Measurement of water availability: understanding the relationship between the physics of water and the level of community welfare at Bumiaji District, Batu City, Indonesia

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Abstract. This research attempts to be part of the Sustainable Development Goals movement goal, especially pillar number six. Bumiaji District Batu City, Indonesia is chosen as an empirical case, with the basic assumption that putting together physical and social infrastructures is a crucial success for poverty alleviation. Total respondents are 552 households proportionally distributed at nine villages classified into poor and non-poor families. Primary data was conducted through a face-to-face interview questionnaire. The first aim found that the non-poor households have better access to safe water than the poor by measuring the five components of Water Poverty Index (WPI), in range the WPI value of 55.26 – 80.12 44.98 – 64.91, respectively. However, the two have one similarity wherein the environment indicates the worst component (25.04 – 37.78). For the second question, applying Social Network Analysis with two indexes of participation and density index also depicts a similar result that the non-poor households have higher social ties than the poor. In conclusion, putting together the balanced development between physical infrastructure and human resources is indispensable, particularly on how important environmental education to prevent land-use conversion from green areas to the built-up area.

1. Introduction

Poverty is viewed as an economic aspect and can be seen from other dimensions caused by the difficulty of access to education, limited facilities and infrastructure, and decent jobs [1]. Badan Pusat Statistik (BPS – Statistic Central Board) (2019) stated that the poverty rate in Indonesia in 2020 amounted to IDR 26.42 million, an increase compared to the previous year, which reached IDR 24.79 million [2]. However, Batu City is famous as one of Indonesia's tourism cities Indonesia, the percentage of poor people in urban areas tends to increase from 6.56% to 7.38% from September 2019 to March 2020. Besides, the rate of poor people in rural areas within the same period increased from 12.60 % to 12.82 % [2].

Access to safe water as a necessary infrastructure is still a significant problem throughout the world, and it is the main concentration to be solved, as stated in SDGs pillars 6. This research attempts to be part of the world movement on dealing with poverty, particularly from access to safe water for all, whereby Bumiaji District of Batu City is chosen as an empirical study. The basic idea of the research is to level up community wellbeing. The development of physical and social infrastructure is indispensable; therefore, the research is designed to answer two main aims. Firstly, holistically
understanding the relationship between water complexity components with poverty in the local spatial area through measurement of Water Poverty Index (WPI) developed by [3]. Secondly, understanding social ties between community members with poverty through Social Network Analysis (SNA) [4,5]. Hence, a proper recommendation based on measurement of the WPI and the SNA might propose to raise the level of community welfare.

2. Methodology

2.1 Data collection and sampling
Primary data collection was carried out by observation and depth interviews towards 552 households at nine villages in Bumiaji District within two weeks with ten surveyors. Based on Bumiaji District in Figures 2018 [2], the representative head of families was chosen in proportionally distribution between low and non-poor households covering 60 and 492 homes, respectively. Then, secondary data were collected from several related government agencies.

2.2 Water Poverty Index (WPI)
The WPI is a useful tool to measure poverty level in the community holistically – to provide an understanding of the relationship between the physical status of water availability, convenience, and the level of community welfare (Sullivan, 2003), covering five components – Resources (R), Access (A), Capacity (C), Use (U) and Environment (E), and the value of WPI is in the range between 0 – 100 [6] and follow the formula that is developed by [3]. Then, the level of WPI is divided into five whereby the higher the value means the lower poverty at a specific area covering severe, high, medium, medium-low and low with the scale of 0 – 47.9, 48.0 – 55.9, 56.0 – 61.9, 62.0 – 67.9, 68.0 – 100, respectively [7]. Besides, referring to [8], the fifth component data were obtained from several sources with primary and secondary data, whereby the data assumption is being adjusted [9].

2.3 Social Network Analysis (SNA)
Social ties formed between people through their affiliation into specific community associations will make the flow of information and resources between community members even smoother to open higher opportunities for them to become more prosperous due to their internal and external information and resources exchange [10]. Along with Tantoro (2014) [11], poverty conditions can be caused by limited relations between communities. One approach that can be taken to determine the social condition of the community is the SNA. According to Ari I R, et al. (2017), the SNA approach through two indices – the rate of participation (RoP) and density is used to determine social ties in the community level whereby the calculation formula is referred to Wasserman and Faust (1994) and utilized analytical software namely UCINET 6.3 with three classifications–high, moderate, and low [4,5,12].

3. Results and discussion

3.1 Water Poverty Index (WPI)
1. Resource (R) and Environment (E)
Based on field observation, there are two types of access to fresh water – from individual wells and piped water connections supplied by local community water management association, namely HIPPAM. Table 1 indicates 6 of 9 villages acquire freshwater with piped water connections provided by the HIPPAM. Meanwhile, the rest three villages obtain fresh water from shallow groundwater sources through private wells. So, the community is counted as having the resource of water availability and valued as 100.
Table 1. Resource (R) and Environment (E) components in Bumiaji District.

| Village    | Groundwater availability (m) | Piped water availability (m³/cap/yr.) | WPI (R) | Water Quality | Open Space Area (Ha) | Area each Village (Ha) | The ratio of Open space WPI (E) | WPI (E) |
|------------|-----------------------------|--------------------------------------|---------|---------------|---------------------|-----------------------|-----------------------------|--------|
| Pandanrejo | 0                           | 90000                                | 100     | 50            | 134.30              | 628.16                | 21.38%                      | 25.11  |
| Sumberbrantas | 0                        | 118800                               | 100     | 50            | 369.95              | 541.70                | 68.29%                      | 25.34  |
| Sumbergondo | 0                           | 55800                                | 100     | 50            | 113.00              | 1,379.23              | 8.19%                       | 25.04  |
| Punten      | 0                           | 221400                               | 100     | 50            | 76.25               | 245.72                | 31.03%                      | 25.16  |
| Giripurno   | 0                           | 300600                               | 100     | 50            | 346.60              | 980.56                | 35.35%                      | 25.18  |
| Bumiaji     | 10                          | 0                                    | 100     | 75            | 241.20              | 844.82                | 21.38%                      | 25.11  |
| Gunungsari  | 10                          | 0                                    | 100     | 75            | 384.39              | 844.82                | 55.84%                      | 37.78  |
| Bulukerto   | 10                          | 0                                    | 100     | 75            | 443.85              | 1,007.00              | 44.08%                      | 25.22  |
| Bulungrejo  | 0                           | 111600                               | 100     | 75            | 639.52              | 6,482.80              | 9.86%                       | 37.55  |

Table 1 also depicts the environmental component as the water quality sub-component calculation and the percentage of vegetation cover. The WPI of the environment component is about 25.04 – 37.78 for the whole villages, whereby the value is lower than 47.9 as the highest line value in the lowest classification of the WPI. In other words, the component of the environment is not in good condition.

2. Access (A)

Regarding resources, it might assume that the whole households are served by clean water for their daily needs. Access to houses with healthy waste is measured through the ownership of an individual septic tank because having a septic tank indicates an effort to treat domestic wastewater. The primary survey found that some houses even have separate restrooms, but some of them, instead of having an individual septic tank, use a communal septic tank. Hence, table 2 displays that the non-poor households have better access than the poor, referring to the three sub-components – access to water, sanitation, and septic tank.

Table 2. Access (A) component in Bumiaji District.

| Village    | No. of House | Water Access (%) | Sanitation Access (%) | Septic Tank Access (%) | WPI (A) |
|------------|--------------|------------------|-----------------------|------------------------|---------|
| Pandanrejo | 5            | 41               | 87                    | 100                    | 63      |
| Sumberbrantas | 6          | 38               | 49                    | 98                     | 97      |
| Sumbergondo | 3            | 31               | 60                    | 99                     | 99      |
| Punten      | 6            | 47               | 63                    | 96                     | 92      |
| Giripurno   | 15           | 82               | 48                    | 98                     | 97      |
| Bumiaji     | 6            | 60               | 49                    | 100                    | 97      |
| Gunungsari  | 11           | 53               | 55                    | 100                    | 98      |
| Bulukerto   | 6            | 52               | 72                    | 93                     | 72      |
| Bulungrejo  | 6            | 81               | 66                    | 98                     | 96      |

*P= Poor People; NP = Non-Poor People; A= Aggregate

3. Capacity (C)

Education level is calculated from the number of people who have a minimum high school education of 12 years of schooling, referring to the Ministry of Education and Culture Regulation (2015) [13]. Table 3 shows that the capacity component did not differ significantly between the poor and the non-poor households. However, education levels in Sumber Brantas and Gunungsari villages are deficient (25 – 35%), meaning that most households have a family member who did not complete their high school.
Table 3. Capacity (C) Component in Bumiaji District.

| Village    | Health level (%) | Education level (%) | Index Gini | WPI (C) |
|------------|------------------|---------------------|------------|---------|
|            | P    | NP   | P    | NP   | P    | NP   |
| Pandanrejo | 98   | 95   | 70   | 75   | 0.42 | 56%  | 59%  |
| Sumberbrantas | 97   | 90   | 25   | 27   | 0.65 | 45%  | 46%  |
| Sumbergondo | 80   | 89   | 40   | 38   | 0.30 | 35%  | 34%  |
| Punten     | 90   | 100  | 63   | 66   | 0.45 | 54%  | 56%  |
| Giripurno  | 93   | 100  | 70   | 70   | 0.42 | 56%  | 56%  |
| Bumiaji    | 86   | 86   | 80   | 85   | 0.40 | 60%  | 63%  |
| Gunungsari | 90   | 90   | 35   | 25   | 0.35 | 35%  | 30%  |
| Bulukerto  | 98   | 100  | 47   | 45   | 0.80 | 64%  | 63%  |
| Tulungrejo | 87   | 87   | 50   | 50   | 0.60 | 55%  | 55%  |

*P= Poor People; NP = Non-Poor People; A= Aggregate

4. Use (U)

Table 4 depicts that the calculation of WPI is in the range between 25.00 – 75.00 for the use component. However, only two villages which have a value higher than 67.9, namely Pandanrejo and Punten villages with 69.00 and 75.00, respectively. Meaning that mostly water consumption is used for domestic needs.

Table 4. Use (U) component in Bumiaji District.

| Village    | Existing Domestic water Use (l/village/day) | Domestic Water Demand (100 x pop) (l/village/day) | Domestic water use | Irrigation rice field (Ha) | Rainwater rice field (Ha) | Utilization of Agricultural Land | WPI (U) |
|------------|--------------------------------------------|--------------------------------------------------|--------------------|---------------------------|--------------------------|---------------------------------|---------|
|            | (a)                                        | (b)                                              | (a)/(b)            | (d)                        | (c)                      | (d)/(e)                         |         |
| Pandanrejo | 1,250                                      | 690                                              | 1.81               | 118                        | 134.3                    | 0.88                            | 69.00   |
| Sumberbrantas | 1,864                                      | 924                                              | 2.02               | 0                          | 369.95                   | 0.00                            | 25.00   |
| Sumbergondo | 1,500                                      | 499                                              | 3.00               | 35                         | 113                      | 0.31                            | 40.50   |
| Punten     | 2,672                                      | 954                                              | 2.80               | 90                         | 76.25                    | 1.18                            | 75.00   |
| Giripurno  | 5,470                                      | 2,182                                            | 2.51               | 196                        | 346.6                    | 0.57                            | 53.50   |
| Bumiaji    | 2,065                                      | 924                                              | 2.23               | 65                         | 241.2                    | 0.27                            | 38.50   |
| Gunungsari | 4,830                                      | 1632                                             | 2.96               | 98                         | 384.39                   | 0.25                            | 37.50   |
| Bulukerto  | 1,784                                      | 832.5                                            | 2.14               | 61                         | 443.85                   | 0.14                            | 32.00   |
| Tulungrejo | 2,365                                      | 913.5                                            | 2.59               | 51                         | 639.52                   | 0.08                            | 29.00   |

According to table 5, the lowest WPI calculation for the poor household is found in Bumiaji Village (44.98). Meanwhile, the highest WPI is occurred in Gunungsari Village (64.91). The value of WPI for the poor household from the lowest to the highest is between 44.98 – 64.91 or between severe up to medium-low level. Meanwhile, the non-poor household is between 55.26 – 80.12, or in the range of high to a low level. Hence, in general, the non-poor household has a lower poverty level than the poor.

Table 5. Water Poverty Index (WPI) at each village in Bumiaji District.

| Village    | WPI Poor | Classification | WPI Non-Poor | Classification |
|------------|----------|----------------|--------------|----------------|
| Bulukerto  | 61.18    | Medium         | 61.36        | Medium         |
| Bumiaji    | 44.98    | Severe         | 65.35        | Medium-low     |
| Giripurno  | 61.28    | Medium         | 66.96        | Medium-low     |
| Gunungsari | 64.91    | Medium-low     | 57.03        | Medium         |
| Pandanrejo | 58.85    | Medium         | 80.12        | Low            |
| Punten     | 54.18    | High           | 73.24        | Low            |
| Sumberbrantas | 52.03 | High           | 55.26        | High           |
| Sumbergondo | 50.64    | High           | 57.95        | Medium         |
| Tulungrejo | 54.28    | High           | 59.95        | Medium         |
The following figure 1 depicts quite a similar pattern between the two households, wherein the worst component is the environment followed by the capacity. Another fact that the use component shows a broader range of value between villages regarding water use for domestic and irrigation purposes. Figure 2 displays a map of the WPI wherein only one town in the poor household has a medium-low level.

![Figure 1. WPI pentagon poor (left) and non-poor (right) households.](image)

![Figure 2. Map of the WPI of poor (left) and non-poor (right) households.](image)

3.2 Social Network Analysis (SNA)

1. Rate of Participation (RoP) and Density

Types of community institutions in Bumiaji District are divided into formal and informal institutions. Each institution has activities that provide benefits and information for the people who participate in these institutional activities. According to the previous research [4, 12, 14], data affiliation is the input data that calculates social capital from respondents' memberships to the existing institutions in the study area.

| Village       | RoP Poor | Classification | RoP Non-Poor | Classification | Density Poor | Classification | Density Non-Poor | Classification |
|---------------|----------|----------------|--------------|----------------|--------------|----------------|------------------|----------------|
| Bumiaji       | 4.37     | Moderate       | 5.04         | Moderate       | 0.44         | Moderate       | 0.66             | Moderate        |
| Giripurno     | 3.07     | Low            | 6.1          | Moderate       | 0.58         | Moderate       | 0.73             | High            |
| Gunungsari    | 4.27     | Moderate       | 6.77         | Moderate       | 0.62         | Moderate       | 1.00             | High            |
| Pandanrejo    | 2.71     | Low            | 7.41         | Moderate       | 0.59         | Moderate       | 0.73             | High            |
| Punten        | 5.26     | Moderate       | 6.1          | Moderate       | 0.55         | Moderate       | 1.00             | High            |
| Sumberbrantas | 2.81     | Low            | 5.2          | Moderate       | 0.60         | Moderate       | 1.00             | High            |
| Sumbergondo   | 3.95     | Moderate       | 4.26         | Moderate       | 0.52         | Moderate       | 0.87             | High            |
| Tulungrejo    | 3.59     | Moderate       | 5.02         | Moderate       | 0.56         | Moderate       | 0.63             | Moderate        |

In general, table 6 displays that the RoP and the non-poor household's Density are higher than the poor. For the RoP, there are 5 of 8 villages classified as low. Meanwhile, whole non-poor households are classified as moderate. On the one hand, the entire low household density is medium; on the other hand, 6 of 8 villages have high density. Three villages show the full value of thickness (1.00), meaning that the whole respondents are connected in the full closed network. In other words, the non-poor
households have stronger social ties than poor households that might give them better able to activate their resources.

4. Conclusion
From the measurement of the WPI, in general, the non-poor household has lower poverty than the poor. Then, from the size of the social capital with two indices – density and participation rate, it shows that the non-poor household has higher social ties than the poor. This is a similar pattern that is important to be noticed. Hence, we might assume that the better flow of information and resources between community members formed from a strong social relationship might be able to mobilize a more significant and broader flow of information and help from both internal and external sides of the community [10]. As a consequence, the non-poor household might have a lower poverty level than the poor. Looking into detail, amongst the five components of the WPI, the environment's element portrays the worst result. Meanwhile, regarding the continuous growth of population and the increased speed of land-use change due to more variety of human activity, it will put the environment in a more dangerous position, mainly due to fast land conversion from un-built up into the built-up area. This situation might worsen since the left unbuilt up spot in the form of a green area does not guarantee that the green area's quality is good enough to support its function. In more detail, open space availability is nearly crucial for future development to prevent the worsening quality and quantity of water due to land use conflict.

Hence, the research's recommendation is strengthening social capital between community members is indispensable from the development activity done by the whole society to the safe environment of their living neighborhood. The more proper understanding of the community about the ground's critical value, the better result might happen for the betterment of a liveable place for all. Besides, good social relations will make it easier for the community to exchange information and resources and foster mutual trust. They can foster values to solve problems together, especially for the poor.

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