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The risk level of water sources consumed community Baubau city: A geographic information system approach

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Abstract

Background: The quality of the air consumed by the community is highly dependent on the quality of the source. sources that will not be protected are easily contaminated by germs or hazardous materials used and disposed of around air sources.

Objective: This study aims to determine the level of risk of clean water sources consumed by the people at Baubau City. Based on these results, the Baubau City government can use it to assist in the decision-making process related to the sanitation program, and in determining the sub-districts that are prioritized in the intervention program.

Methods: This type of research is an observational study with a Geographic Information System (GIS) approach. The number of respondents was 1,720 in 43 villages, each kelurahan was represented by 40 respondents, with the sampling method in each village, namely simple random sampling.

Results: The results showed that 13 villages were declared less at risk, namely Palabusa, Bone-Bone, Tomba, Waborobo, Baadia, Kadolomoko, Kampeonaho, Ngkari-Ngkari, Liabuku, Lakologou, Labalawa, Gonda Baru, and Bugi. The 19 villages at moderate risk are Bukit Wolio Indah, Karya Baru, Wameo, Wangkanapi, Tampuna, Nganganaumala, Wale, Lanto, Lowu-Lowu, Lamangga, Kaobula, Kantalai, Tanganapada, Kaisabu Baru, Tarafu, Batulo, Bataraguru, Sukanayo, and Waruruma. 9 high-risk villages, namely Liwuto, Sulaa, Kadolo, Katobengke, Kadolo Katapi, Kalia-Lia, Kolese, Wajo, and Lipu. Meanwhile, 2 sub-districts are at very high risk, namely Waliabu and Melai sub-districts.

Conclusion: The conclusion is that most of the urban villages in Baubau City include the risk of air source pollution. Most of the villages in Baubau City include the risk of water source pollution, a few are high risk and very high risk.

Keywords: Risk Level; Water Sources; Consumed; Community; Geographic Information System

1. Introduction

Nine million people die annually due to environmental pollution [1]. Unsafe sanitation, and more specifically open defecation, is one of the main causes, leading to fecal contamination of water bodies and transmission of fecal bacteria [2]. The quality of water consumed by the community is highly dependent on the quality of the source. Unprotected sources will be easily contaminated by germs or hazardous materials used and disposed of around water sources. Water pollution that occurs in drinking water sources can pollute the water environment, damage the ecological balance of water, and threaten the safety of drinking water for residents [3].

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In 2017, 5.3 billion people used safely managed to drink water services i.e., they used better water sources that were located on-site, available when needed, and free from contamination. The remaining 2.2 billion people without safely managed services in 2017 include 1.4 billion people with basic services, meaning better water sources are located within a 30-minute round trip, 206 million people with limited services, or water sources that takes more than 30 minutes to collect water, 435 million people draw water from unprotected wells and springs. 144 million people collect untreated surface water from lakes, ponds, and rivers [4].

Polluted water is very dangerous for users, one ch can cause infectious diseases such as diarrhea. Results of Riskesdas 2018. The prevalence of diarrheal disease in Baubau City based on diagnoses by health workers (doctors, nurses, m, midor wivesors) was 6.94%, while based on diagnoses by health workers or symptoms experienced by household members reached 7.38% [5]. Diarrhea can be caused by feces that contaminate water sources. Sanitation improvements at the environmental level alone may not reduce the danger of feces from open canals for public health so there is a need for integrated city-level sewage management is needed in addition to multifaceted interventions to reduce fecal contamination and human exposure [6].

As a result of people's concerns about water source contamination, many of them turn to bottled water. The consumption of bottled drinking water has increased sharply in recent years worldwide [7]. Bottled water is also certainly not free from risks if its management does not meet health standards. In addition, the quality of water is also very dependent on the quality of the source. This situation requires the attention of the government and the community in carrying out interventions to overcome it.

Implementation of interventions on health problems that occur in the community should be carried out on target, interventions are carried out based on the level of risk of each region. To determine the level of risk, surveys and observations are needed in each area to obtain correct data and in accordbyal situation.

This study aims to determine the level of risk of clean water sources consumed by the people at Baubau City. Based on these results, the Baubau City government can use it to assist in the decision-making process related to the sanitation program, and in determining the sub-districts that are prioritized in the intervention program.

2. Material and methods

The research type is an observational study with a Geographic Information System (GIS) approach. This research was conducted in March 2021 in Baubau City. Data collection was carried out by household surveys using questionnaires and observation sheets in all villages in Baubau City as many as kelurahan. Each ward is represented by 40 households so a total of 1,720 households become the survey targets. The sampling method for each ward used was simple random sampling.

Recap of research data using the SPSS version 20.2 application, then an analysis is carried out to determine the level of risk using the interval method, the level of risk is divided into 4 levels, namely less risk, medium risk, high risk, and very high risk. The value used to determine the level of risk is the water sources consumed community value that is not good for each variable, then a percentage calculation is carried out. The percentage value is then taken as the highest and lowest values among all villages and then divided into 4 levels of risk so that the interval value is obtained. This interval value will determine the value of 4 levels of risk so that i is known the level of water sources consumed community risk for each ward that is the target of the survey. Results of this risk level calculation are processed with the Geographic Information System application using QGIS Version 3.26.0, resulting in a water ssources consumedcommunity risk level map with color gradations according to each risk level. Determination of the level of risk based on variables related to water sources in the Environmental Health Risk Assessment (EHRA) Study.

3. Results and discussion

3.1. Protected Water Source

Several types of water sources that are declared protected, such as protected wells, are water that comes from the excavated soil and the circumference of the well is protected by a wall at least 0.8 meters above the ground and 3 meters below the ground, and there is a cement floor as far as 1 meter from the ground. Circumference of wells, Protected springs are sources of ground surface water where water arises by itself and is protected from water that has been used, used for bathing, washing, or others.

Water sources consumed by the community should meet health requirements and be protected from pollutant sources. Most of the clean water sources consumed by the people in Baubau City are protected from pollutant sources, but there is still a small portion of the water sources that are consumed at risk of contamination because they are not protected. Water sources that are at risk of being polluted, even though they are few, can impact many people if they use the water. A bigger impact also occurs if the source of the polluted water is a communal water source, which can be used by almost all residents in the location.

Table 1 Distribution of Respondents Based on Protected Water Sources at Baubau City in 2021

Code	Village	Protected Water Source		Not Protected Water Source		Total	
		Amount (n)	Percentage (%)	Amount (n)	Percentage (%)	Amount (n)	Percentage (%)
001	Bataraguru	34	85.0	6	15.0	40	100.0
002	Batulo	31	77.5	9	22.5	40	100.0
003	Bukit Wolio Indah	36	90.0	4	10.0	40	100.0
004	Kadolo Katapi	37	92.5	3	7.5	40	100.0
005	Tomba	31	77.5	9	22.5	40	100.0
006	Wale	24	60.0	16	40.0	40	100.0
007	Wangkanapi	37	92.5	3	7.5	40	100.0
008	Bugi	40	100.0	0	0.0	40	100.0
009	Gonda Baru	40	100.0	0	0.0	40	100.0
010	Kaisabu Baru	39	97.5	1	2.5	40	100.0
011	Karya Baru	37	92.5	3	7.5	40	100.0
012	Baadia	40	100.0	0	0.0	40	100.0
013	Lamangga	40	100.0	0	0.0	40	100.0
014	Melai	38	95.0	2	5.0	40	100.0
015	Tanganapada	37	92.5	3	7.5	40	100.0
016	Wajo	28	70.0	12	30.0	40	100.0
017	Kalia-Lia	38	95.0	2	5.0	40	100.0
018	Kantalai	37	92.5	3	7.5	40	100.0
019	Kolese	39	97.5	1	2.5	40	100.0
020	Lowu-Lowu	28	70.0	12	30.0	40	100.0
021	Palabusa	30	75.0	10	25.0	40	100.0
022	Kadolo	38	95.0	2	5.0	40	100.0
023	Kadolomoko	40	100.0	0	0.0	40	100.0
024	Lakologou	40	100.0	0	0.0	40	100.0
025	Liwuto	36	90.0	4	10.0	40	100.0
026	Sukanayo	33	82.5	7	17.5	40	100.0
027	Waruruma	40	100.0	0	0.0	40	100.0
028	Kampeonaho	37	92.5	3	7.5	40	100.0
029	Liabuku	37	92.5	3	7.5	40	100.0

030	Ngkari-Ngkari	36	90.0	4	10.0	40	100.0
031	Tampuna	12	30.0	28	70.0	40	100.0
032	Waliabuku	0	0.0	40	100.0	40	100.0
033	Katobengke	24	60.0	16	40.0	40	100.0
034	Labalawa	37	92.5	3	7.5	40	100.0
035	Lipu	12	30.0	28	70.0	40	100.0
036	Sulaa	30	75.0	10	25.0	40	100.0
037	Waborobo	33	82.5	7	17.5	40	100.0
038	Bone-Bone	40	100.0	0	0.0	40	100.0
039	Kaobula	38	95.0	2	5.0	40	100.0
040	Lanto	30	75.0	10	25.0	40	100.0
041	Nganganaumala	34	85.0	6	15.0	40	100.0
042	Tarafu	35	87.5	5	12.5	40	100.0
043	Wameo	36	90.0	4	10.0	40	100.0
	Kota Baubau	1,439	83.7	281	16.3	1,720	100.0

Source : Primary Data 2021

The development and protection of water sources should be one of the considerations in spatial planning. Areas with strategic water sources linked to downstream areas offer opportunities to achieve synergies in spatial planning across various policy sectors and enable new patterns of collaboration between government, business, and civil society [8]. Water sources that are not protected not only have an impact on humans but also have an impact on livestock. The role of natural water as a source of infection for livestock can cause the spread of disease, for daily purposes, it is advisable to use water tanks with a freshfreshwaterly to prevent future outbreaks in animals and humans [9].

3.2. Safe Use of Water Sources

Most people in Baubau City use clean water sources, but there are still many people who use unsafe water sources 46.5% of the total respondents. This situation needs special attention for the community, together with the government to improve the health status of the people in Baubau City. Great risk can occur if this situation is not taken seriously. The existence of industry around drinking water sources can be a source of pollution and can cause water to be unsafe for consumption. For example, drilling shale gas wells can have a negativehurtwater quality and infant health. These results demonstrate the large social costs of pollution water and provide imfortfor to the government to review public drinking water regulations [10**].**

Table 2 Distribution of Respondents by Use of Safe Water Sources at Baubau City in 2021

Code	Village	Use Water Sources Safe		Use Water Sources Not Safe		Total	
		Amount (n)	Percentage (%)	Amount (n)	Percentage (%)	Amount (n)	Percentage (%)
001	Bataraguru	15	37.5	25	62.5	40	100.0
002	Batulo	15	37.5	25	62.5	40	100.0
003	Bukit Wolio Indah	8	20.0	32	80.0	40	100.0
004	Kadolo Katapi	40	100.0	0	0.0	40	100.0
005	Tomba	9	22.5	31	77.5	40	100.0
006	Wale	4	10.0	36	90.0	40	100.0
007	Wangkanapi	11	27.5	29	72.5	40	100.0

008	Bugi	40	100.0	0	0.0	40	100.0
009	Gonda Baru	40	100.0	0	0.0	40	100.0
010	Kaisabu Baru	25	62.5	15	37.5	40	100.0
011	Karya Baru	27	67.5	13	32.5	40	100.0
012	Baadia	24	60.0	16	40.0	40	100.0
013	Lamangga	8	20.0	32	80.0	40	100.0
014	Melai	19	47.5	21	52.5	40	100.0
015	Tanganapada	2	5.0	38	95.0	40	100.0
016	Wajo	7	17.5	33	82.5	40	100.0
017	Kalia-Lia	37	92.5	3	7.5	40	100.0
018	Kantalai	38	95.0	2	5.0	40	100.0
019	Kolese	39	97.5	1	2.5	40	100.0
020	Lowu-Lowu	39	97.5	1	2.5	40	100.0
021	Palabusa	36	90.0	4	10.0	40	100.0
022	Kadolo	14	35.0	26	65.0	40	100.0
023	Kadolomoko	40	100.0	0	0.0	40	100.0
024	Lakologou	35	87.5	5	12.5	40	100.0
025	Liwuto	7	17.5	33	82.5	40	100.0
026	Sukanayo	24	60.0	16	40.0	40	100.0
027	Waruruma	19	47.5	21	52.5	40	100.0
028	Kampeonaho	35	87.5	5	12.5	40	100.0
029	Liabuku	35	87.5	5	12.5	40	100.0
030	Ngkari-Ngkari	32	80.0	8	20.0	40	100.0
031	Tampuna	40	100.0	0	0.0	40	100.0
032	Waliabuku	0	0.0	40	100.0	40	100.0
033	Katobengke	15	37.5	25	62.5	40	100.0
034	Labalawa	36	90.0	4	10.0	40	100.0
035	Lipu	17	42.5	23	57.5	40	100.0
036	Sulaa	3	7.5	37	92.5	40	100.0
037	Waborobo	29	72.5	11	27.5	40	100.0
038	Bone-Bone	12	30.0	28	70.0	40	100.0
039	Kaobula	4	10.0	36	90.0	40	100.0
040	Lanto	18	45.0	22	55.0	40	100.0
041	Nganganaumala	5	12.5	35	87.5	40	100.0
042	Tarafu	17	42.5	23	57.5	40	100.0
043	Wameo	1	2.5	39	97.5	40	100.0
	Kota Baubau	921	53.5	799	46.5	1,720	100.0

Source : Primary Data 2021

Currently, some people have switched to using bottled water for cooking and drinking needs. This situation makes the refill water business mushrooming. So that refilled water is safe, strict supervision is needed by the government, especially the Health Office to ensure the quality of drinking water and safe for consumption by the community. Consumption of beverages using packaged bottles has risks. Drinks in bottled bottles can contain HPC (Heterotrophic Plate Count) bacteria, where their presence is an indicator of drinks containing heterotrophic microbes and bacteria. Under certain circumstances, HPC bacteria can increase public health risks, affect individuals with inappropriate use of bottled water, or cause health problems in immunocompromised patients [11].

3.3. Scarcity of Clean Water

Table 3 Distribution of respondents Based on Clean Water Scarcity at Bau-Bau City in 2021

Code	Village	Experience Clean Water Scarcity		Not Experience Clean Water Scarcity		Total	
		Amount (n)	Percentage (%)	Amount (n)	Percentage (%)	Amount (n)	Percentage (%)
001	Bataraguru	2	5.0	38	95.0	40	100.0
002	Batulo	13	32.5	27	67.5	40	100.0
003	Bukit Wolio Indah	17	42.5	23	57.5	40	100.0
004	Kadolo Katapi	10	25.0	30	75.0	40	100.0
005	Tomba	4	10.0	36	90.0	40	100.0
006	Wale	1	2.5	39	97.5	40	100.0
007	Wangkanapi	11	27.5	29	72.5	40	100.0
008	Bugi	0	0.0	40	100.0	40	100.0
009	Gonda Baru	2	5.0	38	95.0	40	100.0
010	Kaisabu Baru	12	30.0	28	70.0	40	100.0
011	Karya Baru	20	50.0	20	50.0	40	100.0
012	Baadia	0	0.0	40	100.0	40	100.0
013	Lamangga	6	15.0	34	85.0	40	100.0
014	Melai	38	95.0	2	5.0	40	100.0
015	Tanganapada	0	0.0	40	100.0	40	100.0
016	Wajo	9	22.5	31	77.5	40	100.0
017	Kalia-Lia	31	77.5	9	22.5	40	100.0
018	Kantalai	19	47.5	21	52.5	40	100.0
019	Kolese	32	80.0	8	20.0	40	100.0
020	Lowu-Lowu	16	40.0	24	60.0	40	100.0
021	Palabusa	7	17.5	33	82.5	40	100.0
022	Kadolo	24	60.0	16	40.0	40	100.0
023	Kadolomoko	7	17.5	33	82.5	40	100.0
024	Lakologou	1	2.5	39	97.5	40	100.0
025	Liwuto	26	65.0	14	35.0	40	100.0
026	Sukanayo	5	12.5	35	87.5	40	100.0
027	Waruruma	6	15.0	34	85.0	40	100.0

028	Kampeonaho	2	5.0	38	95.0	40	100.0
029	Liabuku	0	0.0	40	100.0	40	100.0
030	Ngkari-Ngkari	0	0.0	40	100.0	40	100.0
031	Tampuna	11	27.5	29	72.5	40	100.0
032	Waliabuku	17	42.5	23	57.5	40	100.0
033	Katobengke	15	37.5	25	62.5	40	100.0
034	Labalawa	0	0.0	40	100.0	40	100.0
035	Lipu	6	15.0	34	85.0	40	100.0
036	Sulaa	18	45.0	22	55.0	40	100.0
037	Waborobo	0	0.0	40	100.0	40	100.0
038	Bone-Bone	0	0.0	40	100.0	40	100.0
039	Kaobula	3	7.5	37	92.5	40	100.0
040	Lanto	7	17.5	33	82.5	40	100.0
041	Nganganaumala	4	10.0	36	90.0	40	100.0
042	Tarafu	6	15.0	34	85.0	40	100.0
043	Wameo	6	15.0	34	85.0	40	100.0
	Kota Baubau	414	24.1	1,306	75.9	1,720	100.0

Source : Primary Data 2021

Scarcity of water results in many people's need for water that is sold both offline and virtual. Virtual water trade should be geared towards becoming more adaptable to sustainable development rather than allowing water-scarce regions to pursue economic development at the expense of scarce water resources [12]. Based on data obtained by the people of Baubau City in general, they do not experience water scarcity, namely 1,306 (75.9%) of 1,720 respondents. However, there are still people who experience a water scarcity of 24.1%. Water scarcity will be a big problem because water is one of the basic needs that people need every day for their survival.

Good water management will determine the water supply to the community so that the community does not experience water scarcity problems. The water supply must be adjusted to the needs. In the commu,nity there can be alscompetingition for the use of water. For example, water sourced from rivers will result in competition for water use both downstream and upstream. Information on increasing competition in water use across sectors between upstream and downstream areas, the results provides useful information for developing adaptation strategies towards sustainable water management [13] [14].

3.4. Risk Level of Clean Water Source

Risk area assessment is calculated by taking variables that have bad values, namely the answers No on protected water sources (A), No on safe water sources (B), and Yes on clean water scarcity (C). Each variable used the value of the proportion of each variable including risk, then each variable was given weight. Variable protected water sources and the use of safe water sources are given a weight of 25% and clean water scarcity is assigned a weight of 50% [15]. Index value risk area used the formula:

$$Risk\ Index = (A\ x25\%) + (B\ x25\%) + (C\ x50\%)$$

From the value obtained, the interval value is calculated using the formula:

$$\frac{Maximum\ Value\ +\ \text{Minimum}\ Value}{Number\ of\ Risk\ Level}$$

$$\frac{71 + 0}{4} = 18$$

interval value is obtained 18. From the interval value, the range of risk level values is obtained as follows:

Table 4 Range of Values for Risk Area Categories

Code	Risk Area Level	Minimum	Maximum
1	Low Risk	0	18
2	Medium Risk	19	37
3	High Risk	38	55
4	Very High Risk	56	74

The level of risk of water sources in Baubau City can be seen in the following table:

Table 5 Risk Area Categories in Baubau city

Code	Village	Index Risk	Risk Level
001	Bataraguru	22	Medium Risk
002	Batulo	24	Medium Risk
003	Bukit Wolio Indah	38	Medium Risk
004	Kadolo Katapi	44	High Risk
005	Tomba	14	Low Risk
006	Wale	30	Medium Risk
007	Wangkanapi	34	Medium Risk
008	Bugi	0	Low Risk
009	Gonda Baru	3	Low Risk
010	Kaisabu Baru	25	Medium Risk
011	Karya Baru	35	Medium Risk
012	Baadia	10	Low Risk
013	Lamangga	28	Medium Risk
014	Melai	62	Very High Risk
015	Tanganapada	26	Medium Risk
016	Wajo	39	High Risk
017	Kalia-Lia	42	High Risk
018	Kantalai	27	Medium Risk
019	Kolese	41	High Risk
020	Lowu-Lowu	28	Medium Risk
021	Palabusa	18	Low Risk
022	Kadolo	48	High Risk
023	Kadolomoko	9	Low Risk
024	Lakologou	4	Low Risk
025	Liwuto	56	High Risk
026	Sukanayo	21	Medium Risk

027	Waruruma	21	Medium Risk
028	Kampeonaho	8	Low Risk
029	Liabuku	5	Low Risk
030	Ngkari-Ngkari	8	Low Risk
031	Tampuna	31	Medium Risk
032	Waliabuku	71	Very High Risk
033	Katobengke	44	High Risk
034	Labalawa	4	Low Risk
035	Lipu	39	High Risk
036	Sulaa	52	High Risk
037	Waborobo	11	Low Risk
038	Bone-Bone	18	Low Risk
039	Kaobula	28	Medium Risk
040	Lanto	29	Medium Risk
041	Nganganaumala	31	Medium Risk
042	Tarafu	25	Medium Risk
043	Wameo	34	Medium Risk

Based on the results of the calculation of the risk level above, a map of the risk area for polluted water sources in Baubau City is produced as follows:

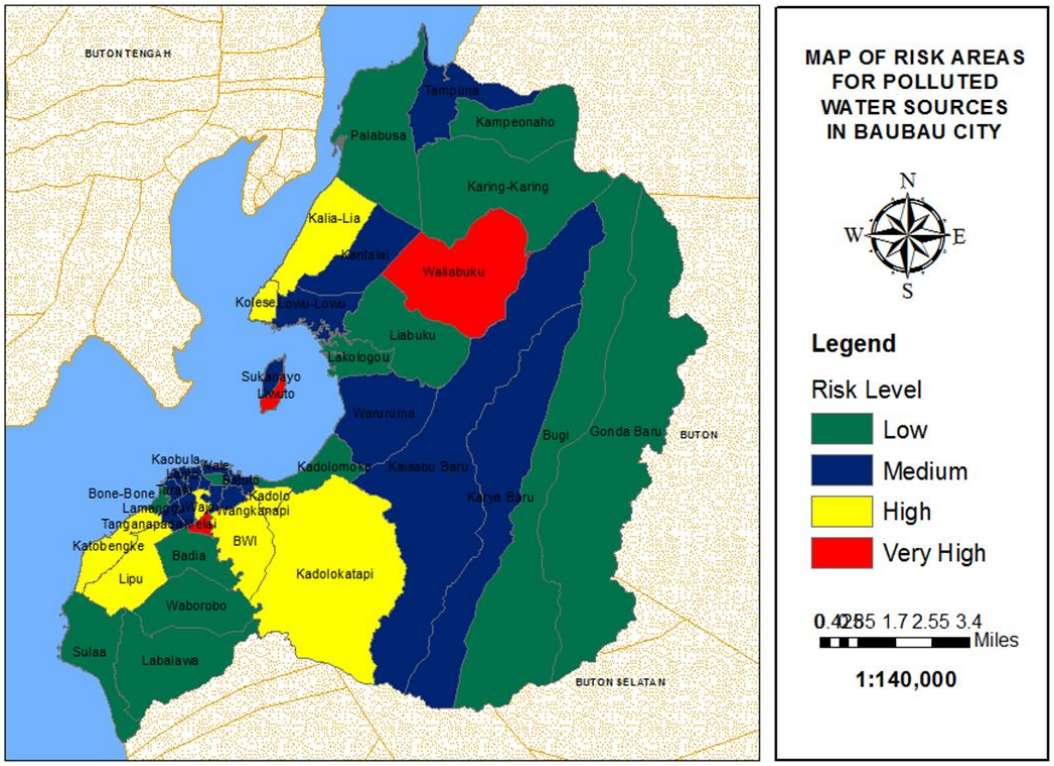

Figure 1 Map of Polluted Water Resources Risk Areas at Bau-Bau City in 2021

Based on the calculation results, 13 villages were declared low risk, namely Palabusa, Bone-Bone, Tomba, Waborobo, Baadia, Kadolomoko, Kampeonaho, Ngkari-Ngkari, Liabuku, Lakologou, Labalawa, Gonda Baru, and Bugi. The 19 sub-districts at moderate risk are Bukit Wolio Indah, Karya Baru, Wameo, Wangkanapi, Tampuna, Nganganaumala, Wale, Lanto, Lowu-Lowu, Lamangga, Kaobula, Kantalai, Tanganapada, Kaisabu Baru, Tarafu, Batulo, Bataraguru, Sukanayo, and Waruruma. 9 high- risk villages, namely Liwuto, Sulaa, Kadolo, Katobengke, Kadolo Katapi, Kalia-Lia, Kolese, Wajo, and Lipu. Meanwhile, 2 sub-districts are at very high risk, namely Waliabu and Melai sub-districts.

Villages with a very high-risk level are the priority areas for intervention. The community in Waliabuku Village uses water from unprotected water sources, so there is a high risk of public health problems, while the Melai Village community experiences a scarcity of clean water.

Risk information is examined through a general decision-making process, and identified serves to detect and characterize risk-related decision problems, indicate the severity and urgency of decisions, state requirements, and workable solution constraints, represent attributes for comparing and evaluating solutions, and act as a rule for maintaining safety or control risk. The use of this risk information in different decision problems implies great diversity in the information requirements for decision-making. Thus, adaptive information support is suggested to provide targeted risk information to specific decision-makers for effective and efficient decision-making in accident prevention in the process industry [16].

4. Conclusion

Most of the villages in Baubau City are at medium risk of water source contamination, a few are at high risk and very high risk. The people of Baubau City must pay attention to the cleanliness of the environment around water sources and protect water sources so that they are not polluted by both bacteria and hazardous materials. Baubau City government should prioritize areas that have a very high-risk level for intervention related to the provision of clean water.

Compliance with ethical standards

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Disclosure of conflict of interest

All authors in the making of this scientific article have no conflict of interest.

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