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Original Research Article

Watershed management index based on the village watershed model (VWM) approach towards sustainability☆

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ABSTRACT

In the current study, we examine the Indonesian government's watershed management program, which was established in 2001. In 2005, the Coordination Team for Rescue of Water Resources (CTRWR) was established to execute the program on a national level. However, at the time, field implementation was a sectoral interest due to the lack of program integration. To this end, the Indonesian government promoted integrated watershed management in 2009, which since then has been implemented by all stakeholders (in Top–Down management form), with application limited to preparing and planning documents. This is mainly driven by the stakeholders' lack of understanding with regard to watershed systems as integrated management units. Field implementation results have not yet been realized, including the promotion of community-based watershed management (through Bottom–Up management). The purpose of our research was to determine the index numbers by measuring the level of cooperation between watershed management workers based on the Village Watershed Model (VWM) specifically surface water which includes six variables: planning, participation, institutional, fund sharing, gender, and management systems. The method used was an ordinal measure with the Likert scale. Our data showed successful watershed management, in which five of the six VWM variables—planning, participation, institutional, fund sharing, and management systems—were in the "good" category with indices ranging from 73.08 to 78.27. The gender variable index (69.12) was in the "medium" category.

1. Introduction

Water is an important natural resource, crucial for the survival of all living things (Javarayigowda, Basavaraju, & Jayaram, 2018; Kiran & Srivastava, 2014; Tejaswini & Sathian, 2018). Water availability is currently decreasing with an increasing demand, mainly due to increasing population, human consumption, agriculture, industry, and livestock needs (Kiran & Srivastava, 2014). Watershed degradation conditions represent driving forces, because watershed natural resources management is exploitative and aggressive, resulting in them exceeding their carrying capacity. Therefore, managing natural watershed resources is crucial for ensuring sustainability. Enhancing sustainability in watershed management implementation requires integration of the four main elements, including natural resources, technology, institutions, and economics or costs (EPA, 1996; Robertson & Nielsen-Pincus, 2009).

The Ministry of Forestry established the Indonesian government's watershed management program in 2001. The Coordination Team for Rescue of Water Resources (CTRWR) was established in 2005 to execute the program on a national level. However, field implementation remains a sectoral interest, and the lack of watershed management system understanding has led to unexpected results. Watershed management is a coordination framework (Thakare, Jadhav, & Kumawat, 2013; Wang et al., 2016) developed by stakeholders aiming to combine plans for programs, policies, and activities, which are used to control water and resources, as well as watershed-related processes (Cole, Feather, & Letting, 2002; Gupta, Goyal, Tarannum, & Patil, 2017). Watersheds

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are ideal management units representing a multidisciplinary approach to resource management, geared towards supporting natural resources such as land, water, and natural disaster mitigation for sustainable development (Erdogan, 2013; Kerr, 2007; Kiran, Rao & GT, 2016; Kiran & Srivastava, 2014; Rajan, Sudhirendar, Eklabya & Hofer, 2017; Sriyana, 2018). To this end, the Ministry of Forestry promoted an Integrated Watershed Management Plan (IWMP) in early 2009. The planning stage involved the parties coordinated preparation of an Integrated Watershed Management Plan document (Sriyana, 2018). Despite these efforts, field implementation remains unrealized, and primarily a sectoral interest. During the same year, the Ministry of Forestry promoted micro watersheds and participatory management, which were continued by the Ministry of Internal Affairs in 2014 as a community-based watershed management system. However, implementing the two programs failed in enhancing sustainability, even after yearly fund transfers from central to the village governments (village funds amounting to Rp. 750 million to 1.5 billion rupiah). Therefore, stakeholders should perform research regarding the implementation of integrated watershed management by developing a management model—that can lead to sustainability—based on the village watershed model. The aim of our current research was to determine the index numbers by measuring the level of cooperation between watershed management workers based on the Village Watershed Model (VWM) specifically surface water, which includes six variables; planning, participation, institutions, distribution of funds, gender, and management systems.

2. Materials and methods

2.1. Data and location

The administrative part of the research was performed in Gebugan and Munding (micro watershed), and in the upper part of the Garang watershed (macro watershed), Bergas sub-district, Semarang district, Central Java province, Indonesia, with a watershed area of 3390 km^2 and 191,190 km^2, respectively (see Fig. 2).

The research was located at 7°7′58.61″ S–7°7′49.14″ S to 110°23′31.44″ E–110°23′58.85″ E, at ~400 m above sea level. The study areas' air temperatures were 24–32 °C, with 24 °C and 32 °C being the lowest and highest recorded temperatures, respectively. The highest rainfall record was 3000 mm/year and the lowest was 2500 mm/year. Land use characteristics in the area of interest (shown in Fig. 1 below) are explained by the following coverage features; forests 76.99 ha, plantation 231.82 ha, settlements 9.69 ha, rainfed rice fields 15.24 ha, bushes 15.24 ha, vacant land 0.41 ha, and moorlands 1.91 ha. In 2013, the coverage was as follows: forests 203.16 ha, plantations 105.96 ha, settlements 9.33 ha, rainfed rice fields 19.01 ha, uplands 1.52 ha, with a regional area of 338.98 ha and river length 4.2 km.

2.2. Variables, population, and samples

In this study, six variables including planning, participation, institutional, fund sharing, gender, and management systems were measured. All research variables are an ordinal measure with a Likert scale based on the indicators that build them. Likert scale is a system developed by Likert to measure the opinion of the respondents towards a set of questions organized by a researcher about a specific topic [15]. Planning variable index: management of the village watershed includes planning documents (r.1), scope of planning (r.2), and plans as references (r.3). Participation variable index: village watershed management includes meeting with community groups (p.1), accommodating community input (p.2), community caring (p.3), presence of infiltration wells in residential locations (p.4), presence of wells carrying in paddy fields (p.5), and tree planting independently by the community (p.6). Institutional variable index: village watershed management includes existence of formal institutions (k.1), existence of watershed care communities (k.2), formal institutional performance (k.3), performance of watershed care communities (k.4), and existence of environmental care groups (k.5). Fund sharing variable index: management of the village watershed includes village government budgets for watershed management (s.1), CSR (Corporate Social Responsibility) funds for watershed management (s.2), and participation funds from the community (s.3). Gender variable index: management of village watersheds includes women's involvement in watershed management (g.1), and watershed management activities in women's activity groups (g.2). Management systems variable index: village watershed management includes ownership of regular watershed management programs by watershed management groups (sis.1), and involvement of group members in systemic watershed management programs.

The study comprised of management workers from the central government, provincial government, district government, private companies, tertiary institutions and village government (Munding and Gebugan, Bergas District, Semarang District). The sampling method used was purposive proportional sampling. Samples were taken by purposive with the criteria of workers who understood about watershed management and watershed conservation techniques, obtained from the overall number of workers (120 workers) as shown in Table 1 below. According to Hill (1998), the number of respondents to be used in the study depends on the population size of the study area. The number of respondents used was taken from the population of workers who were in accordance with the criteria to be correlated based on the level of significance table with a confidence level of 95% (Cohen, Manion, & Morrison, 2002). Based on the method above, the total number of workers were 120, by correction of the population at a confidence level of 95%, we got 100 respondents. Data collection was conducted by distributing questionnaires and interview sheets.

2.3. Analysis method

2.3.1. Watershed management index analysis

Analysis for determining the watershed management index was carried out in two stages: determining the index number using Equations (1) and (2), and the interval category (Augusty, 2006).

$$I = \left(\sum F_i.X_i \right) : n \quad (1)$$

where I is the index, Fi is the percentage of the total respondents who gave answers to the questionnaire i, Xi is the answer score for the questionnaire statement to I, and n is the number of answer items.

Score technique and Likert scale (modified): answers to questions were divided into SD (Strongly Disagree) score = 1; D (Disagree) score = 2; A (Agree) score = 3; and SA (Strongly Agree) score = 4. The category (p) interval determination equation is:

$$p = (HD - LD)/k \quad (2)$$

where, p is the length of the interval in the category.

HD is the highest data (the value of the index in which all respondents answered SA).

LD is the lowest data (the index value in which all respondents answered SD), and k is the number of categories specified. The categories were determined using the lowest data, highest data, and category intervals as shown in Table 2.

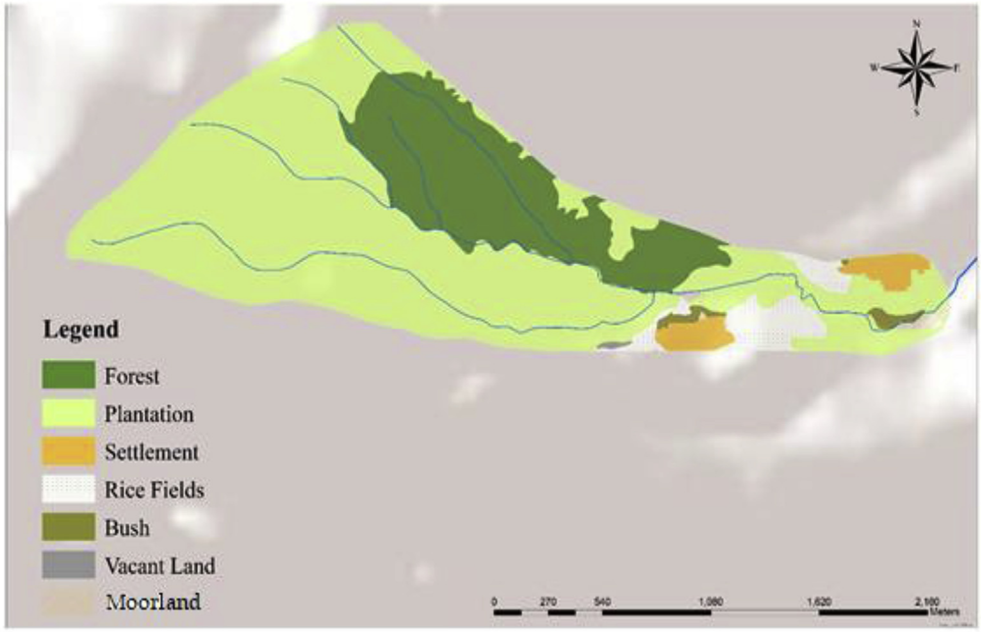

Fig. 1. Land use characteristics of the study area.

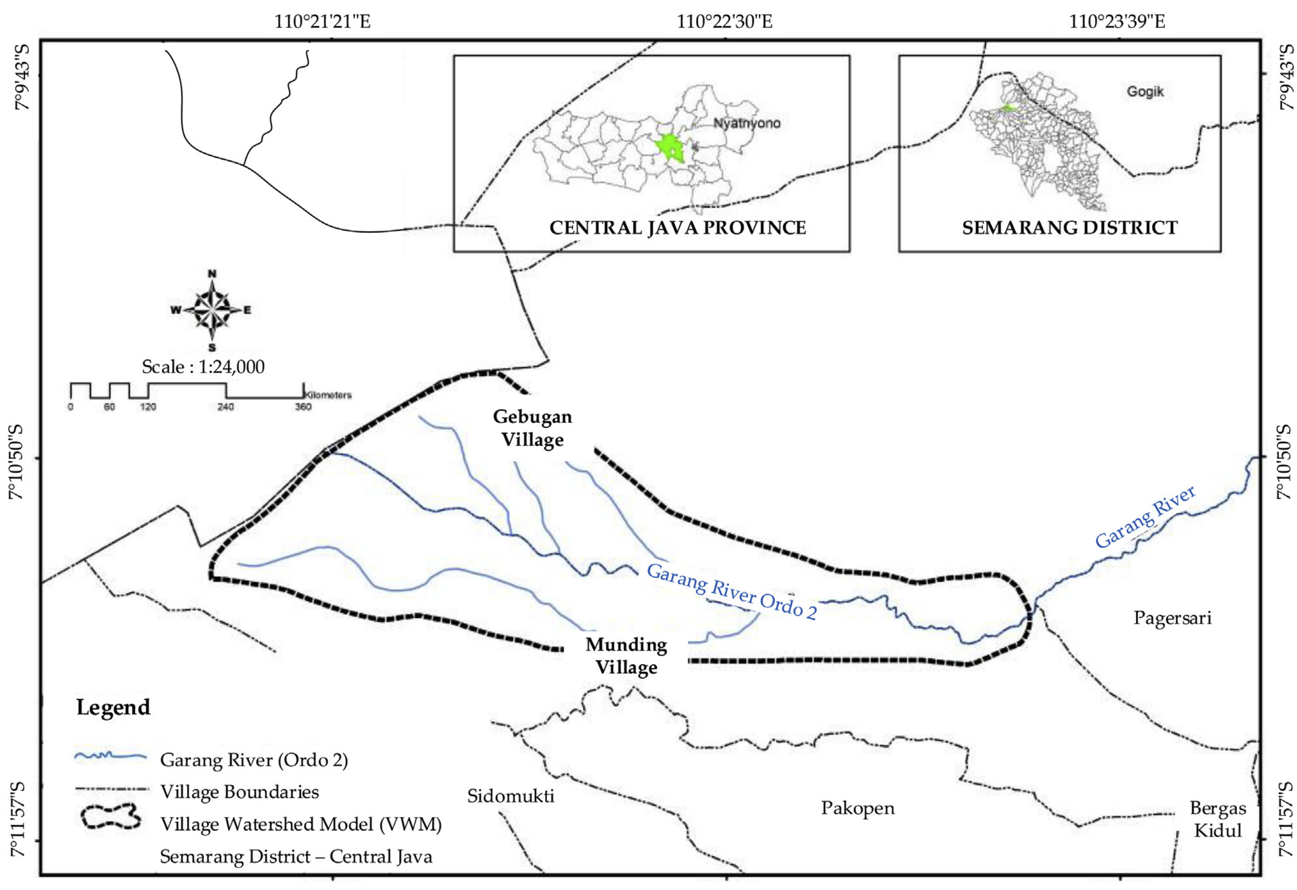

Fig. 2. Location of the study area.

The descriptive analysis was performed using the index number method. In addition, the data quality was tested, which included validity and reliability tests.

2.3.2. Test validity and reliability

We then performed validity and reliability tests on the measurement data obtained from the questionnaires. Data with invalid

Table 1
Sample distribution.

No.	Level of workers	Total workers	Proportional (%)	Total Sample
1	Central government	11	9.17	9
2	Provincial government	13	10.83	11
3	District government	12	10.00	10
4	Private companies	2	1.67	2
5	Tertiary institutions	2	1.67	2
6	Village government	80	66.67	66
	Total	**120**	**100.00**	**100**

Table 2
Categories of watershed management index.

No	Magnitude of the Index	Category
1	≥25 and < 40	Very bad
2	≥40 and < 55	Bad
3	≥55 and < 70	Moderate
4	≥70 and < 85	Good
5	≥85 and < 100	Very good

results were excluded from the analysis. Validity demonstrates the extent to which a questionnaire/measuring instrument matches measured data. Validity was obtained by applying the Pearson Product Moment correlation technique, while instrument measurement reliability was determined using the Cronbach Alpha coefficient. Both analyses were calculated in Statistical Packages for Social Science (SPSS) computer program version 20.00 (Gazali, 2011).

The test include two criteria: (1) validity criteria, if the amount of Corrected item-Total Correlation (r test) > r critical (r_{table}), then the statement item is valid, so it will produce valid data; and (2) if Corrected item-Total Correlation (r test) < r critical (r_{table}) then the statement item is invalid and will therefore produce invalid data too. Therefore, if the Cronbach's Alpha coefficient is > 0.6, then the variables measured by the statement items were reliable, and if the Cronbach's Alpha coefficient is < 0.6, then the variable measured by the statement items were not reliable.

2.3.3. Hydrological analysis

The method used to analyze the amount of rainwater storage based on the participant index, which has been conserved is by using secondary data, namely monthly rainfall and rainy day data. The following steps were used:

1) The rain monthly volume watershed is calculated by multiplying monthly rainfall by the area of the watershed.
2) Runoff volume is the watershed rain volume multiplied by the runoff coefficient (calculated based on the weighted average method).
3) Calculate the volume of rainwater collected in infiltration wells and wells in the rice fields (sedrainponds), assuming that in one rainy day all the volume of rain has been collected in infiltration wells and sedrainponds.
4) Calculate the total rainwater storage due to water conservation in one month based on rainy days multiplied by volume collected in one rainy day.
5) Calculate the percentage of water conservation that is; comparing the rainwater volume collected with the result of runoff volume in a period of one year.

The land area was calculated according to its designation with ArcView GIS program and then the data was analyzed using the Microsoft Excel program.

3. Results and discussion

3.1. Conceptual frame work of integrated watershed management

Village watershed or micro watershed represents areas of land consisting of one or more villages or, one or more sub-districts, which constitute a single ecosystem unit, one-order river tributaries whose function is to collect, store, and drain water originating from rainfall to the next river order, which is naturally limited by topography. Village Watershed (VW) sizes are variable (~1000 ha). VWMs represent participatory management unit models, which are used as strong instruments for coordinating village institutions, use of village funds, and other communities at the village level, aiming to achieve sustainable watershed management. Successful sustainability of activities are conducted through a watershed management approach based on local community participation (Erdogan, 2013; Yavuz & Baycan, 2013; Legesse, Bogale, & Likisa, 2018; Swami & Kulkarni, 2011; Dash, Dash & Kara, 2011; Gebretsadik & Debara, 2017; Narmada et al., 2015).

Village level watershed (micro watershed) management is a participatory (Bottom–Up management) community approach. Village-level institutional involvement comprised of village heads, village development agencies, environmental care communities, and community leaders, has an important role in watershed management. Involvement begins with planning, implementation, operation, and maintenance stages. However, village (Munding and Gebugan villages) or other funding sources are not available for supporting sustainable watershed management.

Macro watershed management is a Top–Down management approach. Supporting institutions consist of offices in Central Java Province (Central Office of Pemali Juana River Region, Central office Watershed Management, Central Java Environment and Forestry Service, Central Java Province Water Resources, and Spatial Planning), higher education institutions, non-governmental organizations communities, Central Java Watershed Management Coordination Forum, and Watershed Forum. These institutions have an important role in mentoring, both on technical and non-technical levels, during the planning, implementation, operation, and maintenance phases. To achieve sustainable watershed management, Integrated Watershed Management (IWM) is required, which combines village-level watershed (micro watershed) management (Bottom–Up management) with macro-watershed (Top–Down management) as seen in Fig. 3 below.

3.2. Validity and reliability test

3.2.1. Validity and reliability test for the "planning" variable

Validity and reliability of the planning variable were tested using the SPSS program, and the results are shown in Table 3.

Corrected item value: the total correlation for all indicators was >0.23, meaning that all indicators involved in constructing the "planning" variable were valid, or instrument and measured values were similar.

Reliability analysis of the "planning" variable using the SPSS program obtained Cronbach's Alpha = 0.71. Cronbach's Alpha coefficient of 0.71 > 0.6 from Cronbach's Alpha standard, this shows that all instruments used to measure the "planning" variable were reliable.

3.2.2. Validity and reliability test for the "participation" variable

Validity and reliability of the participation variable were tested using the SPSS program, and the results are shown in Table 4.

Corrected item value: the total correlation for all indicators was >0.23, which meant that all indicators contributing to the "participation" variable were valid, or instrument and measured values

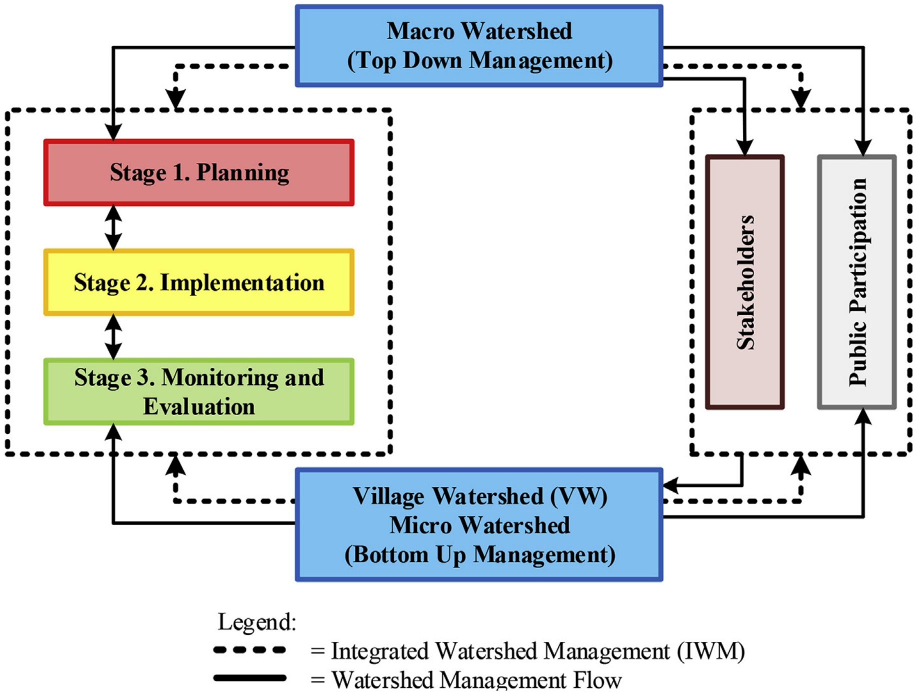

Fig. 3. Framework of integrated watershed management (IWM).

Table 3
Validity of the "planning" variable.

Corrected Item-Total Correlation	r_{table}	Justification	Cronbach's Alpha Test	Cronbach's Alpha Standard
0.612	0.23	Valid	0.71	0.6
0.614	0.23	Valid		
0.237	0.23	Valid		

were similar.

The reliability analysis of the "participation" variable using the SPSS program obtained Cronbach's Alpha = 0.75. Cronbach's Alpha coefficient was 0.75 > 0.6 from Cronbach's Alpha standard, this showed that all instruments used to measure the variable "participation" were reliable.

3.2.3. *Validity and reliability test for the "institutional" variable*

Validity and reliability of the institutional variable were tested using the SPSS program, and the results are shown in Table 5.

Corrected item value: the total correlation for all indicators was >0.23, which meant that all indicators that contributed to the "institutional" variables were valid, or instrument and measured values were similar.

The reliability analysis of the "institutional" variable using the SPSS program obtained Cronbach's Alpha = 0.70. Cronbach's Alpha coefficient was 0.70 > 0.6 from Cronbach's Alpha standard, this showed that all instruments used to measure "institutional" variables were reliable.

3.2.4. *Validity and reliability test for the "fund sharing" variable*

Validity and reliability of the fund sharing variable were tested using the SPSS program, and the results are shown in Table 6 below.

Corrected item value: the total correlations for all indicators was >0.23, which meant that all indicators that constitute the "fund sharing" variables were valid, or instrument and measured values were similar.

The reliability analysis of the "fund sharing" variable using the SPSS program obtained Cronbach's Alpha = 0.67. Cronbach's Alpha coefficient was 0.67 > 0.6 from Cronbach's Alpha standard, this showed that all instruments used to measure the "fund sharing" variable were reliable.

Table 4
Validity of the "participation" variable.

Corrected Item-Total Correlation	r_{table}	Justification	Cronbach's Alpha Test	Cronbach's Alpha Standard
0.236	0.23	Valid	0.75	0.6
0.306	0.23	Valid		
0.294	0.23	Valid		
0.460	0.23	Valid		
0.354	0.23	Valid		
0.238	0.23	Valid		

Table 5
Validity of the "institutional" variable.

Corrected Item-Total Correlation	r_{table}	Justification	Cronbach's Alpha Test	Cronbach's Alpha Standard
0.282	0.23	Valid	0.70	0.6
0.237	0.23	Valid		
0.257	0.23	Valid		
0.266	0.23	Valid		
0.268	0.23	Valid		

Table 6
Validity of the "fund sharing" variable.

Corrected Item-Total Correlation	r_{table}	Justification	Cronbach's Alpha Test	Cronbach's Alpha Standard
0.692	0.23	Valid	0.67	0.6
0.811	0.23	Valid		
0.599	0.23	Valid		

3.2.5. Validity and reliability test for the "gender" variable

Validity and reliability of the gender variable were tested using the SPSS program, and the results are shown in Table 7.

Corrected item value: the total correlation for all indicators was >0.23, which meant that all indicators constituting the "gender" variable were valid, or instrument and measured values were similar.

Reliability analysis of the "gender" variable using the SPSS program obtained Cronbach's Alpha = 0.66. Cronbach's Alpha coefficient was 0.66 > 0.6 from Cronbach's Alpha standard, this showed that all instruments used to measure "gender" variables were reliable.

3.2.6. Validity and reliability test for the "management systems" variable

Validity and reliability of the management systems variable were tested using the SPSS program, and the results are shown in Table 8.

Corrected item value: the total correlation for all indicators was >0.23, which meant that all indicators comprising the "management systems" variable were valid, or instrument and measured values were similar.

Reliability analysis of system variables using the SPSS program obtained Cronbach's Alpha = 0.72. Cronbach's Alpha coefficient was 0.72 > 0.6 from Cronbach's Alpha standard, this showed that all instruments used to measure the variable "management systems" were reliable.

3.3. Watershed management index

The watershed management index is based on the Village Watershed Model (VWM), the index is categorized into five classifications; very bad, bad, moderate, good, and very good (Table 2). Index method analysis provides results of general watershed management in Munding and Gebugan villages (Village Watershed Model), which fell into the "good" category with an index of 74.58. Table 9 and Fig. 4 represent this data. The analysis showed that watershed management indices for all individual variables can be described as follows:

a. For the planning variable index: the watershed management index based on the village watershed model was in the "good" category, with an index value of 78.27.
b. For the participation variable index: the watershed management index based on the village watershed model fell under the "good" category, with an index value of 76.53.
c. For institutional variable index: the watershed management index based on the village watershed model fell under the "good" category, with an index value of 74.05.
d. For fund sharing variable index: the watershed management index based on the village watershed model fell under the "good" category, with an index value of 73.08.
e. For the gender variable index: the watershed management index based on the village watershed model fell under the "moderate" category, with an index value of 69.12.
f. For the management systems variable index: the watershed management index based on the village watershed model fell under the "good" category, with an index value of 76.44.

3.3.1. Planning variable index

For VWM-based watershed management in the planning variable, all three sub-categories were "good" (Table 10 and Fig. 5). The planning document had an index of 78.57 in the "good" category. The planning coverage had an index of 76.79 in the "good" category. The plan, as a reference, had an index value of 79.46 in the "good" category. These data indicate that the planning variables for each village were included in the plans for short and medium term village development activities.

3.3.2. Participation variable index

For VWM-based watershed management in the participation variable, the five elements fell under the "good" category, and one element was under the "moderate" category (Table 11 and Fig. 6). The sub-meeting with community groups had an index of 80.36 in the "good" category. The accommodating community input had an index of 78.57 in the "good" category. Community care had an index of 64.29 in the "moderate" category. Infiltration wells in residential locations had an index of 78.57 in the "good" category. The presence

Table 7
Validity of the "gender" variable.

Corrected Item-Total Correlation	r_{table}	Justification	Cronbach's Alpha Test	Cronbach's Alpha Standard
0.235	0.23	Valid	0.66	0.6
0.235	0.23	Valid		

Table 8
Validity of the “management systems” variable.

Corrected Item-Total Correlation	r_{table}	Justification	Cronbach’s Alpha Test	Cronbach’s Alpha Standard
0.235	0.23	Valid	0.66	0.6
0.235	0.23	Valid		

Table 9
Watershed management index based on VWM.

Statement	Number of Respondents Who Answered (%)						Total Respondents (%)	Category	Variable Index	Watershed Management Index Based on VWM
	SD	D	A	SA						
	1	2	3	4						
r.1	0.00	17.86	50.00	32.14	100		78.57	Good	78.27 (Good)	74.58
r.2	0.00	14.29	64.29	21.43	100		76.79	Good		
r.3	0.00	10.71	60.71	28.57	100		79.46	Good		
p.1	0.00	10.71	57.14	32.14	100		80.36	Good	76.53 (Good)	
p.2	3.57	10.71	53.57	32.14	100		78.57	Good		
p.3	17.86	21.43	46.43	14.29	100		64.29	Moderate		
p.4	0.00	14.29	57.14	28.57	100		78.57	Good		
p.5	0.00	22.22	37.04	40.74	100		79.63	Good		
p.6	3.70	18.52	40.74	37.04	100		77.78	Good		
k.1	0.00	14.81	77.78	7.41	100		73.15	Good	74.05 (Good)	
k.2	0.00	33.33	51.85	14.81	100		70.37	Good		
k.3	0.00	23.08	50.00	26.92	100		75.96	Good		
k.4	0.00	22.22	37.04	40.74	100		79.63	Good		
k.5	3.85	11.54	80.77	3.85	100		71.15	Good		
s.1	0.00	15.38	69.23	15.38	100		75.00	Good	73.08 (Good)	
s.2	0.00	42.31	46.15	11.54	100		67.31	Moderate		
s.3	0.00	3.85	84.62	11.54	100		76.92	Good		
g.1	0.00	36.00	52.00	12.00	100		69.00	Moderate	69.12 (Moderate)	
g.2	0.00	26.92	69.23	3.85	100		69.23	Moderate		
sis.1	3.85	19.23	53.85	23.08	100		74.04	Good	76.44 (Good)	
sis.2	3.85	3.85	65.38	26.92	100	100	78.85	Good		

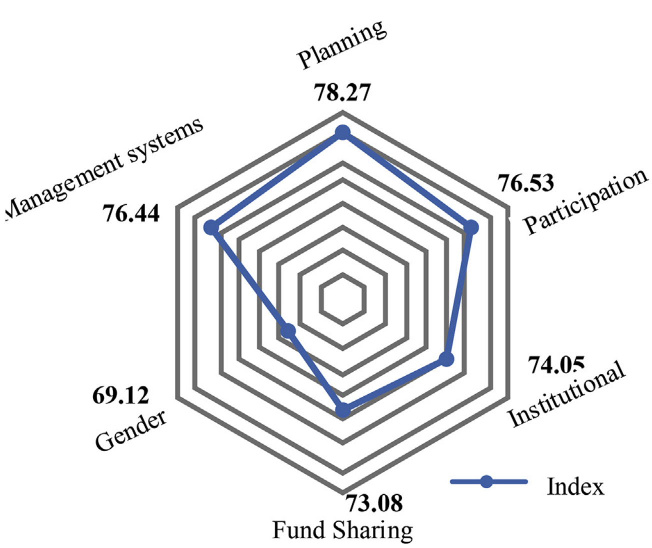

Fig. 4. Watershed management index model based on VWM (Index = 74.58).

Table 10
Planning variable index.

Planning	Category	Index
Planning document (r.1)	78.57	Good
Planning coverage (r.2)	76.79	Good
Plan as a reference (r.3)	79.46	Good

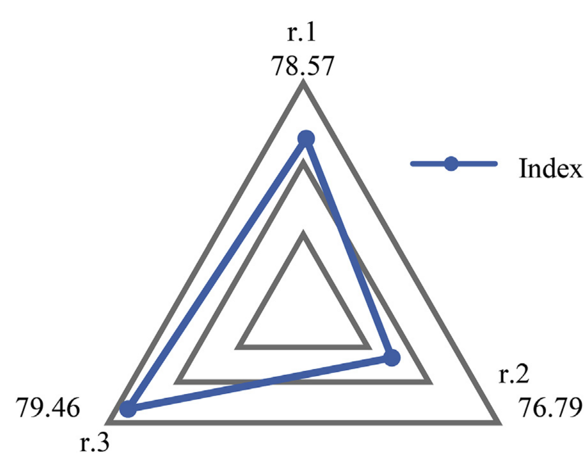

Fig. 5. Planning variable—Village Watershed Model (Index = 78.27).

of wells in the rice fields and others had an index value of 79.63 in the “good” category. Planting trees independently by the community had an index value of 77.78 in the “good” category.

3.3.3. *Institutional variable index*

For VWM-based watershed management in the institutional variable, all five elements fell under the “good” category (Table 12 and Fig. 7). The existence of formal institutions had an index value of 73.15 in the “good” category. The existence of watershed care community had an index value of 70.37 in the “good” category.

Table 11
Participation variable index.

Element	Index	Category
Meeting with community groups (p.1)	80.36	Good
Accommodate community input (p.2)	78.57	Good
Community care (p.3)	64.29	Moderate
The presence of infiltration wells at residential locations (p.4)	78.57	Good
The presence of wells in rice fields and others (sedrainpond) (p.5)	79.63	Good
Planting trees independently by the community (p.6)	77.78	Good

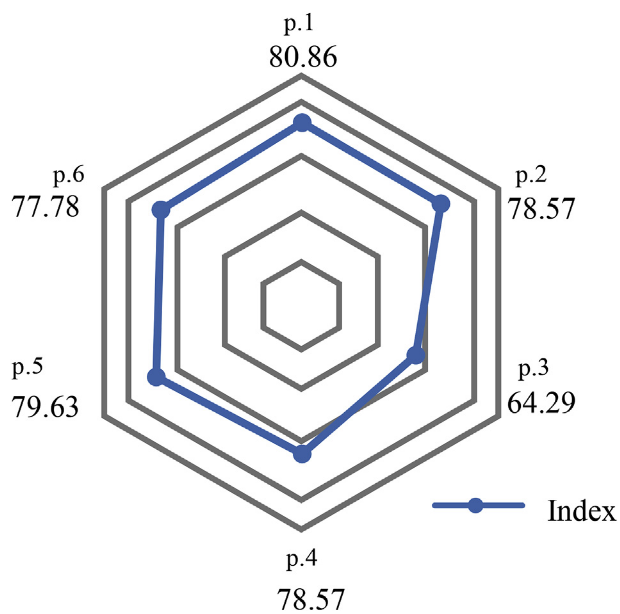

Fig. 6. Participation variable—Village Watershed Model (Index = 76.53).

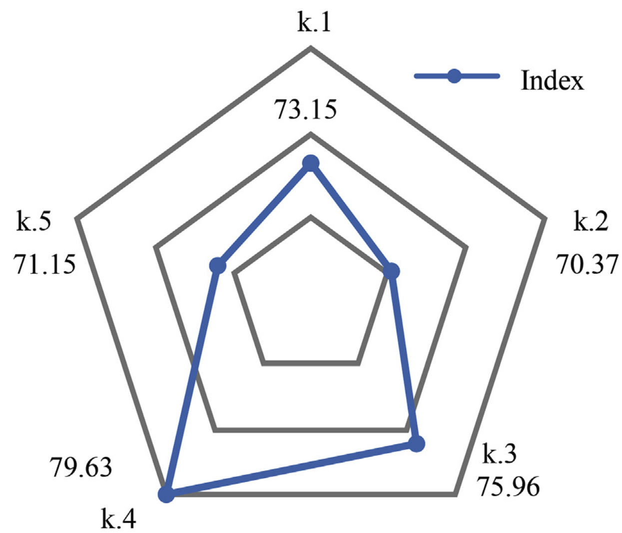

Fig. 7. Institutional variable—Village Watershed Model (Index = 74.05).

The performance of community concerned about watersheds had an index value of 79.63 in the "good" category. The existence of environmental care groups had an index value of 71.15 in the "good" category.

Our results are validated by the establishment of 10 institutions, in both villages as shown in Table 13; with six and four institutions in Munding and Gebugan, respectively. Establishing an institutional coordinator under each Village Development Agency (VDA) chair is a requirement for success in local or community-based watershed management (Dash et al., 2011; Mondal, Singh, Sekar, Sinha, Kumar & Ramajayam, 2016; Sinha, 2015; Tesfaye, Alamirew, Kebede & Zeleke, 2018).

Table 13
Village watershed management agency (VWMA).

Name of the Institution	Village	Coordinator
Prawotosari	Munding (Krajan)	Muhtasori
Waringinagung	Munding (Cemanggal)	Alfitri
KaryaMakmur 1	Munding (Gemawang)	Gian
KaryaMakmur 2	Munding (Gemawang)	Juanto
Usaha Sejahtera	Munding (Gemawang)	Sriyanto
KumpulMulyo	Munding (Gemawang)	Nurhayati
SamiyoRahayu	Gebugan (Lempuyangan)	Mugiyanto
Samiyo Lestari	Gebugan (Bengkle)	M Toad
SamiyoWidodo	Gebugan (TegalMelik)	Tulas
SamiyoTulus	Munding (Krajan)	Kaseri

3.3.4. Fund sharing variable index

VWM-based watershed management in the fund sharing variable included three elements. Two elements fell under the "good" category, while the third was under the "moderate" category (Table 14 and Fig. 8).

For village watershed management, each village (Munding and Gebugan), received funding from the village government, amounting to 5–10% of 1.5 billion per year or ranging from 75 million to 150 million. Apart from village funds, each village received funding from a private company CSR (Corporate Social Responsibility) ranging from 10 to 30 million per year.

3.3.5. Gender variable index

For VWM-based watershed management in the gender variable

Table 12
Institutional variable index.

Element	Index	Category
Existence of formal institutions (k.1)	73.15	Good
Existence of watershed care community (k.2)	70.37	Good
Formal institution performance (k.3)	75.96	Good
Performance of community concerned about watershed (k.4)	79.63	Good
Existence of Environmental Care Groups (k.5)	71.15	Good

Table 14
Fund sharing variable index.

Element	Index	Category
Village government budget for watershed management (s.1)	75.00	Good
CSR Funds for watershed management (s.2)	67.31	Moderate
Participation funds from the community (s.3)	76.92	Good

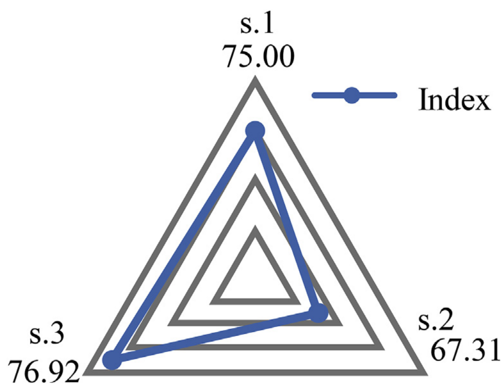

Fig. 8. Fund sharing variable—Village Watershed Model (Index = 73.08).

included two elements, which fell under the "moderate" category (Table 15). The involvement of women in watershed management had an index of 69.00 in the category of "moderate", and watershed management activities in women's groups has an index value of 69.23 in the "moderate" category too.

The involvement of women in village watershed management activities had a significant influence. Women generally manage household activities especially water management (women consume a lot of water during activities like bathing, washing, etc.). Existing forum for women as a means of coordination, direction, and counseling are used to support the success of village watershed management. Women are taught how to use water efficiently.

3.3.6. Management systems variable index

For VWM-based watershed management in the management systems variable, there are two elements, which fell under the "good" category (Table 16).

There is evidence of coordination between stakeholders (provincial watershed forums, district governments, and village governments), which encompasses private parties and universities that join watershed management activities.

3.4. Hydrological analysis

3.4.1. Rainfall storage based on participation variable index

Based on the rainfall data (as shown in Fig. 9 below) from the Bandungan Meteorological Station in the year 2018, the monthly rainfall during rainy season (November to April) ranges from 162 to 358 mm and the number of rainy days ranges from 11 to 16 days. While in the dry season (May to October), the monthly rainfall ranges from 71 to 280 mm and the number of rainy days ranges between (6–10) days.

Based on the community participation index, the results are good. This is an evidence that the community has implemented infiltration wells at residential locations and wells in the rice fields and others (sedrainponds). The number of infiltration wells that have been made is 195 (95% of 205 at residential locations), with a diameter of 1 m and an average depth of 2 m. The community has made 100 sedrainponds with a diameter of 1 m and a depth of 2.5 m. These sedrainponds were made on 40% of the total productive land with an area of 248.97 ha (15.24 ha of rainfed rice fields, 1.91 ha of moorland and 231.82 ha of plantations).

In one year, the rainfall volume in the micro watershed area of Munding-Gebugan in Semarang district is 8,627,041 m^3 with a total area of 338.98 ha. The rainfall storage and conservation can be seen in Fig. 10 below. Rainfall volume in the rainy season (November–April) ranges from 549,148 to 1,213,548 m^3. Water conservation carried out in the micro watershed (Munding-Gebugan) during the rainy season ranged from 57,162 to 83,144 m^3 out of the total volume of water runoff that ranges from 160,958 to 355,698 m^3. After water conservation, the runoff volume decrement ranged between 103,797 and 272,554 m^3 out of the total Watershed volume. Water conservation carried out in the micro watershed (Munding-Gebugan) during the dry season ranges from 31,179 to 51,965 m^3 out of the total volume of water runoff that ranges from 70,543 to 278,200 m^3. After water conservation, the runoff volume decrement ranges between 39,179 and 226,254 m^3 out of the total Watershed volume. The total volume of water conservation in one year in the micro watershed (Munding and Gebugan) is 670,351 m^3 and the total runoff volume (rainy and dry season) is 2,528,636 m^3. Water conservation will reduce the volume of runoff water to 1,858,285 m^3.

Based on these calculations, it can be concluded that water conservation activities through the construction of Infiltration wells and wells in the rice fields (sedrainponds) can conserve water flow in Munding and Gebugan watersheds by 26.51% of the total potential runoff of the watershed.

3.5. Comparative analysis of the VWM approach with other countries' watershed

To realize watershed management towards sustainability, integration between natural resources, technology, institutions and costs is needed (Robertson & Nielsen-Pincus, 2009). The results of this study measured the level of cooperation between watershed management officers, based on the Village Watershed Model (VWM), towards sustainability showing good results compared to previous studies. When compared with previous researchers for example Robertson and Nielsen-Pincus (2009), there are similarities in some variables like technology, institutions and fund sharing, and other variables (planning, gender, watershed

Table 15
Gender variable index.

Element	Index	Category
Women's involvement in watershed management (g.1)	69.00	Moderate
Watershed management activities in women's activity groups (g.2)	69.23	Moderate

Table 16
Management systems variable index.

<Element	Index	Category
Regular ownership of watershed management programs by watershed management groups (sis.1)	74.04	Good
Involvement of group members in a systematic watershed management program (sis. 2)	78.85	Good

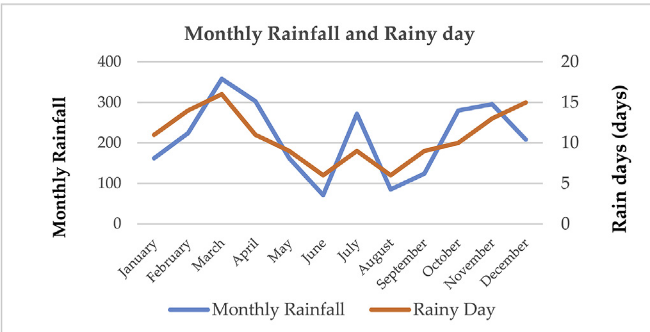

Fig. 9. Monthly Rainfall and Rainy day.

management system) differs. The findings of the fund sharing each year from village funds and planning variable for watershed management are important variables. The fund sharing is a management strategy to achieve sustainability of watershed management implementation, where in other countries it has not been implemented. Planning variable will be used as a basis for planning activity programs to obtain integrated results between all parties involved. This is reinforced by Thakare et al. (2013) from the results of a participatory approach research by taking specialties in the village of Satara Tanda, India that the planning variable is used as a new pattern in the country. Besides that, watershed management based on the VVM approach can be used to determine the strategy for handling watershed improvement. Handling watersheds must begin in the upstream area (village based watershed), then downstream areas that experience flooding, siltation of rivers or reservoirs, so that they do not experience conflict, and can economically reduce the cost of dredging and reduce the occurrence of flooding. Conversely, if handling only focuses on the downstream area and leaves upstream part untouched, the results will not be optimum. To avoid conflict, while reducing the costs of dredging and the occurrence of flooding, integration of watershed management is needed both upstream and downstream.

The watershed management practices research by Salas (2008) in Philippines reveals that implementing watershed management is not just the participation of the governmental or non-governmental institutions, but also signing agreements (structure or institution, practice, finance, administration, decision making and responsibility) as a form of collaboration. The agreement activity has been implemented in micro watershed (Tigum-Aganan watershed), by forming a strong formal institution, holding meetings with the parties, with a program of knowledge transfer activities, and the strategies that should be implemented.

When compared to the Philippines, there are similarities with watershed management in Indonesia, namely after the institution was formed, followed by the signing a memorandum of understanding (MOU) agreement, between the central government with provincial and district government as a form of collaboration of the roles of all parties in carrying out the critical handling of macro watershed. There is a difference in the management of micro watershed in Indonesia, after institutions are formed, they are not accompanied by an agreement (MOU), but accompanied by a decree from the district government to the local government about some of the financial or village funds used for conservation activities and environmental improvement.

The authors found out that there is a need for rural development reform strategies in Indonesia by integrating environmental issues in rural development policies. This reform movement is important in Indonesia, where the authors have made a rural development strategy, as an effort to improve the village watershed (micro), by integrating rural funding policies sourced from the central government given to the village government.

4. Conclusions

From the findings of our study, watershed management towards sustainability can be achieved if there is integration between natural, institutional, technological and financial resources. However much technical and financial aspects are available, without

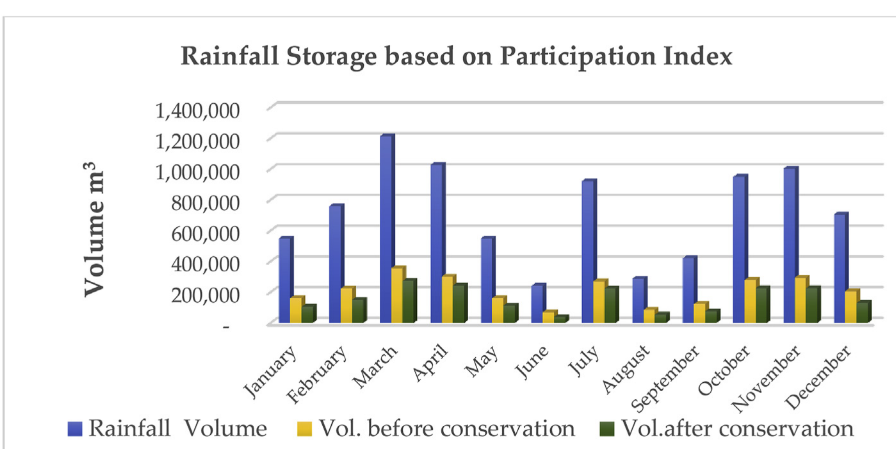

Fig. 10. Rainfall Storage based on Participation.

coordination, integration, synchronization and synergy in the integration of watershed management planning from the central government to the village government, and without the support of integration between related institutions, the watershed management towards sustainability will not be realized.

In this study, it was also found out that the approach of watershed based on village watershed management (VWM) as a participatory watershed management strategy is a result of success. It was found that in terms of village watershed management, the village government felt that watershed management was mandatory and had formed an institution, to carry out water conservation activities or improve the environment by using village funds. The impact of water conservation activities by communities that use village funds is shown; among others by constructing sedrainponds (water storage). This can increase farmers' crop yields. Watershed management based on the VVM approach can also be used to determine the strategy for handling watershed repairs. Handlers should start from the upstream watershed (Village watershed), and then integrate between downstream and upstream, so that the results are optimal. Besides that all stakeholders are involved in integrated watershed management both from the Central Government (Center for Watershed Management, Central River Basin), Central Java Provincial Government (Office of Water Resources and Spatial Planning, Office of Environment and Forestry), Management Coordination Forum Central Java Province Watersheds, and Private Parties, etc.

It was observed that integration and sustainability in the watershed based on village watershed management (VWM) had weaknesses. If there is no watershed management technician in the village area, or if village funding from the central government is stopped, then assistance from relevant stakeholders (Watershed Forum) or other funding sources is needed.

5. Recommendations

1. The Village Watershed Model (VWM) approach should be applied as the best practice.
2. Efforts should be made to increase gender roles in the managing village watershed (through women's groups such as the family welfare development, and making watershed management activities that can be synergized in family welfare development activities).
3. Encouraging entrepreneurs to take part village watershed management efforts.
4. Providing support to watershed activists.

Author contributions

I.S. conceived and designed the study; S.K.P. collected the data; I.S. and J.B.N. analyzed the data and summarized the results; J.G.D.G. and I.S. interpreted the data; J.B.N. and S.K.P. wrote a draft of the manuscript; I.S. and J.B.N. revised and wrote the final manuscript.

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Declaration of competing interest

The authors declare no conflicts of interest.

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