Management strategy of plastic waste in the Cimandiri River-Sukabumi, West Java

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Abstract. Plastic waste is an emerging global and national issue. However, the global concern about plastic waste in the river system is even decreasing. Cimandiri Watershed is the most important watershed within the Sukabumi Regency area which flows to the Palabuhanratu Bay. Nowadays, the plastic pollution of the Cimandiri River water that ends up in the coastal area of Palabuhanratu becoming a sensitive and critical issue. Plastic waste directly threatens local coastal tourism as a major activity of the local economy. Each stakeholder is aware that plastic pollution is a consequence of anthropogenic activities along the stream of the Cimandiri River that are becoming widespread. Several policy steps have been taken by the local government, to resolve the issue and remain unsuccessful but they are still not successful. To resolve the problems, this paper aims to perform policy analysis to formulate the necessary priority policy strategy. The cause-effect analysis and gap analysis were used to resolve the appropriate plastic waste management behavior and management strategy. The management strategies for the proper management of plastic waste management in the Cimandiri River are improving community behavior by raising public knowledge, implementing legal regulation and social processes, developing technological innovation for the handling of transported plastic waste in the river flows and temporary community-friendly landfills, conduct more 3R (reduce-reuse-recycle) and waste bank management training and build policy affirmations on improving the management of plastic waste.

Keywords: ANP; bay, policy; strategy; watershed

1. Introduction
The river's stream is the most significant agent in the downward site that naturally links inland to the upper region and coastal. Different materials drowned in the river flow that eventually ended up in the ocean water were carried by the river system. As the final destination of river flow, river flow has an important function in transporting all solid waste, including plastic waste, from the point-source pollutant to the ocean. In recent years, the increase of plastic waste has led to the use of plastics in human life in both terrestrial and marine environments and there are complex issues linked to the input of waste in coastal areas [1-4]. Plastic waste, oxidized internally by exposure to ultraviolet radiation or mechanically degraded to microscopic size, also called microplastic, can be biologically degraded by microorganisms [5-7].
The Cimandiri Watershed is one of the watersheds that flow into Pelabuhanratu Bay and maybe polluted with macro and microplastic waste [8]. Among the rivers that flow into Palabuhanratu Bay in the Sukabumi Regency, the Cimandiri River is the most important. The region of Sukabumi Regency and Cianjur Regency covers the upper stream area of the Cimandiri River. Then, the socio-economy dynamic of those two upper areas will finally be connected via river stream to the downstream coastal site in the Palabuhanratu Bay [9]. Plastic waste is a global concern. Plastic waste island base pollution source, anthropogenic base, and flows to the seawater through river water flows. Furthermore, the characteristics of the dynamic estuary region and the high population activities in the upper area of the Cimandiri Watershed are the major source of plastic waste that flows towards Palabuhanratu Bay [10]. The most important source of plastic waste is socio-economy activities that use plastic as disposal material of the community who live along or connected with the Cimandiri riverbed.

The improper plastic waste management leads to land-based plastic leakage that flows to the ocean water. The plastic waste transported by river flows is irrelevant to the administration boundary. The plastic waste management must be underlined on an integrated approach from upper to downstream areas. There are a lot of factors constituting plastic management that relate to various interests such as environment, aesthetic, and its potential to narrow the water stream that results from the flood.

Nowadays, the most sensitive issue of Cimandiri River plastic wastes its potential to insult tourism activities in the coastal area of Palabuhanratu Bay. Because this area is traditionally a major tourism destination with economic significance for locals. Therefore, this paper aims to address the management strategy to handle plastic waste in the Cimandiri River. This management strategy is fundamental for either environmental-aesthetic or economical perspectives.

2. Material and method

2.1. Time and location
The research was conducted in 2020. The study site covers the area of Cimandiri River which is under Sukabumi Regency authority.

2.2. Data collection method
The data obtained during the analysis both primary and secondary data. Throughout observation and focus group discussion, the primary data collected (FGD). The Head and Officers of the Fisheries and Maritime Affairs Division, Head and Officers of the Environment Office, Officers of the Local Government Development Planning Department, Researchers, Research Assistance, and Students were the FGD participants. Although literature reviews on several previous studies carried out by several researchers on similar subjects have been collected for secondary data.

2.3. Data analysis
Data analysis was conducted by explored Cause-effect Analysis [11] and Gap Analysis [12].

3. Result and discussion

3.1. Characteristic of Cimandiri River
Sukabumi is an area 4,145 km² in width, with its total population is 265 million inhabitants. Sukabumi Regency is administratively consisting of 47 units of sub regency [9]. The width is more than 25 times Bandung City's width and makes it one of the widest districts of West Java Province.

The Cimandiri river is one of 4 rivers flowing into Palabuhanratu Bay. The Cimandiri River is originated from the Gede-Pangrango mountain area in the northeast area and the Salak Mountain in the north area. The whole Cimandiri Watershed covers 201,431 hectares areas which embrace Padalarang and Halimun Mountain conservation area as the upstream and finally flows into Pebaluhanratu Bay [13]. Those whole areas are part of Sukabumi Regency and Cianjur Regency. The Cimandiri Watershed has
65.9 km long with permanent and intermittent rivers [14], which consist of 56 permanently sub-rivers and its river order categories into 1 up to 7 levels.

The Cimandiri Watershed has several sub-rivers including Cicatih, Cipelang, Citakir, Cibodas, and Cidadap where all of them in the northern area of Sukabumi Regency [12]. Several activities utilized the water instream of Cimandiri River including a micro hydropower plant, rafting, and fisheries.

![Map of the Cimandiri Watershed](image)

**Figure 1.** The Cimandiri watershed in the Sukabumi Regency.
(Source: Pe et al., 2020 [15]).

### 3.2. Solid waste production and management issues
Currently, there is no exact number of plastic waste or even solid waste production in the Sukabumi Regency. The estimation number based on the daily solid waste transported to the final landfill during the focus group discussion figure out the volume of solid waste production daily (table 1).

| No. | Item                      | Unit   | Volume | Proportion (%) |
|-----|---------------------------|--------|--------|----------------|
| 1.  | Solid Waste Production    | Ton/day| 180    | 100            |
| 2.  | Solid Waste Processed     | Ton/day| 68     | 37.78          |
|     | a. local collector        | Ton/day| 40     | 22.22          |
|     | b. waste banks            | Ton/day| 10     | 5.5            |
|     | c. trash collector at a final landfill site | Ton/day | 18 | 10 |

The Local Environmental Agency is a responsible agency to manage all of the solid waste produced by inhabitants. This is including activities of transporting, reducing, and processing solid waste. However, the processing capacity is much lower than the total solid waste production. Nowadays, solid
waste transportation service covers 36 out of a total of 46 sub-districts (76.57%), but it is covering only 23% of total households. Due to the geographical characteristic and its width of Sukabumi Regency make the transporting services are not practicable in entire district especially in the rural areas. This situation is faced by the whole solid waste including plastic waste transportation. This situation leads to the severe problem of plastic waste management which is characterized by improper handling of plastic waste.

There is a commitment to reduce waste and plastic production in Indonesia. According to Indonesia’s Presidential Speech during the Leader Summit, G20 in Humberg (July 2017), Indonesia commits to reduce waste by 3R (reduce-reuse-recycle) until 30% in 2017 while the target for reducing plastic waste as much as 70% in 2025. For implementing this commitment there 5 strategies as reflected in Indonesia’s National Plan of Action for Plastic Waste Reduction. These are: 1) Behavioral Change, 2) Reduce Land-based Leakage, 3) Reduce Sea-based Leakage, 4) Enhance Law Enforcement and Financial, 5) Research and development.

Concerning Law No.23/2004 on Local Government and Law No.18/2008 on Waste Management, waste management (including plastic waste) is a shared task between national and local government. There is must be intergovernmental coordination and collaboration. To complement national policies, the government of Sukabumi Regency in concern to its authorities has issued policies and took several actions as efforts for combating plastic waste. These efforts are: 1) Campaigns for increasing local community awareness on waste management, 2) Conduct training on 3R for the local community especially women group, 3) Carry out training on waste banks management for local people, 4) Multi-stakeholders beach clean activities which are participated by Government agencies, NGOs and companies especially trough corporate social responsibility program, 5) Issue Head of Regency (Bupati) Regulation (Perbup) No. 81/2019 on SUKABUMI Bestari -Bersih Tertib-Asri (clean-orderly-beautiful) which consist of basic points: a) The limitation of plastic bags usage (effectively starts in November 2020), b) Free waste zones/areas, c) Administrative sanction/penalty according to Bupati Regulation for red-handed violation. However, these efforts still far enough to solve and properly manage plastic waste management problems. There are some issues and concerns that remain in the site which currently challenges plastic waste management in the Cimandiri River. These issues are:

1. Low awareness and understanding of the recycling process of the local community
2. Improper behavior of the community along the Cimandiri River
3. Less capacity for waste management (transporting, processing, reducing) due to classic governmental problems i.e lack capacity of infrastructures, inadequate human resources, and budget constraint
4. Overcapacity of the final landfill site
5. Lack of controlling capacity of plastic waste flows through river flow from both of Sukabumi City and Sukabumi Regency area (especially during the rainy season)
6. The difficulty to find a suitable site for temporary landfill sites (environmental aesthetic and bad smell concerns)
7. The local government regulation (Perbub) is still not effectively implemented yet

3.3. Required actions and management strategies

Based on the identified challenges as a phenomenon, further analysis is conducted using the cause-effect analysis [10]. This analysis was applied for having ideas on the core of the problems. The analyses result from several cores of the problems as is drawn in figure 2.

Based on figure 2, the core of the plastic waste management problems (on the most left side) are including lack of a public campaign, no penalties, lack of technical innovation, less training on 3R, and inadequate infrastructure, human resource, and budget for developing proper plastic waste management. All of those identified problems are the current or existing conditions that reflect the unideal circumstances for proper plastic waste management. The gap analysis [11] is the next analysis to address the required actions to improve the condition. The benchmark of the ideal situation is settled up at the ideal circumstances for plastic waste management. The logical gap analysis is in figure 3.
The required actions to reach sophisticated circumstances for plastic waste management are including several actions: create an effective public campaign, enforce Bupati Regulation No. 81/2019 and develop social contract on plastic waste management, conduct technical research on trapping plastic waste in the river flows and social-friendly temporary landfill site, do more training on 3R for local people and improve local government policy to provide sufficiently of infrastructures, human resources, and governmental budget. These actions are needed as a pre-requisite for proper plastic waste management.

The public campaign must be designed using appropriate local approaches (values, languages, and culture), to secure the messages touch the local properly. However, most challenges are how to change local people's behavior on managing solid waste from the very beginning stage and at the upstream level. The changes have to be reached the people at the household, commercial sites (modern and traditional markets, kiosks, malls, factories), public facilities, and offices. The changes need to be grasped through formal and informal approaches. Formal regulation enforcement is essential as a formal approach but it still needs to be accompanied by an informal approach. To avoid transactional actions, the behavior changes must be securely institutionalized by the inner understanding and awareness of local people throughout social processes. For doing so, the agreement on plastic management at the community member is fundamental to be rise up and established as a shared norm including incentive and disincentive mechanism.

One of the powerful instruments to control and manage plastic waste management in local government policy. It is not only on formal regulation enforcement but also better public service provisions for improving plastic waste management. Providing adequate infrastructures, human resources, and budget is expected to stimulate the management services for transporting, reducing, and processing plastic waste as a part of solid waste handling.
Figure 3. The gap analysis on required actions for plastic waste management in the Cimandiri River.

The strategic approach for managing the plastic waste in the Cimandiri River then can be summarized in four (4) ways. These are:

1. Changes community behavior through a public campaign, enforcement of Bupati Regulation No. 81/2019, and development of community agreement and institutionalization.
2. Technical innovation development on plastic waste trapping and community-friendly temporarily landfill technic innovations
3. Conducting training on 3R and waste bank management
4. Developing policy affirmation on improving plastic waste management infrastructure, improving human capacity, and providing adequate budget

4. Conclusion and recommendation
The management strategies for developing proper management of plastic waste management in the Cimandiri River are changes community behavior through increasing public awareness, enforce legal regulation and social processes, develop technical innovation for handling transported plastic waste in the river flows and community-friendly temporarily landfill, conduct more training on 3R and waste bank management and develop policy affirmation on improving plastic waste management. The policy needs to boost the sufficient provision of infrastructure, human capacity, and government budget allocation. For better and integrative management, development of collaborative mechanism and platform among the adjacent local government authorities which is share areas for Cimandiri River streams.
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