The Strategies of Sustainable Watershed Management at Bedog Sub-Watershed, Special Region of Yogyakarta

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Abstract. A watershed plays significant roles for maintaining the balance of ecosystem, particularly on the fluvial landform dynamics. Bedog Sub-Watershed as a part of Progo Watershed flows across 11 sub-districts from Sleman and Bantul Regency. This sub-watershed indicates rural-urban characteristics and multi-aspects problems, such as the loss of croplands, a massive land-use changes into built-up area, and the decrease of environmental carrying capacity. On the purposes of preventing the negative aftermaths, this research aimed to create the strategies of sustainable environmental management in case of Bedog Sub-Watershed. This research used secondary data from regional planning products, PODES data, and the relevant literature. Primary data was acquired from in-depth interview with BPDASHL Serayu-Opak-Progo and agricultural-related government agency to gain governmental perspective of watershed management. This research used qualitative descriptive technique to analyse the result of interview. Livelihood assets were calculated by scoring index. The SWOT and DPSIR analysis were conducted to create the relevant strategies implying physical, social-economy, and regional development perspectives in the post-COVID-19 pandemic. The strengthening of government’s institutional aspects was the key to the management followed by necessary comprehensive study in Bedog Sub-Watershed management.

1. Introduction

A watershed has been part of most human life nowadays, starting from home, livelihood, and resources, since it is one of hydrologic basic on this earth [1,2]. Watershed faces many problems and challenges from human activity. Population pressure, loss of croplands, massive land-use changes into built-up area, and environmental carrying capacity depressions have an have decreased the carrying capacity of watersheds [3]. On the top of this case, government should play a significant role to understand the whole dynamic process of watershed development [4]. Every problem faced by watershed must be concerned by the government. It must be understood that watershed affects the livelihood of community as the sources of water, agricultural activity, etc. [5]. The complexity of management appears as the consequences of watershed significant role and the spatial condition across multiple region [5,6]. Further discussion of watershed management will be directed into the previous statement about its problems and challenges in local scale of Indonesia or the other regions [6,7].
In Indonesia, watershed management mostly deals with lack of communication, coordination, and proper regulation [7]. Since the flow of rivers within watershed will cross-over several administrative regions, the affected government must coordinate each other to manage the watershed. This also happens in Bedog Sub-Watershed, a part of Progo Watershed, which flows in Sleman and Bantul Regency, Special Region of Yogyakarta. The complex problem and management of Bedog Sub-Watershed raise along with the urban development in Yogyakarta [8]. The massive land-use change and run-off along with the pollution from agricultural and industrial activity nowadays happen here, making it to be vulnerable of any sources of pollutions and quality degradation. [8–12].

Population continues to increase, causing the activity and the pressure of population on the environment to be higher. It led to the land use conversion, particularly from agriculture towards built-up land. For example, in Godean district, there was conversion of agricultural land to non-agricultural by 168 Ha within 5 years (2014 – 2020) [13]. The decrease around agricultural land causes the carrying capacity is reduced, there is an indication that the utilization of the land exceeds the ability of the carrying capacity of the land so that it becomes inefficient. Bedog sub-watershed has physical-environmental elements, social characteristics, and parties involved in its management practices, requires sustainable environmental management. A combination of SWOT and DPSIR analysis maybe conducted to formulate the strategies [14,15]. The context of sustainability in watershed management may be represented by the balance of ecological system and prevention of continuous degradation in watershed area [16,17]. Thus, this study aims to interrogate comprehensive problems relating to physical and socio-environmental aspects as an attempt to formulate sustainable development and management strategies in Bedog sub-watershed.

2. Methods
This research was conducted in the Bedog Sub-Watershed, Sleman and Bantul Regency. This area has been experiencing massive urban development with continuous land-use change from agriculture land into built-up area [8,18]. As the result of urban expansion process, Bedog Sub-Watershed needs to adapt with the changes of physical and social condition in rural-urban area.

2.1. Object of Study
This research covers all villages and sub-district within the Bedog Sub-watershed. The object of study implying a whole regional planning product and livelihood assets gained from PODES data in 2020. Regional planning products include spatial planning and comprehensive planning were collected. On the other hand, several key informants from BPDASHL Serayu Opak Progo (SOP) as the watershed management institution and agricultural agencies from Sleman (Department of Agriculture, Fisheries and Forestry of Sleman Regency or DP3 Sleman) and Department of Agriculture, Food, Marine and Fisheries of Bantul Regency Bantul (DPKPP Bantul) were selected to provide information about watershed management through in-depth interview process.

2.2. Data Processing and Analysis
This research used primary and secondary data. Primary data were generated by conducting in-depth interviews as a process of digging in depth, open, and free information with problems and research focus and is directed at the research center [19,20]. This process was conducted by interviewing key persons. Several key informants were selected, including the representatives BPDASHL SOP, DP3, and DKPP, to provide information about watershed management in Bedog Sub-Watershed. These agencies were selected since they shall generate reliable information to answer research objectives as their main roles and functional duties (Tugas Pokok dan Fungsi or tupoksi) in managing Bedog Sub-Watershed. Furthermore, this study used descriptive qualitative and quantitative analyses to analyze the data. Qualitative data analyses according to Miles and Huberman (1992) consist of three stages: data reduction, data presentation, and drawing conclusions or verification [20]. The method to test the accuracy of data is by verifying the data (results of in-depth interviews) and then comparing it with the data issued by relevant agencies/services. These secondary data was gained from PODES year 2020 and
regional planning product. PODES data were processed by scoring to get the dominance of livelihood assets. Meanwhile, the planning document were processed and analysed by documentation study. As for the method used to test the level of accuracy of the scoring results, it is done by matching the results with data from other sources that are related. Both primary and secondary data were analysed by using SWOT and DPSIR analysis. The DPSIR in watershed analysed provide vulnerability description along with policy responses [15,21]. This combination composed the strategies of sustainable watershed management.

3. Results and Discussion

Bedog Sub-Watershed management involves cross-border coordination between Sleman Regency and Bantul Regency. The strategies for sustainable management accomplish the complexity of ecological perspective with urban challenge.

3.1. Potencies and Problems Analysis of Bedog Sub-Watershed

Potencies and problems in Bedog Sub-Watershed come from ecological and institutional aspects. Environmental physical and social assets are represented by each region crossed by the sub-watershed. Inter-region approach shown by multi-administrative coordination result in complex management.

3.1.1. Existing planning and condition in Bedog Sub-Watershed.

Sleman Regency Regulation Number 12 of 2012 concerning Spatial Planning of Sleman Regency 2011-2031, it is known that in the sub-district which is included in the administrative boundaries of the Bedog Sub-watershed, it is designated as a protected area and a cultivation area. Protected areas include nature reserves (national parks), zone II disaster areas, zone III disaster areas, and water catchment areas, while the designation for cultivation areas includes national parks, horticulture, food crop agriculture, and settlements. Regional Regulation of Bantul Regency Number 04 of 2011 concerning Spatial Planning of Bantul Regency in 2010-2030 and is detailed in the detailed spatial planning map (RDTR) of the sub-districts traversed by the Bedog Sub-watershed which has a designation in the form of cultivation areas, such as settlement zones, industry, trade and service zones, and agricultural zones.

There are several potencies of Bedog sub-watershed. BPDASHL and their partners have committed to develop the Bedog Sub-watershed by sustainable management approach. They create Bedog Sub-watershed Development Program, a physical aspect development program such as permanent irrigation lines. This program also supports water resources and agriculture development in Sleman Regency, likewise the four spring belts are used to fill clean water and agricultural irrigation. On the other hand, there are community commitment to participate in government programs, like socialization or training, regarding agricultural development and preserving the environment.

Despite the potencies, Bedog Sub-Watershed also faces problems. The change in the function of agricultural land is caused by a shift from the agricultural sector to be non-agricultural sector like industry. It may lead to the decline in ecological functions, including the decrease of carrying capacity of the environment in the Bedog Sub-watershed. The degraded land quality is also caused by the excessive use of inorganic chemicals which have an impact on the soil structure along with agricultural and livestock activities. The source of emissions generated from agricultural activities comes from the use of chemical fertilizers and organic fertilizers (methane and urea emissions).

Population dynamic may become the other problem. The increase in population is in line with the increase in the amount of waste produced. It is difficult to handle the short-term waste using open dumping without any treatment. and there are still at least temporary waste collection facilities (TPS). On the other hand, population may suffer food-stock loss. The decline in food production caused by the loss of agricultural land in the Bedog Sub-watershed. It gets severe since the interest of the younger generation to work in the agricultural sector.

Institutional factors are a key determinant for successful water resource development. The institutional management of natural resources can be divided into 4 aspects: regulators, developers, operators, and users [22]. Efforts to improve the quality of the environment can be done by improving
institutional dimensions of environmental management [23]. Strengthening institutional aspects is a key to the management which will become a driving force for changes in controlling sub-watershed sustainable management. The government’s aspects of Bedog sub-watershed management in this study include related agencies representing the DPKP Bantul, DP3 Sleman, and BPDASHL SOP. The agencies and community are actively involved in various activities, such as coordination meetings and collaborations in the management and development of the Bedog sub-watershed. This is proven by the in-depth interview that is quoted as saying in this paper.

“Our activities at Dinas also improve quality and maintain quantity in Bedog sub-watershed.” (Informant 1: DPPKP Kabupaten Bantul).

“Sub-watershed management is carried out in a coordinated manner by involving relevant agencies, cross-administration and involving community participation” (Informant 3: BPDASHL).

Programs or activities carried out by the DKPP Bantul are implemented not only at the boundaries of the Bedog sub-watershed but also on commodities, land, etc. The management of the Bedog sub-watershed depends on the direction of BAPPEDA by involving the cooperation of various agencies to support the sustainability of the Bedog sub-watershed. The various work programs carried out by each agency in the management of the Bedog Sub-watershed are as follows:

| DPPKP BANTUL | DP3 SLEMAN | BPDASHL |
|--------------|------------|---------|
| Cultivation training, seeding, post training, P3A training, financing for farmers. | Development of physical aspects, rehabilitating irrigation lines and tertiary | Kebun Bibit Rakyat (KBR) activities are carried out independently by community groups with a total of 50,000 seedlings. |
| Construction of physical aspects of irrigation canal construction, construction of dams, assistance for AUSIFAM and SUSABWO (Seloklah Lapang lajar Logam) | LP2B land socialization in the community which began to be institutionalized in 2017 with various schemes (cooperation with FI and UPT BPN Village Extension Center). | The relationship between the management of the Bedog sub-watershed and the surrounding sub-watershed in the management and planning of regional development. |

In accordance with the mandate of Law Number 41 Year 2009, there are protection and realization schemes of Sustainable Food Agricultural Land (LP2B) in Bantul Regency (14,000 Ha) and Sleman Regency (18,434 Ha). Anticipation and efforts to deal with impacts of land conversion in the Bedog sub-watershed covers several instruments. There is coordination and discussion forum implying integrated investment and management between government from Sleman and Bantul Regency.

The policy also involves agricultural sector, like planting productive seeds through KBR, KBD, as well as providing free seeds to communities in the Bedog Sub-watershed. On the other hand, Kasihan and Sewon Sub-regencies became pilot projects in making RDRTK (Perda No. 8 of 2019 for Sewon Regency and Perda No. 9 of 2019 for Kasihan Regency). This action is followed by commitment to carry out various activities such as approaches to farmers.

From an institutional standpoint, Bantul and Sleman Regency have a group of Gapoktan or a combination of farmer groups, KWT (Group of Women Farmers), which engage in the use of yards and Agricultural product processing. Bantul Regency has a Water User Farmers Association or P3A which plays a role as an institution for administration, management of irrigation networks, and network links from upstream to downstream to identify good and bad irrigation channels. In addition, Sleman Regency also has a network store with Mirota Kampus and a food barn.

Obstacles and challenges faced by the DKPP Bantul and the DP3 Sleman in Bedog Sub-watershed management and development are agricultural land conversion, the lack of interest of younger generations in agricultural land cultivation, constrained ownership of land assets, budget, farmer mindset, and farmer regeneration. The refocusing of the diverted budget for COVID-19 handling programs has an impact on the minimal number of activities that can be carried out.
A flooding is the major threat in Bedog. Several locations of Bantul regency which are in the downstream area are vulnerable to flood during rainy seasons. To overcome this threat, the government did forest and land rehabilitation through vegetative methods and civil engineering. Flood management strategy run by BPDASHL focuses on catchment areas. BPDASHL also did several efforts to minimise land conversion and land narrowing such as maintaining land cover in the form of mixed gardens by planting productive seeds through KBR, KBD activities, and providing free seeds to communities in Bedog Sub-watershed areas. In line with this, the DKPP Bantul and DP3 Sleman anticipate and handle productive agricultural land conversion to non-agricultural land by holding discussions in a coordination forum with Integrated Investment and Licensing Office. Three results of the discussion are: Rejected, Recommended, and Considered.

Regarding agricultural land conversions, DKPP Bantul try to approach farmers with training, aid, and appreciate farmers who do not convert their agricultural land. In addition, the farming road program also reflects an effort from the government to control land-use changes. This program requires farmers to sign a commitment form so that they will not change the land function when activities are carrying out. Institutional aspects place BPDASHL SOP as the key actor. However, the Standard Operational Procedure of BPDASHL is too broad and causes limitations. Therefore, a coordination between Bantul and Sleman Government is needed to address this issue.

3.1.2. Dynamics of Livelihood Assets in Bedog Sub-Watershed.

Livelihood assets include natural, physical, financial, human, and social assets. Each village and sub-district area in this study has tendency to be superior to certain types of assets compared to other areas. This is caused by the differences in the characteristics of each region. The livelihood assets of the Bedog sub-watershed community are represented by 11 sub-districts consisting of 51 villages within it. Each village in each sub-district has a different asset value. However, all sub-districts in the Bedog sub-watershed have better at natural and social assets compared to the other assets. Below is the table showing the types of superior assets in each sub-district.

| No | Sub-Districts | Natural | Physical | Social | Financial | Human |
|----|---------------|---------|----------|--------|-----------|-------|
| 1. | Pakem         | ✓       |          | ✓      |           |       |
| 2. | Turi          | ✓       |          | ✓      |           |       |
| 3. | Sleman        | ✓       |          | ✓      |           |       |
| 4. | Mlati         | ✓       |          | ✓      |           |       |
| 5. | Gamping       | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 6. | Godean        | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 7. | Kasihan       | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 8. | Pajangan      | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 9. | Bantul        | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 10.| Sewon         | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 11.| Pandak        | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |

Data processed from interpretation (2021)

3.2. Strategies of Sustainable Watershed Management in Bedog Sub-Watershed

The strategies based on SWOT analysis and DPSIR analysis. In response with existing dynamic of environment, the strategies accomplish ecological condition and institutional perspectives

3.2.1. SWOT analysis. The preparation of the analysis of Strengths, Weaknesses, Opportunities, Threats (SWOT) in the Bedog Sub-watershed is based on existing conditions and strategic issues.

| No | Sub-Districts | Natural | Physical | Social | Financial | Human |
|----|---------------|---------|----------|--------|-----------|-------|
| 1. | Pakem         | ✓       |          | ✓      |           |       |
| 2. | Turi          | ✓       |          | ✓      |           |       |
| 3. | Sleman        | ✓       |          | ✓      |           |       |
| 4. | Mlati         | ✓       |          | ✓      |           |       |
| 5. | Gamping       | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 6. | Godean        | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 7. | Kasihan       | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 8. | Pajangan      | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 9. | Bantul        | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 10.| Sewon         | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |
| 11.| Pandak        | ✓ ✓     | ✓ ✓      | ✓ ✓    | ✓ ✓ ✓     | ✓ ✓ ✓ |

Data processed from interpretation (2021)
The role of BPDASHL SOP, DKPP, DP3, and the Environment Service in the management process
- Routine environmental management (socialization, monitoring, and evaluation)
- Biodiversity and agricultural resources potency

The agricultural and livestock activities may cause pollution due to the emissions produced
- The volume increase of hazardous waste caused by population and industrial rise
- Limited human resources in agriculture and the ability of labor in the agricultural sector.

### Opportunity
- Collaboration with other parties like universities and environmental institutions in the development of agriculture and animal husbandry
- The existence of environmental groups and farmer groups
- The presence of local wisdom in traditional culture

### Strategy (S-O)
- Optimizing the role of institutions such as BPDASHL SOP, DP3, DKPP, and Department of Environment in management process
- Improving farmer institutions and empowering farmers
- Increase the use of agricultural technology applications

### Strategy (W-O)
- Increase the data availability on natural resources and environment as well as the development of sustainable agriculture through the collaboration with other parties.
- Capacity building of human resources working in the agricultural sector

### Threat
- Growth of activities that potentially cause pollution and damage as negative impact on agricultural land
- The increasing complexity of environmental issues that have an impact on land quality and ecology degradation

### Strategy (S-T)
- Carry out environmental studies.
- Managing vegetation cover and conserving natural resources.
- Optimizing the use of yardland
- Increase community participation in management.
- Increase employee motivation in fulfilling environmental services.

### Strategy (W-T)
- Raise farmers' awareness to use environmentally friendly materials.
- Improving community-based for waste management with 3R principles and environmentally friendly technology.

Data processed from interpretation (2021)

The process of preparing programs and activities needs to consider a strategy that is seen from a potential study in the form of strengths and weaknesses, as well as considering external aspects (opportunities and threats). The main strategy in regional development in the Bedog sub-watershed is emphasized on elements of environmental sustainability and agricultural conditions, such as: Study and arrangement of the environment, the importance of structuring and securing agricultural land, by establishing sustainable food agricultural land (LP2B), as well as providing certificates for farmers so that in the land management process there is a legal obligation (avoiding the conversion of agricultural land) and also providing intensive for farmers, which aims to improve the welfare of farmers.

Environmental pollution (water and air), policies are needed to use varieties that produce low emissions and provide quality feed with low crude fibre and use of low emissions forage. Control of environmental pollution through adjustment of licensing regulations for integrated wastewater disposal and increased supervision for the industry. The implementation of the strategy in the form of an activity program for the sustainable management of the Bedog Sub-watershed is carried out by considering the priorities in order.

### Table 3. Stages of SWOT strategies

| Stage 1 | Stage 2 | Stage 3 |
|---------|---------|---------|
| Protection of fertile agricultural lands, which aims to emphasize the conversion of land to non-agricultural uses. The decline in food supply and productivity from agricultural | Controlling pollution and environmental damage. Strengthening the control of environmental pollution through adjustment of licensing regulations for integrated wastewater disposal. | Group empowerment. The form of activity can be in the form of routine socialization aimed at raising public awareness to maintain environmental sustainability |

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land will hurt the availability of food supply.

- Determine priority areas for agricultural development based on various functions, by knowing these priorities are expected in policymaking and development is right on target (as needed).

- Establish an agricultural cultivation system that ensures the food needs of the population as well as the development of more diverse types of agricultural commodities (diversification) through optimizing the use of home gardens.

- Increasing the availability of public green open space in urban areas and strategic areas.

- Developing environmental capacity by providing community awareness about the importance of protecting the surrounding environment.

- Managing vegetation cover and conservation of natural resources, aiming to maintain the main function of an ecosystem (river).

- Carrying out regional waste management, it is necessary to have integrated waste disposal or final disposal program.

- Increase cooperation with other parties, such as educational institutions, by utilizing technology and knowledge.

- Improving institutions and empowering farmers, after the farmers have sufficient capacity and balanced with good productivity, the next stage is the development of various commodities (processing to marketing).

Increasing the availability of public green open space in urban areas and strategic areas.

3.2.2. DPSIR analysis.

DPSIR analysis within this research implying more qualitative analysis.

Drivers

The large number of populations can be a potential as well as a burden for a region. The increase in population that exceeds the capacity of the environment can cause various problems. This is because every resident need energy, land, and resources to survive. If the population can survive at an ideal level, a balance between the environment and population regeneration will occur. But, the population is growing faster than the earth's and the environment's ability to repair existing resources.

The number of populations have an impact on the conversion of agricultural land. The large population puts pressure on agricultural land which can have an impact on decreasing land productivity. One of the environmental problems in the Bedog Sub-watershed is the increasing trend of land conversion. For example, in Kasihan and Sewon sub-districts, which are close to the city center, there is a high rate of land conversion. The high population is directly proportional to the need for shelter, food, and high energy as well as the volume of waste produced.

Pressures

The Pressures are the direct stresses deriving from the anthropogenic system and affecting the natural environment [24–27]. Pressures in the Bedog sub-watershed are all forms of activity that can quickly provide pressure or any changes from the initial conditions. Population growth in the watershed area as a form of urbanization has consequences on increasing land for settlements. Population pressure will be higher and followed by several other impacts. This condition often leads to the conversion of agricultural land [28]. In addition to agricultural areas, protected areas are also threatened with conversion into built-up land. The Bedog sub-watershed is in a suburban area where land conversion is very likely due to urbanization. Residential areas that appear on the outskirts of urban areas are a form of service efficiency.

A comparison of land-use changes in the sub-watershed area in 2016 and 2020 showed a decrease around garden land and irrigated rice fields. An increase followed the decline around agricultural land and gardens in residential land. The rise in Settlement Land indicates the construction of new housing in the Bedog Sub-watershed area. It will impact food availability and environmental conditions in the watershed area. Previous research in the Gorganroud watershed [29] has shown that watershed health
has deteriorated over time due to socioeconomic activities and related pressures. This condition also happened in the Axios River watershed and Thermaikos Gulf [15]. Industry, agriculture, livestock, and urbanization, are the benchmarks of socio-economic drivers that put various pressures on the system, changing its natural conditions as the anthropogenic system impact.

**States**

High population growth and density cause the changes in environmental quality. The decrease in environmental quality in the Bedog Sub-watershed is marked by a decrease in the carrying capacity of the environment. The carrying capacity of the land shows the ability of the land to support the existing population. The assumption used is that the wider the land area in each sub-district in the Bedog sub-watershed area, the higher the carrying capacity of the land and vice versa, the higher the population, the higher the need for land both for settlements and other socio-economic activities, causing a decrease in the carrying capacity of the land. In addition, population growth and high density also cause changes in environmental conditions such as environmental pollution and reduced recharge areas. The large population results in an increase in the volume of waste.

**Impacts**

The impact is defined as effects on human health, nature, and manufactured capital resulting from changes in the State of the environment [30]. Impacts are the effects that the environmental changes have on human and non-human health status [25,31]. Population growth has an impact on the need for land, which also increases. Population pressure will put pressure on the area, which eventually leads to land conversion. The availability of agricultural land for food will decrease, and a protected area protects environmental sustainability.

Landslides and floods are some of the impacts of the conversion of protected areas. Based on the data, there were two landslides and four flood disasters in 2021. Disaster events occurred and were spread in five sub-districts. Based on regional characteristics, the five sub-districts are located on the outskirts of urban areas with physical conditions dominated by built-up land. Population pressure and the existence of protected areas are very important in maintaining environmental ecosystems.

**Responses**

Responses show the policy and strategy as the real action and implementation of analysis. Based on regional development planning perspective, there are several recommendations of strategy. First, institutional strengthening is required to protect the environment. The following holistic studies and spatial re-organization must be conducted to support the conservation policy respectively. In fact, the land use changes here happened since long ago, particularly in late 1990s [32]. The continuous studies are required to compose database of ecological data, particularly time-series data, to undertake continuous study. Watershed data provision is underlined to get along with well-managed area. After that, the government may be able to build partnership with other stakeholders to raise people awareness on watershed sustainability, implying rice fields protection, farmers education, until proper land management. Despite the whole efforts, an effective coordination between two local governments, Sleman and Bantul, is still required first to maintain the synergy and preventing policy overlapping on sustainable watershed management. Integrated watershed management throughout collaboration is important as policy response, which was also recommended in other case like in Chehel-Chay Watershed, Iran, and Chaohu Lake Watershed, China [33,34]. In the era of post-COVID 19 pandemic, sustainable strategies are still focus on maintaining institutional synergy and coordination since there are many adaptations to overcome pandemic challenges and problems.

4. **Conclusion**

The sustainable watershed management strategies are still placing government institution as the main actor. BPDASHL SOP is the coordinator of the whole Bedog Sub-Watershed management. Inter-region communication forum which is already formed by BPDASHL must maintain its coordination and synergy to make sure the consistent watershed management policy.

Based on SWOT-DPSIR analysis, the regional development perspective involves both physical and social-economy aspects of planning process. Physical aspect underlines the efforts to prevent more
quality degradation of environment while the social-economic aspect implies the farmers empowerment. On the top of them, institutional strengthening along with holistic studies and integrated database must be conducted to accommodate watershed dynamic. In this era of post-COVID 19 pandemics, the government need to adjust the whole budgeting and planning process which has been re-focused into pandemic countermeasure. In case of implying sustainable watershed management, the whole plans may be revised to undertake the programs for Bedog Sub-Watershed.

As this research is not perfect yet, it is suggested for the future researcher to conduct further research on the similar area. Future researcher may use the different method and more data. More primary data collected will provide better conclusions regarding the sustainability of watershed management. An example is the collection of data from direct measurement in the field which has not been done in this research because of the pandemic situation.

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