Physical and social infrastructures: understanding holistic water poverty eradication in Indonesia

I R D Ari1,2, S Hariyani1 and B S Walojo1

1Department of Regional and Urban Planning, Faculty of Engineering, Brawijaya University, Indonesia
2E-mail: dwiari@ub.ac.id

Abstract. Poverty issues becomes more complex from time to time, as it comes to the whole world’s attention as it is stated in the first pillar of the SDGs. This research is trying to search an appropriate tool on how to be able to propose a more precise strategy on dealing with poverty with basis assumption that it must put it together for both physical and social developments. Applying case study of Tumpang District in Malang Regency, Indonesia as one of the poor districts, the result is conducted. The first research aim is to measure poverty level through the five components of the Water Poverty Index (WPI). General result indicates that the study area in the unit of analysis of village, there is no significant poverty level, though the district is categorized as the poverty. The second measurement is in order to build a better understanding of social capital in the community level through measurement of the indexes – rate of participation and density using Social Network Analysis (SNA). General result indicates that residents tend to involve into informal institution than the formal one. However, at the final stage of Spatial Regression Analysis that put it the WPI value as the dependent variable, and the two value of indexes of the SNA as the independent variables along with physical distance to the public facility, the result indicates that participation in the formal institution might give a significant influence to the success of lessening poverty level. Hence, this research proposes two main strategy in order to eradicate poverty though the development of both physical and social infrastructures, and to bring people closer distance to the formal institutions.

1. Introduction
Water is important for social life and adequate water supply is a prerequisite for good human and economic development [1]. SDGS (Sustainable Development Goals) also have a goal to create safe and affordable drinking water for all by 2030. It requires we invest in adequate infrastructure, provide sanitation facilities, and encourage hygiene. Protecting and restoring water-related ecosystems is essential [2]. Poverty in this study uses the WPI approach to measure water poverty that occurs in Tumpang District. Water Poverty Index is a method used to identify community poverty using five variables including resources, access, capacity, use and environment which will be calculated by multiplying the weights in each of its components [1,3].

Poverty can be caused by limited infrastructure including access to health, education, housing and sanitation services, and clean water [4]. Infrastructure has an influence on improving regional economic aspects. Infrastructure can encourage economic growth or increase people's income [5]. In addition, social conditions also affect poverty levels. Social condition is important to increase their knowledge, skill, and information. So, good condition in social dimensions is important to reduce poverty. Households with better community links have the ability to manage their problems by community-based management systems [6,7]. The household who have more frequent social interaction can assume that they influence each other and can adapt the preference of others [6]. Social Network Analysis (SNA) is
a way to analyze the link between people and people, people and organizations [8]. The SNA views social relationships not only about the individual but also linkages among people [9]. So that, this research assumes that in order to reach the target of poverty eradication movement, it is important to develop both physical and social infrastructures as two indispensable aspects.

Malang Regency has the highest number of poor people in East Java Province at about 293,740 people (11.49%). Then, Tumpang District with total area at around 72.09 Km2 and occupied by 75,440 inhabitants or 20,544 households is the third-highest ranking of Raskin (Poor Rice Program) recipients (7,522 households or 19.08%) among the whole 32 districts in Malang Regency [10]. Using the district as a case study, there are three main research questions that will be used to propose a poverty eradication recommendation: i) what is the poverty level in the district, ii) how is the social structure in the community level, and iii) how is the model of spatial poverty alleviation in the research area.

2. Methods

2.1. Data collection and sampling
Primary data are collected through face-to-face questionnaire survey to 608 selected head of households at 15 villages in the district. Since main aim of the research is for having proper understanding the whole situation of the community at the district in the level of village, the selected respondents are distributed through stratified proportional sampling consist of poor and non-poor households, as well as their representativeness in both formal and informal community groups. Secondary data are compiled from each village at the government offices in the district, and Local Drinking Water Company (PDAM) Malang Regency.

2.2. Water Poverty Index (WPI)
The WPI is an effective tool to measure poverty level in the community holistically, through its five components namely Resources (R), Access (A), Capacity (C), Use (U) and Environment (E) [1]. The WPI benchmark scale is divided into 5 classes [11]: 0 – 47.9 are classified as severe; 48.0 – 55.9 are classified as high; 56.0 – 61.9 are classified as medium; 62.0 – 67.9 are classified as medium low; and 68 – 100 are classified as low poverty index. Formula of the WPI is labelled as follows in Eq. 1:

$$WPI = \frac{wr \cdot R + wa \cdot A + wc \cdot C + wu \cdot U + we \cdot E}{wr + wa + wc + wu + we}$$  

Where:
- \(wr\): weight value of water resources
- \(wa\): the weight of the accessibility value
- \(wc\): weight value of capacity
- \(wu\): the weight of the usage value
- \(we\): weighting of environmental values
- \(R\): resources
- \(A\): access
- \(C\): capacity
- \(U\): utilization
- \(E\): environment

Weight factor for each component is equal to 1, then final value of the WPI is in the range of 0 - 100, wherein the higher value indicates the lower condition of poverty [12]. The weight factor for the calculation uses a balance methodology.

The following Table 1 describes detail component and sub-component of the WPI in Indonesia that is applied for the research.

2.3. Social Network Analysis (SNA)
The UCINET 6.683 is applied for measuring social capital at the community level through two indexes of the SNA namely rate of participation (RoP) and density [13]. The RoP and density will be placed as independent variables of social network of each village at the spatial regression analysis. Basically, the
RoP and the density are classified into three levels: Low, Medium, and High, so that we might be able to compare the RoP and the density among villages in the district [6]. The higher level of the RoP might represent the more active participation of the respondents within a village that might see it as a network. The closer the value of the density to 1 describes a higher close relationship that exists in a network [9].

Affiliation data for the SNA [9, 14] is compiled from respondent’s memberships into existing community groups in their living neighborhood, that is differentiated as type of formal and informal networks [14]. The formal networks are assumed to be built from affiliation of the respondents towards their memberships into legal institutions recognized by the government consist of i) Village Legislative Agent (BPD), ii) Village Coop Agent (KUD), iii) Farmer Association (GAPOKTAN), iv) Integrated Health Services (POSYANDU), v) Empowerment of Family Welfare (PKK), and vi) villages government. Meanwhile, the informal networks are assumed as a network that is formed by the residents that is voluntarily designed by the residents themselves consist of i) male and ii) female Quran Recitation, iii) communal work, and iv) social gathering.

Table 1. Variables of WPI in Indonesia.

| No | Component | Sub-component | Data |
|----|-----------|---------------|------|
| 1  | Resource (R) | Volume surface water | Primary data |
| 2  | Access (A) | Number of households with access to clean water | Primary data |
| 3  | Capacity (C) | Public welfare | Secondary data |
| 4  | Use (U) | Standard basic water needs (liter/ per capita/day) | Secondary data |
| 5  | Environment (E) | Quality of surface water and ground water | Secondary data |

Source: Sullivan (2002) and field estimation

2.4. Spatial Autoregressive (SAR) model
In the research, GeoDa opensource developed by Dr. Luc Anselin and his team [15] by Queen Weight Matrix that defines a village's neighbors as those with either a shared border or vertex is applied in the spatial model. The measurement of spatial autocorrelation (SA) through Moran’s I or Local Indicator of Spatial Autocorrelation (LISA) will be mapped in the LISA cluster map [16] into four categories (high-high, low-low, high-low, or low-high). Thus, the WPI result might have a positive value (it could make a group of high-high or low-low) or negative value (it could make a group of high-low or low-low).

Finally, the research uses spatial regression to identify what variable that have influence for the WPI in the district, whereby the independence variable contains informal and formal RoP, informal and formal density, and travel time to Senior High School.

3. Result and discussion

3.1. Characteristic of Tumpang District
The government assistance program for poor families in the district are Raskin (Poor Rice Program) and PKH (Program of Social Support for Poor Family). The percentages of the Raskin and the PKH recipients are 36% and 15% of the total households in the district, respectively [10]. The highest number of the Raskin recipients are in Pulungdowo Village (851 households), and the lowest number is in
Malangsuko Village (178 households). The highest PKH recipients are in Tulusbesar Village (363 households), and the lowest number is in Malangsuko Village (63 households).

| Village         | Ngingit | Kidal | Kambbingan | Pandanajeng | Pulungdowo | Bokor | Slamet | Wringinsongo | Jeru | Malangsuko | Tumpang | Tulusbesar | Benjor | Duwet | Duwet Kragen |
|-----------------|---------|-------|------------|-------------|------------|-------|--------|--------------|------|-------------|---------|-----------|--------|-------|------------|
| Education Level (%) | 50      | 67    | 38         | 63          | 75         | 86    | 46     | 59           | 60   | 72          | 58     | 89        | 62     | 59     | 62         |
| Gini Index      | 0.52    | 0.65  | 0.27       | 0.33        | 0.40       | 0.42  | 0.57   | 0.77         | 0.60 | 0.49       | 0.52   | 0.80      | 0.33   | 0.78   | 0.35        |

Table 2 displays that the lowest number of residents who graduated from Senior High school lives in Kambbingan Village (38%), meanwhile the highest one lives in Tulusbesar Village (89%). Results of the Gini index indicates that 8 of 15 villages have the value above 0.5, meaning that there is high income inequality occurred in the district since the value of the Gini Index tends to be close to 1.

3.2. **Water Poverty Index (WPI)**

3.2.1. **Resource (R) and Access (A) components.** Based on the primer survey, type of water resources used by the community are groundwater (individual well) and household connection though piped water distributed by local community water association namely HIPPAM. The following Table 3 illustrates the WPI measurement of the first and second components.

| Villages       | AWS | AG (m) | WPI value | APW (m³/capita/year) | WPI (R) | CWA | SA | STA | WPI (A) |
|----------------|-----|--------|-----------|----------------------|---------|-----|----|-----|---------|
| Ngingit        | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Kidal          | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Kambbingan     | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Pandanajeng    | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Pulungdowo     | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Bokor          | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Slamet         | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Wringinsongo   | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Jeru           | 0   | 0      | 100       | 10530                | 100     | 100 | 100| 100 | 100     |
| Malangsuko     | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Tumpang        | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Tulusbesar     | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Benjor         | 0   | 0      | 100       | 8575                 | 100     | 100 | 100| 100 | 100     |
| Duwet          | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |
| Duwet Kragen   | 0   | 10     | 100       | 100                  | 100     | 100 | 100| 100 | 100     |

AWS = Availability of Water Surface; AG = Availability of Groundwater; APW = Availability of Piped Water
CWA = Clean Water Access; SA = Sanitation Access; STA = Septic Tank Access

Except residents who live in Jeru and Benjor villages, majority residents have access to water resources from shallow groundwater in depth of 10 meters, whereby they build their individual well. In other words, none of the villagers use resources from the surface water that cause them a certain distance to acquire it to their homes (data result of AWG for all are zero), though we might only able to define...
that water pipeline network is only available within the two villages though the HIPPAM. Hence, in general in the point of view of the first component, the value of WPI for the whole villages is 100. Meaning that there is no poverty of the community in the district from the resource’s component since the whole households have both piped and non-piped water connection.

For the second and third subcomponents, access to sanitation and septic tank for each house, it found that each house has their own latrine, as well as septic tank within their parcel of land. Then, the value of sanitation access and septic tank access is also calculated as 100%, representing that all respondents are served by sanitation and septic tank access.

3.2.2. Capacity (C) and Use (U) components. Component of the Capacity (C) consists of three subcomponents. The first subcomponent is health level that is measured from the historical fact whether within their family they have a family member that died before 5 years or whether they have a very severe disease. For the second subcomponent, regarding the regulation of the Indonesian Ministry of Education and Culture (2015), level of education for Indonesian citizen is that they have to complete 12 years schooling or similar to minimum level of Senior High School. Then, for the third subcomponent, the Gini Index is necessary to be calculated from the secondary data for regional income of Malang Regency and from the primary data for household income. A comparison between the standard water supply requirements with domestic water needs shows that the water source is able to serve the water needs of the respondents. There are three villages that do not have paddy fields and irrigation channels, namely Benjor Village, Duwet Village, and Duwet Krajan villages.

Table 4. Water Availability Index (WAI) for Capacity (C) and Use (U) Components.

| Villages   | HL  | EL  | GI  | WPI (C) | DN  | EDWU | E/S | IR  | RR  | UAL | WPI (U) |
|------------|-----|-----|-----|---------|-----|------|-----|-----|-----|-----|---------|
| Ngingit    | 100 | 50  | 0.52| 51      | 20800| 13000| 1.60| 90.54| 593.99| 0.15| 57.50   |
| Kidal      | 100 | 67  | 0.65| 66      | 36000| 21400| 1.68| 62   | 554  | 0.11| 55.50   |
| Kambingan  | 100 | 38  | 0.27| 33      | 29700| 16400| 1.81| 57   | 315.93| 0.18| 59.00   |
| Pandanajeng| 100 | 63  | 0.33| 48      | 20310| 12700| 1.60| 186  | 80.5  | 2.31| 100.00  |
| Pulungdowo | 100 | 75  | 0.4 | 58      | 41625| 23400| 1.78| 328.15| 358.36| 0.92| 96.00   |
| Bokor      | 100 | 86  | 0.42| 64      | 17160| 11900| 1.44| 80   | 48.9  | 1.64| 100.00  |
| Slamat     | 100 | 46  | 0.57| 52      | 19240| 11900| 1.62| 161.18| 35.77 | 4.51| 100.00  |
| Wringinsongo| 100 | 59  | 0.77| 68      | 15525| 8100 | 1.92| 101.13| 37.37 | 2.71| 100.00  |
| Jeru       | 100 | 60  | 0.6 | 60      | 105300| 17900| 5.88| 127  | 249.4 | 0.51| 75.50   |
| Malangsoko | 100 | 72  | 0.49| 61      | 18000| 9100 | 1.98| 62.94| 260.42| 0.24| 62.00   |
| Tumpang    | 100 | 58  | 0.52| 55      | 43680| 29400| 1.49| 137.73| 438.14| 0.31| 65.50   |
| Tulubesar  | 100 | 89  | 0.8 | 85      | 24440| 16800| 1.45| 101  | 329.5 | 0.31| 65.50   |
| Benjor     | 100 | 62  | 0.33| 48      | 85750| 8700 | 9.86| 0    | 1018.08| 0.00| 50.00   |
| Duwet      | 100 | 59  | 0.78| 69      | 17510| 10300| 1.70| 0    | 1213.12| 0.00| 50.00   |
| Duwet Krajan| 100 | 62  | 0.35| 49      | 20115| 12000| 1.68| 670.7| 0.00  | 50.00|        |

1 HL = Health Level; 2 EL = Education Level; 3 GI = Gini Index
4 DN = Domestic Needed, 100xtotal residents (L/village/day); 5 EDWU = Existing Domestic Water Use (L/village/day); 6 E/S = Existing/Standard; 7 IR = Irrigation Rice fields (Ha); 8 RR = Rainwater Rice fields (Ha); 9 UAL = Utilization of Agriculture Land

Table 4 indicates result of the third component of WPI, wherein for the first subcomponent, it seems that they have good health level in general. For the second subcomponent, the lowest level of education is in Kambingan Village, wherein only 38% of the households have completed their Senior High School. Then, for the third subcomponent, it is also found that the lowest Gini index is also found in Kambingan Village. Meaning that there is the worst income inequality in Kambingan Village than to other villages. As a result, for the third component, the lowest WPI is also found in Kambingan Village.

Table 4 also displays that the average water domestic demand is lower than the standard of water needs, it means that people use water in an excessive manner and are still limited to standard water needs. The fourth component of WPI indicates that there is no severe poverty at any village, however, there are only 6 villages which have good value of it.
3.2.3. Environment (E) indicators. The approach to determine the percentage of vegetation cover is calculating the area of green space and compare it to the total area. The vegetation cover uses secondary data, and water quality is calculated using STORET method, based on the total combination of the five components, especially for the fifth component of WPI the whole villages indicate severe poverty level.

Table 5. Water Availability Index (WAI) for Environment (E) Component.

| Villages      | WQ    | GOS    | Area   | WPI (E) |
|---------------|-------|--------|--------|---------|
| Ngingit       | 50    | 593.99 | 684.53 | 25.43   |
| Kidal         | 50    | 554.00 | 616.00 | 25.45   |
| Kambingan     | 50    | 315.93 | 372.93 | 25.42   |
| Pandanajeng   | 50    | 80.50  | 266.50 | 25.15   |
| Pulungdowo    | 50    | 358.36 | 686.52 | 25.26   |
| Bokor         | 50    | 48.90  | 128.90 | 37.69   |
| Slamet        | 75    | 35.77  | 196.95 | 37.59   |
| Wringinsongo  | 50    | 37.37  | 138.50 | 25.13   |
| Jeru          | 75    | 249.40 | 376.40 | 37.83   |
| Malangsuko    | 50    | 260.42 | 323.36 | 25.40   |
| Tumpang       | 75    | 438.14 | 575.87 | 37.88   |
| Tulusbesar    | 50    | 329.50 | 430.50 | 25.38   |
| Benjor        | 75    | 1018.08| 1018.08| 38.00   |
| Duwet         | 50    | 1213.12| 1213.12| 25.50   |
| Duwet Krajan  | 50    | 670.70 | 670.70 | 25.50   |

*WQ = Water Quality; GOS = Green Open Space

Table 5 depicts the highest value of the fifth component of WPI occurs in Benjor Village (38.00) and the lowest value occurs in Wringinsongo Village (25.13). However, in general, we may conclude that especially for the fifth component of WPI the whole villages indicate severe poverty level.

3.2.4. Result of the WPI in Tumpang District. The following Table 6 displays the compilation result of the five components of the WPI. There are two components which have a very good value consist of Resources and Access. The whole combination of the five components, in general it gives a satisfactory result that the whole villages in the district are in the safe level of WPI.

Table 6. Water Poverty Index in Tumpang District.

| Villages      | R   | A   | C   | U   | E   | WPI | Classification    |
|---------------|-----|-----|-----|-----|-----|-----|-------------------|
| Ngingit       | 100 | 100 | 51  | 57.5| 25.4| 66.6| Medium Low        |
| Kidal         | 100 | 100 | 66  | 55.5| 25.4| 69.3| Low               |
| Kambingan     | 100 | 100 | 33  | 59.0| 25.4| 63.1| Medium Low        |
| Pandanajeng   | 100 | 100 | 48  | 100.0| 25.15| 80.13| Low              |
| Pulungdowo    | 100 | 100 | 58  | 96.0| 25.26| 81.03| Low              |
| Bokor         | 100 | 100 | 64  | 100.0| 37.69| 85.08| Low              |
| Slamet        | 100 | 100 | 52  | 100.0| 37.59| 82.40| Low              |
| Wringinsongo  | 100 | 100 | 68  | 100.0| 25.13| 84.57| Low              |
| Jeru          | 100 | 100 | 60  | 75.5| 37.83| 76.04| Low              |
| Malangsuko    | 100 | 100 | 61  | 62.00| 25.40| 70.38| Low              |
| Tumpang       | 100 | 100 | 55  | 65.50| 37.88| 71.60| Low              |
| Tulusbesar    | 100 | 100 | 81  | 65.50| 25.38| 75.99| Low              |
| Benjor        | 100 | 100 | 48  | 50.00| 38.00| 64.89| Medium Low       |
| Duwet         | 100 | 100 | 69  | 25.00| 25.50| 68.17| Low              |
| Duwet Krajan  | 100 | 100 | 49  | 25.00| 25.50| 63.72| Medium Low       |
Based on the results of the WPI analysis as depicted in Table 6, there are four villages which have Medium Low result, meanwhile the rest of 11 villages have a better condition, though there are only 5 of 11 that might categorize as they have no poverty regarding water issues. Into more detail, general value of WPI from the Environment’s component shows a very serious problem that needs to put attention on how to improve it. The next component that is need to pay attention on it is about the fourth component – Use, wherein three villages have a severe condition. Therefore, the lesson learned from the WPI result shows that is important to tackle the poverty issue that is caused by Environment component, especially related to water and that improvement actions are necessary. Regarding the components of Capacity and Use, it is also important to notice in the priority on how to improve it in order to increase the value. Lastly, for the two-perfect value of components Resources and Access, it does not mean that nothing needs to be done. It is very important to keep it good for the two components, particularly for the Access component that is still very important to improve the access for each household for having direct piped-water connection in order to secure their both quantity and quality access to safe water.

Figure 1 shows the WPI classification regarding their location consist of two classification. The lowest WPI value (63.16) in Kambingan Village, with the value of the variable not too high being the accessibility, water use, and environment components. Meanwhile, the highest WPI value is in Slamet Village (85.08).

![Figure 1. Map of The WPI in Tumpang District.](image)

3.3. Social Network Analysis (SNA)

3.3.1. Rate of Participation (RoP). The RoP is a measurement carried out to measure the level of community participation in institutions at every village in the district. Based on the results Table 7, the highest formal RoP value is in the Duwet Village (0.59). The lowest is in Wringinsongo Village which is 0.21. Meanwhile, in general, the level of participation of the informal community on majority villages are in the high classification, with only 2 villages that have a moderate classification. Informal RoP with High classification are found in 13 villages, meanwhile those with Medium classification are in Malangsuko and Ngingit villages.

3.3.2. Density. The following Table 7 indicates result of density between formal and informal networks for each village. In general, it can be seen that the density value that is formed from the informal network
gives higher value than the formal one. This result indicates that the residents tend to join in the informal community groups rather than to the formal groups.

Table 7. RoP and Density in Tumpang District.

| Villages     | F-RoP | C        | I-RoP | C        | FD | C    | ID | C    |
|--------------|-------|----------|-------|----------|----|------|----|------|
| Ngingit      | 0.56  | L        | 3.48  | H        | 0.48 | M    | 0.989 | H    |
| Kidal        | 0.54  | L        | 3.73  | H        | 0.23 | L    | 0.798 | H    |
| Kambingan    | 0.59  | L        | 3.41  | H        | 0.54 | M    | 0.850 | H    |
| Pandananjeng  | 0.56  | L        | 1.37  | H        | 0.50 | M    | 0.720 | H    |
| Pulungdowo   | 0.56  | L        | 2.81  | H        | 0.29 | L    | 0.835 | H    |
| Bokor        | 0.58  | L        | 3.24  | H        | 0.44 | M    | 0.799 | H    |
| Slamet       | 0.48  | L        | 6.55  | H        | 0.34 | M    | 0.873 | H    |
| Wringinsongo | 0.41  | L        | 2.67  | M        | 0.54 | M    | 0.991 | H    |
| Jeru         | 0.37  | L        | 1.19  | M        | 0.46 | M    | 0.933 | H    |
| Malangsuko   | 0.33  | L        | 3.27  | H        | 0.33 | L    | 0.786 | H    |
| Tumpang      | 0.32  | L        | 3.44  | H        | 0.24 | L    | 0.924 | H    |
| Tulusbesar   | 0.35  | L        | 3.26  | H        | 0.28 | L    | 0.753 | H    |
| Benjor       | 0.35  | L        | 1.73  | H        | 0.34 | M    | 0.931 | H    |
| Duwet        | 0.32  | L        | 3.05  | H        | 0.27 | L    | 0.970 | H    |
| Duwet Krajan | 0.21  | L        | 3.14  | H        | 0.25 | L    | 0.989 | H    |

*F-RoP = Formal RoP, I-RoP = Informal RoP, FD = Formal Density, ID = Informal Density; C = Classification, L = Low, M=Medium, H = High

In to more detail, it can be seen that formal density values are divided into 2 classifications – Low and Medium. The lowest value is in Bokor Village (0.23), meanwhile the highest value is in Duwet Village (0.54). The highest value of informal density occurs in three villages Tulusbesar, Tumpang, and Wringinsongo (0.99) – really close to 1 or a closed network. Meanwhile the lowest value is in Benjor Village with a value of 0.72.

Density describes how dense relationships among community members through their knot into a certain community groups with all their purposes and activities. Since the formal density has lower value than the informal one, it might assume that in case there is a very important information comes from the government the flow of information will be very slow if the information goes to the citizens through a kind of formal institution. In other words, in case for Tumpang District it seems that the more effective flow of information as well as resources if it is through a kind of informal institution, such as the existing local community group.

3.4. Spatial Autoregressive (SAR) model

3.4.1. Spatial weight. Spatial weight is a picture of the relationship between locations that give effect to each of the surrounding locations. Spatial weights are visualized with the histogram generated by GEODA software.
In Figure 2, the neighborhood formed from spatial weights uses queen contiguity. The light blue color in the bar chart shows the lowest number of neighbors which has 1 neighbor namely Duwet Krajan Village and the pink color in the bar diagram shows the highest number of neighbors which has 5 neighbors namely Bokor, Malangsuko, Tumpang, Benjor, and Pandanajeng villages.

3.4.2. **LISA Map.** Lisa Map’s function is to determine the neighborhood based on the proximity of the measured variable.
Figure 3 shows a cluster of the WPI data which is depicted based on differences in color. The red color means High-High or the region has a High WPI value and is surrounded by areas that have high WPI too. The areas identified as High-High are Slamet, Wringinsongo, Bokor, and Pulungdowo villages.

3.4.3. Spatial regression. In the first classic test, the variables that must be reduced are informal RoP, informal density, formal density and SMA travel time. The remaining variable is the formal RoP which will be continued in the classical test 2. In classical test 2, the probability generated by the formal RoP variable is 0.00 (significant). Thus, the formal RoP will be continued in the spatial lag test because it has an LM-Lag value of 0.03 (significant). Based on the significant value on the Breusch-Pagan test that is 0.98 or greater than 0.05 so it shows the absence of heteroskedasticity. The test results can prove that spatial lag model can be used in this research.

\[
\hat{y} = 40.0628 + 0.1780605 \sum_{i=1}^{n} W_{ij} + 36.7303 X_1 
\]

\[
y = \text{Water Poverty Index} \\
W_j = \text{spatial weight} \\
X_1 = \text{RoP formal}
\]

Result of the spatial regression model, the formal rate of participation variable has the influence to increase the WPI value with a positive influence of the formal RoP. Meaning that in order to deal with poverty issue it is important to strengthen resident’s participation or involvement through their formal institutions. Then, regarding the spatial weight, it is necessary to put into consideration about the geographic distance between villages that in case there are a cluster poor village might result with a more difficult effort for the villages to escape from their poor situation.

4. Conclusion
That is true that the research result indicates that in order to deal with poverty particularly referring to water poverty (SDGs pillar 1 and 6), it is not enough if we only focus upon physical infrastructure development. Up most of it, the development of social infrastructure in the community level through strengthen social capital among community members and its affiliation to formal – informal community groups/institutions within a network is an indispensable effort, along with the physical infrastructure development.

The low value of the WPI’s result indicates that in order to eradicate poverty level, it is necessary to put together the development of both physical and social infrastructures. That is true that component of resources and access have already been good, however, the number of households who utilize resources from shallow ground water, as well as acquiring access to clean water directly from the well are significant. There is no guarantee whether the quality of water from the ground water will always be in the safe water category since there are no regular water quality checking. Next, regarding result of the component of capacity, even if the result is in the medium level, but one thing important to be noticed is that value of education level and inequality of income is quite significant too. The fourth component indicates moderate level result too, however, when we look into more detail, there is a tendency on growing tension to the agriculture land and its activity, whereby water use seems to have more and more conflict in the future between different land uses. The low level of the WPI value, the fifth subcomponent, illustrates the worst result from the villages. The WPI is a holistic approach to deal with poverty in the community level, the overall result concludes that in order to eradicate poverty level is once again it is indispensable between development of physical and social infrastructures.

The measurement of social capital in order to have a better understanding of the community social structure through the two indexes of rate of participation and density, precisely illustrates on how high residents’ involvement into an informal institution that exist in their living neighborhood. It implies that flow of information, as well as resources in any kind of forms might give more effective result through its informal networks. However, the further analysis through spatial regression model indicates that formal institution might give a significant influence on the development of water poverty eradication effort, along with the geographical distance where the village lies between their neighborhoods. The result implies that the poverty alleviation movement would not give a satisfactory result since the
programs might reach the community through its formal institution that is not popular or only a few residents who involve in it.

Thus the propose strategy in order to reach poverty eradication targets are i) it is necessary to put together the development of both physical and social infrastructures; ii) it is indispensible to develop people’s awareness through the higher involvement in to formal institutions’ movement – or in other words it is no longer unavoidable that residents should be part of both formal and informal institutions for gaining more positive and constructive results.

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