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Environmental risk analysis of The Bedadung Watershed By Using DPSIR

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Abstract. Bedadung River is one of the most strategicrivers located in the Bedadung Watershed in Jember. This river crosses Jember with a length of 46,875 meters and it is used as a source of raw water and irrigation as well as a source for PDAM in Jember. Along with many activities of the community, the water pollution load increases significantly. In general, the source of pollution comes from anthropogenic activities in the form of exposure to domestic waste, industrialization, population growth, pesticides and fertilizers, organic and inorganic waste, urban development and weak management systems. This study aims to analyze the environmental risks in the bedadung watershed based on water quality data using DPSIR method.The DPSIR (Driver-Pressure-State-Impact-Response) framework has been used as one of the tools in environmental risk analysis that shows the existence of linear interactions between human activities-pressure and impact. In general, human activities are part of the drivers and human needs that can cause pressure on the environment.This pressure has the potential to cause certain negative impacts that need handling to reduce it. The DPSIR framework which being used is Driver (industry, garbage); Pressure (changes in the chemical composition of water); State (physical and chemical characters); Impact (changes in water quality); and Response (limiting waste disposal to rivers).

1. Introduction

The construction and development of a certain area can be seen from society towards the targetted progress.It is the consequences in promoting social, economic and physical of a region itself.In the developmentimplementationover time, the role or function of the land as the "scope" area of development assistance is very essential to this case. Hence it is also closely related to the availability of the water needs. Water plays an important role in people's lives in various aspects. The demands for the needs of the population to achieve a higher level of prosperity are increasing, so that the volume and type of activitiesrequire more spaces. Therefore, environment is dynamic, in order to survive in such kind of condition, all the living creatures need toadapt themselves[1] the form of an environmental adaptation is the management of water resources[2].In general, water resources management can be classified into planning, developing, distributing water resources optimally both in terms of quality and quantity [3], [4].

Watershed is one of the important parts in supporting the availability of water for a certain region because its function is to collect, to store and to drain water from rainfall to lakes or to the sea naturally[5].The Bedaung watershed islocated in Jember.The largest river is the BedadungRiver which crosses Jemberalong 46,875 meters and is able to irrigate 93,000 hectares of paddy fields[6]it is functioned as a source of clean water supply for community and one of the raw water sources for PDAM in Jember[7]. In addition, people use this river to wash, to have bathing and to dothe other toilet activities[8]–[10].

Pollution load is the amount of a pollutant contained in water or waste. The amount of this pollution load greatly affects the water quality and it can be an indicator of whether the water is polluted or not. Obviously, the potential domestic waste is a household waste which waste is disposed of in sewers withinthe river basin watershed, while real domestic waste is household waste from which waste is discharged directly into the main river or through waterways that directly lead to the main river [11]. However, the water quality of the Bedadung River has been physically polluted, so that it is not allowed to be used as a source of clean water. It belongsto the category IV in 2010, and it is predicted to receive pollutants from domestic and irrigation activities sequentially in the amount of 30,853,565.80 m3 / year and 313.14 m3 / year[12], [13] Every chemical-biological and physical change from water which can adversely affect organisms is the contamination of water which comes from waste from houses, hospitals, chemical factories, remnants of artificial fertilizers, pesticides and so on [11], [14], [15]. If the management of water quality and wastewater management is weak, it will further increase the potential for the water sources and water bodies to be polluted [16], [17].

Environmental Risk Analysis (ARL) is the process of estimating or assessing risks in organisms, systems, or populations (sub) with any uncertainty that accompanies them, after being exposed by certain agents, taking into account the characteristics of agents and specific targets and determining justification for taking remediation steps or transfering the contaminants [18]–[22].Some of the factors that cause environmental risks areincluding dirty water, sanitation and hygiene; urban air pollution; indoor smoke from solid fuel; lead exposure; and climate[23].

The DPSIR conceptual framework / Driving Force-Pressure-State-Response is utilized to diagnose, to predict, and to monitor the management of aquatic ecosystems and mitigate harmful impacts on the aquatic environment[24]–[26].The DPSIR framework assumes that social, economic, and environmental conditions are interrelated and shown by the driving force that conceptually causes environmental changes by creating pressure on the environment [27]–[29].Bedadung River is the source of raw water for the Regional Water Company of Jember Regency, but previous research revealed that urban activities in Jember Regency increased the potential for Bedadung River pollution to reach the heavily polluted point of the Patrang, Sumbersari, Kaliwates and MangliSub-District [30].To make the Bedadung river a source of raw water, these pressures must be reduced.This study analyzes environmental risks in the Bedadung River Basin based on community activities around the river and potential pollution that occurs in the Bedadung River.Previous research carried out in the Bedadung River Basin was only about evaluating the chemical physical conditions.This study aims to analyze the environmental risks that occur in these three districts' segments using DPSIR framework.

2. Methods

This research isconductedin the Bedadung River, especially in the Bedadung watershed. The research location of the upstream Bedadung River is located in Patrang, Sumbersari and KaliwatesSub-Districts. Researcherconductedthis research in April 2019 – Juni 2019.

This research is conducted by collecting some referencesabout the current situation of the Bedadung watershed to determine the newest condition of Bedadung River. The study is done by searching the

literature references related to water quality, people's behavior around the river Bedadung and the updated regulations inBedadungriver.The research area can be seen on figure 1 below.

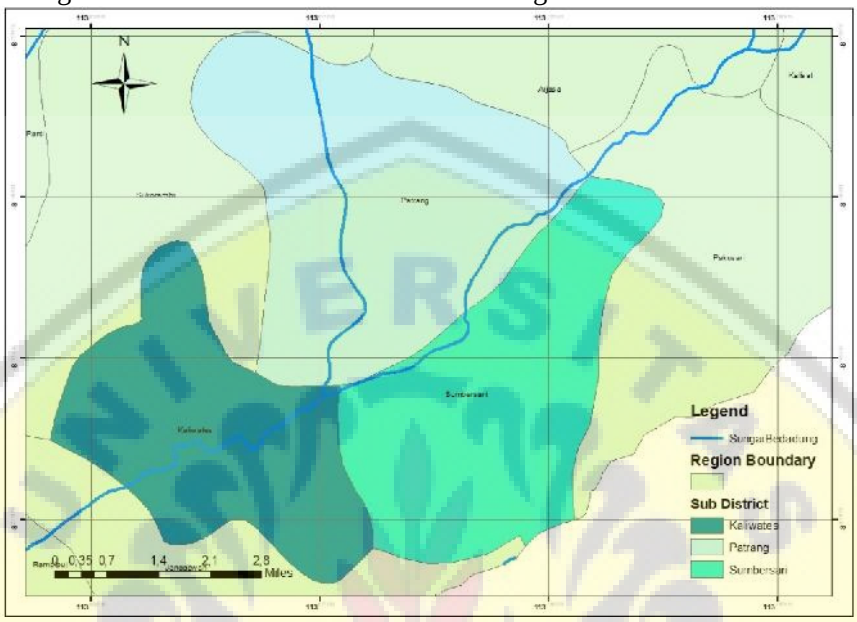

Figure 1. Research Location Map

2.1 DPSIR Framework

Driving Force, Pressure, State, Impact and Response (DPSIR)belong to the development of analytical models PSR (Pressure State-Response). Analysis is carried out to understand the condition of the elements forming space and the causal relationship of the conditions formation in the space area, which later will be taking to the existing regional development policies. The analysisincludesthe current conditions and trends in the future with the data and information collected in the process of studying literature and information. DPSIR Framework consists of 5 parts, namely;

a. Driving Force
   It explains about some issues that have been developing atthe society. Driving Force is a human activity that leads to various activities that makes an extra pressure on the envirosnment.
b. Pressure
   It denotes how some problems occurred. Pressure is the result of the production or consumption process caused by the presence of driving force of human activities in order to fullfill their needs. The level of pressure on the environment depends on driving force and other factors that are related to human and environmental interactions.
c. State (A Current Condition)
   A state shows the comparation of the previous state and the current situationof the environment at the moment. State (A Current Condition) is the result of a certain pressure on the environment in a certain area. State is a physical, chemical and biological condition of a certain area, such as; pollution, degraded resources, and many others.
d. Impact
   Impactis a condition after a certain problem happened.State changes some impacts on the environment, health and socio-economic conditions of society.
e. Response
   Response is a feed back which must be done to overcome certain problems that usually involve the stakeholders. The response of a community or policy makers is the result of an unwanted impact. It

obviously can affect every part of the causal relationships' chain from the trigger's factors to the impacts that occur on the environment.

The chart below shows the DPSIR framework adopted from the European Environment Agency (EEA).

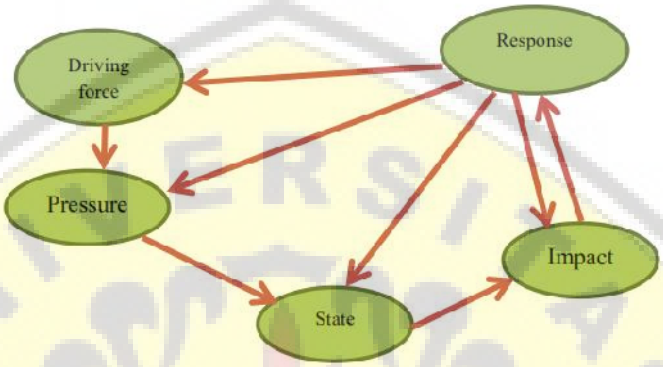

Figure 2. DPSIR Framework[25]

3. Result and Discussion

The DPSIR framework assumes that social, economic and environmental conditions are things that are interconnected. This connection is shown by the driving force that conceptually causes environmental changes by creating pressure on the environment. In turn, this will affect environmental conditions. The impact that emerges can be in the form of impacts on ecosystems, the economy, and also the community. A negative impact that arises will be responded by the community in various ways, taken example, by formulating policies on governance and protection of water resources. If the policy are made, it will give a certain effect (whether it is purposed or not),then it will affect the driving force, pressure, state and impact.DPSIR Analysis of Bedadung Watershed has been compiled based on each of the problems and issues that develop in the community as a trigger factor and strategy formulation in response.

In Jember Regional Regulation Number 1 of 2015 which concerns about Regional Spatial Planning (RTRW), it is stated that in 2015-2035, the planned system of activities in the Patrang and Sumbersari Districts would be used as an urban system in Jember. As the population increases and community activities vary, the potential for pollution increases. Community activities that are usually carried out in the bedadung river vary, such as bathing, washing latrines and garbage disposing in the river [31]. The ironic fact is that the Bedadung river water is still utilized by the Regional Drinking Water Company (PDAM) of Jember Regency as a source of raw water. In addition, people around Bedadung river also consume the river fish. They take the fish for self-consumption and for sale [31].

Table 1. The Criteria for Water Quality Based on Classes according to Government Regulation Number 82 of 2001

No.	Parameter	Unit	Class				Comments
			I	II	III	IV	
1	TSS	mg/L	50	50	400	400	For conventional drinking water treatment, suspended residues ≤ 5000 mg / L

2	pH		6 – 9	6 - 9	6 – 9	5 - 9	If naturally out of the range, it is determined based on natural conditions
3	BOD	mg/L	2	3	6	12	
4	COD	mg/L	10	25	50	100	
5	DO	mg/L	6	4	3	0	

Source:[32][33]

Table 2. Value of River Water Pollution

No.	**Name of River**	**pH**	DO (mg/l)	BOD (mg/l)	COD (mg/l)
1	Bengawan Solo	7.8	2.7	6.5	14
2	Bedadung	6.9	5.4	5.0	11
3	Sampean	7.0	4.1	6.1	20
4	Kali Baru	6.7	4.1	5.0	4

Source: [34]

Values of pH, DO, BOD and COD Bedadung river is still in the third grade so it is still feasible to be used as drinking water. However, we must maintain the water quality, so that it continues to increase because if it is left unchecked, the quality of the bedadung water will be decreasing over time.Overall, the DPSIR framework in the Bedadung River is presented in Figure 3 with detailed explanation in the sections that are presented below.

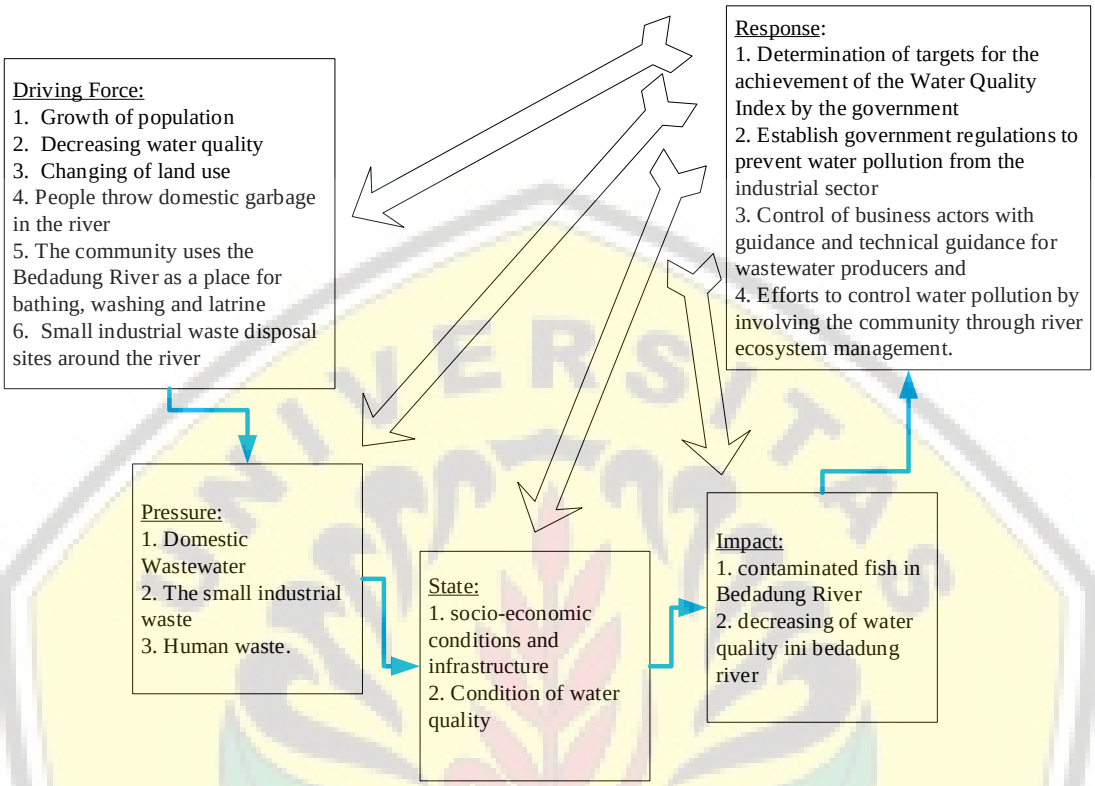

Figure 2. DPSIR Framework in Bedadung River

3.1. Driving Force

There are some issuesrelated to the development at the society which areexplained in Driving force. All activities that can put pressure on the environtmentwhich come from human activities is called as a driving force. Driving force at Bedadung River are shownin Figure 3.

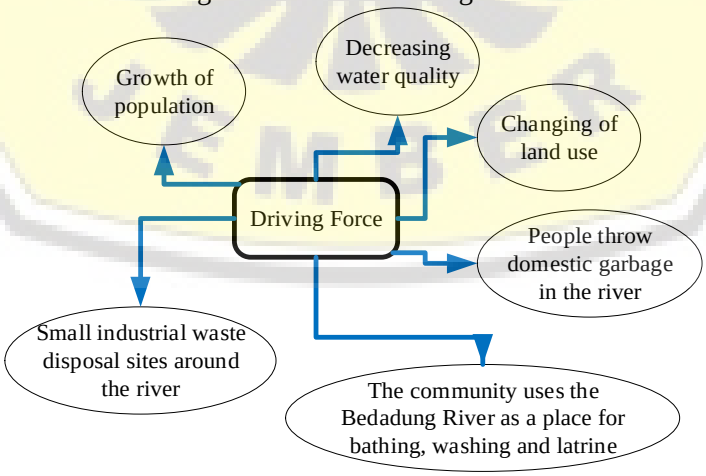

Figure 3. Driving Force in Bedadung River

Another driver that also becomes a trigger is shown by the number of population in the three sub-districts which are quite large. The population of Jember reaches 2,430,185 people with the population density reaches 735 people / km2 [10]. The population in Patrang is 98,419 people [35], Sumbersari with 131,554 people [36], and Kaliwates with 116,535 people [37]. The three sub-districts have high densities which reach 2660.66 people / km^2 for Patrang District, 3550.74 people / km^2 for Sumbersari and 4672.60 people / km^2 for Kaliwates. This population density affects the amount of waste, it is the waste which comes from activities carried out by the community such as; washing and bathing. Besides, the river is also the place of disposal waste that can pollute the river [38]. The population is functioned as a driving force because peopleuse the water to drink. The water needs increases as the more people consume it daily. In fact, human needs to drinking the water reach 2.5 to 3 liters per day, it can be seen in the table below.

Table 3. Simplified table of water requirements for survival (per person)

Type of need	**Quantity**	**Comments**
Survival (drinking and food)	2.5 to 3 lpd	Depends on climate and individual physiology
Basic hygiene practices	2 to 6 lpd	Depends on social and cultural norms
Basic cooking needs	3 to 6 lpd	Depends on food type, social and cultural norms
Total	**7.5 to 15 lpd**	Lpd:Liter per day

Source: [39]

Driving Force also leads to a variety of activities that can put pressure on the environment such as the need for shelter, food and drinks.Along with the population growth, the need for shelter leads to the exploitation of natural resources. There is a significant effect of land use on a discharged peak. The area of land use has a significant effect on a discharged peak, namely a land that has been utilized for the buildings and the empty land. Land use that mostly influence the discharged peak is the built land [40]. In conclusion,the discharged peak will increase along with the increasing built land in the three sub-districts. The Bedadung River is physically polluted, it cannot be functioned as a source of clean water. Bedadung River belongs in category class IV in 2010, and it is predicted to receive pollutants from some domestic activities and irrigation approximately around 843.565,80 m^3/year and 313,14 m^3/year [12], [41]. This problem also increases the environmental risk in Bedadung River.Besides domestic waste and irrigation, the industrial waste also contributes to decrease the water quality in Bedadung River. Some industrial wastes are throwninto the river Bedadungincludingtempe industrial waste, laundry waste, ink, thinner and oil waste[42].

3.2. Pressure

Pressure is the result of the production or consumption process caused by the presence of driving force of human activities to fullfill their daily needs. The level of pressure on the environment depends on its driving force and the other factors that are related to human and environmental interactions. Some of the pressure on the Bedadung river are based on the driving force which is described below. It can be seen in Figure 4.

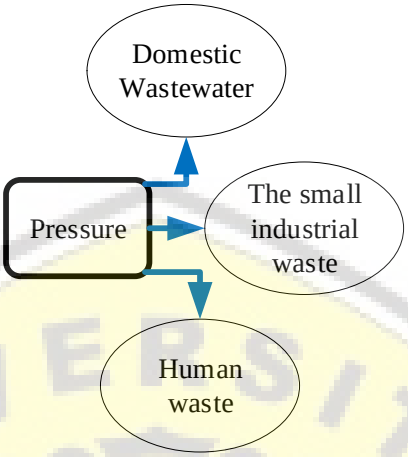

Figure 4. Pressure in Bedadung River

The main cause of the decereasing water quality is waste water, from which the main pollutant sources are domestic wastewater and industrial wastewater. The amount of domestic wastewater dependson the number of residents in a certain region. It can be seen from the projections of the population in Patrang, Sumbersari and Kaliwates Sub-districts. Almost 348,408 people live in those three sub-districts. It obviously increases the potential domestic wastewater hence their activities must be much more dense. The higher the amount of waste water, the lower the possibility for the water to be used as a drinking water.

Human waste makes the water quality got worse. The impact of water quality depends on the quality of water that is impacted by the composition and concentration of chemicals in wastewater. Some of the effects that have always been the topic to discuss are the increased nutrient content and bacterial pollution [43]. Nutrient is one component in the food that an organism needs to grow. Excess nutrient in water (eutrophication) causes hypoxia (lack of oxygen). Hypoxia occurs because the aquatic ecosystem experiences excess production which is characterized by an algal explosion. Hypoxia can cause a mass death of fish. In addition, one of the genera Cyanobacteria, Mycrocystis, contains microcystin which is toxic to both humans and fish. A Microcystin poisoning in humans can cause a failure of the liver function and it often leads to death [27].

3.3. State

State (Existing Condition) is the result of pressure on the environment in a certain area. State can be defined as a current physical, chemical and biological condition of a certain area such as pollution, degraded resources and many others. The area around Bedadung river is a region that is socio-economically well developed. It is proved by the good irrigation infrastructure with a high availability of water[44]. Although in the table 2 shows that the water quality of Bedadung river still meets the existing quality standards, namely the pH values of DO, BOD, and COD, each of them is 6.9; 5.4 mg / l; 5.0 mg / l; 11 mg / l. Munandar research states that from the AAS test results on broom fish caught in the Bedadung river showed that the average Pb heavy metal content is 0.2563 ppm and the content of Cd is 0.172 ppm. The Pb heavy metal for food (fish) and the processed products is still below the maximum threshold. Whereas, the heavy metals Cd for food (fish) and the processed products exceeds the maximum threshold are based on SNI 7387: 2009. Although the heavy metal Pb is still below the maximum threshold, it still remains as a serious concern [31].

3.4 Impact

When people areallowedto continuously doing the bad behavior in utilizing the bedadung river, such as; throwing their domestic waste, taking bath, washing,doing the other toilet activities, and even throwing the industrial garbage to the Bedadung River, it will absolutely be worsening the condition of the Bedadung River. Moreover, the water quality in Bedadung river got worse and the Bedadung river will not be aesthetically beautiful. The reduced quality of water in the Bedadung River will also have an impact on its biota.There are 5 types of fish caught in the BedadungJember river, namely: 1) plecos fish (Hypostomusplecostomus), 2) Tilapia (Oreochromis niloticus), and 3) silver rasbora fish (Rasbora argyrotaenia), 4) spotted barb fish (Puntius) brammoides), and 5) comet goldfish (Carassius auratus). The fish caught have high economic value, both because of their nutritional content and price. In the study of Mundandar and Eurika, it was found that broom fish caught in the Bedadung River showed that the average heavy metal Pb content was 0.2563 ppm and Cd was 0.172 ppm [45]. Even though the Pb heavy metal is still below the maximum threshold, it still must be a serious concern. This is due to the nature of heavy metals in the food chain is bioaccumulation. As explained by [47] that heavy metals can enter the body tissues of aquatic organisms through the food chain, gills and diffusion through the surface of the skin. Biological accumulation can occur through direct absorption of heavy metals contained in bodies of water, so that aquatic organisms that live in waters are heavily polluted by heavy metals, their tissues will contain high levels of heavy metals as well. As in the study *[31]* which shows that fish in the bedadung river already contained heavy metals. The consumption of fish and processed fish products which are contaminated with heavy metals has a harmful potential to cause various diseases, both in a short and in a long run. Pb and Cd heavy metal poisoning can cause an acute and a chronic poisoning *[31]*. Even though there are some people still do fishing in the Bedadung river, both for their self-consumption and for selling it in the market.

3.5 Response

In order to improve the Water Quality Index, the East Java Provincial Government has set a target for achieving the Water Quality Index in the 2014-2019 RPJMD revised planning document. Water pollution prevention efforts from the industrial sector are carried out by the implementation of Governor Regulation No.72 of 2013 and Governor Regulation No.52 of 2014 concerning Waste Water Quality Standards for Industries and Other Business Activities [46,48].

The business controls need to be done with a specific and technical guidance to the waste water producers. An enforcementof the environmental permits and recommendations in the form of AMDAL, UKL-UPL Law enforcement which is applied to industries that have not fulfilled the provisions in Law No.32 about 2009 Water pollution from the domestic sector (residential settlements and real esatate) can be done by encouraging the manufacture of IPLT and Communal WWTP Water pollution control efforts by involving the community through the management of river ecosystems.

4. Conclusion

The status of the bedadung river isstill in the 3rd class, which means it still meets the requirements to become a raw source for drinking water. However, when the people in the 3 sub-districts still doingsome activities that can pollute the river, such as; bathing, washing latrines and even throwing their domestic and industrial waste, the quality of Bedadung river will absolutely be worsening. Besides, it gives a massive negative impact for both of the environment and the community itself.

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