a z-score of 0.59, Wonogiri Regency with a z-score of -0.46, and the lowest is Karanganyar Regency with a z-score of -1.17. The higher the z-score value for the number of women who act as family heads (without husbands), the higher the SoVI score for that area. Women who have the role of family head will be more vulnerable than families with male family heads. In earning a living, men are usually stronger, especially the head of the family is the responsibility of men, so that men will be more able to be responsible for their families than female heads of families. The following is a graph of the number of women who act as heads of families (without husbands) in Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency. One measure of family structure is the number of women who have the role of head of the family. Based on the results of the analysis, it is known that Sragen Regency has a score of 6, Sukoharjo Regency with a score of 5, Wonogiri Regency and Karanganyar Regency both have a score of 4. The higher the score for the family structure owned by an area, the higher the SoVI score for that area.

**Figure 10** describes the conditions of social dependence between districts. Sukoharjo Regency and Karanganyar Regency both have the same social dependency component score, namely 3. Wonogiri Regency and Sragen Regency also have the same score, namely 2. The more scores of the social dependency components obtained, the higher the SoVI score of the area. One of the sub-components in social dependence is the number of BPJS Kesehatan users in the area. The more people who participate in health insurance will increase the dependence of the community on the government. The following is a graph of BPJS Kesehatan users in Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency: the highest z-score for BPJS Kesehatan users is Sukoharjo Regency with a z-score of 0.930059, Karanganyar Regency with a z-score of 0.484806. Sragen Regency with a z-score of -0.03697, and Wonogiri Regency with a z-score of -1.37789. The higher the z-score value of BPJS Kesehatan users in an area, the higher the SoVI score of that area. After obtaining the SoVI score for each regency, in order to classify the regency into different level of vulnerability (low, medium, and high vulnerability), vulnerability classes are made. The calculation for classes' setup is as follow:

Data quantity: 4  
 $K = 1 + 3.3 \log n$   
 $K = 1 + 3.3 (\log 4)$   
 $K = 1 + 3.3 (0.6)$   
 $K = 1 + 1.98$   
 $K = 2.98$  rounded up into 3  
Range = 30-22  
= 8  
Interval = 8/4  
= 2.6 rounded up, to 3

The classes set:

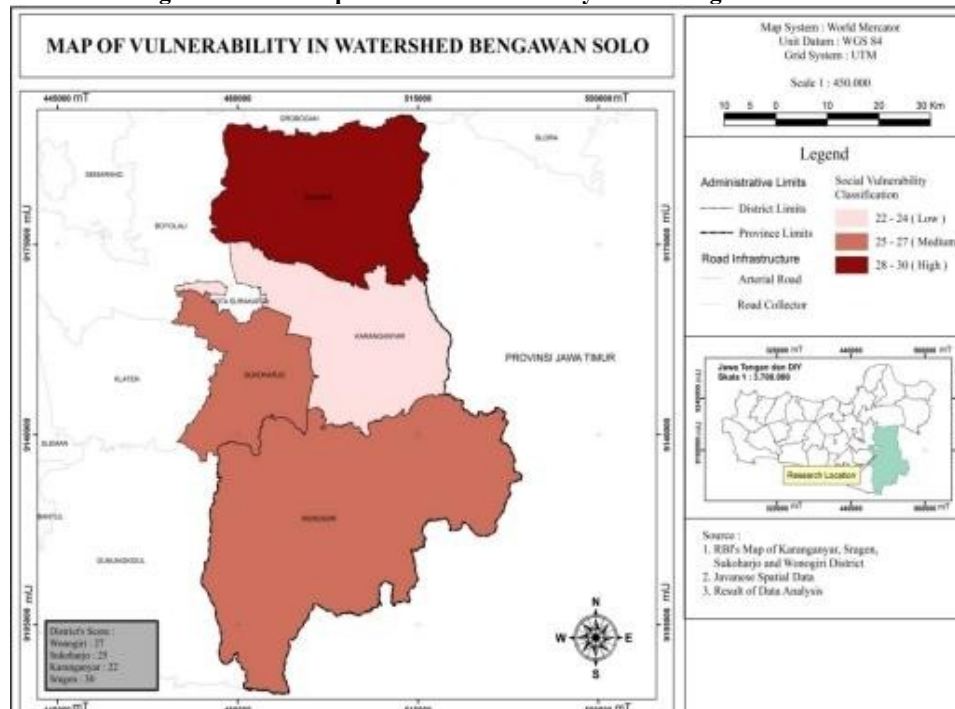
1 (low vulnerability) = 22 up to 24

2 (medium vulnerability) = 25 up to 27

#### 4.2 Map of Vulnerability using GIS

This research relied on GIS to illustrate the level of vulnerability of each area. The vulnerability map of Wonogiri, Sukoharjo, Karanganyar, and Sragen Regency is presented in Figure 11. Based on Figure 11, the area depicted with dark red color is the area with higher vulnerability, compared to the area with light color. Figure 1 illustrates that the area with the highest vulnerability level is Sragen Regency. Sukoharjo and Wonogiri Regency are the area with medium vulnerability, while Karanganyar Regency is the area with the lowest vulnerability level. The level of vulnerability is affected by the city/village and occupancy component. This result is in line with the research conducted by Widiarto and Kingma (2014) and Setyaningrum and Giyarsih, (2012), concluded that the floods in Sragen would have been impacted to the farmer households. Further, Setyaningrum and Giyarsih (2012) the vulnerability of the community around Kali Code riverbank is affected by economic sector.

Figure 11. The Map of Social Vulnerability in the Bengawan Solo Watershed Area



Source: Data processing



### 4.3 Socio-Economic Effect

Natural disasters will actually have an impact on the condition of areas that have high vulnerability to the occurrence of these disasters, this refers to the upstream part of the Bengawan Solo river (Sragen Regency, Sukoharjo Regency, Wonogiri Regency, Karanganyar Regency). The impact of an area's vulnerability to flooding can disrupt economic development and growth, as well as social vulnerability (Widiarto & Kingma, 2014; Lawal & Arokoyu, 2015)

**Table 3. Socioeconomic Performance Indicator Relates SoVI Score**

Regency	Socioeconomic Performance Indicator			
	SoVI	P0*	P2*	HDI*
Sragen	30	15.48	0.63	70.34
Sukoharjo	25	9.52	0.26	73.88
Wonogiri	27	13.66	0.51	66.84
Karanganyar	22	12.97	0.47	73.41

Notes: \*average index (2010-2018); P<sub>0</sub>: Poverty Index (%); P<sub>2</sub>: Poverty Severity Index  
Source: Central Bureau Statistic, (Data Processed)

Referring to Rose & Krausmann (2013) there are many aspects that hampered when a disaster occurs, one of which is the socio-economic aspect. An area that often faces natural disasters such as floods usually has a socio-economic effect on people's lives compared to another area that is not affected. Disruption to the socio-economic conditions in an area can increase the vulnerability of the area and a high level of vulnerability will affect poverty. Vulnerability itself is a condition or a consequence of circumstances (physical, social, economic, and environmental) that affects disaster prevention and management efforts (Lawal & Arokoyu, 2015); (Suryanto & Rahman, 2019).

Sragen regency which has high vulnerability to disasters has a high percentage of poverty and poverty severity index or expenditure disparity among residents, on the other hand, regions with lower SoVI scores than Sragen regency have lower poverty levels and lower disparities (Table 4). Social and economic vulnerability is the cause and effect of the large loss of flood disasters and the economic level of the community (high percentage of poverty and high poverty severity) makes people in disaster-prone areas have lower economic vulnerability because economically high areas are considered capable of protecting their lives (Hapsoro & Buchori, 2015).

Disasters (floods) have a tendency to influence cultural factors, livelihoods, and reasoning at the local socio-economic scope. Economic losses due to flooding can be directly observed (for example damaged houses or destroyed business sectors) which have an impact on output losses (unable to produce) and will later create poverty as a result of adjusting the changing structural conditions of society (Enenkel et al., 2015); (Kousky, Michel-Kerjan, & Raschky, 2018).

**Table 4: Human Development Index dan Poverty Index in Upper Bengawan Solo Watershed, 2010-2018 (in Percent)**

	Regency	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>HDI</b>	Sragen	67.67	68.12	68.91	69.95	70.52	71.1	71.43	72.4	72.96
	Sukoharjo	71.53	72.34	72.81	73.22	73.76	74.53	75.06	75.56	76.07
	Wonogiri	63.9	64.75	65.75	66.4	66.77	67.76	68.23	68.66	69.37
	Karanganyar	70.31	71	72.26	73.33	73.89	74.26	74.9	75.22	75.54
<b>P<sub>0</sub></b>	Sragen	17.5	17.9	16.7	15.9	14.9	14.9	14.4	14	13.1
	Sukoharjo	10.9	11.1	10.2	9.9	9.2	9.3	9.1	8.8	7.4
	Wonogiri	15.6	15.7	14.6	14	13	12.9	13.2	12.9	10.8
	Karanganyar	13.9	15.2	14	13.5	12.6	12.4	12.4	12.2	10

Notes: P<sub>0</sub>= Poverty Index; HDI: Human Development Index  
Source: Central Bureau Statistic (Data Processed)

If there is a flood in the upstream area of the Bengawan Solo river, the possibility of economic loss is very high. The economic loss of floods is a trend and extreme projections related to water (floods) that cause economic and life damage, where flood events can be expensive, such as in Central and Eastern Europe in 2013 which caused losses of 15 billion Euros (Jonkman & Kelman, 2005) and (Kunreuther & Michel-kerjan, 2007).

The trend of poverty reduction and increase in HDI (2010-2018) which contradicts the SoVI measurement shows

that the index is valid (Table 4). Based on SoVI, Sragen, which has a high level of vulnerability (Table 4), is the area with the highest poverty but in a decreasing trend, as well as HDI which continues to increase from year to year. The trend of reducing poverty and increasing HDI also occurs in other upstream areas of the Bengawan Solo river, meaning that there are efforts to prevent and mitigate disasters (floods). The increase in HDI is an indicator in the economic development of the community which continues to improve which also has an impact on reducing poverty, so that people with high economies are able to protect their lives or be able to rise up in the event of a natural disaster.

## 5. CONCLUSION

The Social Vulnerability Index (SoVI) calculation revealed that the area with the highest vulnerability is Sragen Regency followed by Wonogiri and Sukoharjo Regency, and Karanganyar Regency with the lowest vulnerability. Furthermore, the result of socio-economic description based on all the 10 components, Sragen Regency is the most vulnerable area with the highest score on socio-economic status, age, gender, village/city, occupancy, and family structure. Meanwhile, the other three regencies have the relatively the same result in each component.

The result of vulnerability map analysis based on GIS showed that the area with the highest vulnerability is Sragen Regency followed by Wonogiri and Sukoharjo Regency with medium vulnerability, and Karanganyar Regency with the lowest vulnerability. The map also shows that the areas, that geographically adjacent and have a different administration, have a vulnerability level with GIS insignificant difference.

The implication of this study is that local governments can reduce the level of social vulnerability by paying attention to some SoVI indicators. Reducing the level of social vulnerability will directly reduce the risk of increasing poverty, income disparities, and increased government spending. Local governments can allocate budgets to develop strategies to reduce disaster damage by providing provision to communities in vulnerable areas to be more responsive to disasters.

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## Final Revision

# DO SOCIAL-ECONOMY VULNERABILITY INDEX AND POVERTY INDEX HAVE CORRELATION? STUDY IN BENGAWAN SOLO WATERSHED

**SURYANTO**✪

*Universitas Sebelas Maret  
FEB UNS, Jalan Ir.Sutami 36A Surakarta  
Email: suryanto\_feb@staff.uns.ac.id*

**RATIH KUMALASARI**

*Universitas Sebelas Maret*

**DANUR C. GURITNO**

*Universitas Sebelas Maret*

**NUGROHO SAPUTRO**

*Center for Fintech and Banking, Universitas Sebelas Maret*

**SABAR MARNIYATI**

*Universitas Surakarta*

## ABSTRACT

The components to measure of disaster risk (i.e flood) are level of hazard, vulnerability of individual/community, and capacity of individual/community. Research related to vulnerability is based on the level of probability of a region experiencing a disaster, while vulnerability is based on conditions where individual/community cannot cope with disasters. The aim of the study was to measure the level of vulnerability of the socio-economic and institutional society. This research tried to explain the level of social vulnerability among the communities in upper Bengawan Solo watershed. SoVI makes more appropriate parameters for measuring social vulnerability than relying only on partial socioeconomic data.

The data generated from relevant institution, such as Central Bureau of Statistic (Badan Pusat Statistik–BPS), Social Service Institution (Dinas Sosial), National Population and Family Planning Board. Data needed such as socio-economic community, demography, age, family structure, village-city, education, and unemployment rate. We find the data from the related agencies. The first step analysis is to adapt the measurement of vulnerability (SoVI) that has been developed. After the measurement of the SoVI is carried out then it is classified relatively between districts (Sragen, Sukoharjo, Wonogiri, and Karanganyar) in the upstream Bengawan Solo Watershed. The results show highest SoVI total score (the most vulnerability) is Sragen Regency, followed by Wonogiri and Sukoharjo, and the lowest is Karanganyar. Meanwhile, Sragen has the highest scores in social-economy components score such as age, gender, rural/urban, occupation, and family structure. It implies that when disasters attack to Sragen, their community will be more suffering potentially.

**Keywords:** social economy, community, vulnerability, risk

\*) The research is part of the output of the research grants of Higher Education 2017-2018

**Keywords:** leave one blank line after the abstract and write the keywords.

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## 1. INTRODUCTION

Disaster is a phenomenon that occurs as a result of the impact of hazards and vulnerabilities simultaneously that can affect environmental conditions or areas in managing threats (Oxfam, 2012 in Hapsoro & Buchori, 2015). Floods that occur every year in several districts or regencies that pass through the river cause socio-economic vulnerability in these districts or regencies

Societies that have a high dependency on natural resources are very vulnerable to changes in rainfall (Boissière et al., 2013; Lintner et al., 2012 in Auliyani & Wahyuningrum (2020)). Societies in Java island especially some parts of regencies in Bengawan Solo Watershed are often experienced by floods. According to National Board for Disaster Management (BNPB) in 2015, Java Island is the most frequently exposed by the flood. Societies in Java Island suffered physical losses of up to USD 4,502 million and drought with a loss of up to USD 3,899 million (Amri et al., 2016).

The Bengawan Solo is the largest watershed and longest river flow on the island of Java, Indonesia. This river has a length of 548.53 km with a watershed area of 16,100 km<sup>2</sup> and crosses two provinces, namely Central Java and East Java. Its area covering ± 12% of the entire island of Java. Bengawan Solo has a problem of drought and seawater intrusion during the rainy season in several areas where floods often occur and vice versa in the dry season which results in considerable loss of property and human life (Ministry of PUPR, 2010). Therefore, studies on vulnerability in the Bengawan Solo watershed are needed to prevent greater material and non-material losses related to natural disasters.

According to BPS (2018), Central Java has seven regencies/municipalities that are passed by the Bengawan Solo River. Among the seven regencies/municipalities, Surakarta is an area that does not have large agricultural land. Surakarta as a municipality has a small contribution from agricultural sector. Surakarta has farmland for rice production area only 36 hectares and produces 230 tons per year (2018). Meanwhile, other areas such as in Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency, and Sragen Regency have broader agricultural land areas. The impact of climate change, especially flooding in the agricultural sector, triggers the increased social vulnerability. In this research, the areas to be studied are Wonogiri, Sukoharjo, Karanganyar, and Sragen regencies.

Climate change has been believed as one of the factors that causing the flood in several areas. Climate change is the change in climate variables, especially air temperature and rain intensity that occur gradually around 50 to 100 years (Kifli, Mulyo, & Sugiyarto, 2015); (Hettiarachchi, Wasko, & Sharma, 2018). When the disaster struck to society, there will be many aspects that get hampered such as the socio-economic aspect. Areas that frequently faced natural disasters such as floods usually have to bear the negative impacts in socio-economic life than other areas. The disruption in the social-economy condition in an area can increase the vulnerability of the area.

One of the most affected groups is the agriculture sector. For farmers, the land is an earning asset that can generate revenue (Giyarsih et al., 2011). Therefore, when their farmland is flooded, they cannot cultivate their crops which reduces their revenue. There is a correlation between the population's vulnerability to poverty and their residence ecosystem, thus the level of poverty will differ from each agro-ecosystem (Giyarsih et al., 2011). The vulnerable society will harder to cover their basic needs compared to the less vulnerable society. However, the vulnerability can also be caused by the socioeconomic conditions of the community. One of the factors causing vulnerability is poverty. People who are in poor condition will tend to be vulnerable. This means that the factors of vulnerability and poverty are thought to have a positive relationship.

Measurement of social vulnerability has been carried out using several approaches, for example, the Social Vulnerability Index, the Livelihood Vulnerability Index, or the Climate Disaster Resilience Index. All measurement models rely on relative comparisons between regions in a single study. Meanwhile, the poverty indicators show individual conditions and do not show collective conditions. This study aims to find out whether the vulnerability has a relationship with the poverty index. If poverty has a relationship with vulnerability, then SoVI in the Bengawan Solo watershed can be predicted from the poverty level. Research areas in Bengawan Solo watershed covers for the regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen.

## 2. LITERATURE REVIEW

Disaster Risk Management (DRM) could not be success without concern to improve the capability of society. DRM will need to address not only the physical aspect, but also the economic and social factors which influence the greater society and reinforce the impact of hazardous events (White and Howe, 2002). A better preparation and precisely calculation of risk is an important and long overdue addition to the hazard mitigation planning and implementation processes (Tate, 2013) especially in the context of climate change adaptation and disaster risk reduction strategies.

Social vulnerability is measured using various method in the previous researches. SoVI has introduced by Shirley, Cutter, and Boruff., (2003), they developed SoVI to identify and mapping the level social vulnerability in Mississippi Delta Region. This model has been adapted and adjusted depend on local characteristics aspects. Research by Lawal & Arokoyu, (2015) and use the Social Vulnerability Index method in measuring the vulnerability.

Vulnerability can be defined as a weakness to anticipate the potential for something that has a risk. Lawal & Arokoyu (2015) stated that vulnerability is a loss of life or properties as the result of a natural disaster. Furthermore, according to Miyan (2015) and Lawal & Arokoyu (2015), vulnerability consists of two categories, namely biophysical and social vulnerability. Biophysical vulnerability can cause food insecurity, drought, flood, bad weather, etc, meanwhile social vulnerability leads them to suffer from disease, loss of property, etc. They conducted research to measure social vulnerability in Sub-Sahara area especially West Africa. They found that the impact of disasters tends to be more devastating in developing countries as a result of the interaction between population growth, land pressure, economic growth, technological innovation, social expectations, and growing interdependence. They also resulted the differentiation of the social vulnerability score among Local Government Areas (LGA) by Social Vulnerability Index.

Implementation of the index of social vulnerability (SoVI) has been conducted by Lawal and Arokoyu (2015) used a sample of Nigeria's Southwest Zone, which consists of six states, namely Ekiti, Lagos, Ogun, Ondo, Osun and Oyo and this region have a total of 137 local government areas (LGA), the result indicates that Ondo and Ekiti have LGAs are more vulnerable than other countries in the region. While research by Shirley et al., (2003) establish several spatial patterns in SoVI calculation, in which the most vulnerable regency located in East Metropolitan area, South Texas, and Mississippi Delta area. Another research conducted by Setyaningrum & Giyarsih, (2012) found that the vulnerability level of the community that resides around Kali Code Riverbank is low and more affected by the economic factor. They conclude that social and economic vulnerability with societies perception have negative correlation. It will impact to high loss potential toward societies.

Meanwhile, Suryanto (2017) supported the finding from Setyaningsih & Giyarsih (2012), in his research tried to valuate the negative impact of flood in Surakarta city. He stated a vulnerable area to the natural disaster is often socially vulnerable more compared to the areas that less prone to natural disasters. Research from Widiarto & Kingma, (2014) also reported that impact of vulnerability to flood can disrupt the development and economic growth in Sragen.

Another research on vulnerability is conducted by Shah, Dulal, Johnson, & Baptiste, (2013), which analyze farmers' vulnerability toward climate change. The method used is different from SoVI method, they tried to estimate with another approach. They used the Livelihood Vulnerability Index (LVI) method. Razafindrabe, et al. (2009) in contrast, examined the resilience of a region toward disasters that occur as an effect of climate change on the Asian coastal area. The method was the Climate Disaster Resilience Index (CDRI). Research conducted by Shah et al., (2013) found that Narvia is more vulnerable than Caroni, especially in socio-demographics, health condition and water availability, natural disaster, and climate variability. Razafindrabe et al., (2009) suggest that the type of vulnerability in each area varies. Thus, a policy that should be taken for the area will be different.

Almost all SoVI or LVI measurements rely on data which is then compared between regions. This measurement relies on relative sizes and contains weaknesses if several areas used have almost the same level of vulnerability.

## 3. METHODOLOGY

Bengawan Solo Watershed through 17 regencies/municipalities in two provinces, Central Java and East Java. There two steps to analysis the data, first step is calculation of social vulnerability index and second step is Geographical Information System. In SoVI method we describes the socio-economic living, the level of social

vulnerability, the comparison mapping of social vulnerability as a basis of consideration for the development policy of Bengawan Solo watershed area. The Social Vulnerability Index (SoVI) has been developing to measure the vulnerability level in each regency. After the SoVI score is obtained, a Geographical Information System conducted to describe the most vulnerable regency.

The research took place on the areas located around Bengawan Solo watershed with the developed agricultural sector. Therefore, the four regencies which located in Bengawan Solo River watershed are chosen for this study namely: Wonogiri, Sukoharjo, Karanganyar, and Sragen. Four regencies has known as main supplier for rice to Java island people, especially in Central Java Province.

SoVI approach relied on secondary data, that has been generated from other institutions or organizations related to this study. This data will be used to examine the social vulnerability level of the society in Bengawan Solo River watershed area. The secondary data are obtained from the Central Bureau of Statistic (Badan Pusat Statistik-BPS), Social Service Office (Dinas Social-DinSos), One-door Integrated Investment and Licensing Offices (Dinas Penanaman Modal dan Perijinan Terpadu Satu Pintu-DPMPTSP), Population and Family Planning Bureau (Badan Kependudukan dan Keluarga Berencana Nasional), General Election Commission (Komisi Pemilihan Umum-KPU), and Financial and Regional Assets Management Office (Dinas Pengelolaan Pendapatan Keuangan dan Aset-DPPKA), which located in the Regency of Wonogiri, Sukoharjo, Karanganyar, and Sragen.

The SoVI score for each regency calculated using Microsoft Excel and SPSS 16 based on estimating for each regency. The results discussed descriptively to get socio-economic conditions for each regency. GIS method used to figure out the level of vulnerability among four regencies. By the GIS approach, it makes easier for us to analyse data on vulnerability.

**Social Vulnerability Index (SoVI) Analysis:** a method that will generate the social vulnerability score for each area in this research. Therefore, in order to provide the score that will be used in the SoVI calculation, the z-score of each sub-component should be computed previously, Z-score is needed because the size and data units used in the analysis are different. The socioeconomic measurement differs from the measurement for age and property. The Z-score accommodates the different unit measurements into comparable unit among regions. The Z-score calculated using the following formula:

$$z = \frac{x - \mu}{\sigma}$$

Note:

z = z-score

x = base value

$\mu$  = the average value

$\sigma$  = standard deviation

After the z-score is computed, which mean the standard value for each sub-component is obtained, a varimax rotation method is used to know the correlation between a sub-components with another sub-component. The aim of varimax rotation is to test whether the factor score of each component is overlapping with other components. Based on the Rotated Component Matrix in the varimax rotation output, if there is more than one component that has a score above 0.50 then the component is overlapping with other components, thus the component should be eliminated.

After the overlapping components are eliminated, the next step is to decide whether the remaining components represent more than 50 percent of the total components before elimination. If the remaining component represents more than 50 percent than the total component, the SoVI score computation can be continued.

The remaining components that represent the total component are scored. The scoring is conducted by categorizing the z-score into the classes or groups that have had prepared. The groups is calculated based on Sturgess Formula and it is needed to determine how many groups of vulnerabilities can be created based on the data. The classification of vulnerable groups is determined in a range based on the calculation results. For example, the category is vulnerable if the SoVi score is above 70. The class determination of the Sturgess model can be determined based on a formula,

Number of Class =  $1 + 3.3 \log n$ , with n, is the number of n data

Range = highest score – the lowest score

Class length = Range/K

After the class has prepared, the z-score of each component is classified into the class. Moreover, each sub-component is analyzed whether it increases or decreases the vulnerability. The next step is by adding up all the sub-components, which represent the SoVI score. This score will be used to prepare the vulnerability map. The area with the highest SoVI score is the area with the highest level of social vulnerability, vice versa. The classification of vulnerability level is based on the class. In this research, the classification is divided into three classes, namely, low, medium, and high vulnerability. The classification of vulnerability classes use a relative scale; the same method used for the scoring (Appendix 2).



The explanation of social vulnerability indicators refers to Shirley, Cutter, and Borruf, (2003), (Kusenbach, Simms, & Tobin, 2010), Lee, (2014), and McEntire, (2012) of social-economic status are used to describe the level of a region's macroeconomy. The number of votes in the presidential election illustrates the awareness of the economic preference of candidates. The higher the regional domestic regional gross, the higher the capacity of an area to overcome the risk of flooding.

Age indicator shows the age composition of the population of an area. If more and more of the population is elderly, it shows that the population is more vulnerable. With almost the same explanation, it also occurs in the health indicator. The higher the number of doctors in an area, the lower the level of vulnerability faced.

The property indicator shows the level of dependence of the GDRP on the agricultural sector. If the contribution of the agricultural sector is high, the regency will have a high dependence on the agricultural sector. Meanwhile the agricultural sector is very dependent on the climate. Conversely, the region has a low vulnerability if the dependence on the agricultural sector is low.

The other SoVI indicators are sex, demography, and social dependence. Sex is an indicator that shows the proportion of the sex of the population. Meanwhile, demography reflects the level of population density and social dependence shows the proportion of the population who has participated in the BPJS insurance program. The proportion of the population that is dominated by women is considered to have a higher vulnerability. Meanwhile, a high level of population density is considered to have a higher level of vulnerability.

**Table 1. The Indicator and Sub-indicator of *Social Vulnerability Index (SoVI)***

<b>Indicator</b>	<b>Sub-indicator</b>	<b>Sub-indicator explanation</b>
Social-economy status	Per capita income	The income earned by a person in a specific year
	The dependency ratio of government to general allocation fund.	The Amount of General Allocation Funds in Regency/City income balance funds
	The number of votes in the presidential election	The number of voters who voted in the 2014 presidential election
	The percentage of family welfare	The number of households having more total income than regional minimum wage.
	The percentage of people live under poverty line	The number of poor people
Age	The number of households that own car	The number of households that own car
	Average age	The average age of population in a regency/city
	The number of elderly	The number of population over 65 years old
Property	The number of toddlers	The number of children under 5 years old
	The rental cost of occupied housing	Average rental cost housing paid by community
	The number of Building Permit (IMB)	The number of building permit that issued by government
	The number of companies	The number of companies in regency/city
	Company productivity	The average value of company productivity
Health	GRDP Agriculture	Agricultural sector contribution to Regency / City income
	The number of doctors	The number of doctors, nurse, and midwife.
	The number of people living in nursing homes.	The number of people living in nursing homes.
Demography	The number of health facilities.	The number of health facilities such as hospital and health center.
	The percentage of population change	The comparison of population changes from the previous year
	Birth rate	Number of births in a Regency / City

	Population density	in 1 year The average of population density in district/ city.
Education	The number of high school graduate	The number of residents who have a high school certificate
Sex	The number of female	The number of female citizenship
Unemployment	The number of unemployment	The number of unemployed workforce
Rural/urban area	Land used by farmers	The amount of land used for agriculture
	The number of farmers	The number of residents who work as farmers
	The population of urban area	The number of residents living in urban areas
Social dependence	Social dependence Number of BPJS Health users	Number of residents using BPJS Health facilities
	Number of people with special needs	The number of people who have physical, and mental limitations
Renter Job	The percentage of renter	The number of people who rent house
	Working workforce	The number of workforce employed
	The number of working female	The number of female work force employed
	The number of worker in agriculture, fishery, and forestry (primary industry)	The number of people whose livelihoods work in the agriculture, fisheries, mining and forestry sectors
	The number of residents working in the transportation, communication and other public facilities sectors	The number of residents working in the transportation, communication and other public facilities sectors
	Number of people working in the public service sector (services)	Number of residents whose livelihoods work in the public service sector (services)
	The number of Indonesian Migrant Workers (TKI)	The number of Indonesian Migrant Workers (TKI)
Family structure	The average number of family member	The average member in one family.
	Women as head of the family	Population of women who act as heads of families (do not have husbands)

Source: modified from Shirley, Cutter, and Borruf, (2003)

**Socio-Economics Description:** this analysis is conducted to describe the socio-economic condition of the communities that reside in the Bengawan Solo River watershed area. The socio-economic description is conducted using descriptive statistic method. The data used in this analysis is the result of z-score in the SoVI assessment. Each main component will be used to compare the vulnerability in each area, which will simplify the description of the socio-economic condition.

**The Analysis Using Geographical Information System (GIS):** GIS will be conducted to describe the most vulnerable regency among the four regency, based on the SoVI score.

This part explains how the research is conducted, research deGISn, data collecting techniques, instrument development, and data analysis techniques.

**Table 2. Summary of Research Method**

Research Objective	Analysis Tools	Data	Result
Social Vulnerability of the community that live at Bengawan Solo River	Social Vulnerability Index (SoVI)	Secondary Data	Social Vulnerability Index

watershed area

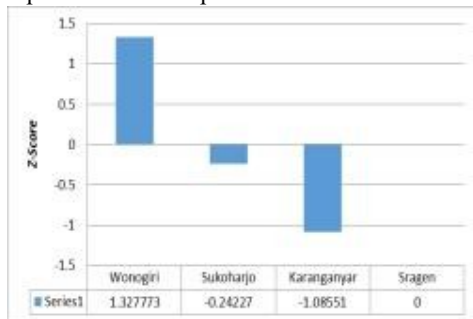
Mapping of the most vulnerable area at the Bengawan Solo River watershed areas      Geographical Information System (GIS)      Secondary Data      Social Vulnerability Map

Source: research method (2017)

#### 4. Result and Discussion

##### 4.1. Social-Economic Description

This analysis is performed to understand the social-economy life in Bengawan Solo watershed. Descriptive statistic is utilized to explain the social-economy description. The data employed are from z-score calculation in the process of SoVI scoring (see on Appendix 1). Each main component will be explained the comparison in each area. Thus, it will be able to see the description of social-economy (see on Appendix 2). Some figures below represent each component of SoVI variable.



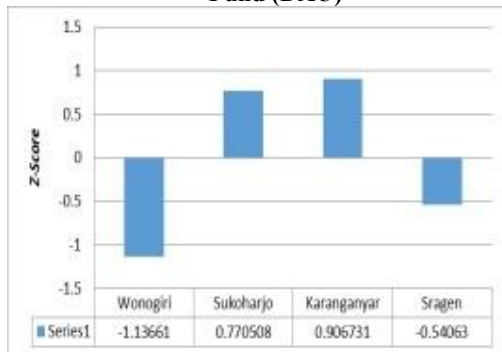
Source: Central Bureau of Statistics

**Figure 1. Dependence of Transfer Allocation Fund (DAU)**



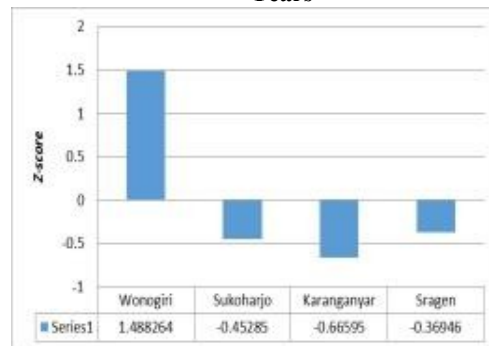
Source: Central Bureau of Statistics

**Figure 2. The Number of Citizens Older than 65 Years**



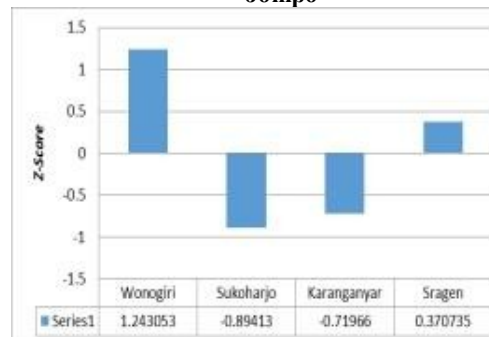
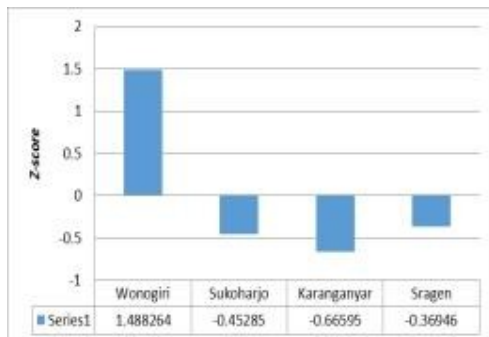
Source: Central Bureau of Statistics

**Figure 3. Jumlah Perusahaan**

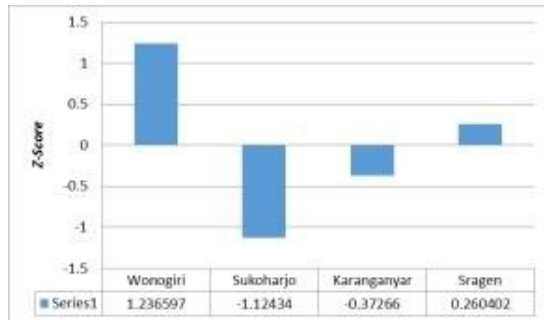


Source: Central Bureau of Statistics

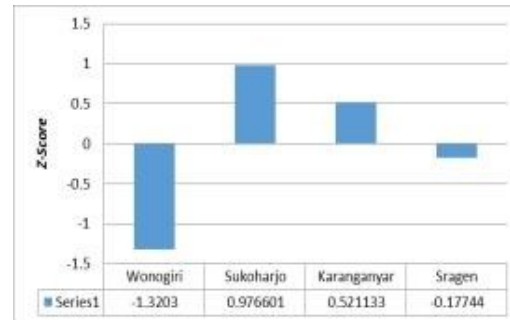
**Figure 4. Jumlah Penduduk yang Tinggal di Pantai Jompo**



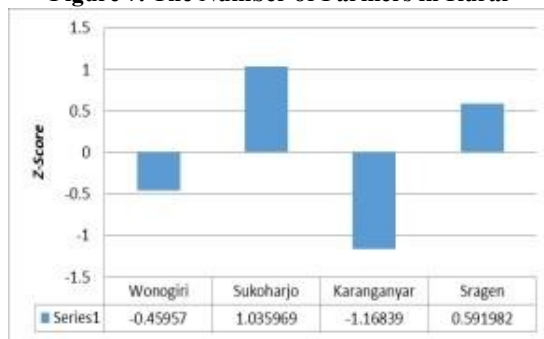
Source: Central Bureau of Statistics  
**Figure 5. Birth Rate**



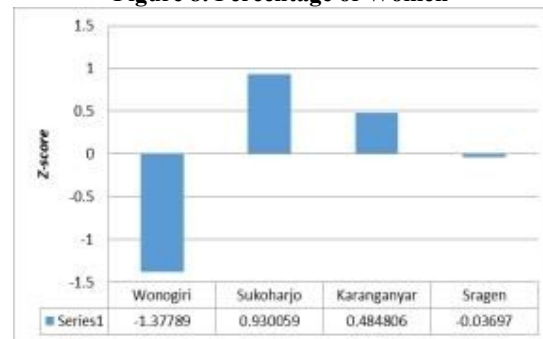
Source: Central Bureau of Statistics  
**Figure 6. Proportion of Citizens Living in Rural/Urban**



Source: Central Bureau of Statistics  
**Figure 7. The Number of Farmers in Rural**



Source: Central Bureau of Statistics  
**Figure 8. Percentage of Women**



Source: Central Bureau of Statistics  
**Figure 9. Woman as Head of Household**

Source: Central Bureau of Statistics  
**Figure 10. Health Insurance Members**

In Figure 1, the highest regional dependence on DAU is Wonogiri Regency with a z-score of 1.328, Sragen Regency with a z-score of 0, Sukoharjo Regency with a z-score of -0.242, and the lowest score is Karanganyar Regency with a z-score of -1.086. Figure 1 explains that the highest socio-economic status score is Sragen Regency with a score of 3, Wonogiri Regency and Sukoharjo Regency have the same score, namely 2, and the lowest score is Karanganyar Regency with a score of 1. The more scores of the components of socioeconomic status obtained indicate the area increasingly vulnerable. One of the sub-components of socio-economic status is dependence on DAU. The greater the General Allocation Fund (DAU) received by a region indicates that the dependence of a region in meeting its needs is still very high. The following is a graph of the dependence of Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency on the General Allocation Fund (DAU).

Figure 2 explains that the highest age component is in Wonogiri and Sragen districts with a score of 8, Sukoharjo and Karanganyar regencies also have the same score, namely 7. The more scores you get in the age component, the more SoVI scores are obtained in the area. An area with a larger number of people with an average age means that the area has a greater potential for vulnerability than an area with a small average age. The highest limit for a person's productivity is at the age of 65 years. In figure 2, the more age a person is, the less distance it will be from the age of 65, which means that someone's chance to be productive is less than the younger one. The district with the highest average age was Wonogiri Regency with a z-score of 1.338 then Sragen Regency with a z-score of 0.125, followed by Karanganyar Regency with a z-score of -0.482, and the lowest was Sukoharjo Regency with z-score of -0.981.

Figure 3 explains the property score shows that the less property score in an area indicates that the area is more vulnerable than other areas. Wonogiri Regency has the highest score among the other 4 districts, namely -6, Sragen Regency with a score of -7, Sukoharjo Regency with a score of -8 and Karanganyar Regency with the lowest score, namely -9. One of the sub-components in property is the number of companies. An area with many operating companies indicates that the area is quite advanced. Furthermore, people who work for companies have a lower vulnerability. This possibility is caused when working in a community company has a fixed salary that can be used to meet their needs. In figure 3, the district with the highest number of companies is Karanganyar Regency with a z-score of 0.907, then Sukoharjo Regency with a z-score of 0.770508, Sragen Regency with a z-

score of -0.54063, and the number of companies is the least located in Wonogiri Regency with a z-score of -1.13661. The less z-score of the number of companies in an area, the less the number of companies in the area, and can increase the social vulnerability score.

**Figure 4** explains the regional health component score which has the lowest score is Sragen Regency with a score of -1, the other three districts namely Wonogiri Regency, Sukoharjo Regency and Karanganyar Regency each have the same score, namely 0. The greater the score of an area will increase the vulnerability score. social area. One of the sub-components in the health component is the number of people living in nursing homes. The nursing home used in this study is a nursing home that is managed by the government, so that the greater the number of people in the nursing home, it means that the costs borne by the government will increase. **In figure 4**, when the z-score in an area is getting higher, it will increase the social vulnerability in that area. The highest z-score was in Wonogiri Regency with a score of 1.488, Sragen Regency with a z-score of -0.369, Sukoharjo Regency with a z-score of -0.452, and the lowest was Karanganyar Regency with a z-score of -0.666. The greater the z-score of the number of people living in nursing homes, indicating that the area is more vulnerable than other areas. The highest score for the population component was Karanganyar Regency with a score of 6, Sukoharjo Regency and Sragen Regency with the same score, namely 5, and Wonogiri Regency with the lowest score of 4. The higher the population component score will increase the SoVI score obtained by the region.

**In figure 5**, the higher the z-score, the higher the SoVI score in that area. The following is a graph of the birth rates from Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency. The picture shows that Wonogiri Regency is an area that has the highest z-score, namely 1.49, Sragen Regency has a z-score of -0.37, Sukoharjo Regency has a z-score of -0.45, and the lowest is Karanganyar Regency with z-score of -0.67. The more basic z-score value of a region's birth rate, the higher the SoVI score of that area. Wonogiri Regency and Sragen Regency have the same gender component score, namely 3, Sukoharjo Regency and Karanganyar Regency both have a score of 2. The more gender component scores that are owned by an area will increase the SoVI score of the area.

**Figure 6**, explains that Wonogiri Regency has the highest z-score with a z-score of 1.24. The regency with the second highest z-score was Sragen Regency with a z-score of 0.37, Karanganyar Regency with a z-score of -0.72, and the lowest was Sukoharjo Regency with a z-score of -0.89. The scores for the rural / urban component of the four districts have the same score, namely 5. **In figure 6**, the more scores the rural / urban component has in an area, the more it will increase the area's SoVI score. The number of people living in villages and in cities will affect the level of social vulnerability of the community. The more people who live in villages and in cities will both increase their vulnerability.

**Figure 7**, explains the sub-components that exist in the rural / urban component, one of which is the number of farmers in rural areas. The more people who work as farmers in the village will increase their vulnerability. This is because farmers are jobs that depend on resources, so that when the resources are disturbed, the farmers' lives will also be disturbed. The following is a graph of the number of rural farmers from Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency, and Sragen Regency. **In figure 7**, the z-score for the sub-component of the number of farmers in rural areas is Wonogiri Regency with a z-score of 1.24, then Sragen Regency with a z-score of 0.26, Karanganyar Regency with a z-score of -0.37, and the lowest is Sukoharjo Regency with a z-score of -1.12. The z-score value of the sub-component of the number of farmers in rural areas will increase the social vulnerability score in the area. Sragen Regency has the highest score for the work component with a score of 6, Wonogiri Regency has the second highest score with a score of 5, Sukoharjo Regency has a score of 4, and Karanganyar Regency has the lowest score, namely 3. The greater the score of the work component of an area, the higher the total SoVI score for that area.

**In Figure 8** it is known that the work sub-component measured is the percentage of people working in the service sector. The service sector is a sector of employment with a low level of vulnerability compared to other sectors. This is because the service sector is not too dependent on existing natural resources. Based on the results of the Z score analysis, it is known that Sukoharjo Regency has the highest Z-score for the proportion of people working in the service sector with a Z-score of 0.98, then Karanganyar Regency with a z-score of 0.52, Sragen Regency with a Z-score of -0, 18, and the lowest is Wonogiri Regency with a z-score of -1.32. The higher the Z-score for the percent of people working in the service sector, the lower the social vulnerability score for the area.

**Figure 9** shows that the district with the z-score of the number of women who act as head of the family (without husbands) is Sukoharjo Regency with a z-score of 1.04, Sragen Regency with a z-score of 0.59, Wonogiri Regency with a z-score of -0.46, and the lowest is Karanganyar Regency with a z-score of -1.17. The higher the z-score value for the number of women who act as family heads (without husbands), the higher the SoVI score for that area. Women who have the role of family head will be more vulnerable than families with male family heads. In earning a living, men are usually stronger, especially the head of the family is the responsibility of men, so that men will be more able to be responsible for their families than female heads of families. The following is a graph of the number of women who act as heads of families (without husbands) in Wonogiri Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency. One measure of family structure is the number of women who have the role of head of the family. Based on the results of the analysis, it is known that Sragen Regency has

a score of 6, Sukoharjo Regency with a score of 5, Wonogiri Regency and Karanganyar Regency both have a score of 4. The higher the score for the family structure owned by an area, the higher the SoVI score for that area.

**Figure 10** describes the conditions of social dependence between districts. Sukoharjo Regency and Karanganyar Regency both have the same social dependency component score, namely 3. Wonogiri Regency and Sragen Regency also have the same score, namely 2. The more scores of the social dependency components obtained, the higher the SoVI score of the area. One of the sub-components in social dependence is the number of BPJS Kesehatan users in the area. The more people who participate in health insurance will increase the dependence of the community on the government. The following is a graph of BPJS Kesehatan users in Wonogiri

Regency, Sukoharjo Regency, Karanganyar Regency and Sragen Regency: the highest z-score for BPJS Kesehatan users is Sukoharjo Regency with a z-score of 0.930059, Karanganyar Regency with a z-score of 0.484806. Sragen Regency with a z-score of -0.03697, and Wonogiri Regency with a z-score of -1.37789. The higher the z-score value of BPJS Kesehatan users in an area, the higher the SoVI score of that area.

After obtaining the SoVI score for each regency, in order to classify the regency into different level of vulnerability (low, medium, and high vulnerability), vulnerability classes are made. The calculation for classes' setup is as follow:

Data quantity: 4

$$K = 1 + 3.3 \log n$$

$$K = 1 + 3.3 (\log 4)$$

$$K = 1 + 3.3 (0.6)$$

$$K = 1 + 1.98$$

$$K = 2.98 \text{ rounded up into } 3$$

$$\text{Range} = 30-22$$

$$= 8$$

$$\text{Interval} = 8/4$$

$$= 2.6 \text{ rounded up, to } 3$$

The classes set:

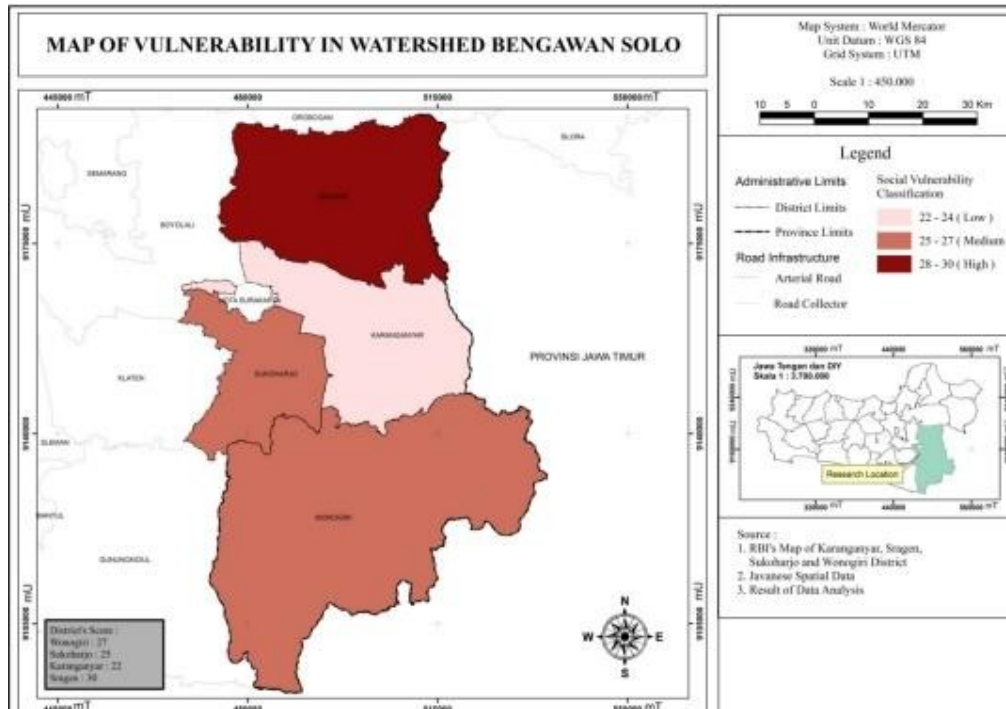
$$1 \text{ (low vulnerability)} = 22 \text{ up to } 24$$

$$2 \text{ (medium vulnerability)} = 25 \text{ up to } 27$$

#### 4.2. Map of Vulnerability using GIS

This research relied on GIS to illustrate the level of vulnerability of each area. The vulnerability map of Wonogiri, Sukoharjo, Karanganyar, and Sragen Regency is presented in Figure 11. Based on Figure 11, the area depicted with dark red color is the area with higher vulnerability, compared to the area with light color. Figure 1 illustrates that the area with the highest vulnerability level is Sragen Regency. Sukoharjo and Wonogiri Regency are the area with medium vulnerability, while Karanganyar Regency is the area with the lowest vulnerability level. The level of vulnerability is affected by the city/village and occupancy component. This result is in line with the research conducted by Widiarto & Kingma, (2014) and Setyaningrum & Giyarsih, (2012), concluded that the floods in Sragen would have been impacted to the farmer households. Further, Setyaningrum and Giyarsih (2012) the vulnerability of the community around Kali Code riverbank is affected by economic sector.

**Figure 11.** The Map of Social Vulnerability in the Bengawan Solo Watershed Area



Source: Data processing

#### 4.2.3. Socio-Economic Effect

Natural disasters will actually have an impact on the condition of areas that have high vulnerability to the occurrence of these disasters, this refers to the upstream part of the Bengawan Solo river (Sragen Regency, Sukoharjo Regency, Wonogiri Regency, Karanganyar Regency). The impact of an area's vulnerability to flooding can disrupt economic development and growth, as well as social vulnerability (Widiarto and Kingma, 2014, Rawal and Arokoyu, 2015).

**Table 3. Socioeconomic Performance Indicator Relates SoVI Score**

Regency	Socioeconomic Performance Indicator			
	SoVI	P0*	P2*	HDI*
Sragen	30	15.48	0.63	70.34
Sukoharjo	25	9.52	0.26	73.88
Wonogiri	27	13.66	0.51	66.84
Karanganyar	22	12.97	0.47	73.41

Notes: \*average index (2010-2018); P<sub>0</sub>: Poverty Index (%); P<sub>2</sub>: Poverty Severity Index  
 Source: Central Bureau Statistic, (Data Processed)

Referring to Giyarsih et al (2011), there are many aspects that are hampered when a disaster occurs, one of which is the socio-economic aspect. An area that often faces natural disasters such as floods usually has a socio-economic effect on people's lives compared to another area that is not affected. Disruption to the socio-economic conditions in an area can increase the vulnerability of the area and a high level of vulnerability will affect poverty. Vulnerability itself is a condition or a consequence of circumstances (physical, social, economic, and environmental) that affects disaster prevention and management efforts (Bakornas, 2009).

Sragen regency which has high vulnerability to disasters has a high percentage of poverty and poverty severity index or expenditure disparity among residents, on the other hand, regions with lower SoVI scores than Sragen regency have lower poverty levels and lower disparities (Table 4). Social and economic vulnerability is the cause and effect of the large loss of flood disasters and the economic level of the community (high percentage of poverty and high poverty severity) makes people in disaster-prone areas have lower economic vulnerability because economically high areas are considered capable of protecting their lives (Hapsoro and Buchori, 2015).

Disasters (floods) have a tendency to influence cultural factors, livelihoods, and reasoning at the local socio-economic scope. Economic losses due to flooding can be directly observed (for example damaged houses

or destroyed business sectors) which have an impact on output losses (unable to produce) and will later create poverty as a result of adjusting the changing structural conditions of society (Artiani, 2011; Kumulawati, 2015).

**Table 4. Human Development Index dan Poverty Index in Upper Bengawan Solo Watershed, 2010-2018 (in Percent)**

	Regency	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>HD I</b>	Sragen	67.67	68.12	68.91	69.95	70.52	71.1	71.43	72.4	72.96
	Sukoharjo	71.53	72.34	72.81	73.22	73.76	74.53	75.06	75.56	76.07
	Wonogiri	63.9	64.75	65.75	66.4	66.77	67.76	68.23	68.66	69.37
	Karanganyar	70.31	71	72.26	73.33	73.89	74.26	74.9	75.22	75.54
<b>P<sub>0</sub></b>	Sragen	17.5	17.9	16.7	15.9	14.9	14.9	14.4	14	13.1
	Sukoharjo	10.9	11.1	10.2	9.9	9.2	9.3	9.1	8.8	7.4
	Wonogiri	15.6	15.7	14.6	14	13	12.9	13.2	12.9	10.8
	Karanganyar	13.9	15.2	14	13.5	12.6	12.4	12.4	12.2	10

Notes: P<sub>0</sub>= Poverty Index; HDI: Human Development Index

Source: Central Bureau Statistic (Data Processed)

If there is a flood in the upstream area of the Bengawan Solo river, the possibility of economic loss is very high. The economic loss of floods is a trend and extreme projections related to water (floods) that cause economic and life damage, where flood events can be expensive, such as in Central and Eastern Europe in 2013 which caused losses of 15 billion Euros (Jonkman and Kelman, 2005; Kunreuther and Michel-working, 2007; United Nations International Strategy for Disaster Reduction Secretariat, 2009; Munich Re 2014 in Carrera, 2014).

The trend of poverty reduction and increase in HDI (2010-2018) which contradicts the SoVI measurement shows that the index is valid (Table 4). Based on SoVI, Sragen, which has a high level of vulnerability (Table 4), is the area with the highest poverty but in a decreasing trend, as well as HDI which continues to increase from year to year. The trend of reducing poverty and increasing HDI also occurs in other upstream areas of the Bengawan Solo river, meaning that there are efforts to prevent and mitigate disasters (floods). The increase in HDI is an indicator in the economic development of the community which continues to improve which also has an impact on reducing poverty, so that people with high economies are able to protect their lives or be able to rise up in the event of a natural disaster.

## 5. CONCLUSION

The Social Vulnerability Index (SoVI) calculation revealed that the area with the highest vulnerability is Sragen Regency followed by Wonogiri and Sukoharjo Regency, and Karanganyar Regency with the lowest vulnerability. Furthermore, the result of socio-economic description based on all the 10 components, Sragen Regency is the most vulnerable area with the highest score on socio-economic status, age, gender, village/city, occupancy, and family structure. Meanwhile, the other three regencies have the relatively the same result in each component.

The result of vulnerability map analysis based on GIS showed that the area with the highest vulnerability is Sragen Regency followed by Wonogiri and Sukoharjo Regency with medium vulnerability, and Karanganyar Regency with the lowest vulnerability. The map also shows that the areas, that geographically adjacent and have a different administration, have a vulnerability level with GIS insignificant difference.

The implication of this study is that local governments can reduce the level of social vulnerability by paying attention to some SoVI indicators. Reducing the level of social vulnerability will directly reduce the risk of increasing poverty, income disparities, and increased government spending. Local governments can allocate budgets to develop strategies to reduce disaster damage by providing provision to communities in vulnerable areas to be more responsive to disasters.

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