Sustainability Window Approach for Fisheries Management: A Case Study of Coral Reef Fisheries at the Coastal Area of Ternate Island, North Maluku Province
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SUSTAINABILITY WINDOW APPROACH FOR FISHERIES MANAGEMENT AT THE COASTAL AREA OF TERNATE ISLAND, NORTH MALUKU PROVINCE

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ABSTRACT

Aims: This study aims to assess the value sustainable development opportunity of the coral reef fisheries activities in Indonesia from the ecological, economic, and social aspect, with a case study of coral reef fisheries at the coastal area of Ternate Island, using the Sustainability Window (SuWi) approach. **Methodology and Results:** The data was collected from statistical data from relevant institutions and literature study, which consists of ecological, economic and social data, and analyzed using the Sustainability Window approach to determine the sustainability of the fisheries development. The result shows that the Sustainability Window of the coral reef fisheries in the research area tends to move towards sustainable development, where the national policy in catch fisheries management has an impact on the sustainable development and management of coral reef fisheries at the coastal area of Ternate Island. **Conclusion, significance and impact study:** The Sustainability Window of coral reef fisheries at the coastal area of Ternate Island tends to move towards sustainable processes, with the width of sustainability window that not too narrow to the coral reef fisheries activities at the provincial and national levels. This condition attaches strings to a precautionary approach in policy decision for the management process, and consideration to the effect that can result from the development policy, both at the provincial and national level. The use of Sustainability Windows approach can provide a new simple way for assessing whether the development has been towards a more sustainable direction or not.

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- Coral reef fisheries
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1. INTRODUCTION

Many perspectives on sustainability which include biological resource to the sustainability of social and economic of the human population that depends on the sustainability itself (Wilson *et al*., 2007). The economic growth, environmental protection, and social development were indicated as three main pillars of sustainable development as reported in the IUCN documents (Adams, 2006). There is a clear divide between those who define sustainability only in the frame of ecological sustainability and those who focus on people sustainability, while sustainability should involve socio-ecological perspective if it scope in global changes, and can be effective within culture, social perspective, and within the increasing development (Hilborn *et al*., 2015).

In the last decade, sustainable development concept has become more intensely used in nations around the world to implement their development policy both at the national and international level. Sustainable development becomes a core element for many government policies in many countries and other strategic institution (Ekins and Simon, 2001).

The core of the sustainable development concept comes from three basic concepts, which imply a balance between the three pillars of sustainability, which is environmental sustainability that focused on maintaining the environmental quality that needed to conduct economic activities and preserve the quality of human life; social sustainability that ensures the human right and equity, preserve the cultural identity, respect for cultural diversity, ethnic, and religions; and economic sustainability that needed to maintain the value of natural, social, and human capital, which is needed for income and living standards (Klarin, 2018).

The history of fisheries management and the analysis of the success of fisheries management has shown that the focus of management on the resources is insufficient to achieve the best fit of fisheries management which is compatible with environmental management (Fulton *et al*., 2011). Focusing on environmental status alone can result in a lack of information related to the negative impacts of stock production (Peterson and Stead, 2011). External factors as well as other various pressures, also the global change, can result in natural changes, resulting in changes in the ecosystem. As a result, any management method that only relies on static measurement or management will decline especially for resource stock in an area with a limited resource (Brown *et al*., 2012). To be successful in managing fisheries resources, the management methods must be dynamic and sensitive to changes that occur and

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are a series of processes, not as an end result (Hilborn *et al*., 2015).

In the field of fisheries, the development of successful management strategies requires general acceptance from all stakeholders, which often have conflicting goals and interest. In situations where industrial activities have minimal effect on the environment, conflicts will be more limited. However, when the key stock overfishing occurs, the conflict between stakeholders will emerge, due to different perspective between preserve and protect the natural resource and how much value is needed to maintain the sustainability of capital and incomes. One of the fisheries activities that need to be more considered in fisheries development and management in Indonesia is coral reef fisheries. It is one of the subsistence activities for societies that live along the coastal area of the nation. Opportunities for the development of coral reef fisheries activities require an assessment to provide information about their development value based on their related development aspects, so the management policy can be adjusted for each management aspect.

The purpose of this study is to assess the value sustainable development opportunity of the coral reef fisheries activities in Indonesia from the ecological, economic, and social aspect, with a case study of coral reef fisheries at the coastal area of Ternate Island, using the Sustainability Window (SuWi) approach.

2. RESEARCH METHODOLOGY

2.1 Data Collection

The data for the research is obtained from statistical data from relevant institutions and literature study, consisting of production data and value from coral reef fisheries, and fisherman exchange rate data as indicators of fisherman welfare. The data used in the analysis is data from the period 2012 to 2017.

2.2 Data Analysis

The analysis of the opportunity of sustainable development of coral reef fisheries activities in the coastal area of Ternate Island was carried out using the Sustainability Window (SuWi) approach model, which is a development of the Advance Sustainability Analysis (ASA) model developed by Jyrki Luukkanen from Finland Futures Research Center, University of Turku,

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Finland (Kavio-oja *et al*., 2001; Luukkanen *et al*., 2015; Panula-Ontto *et al*., 2015). The Sustainability Window (SuWi) is a new analytical tool for assessing sustainable development using three dimensions of development (environmental, economic, and social). This method provides information about the maximum and minimum economic development value that needed to manage social and environmental development towards more sustainable goals (Luukkanen *et al*., 2015).

SuWi analysis uses three different indicators, which is environmental, economic, and social dimensions. Those three indicators must have the same form; whereby the weighting and normalizing process was carried out for each indicator to obtain uniformity of index value for all sustainable development. The use of SuWi method makes it easy to analyze sustainable development using various indicators and different periods, and analyze the dynamic changes of sustainability over time based on the width of SuWi. The method provides a new perspective for analyzing sustainability trends and the impact of their sustainable development policies.

The width value of SuWi for coral reef fisheries management in the coastal area of Ternate Island can be obtained from the difference between the maximum (SWCRFmax) and minimum (SWCRFmin) Sustainability Window of coral reef fisheries, which is calculated using the modified Equation (1) and (2), based on the result of the index data:

$$SWCRF_{max} = \frac{EcnCRFI_{t1}}{CICRF_{t1}} CICRF_{t0} \quad (1)$$

$$SWCRF_{min} = \frac{EcnCRF_{It1}}{SocCRFI_{t1}} SocCRF_{t0} \quad (2)$$

where, EcnCRFI is an index of production value of coral reef fisheries in the coastal area of Ternate Island, CICRF is an index of the catch of coral reef fisheries in the coastal area of Ternate Island, and SocCRFI is an index of fishermen earnings from coral reef fishing activities in the coastal area of Ternate Island.

The width of SuWi for coral reef fisheries is then compared with the width of SuWi of coral reef fisheries activities at the provincial and national level, to determine the position of the sustainability development of coral reef fisheries and their resource management in the research area against both provincial and national sustainability. The width of SuWi for coral

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reef fisheries at the provincial and national level is calculated using modified Equation (3) until Equation (6) as follow:

$$SWCRFPv_{max} = \frac{EcnCRFPvI_{t1}}{CICRFPv_{t1}} CICRFPv_{t0} \quad (3)$$

$$SWCRFPv_{min} = \frac{EcnCRFPvI_{t1}}{SocCRFPvI_{t1}} SocCRFPvI_{t0} \quad (4)$$

$$SWNDF_{max} = \frac{EcnNDFI_{t1}}{CINDF_{t1}} CINDF_{t0} \quad (5)$$

$$SWNDF_{min} = \frac{EcnNDFI_{t1}}{SocCINDF_{t1}} SocCINDF_{t0} \quad (6)$$

where EcnCRFPvI is the index of production value of the province coral reef fisheries, CICRFPv is the index of catches of the province coral reef fisheries, SocCRFPv is the index of fisherman earnings from coral reef fisheries at North Maluku Province which is calculated from the fisherman exchange rate index (NTN) of North Maluku Province, EcnNDFI is the index of production value of the national demersal fisheries, CINDF is index of national demersal fisheries catches, and SocCINDF is index of fisherman earning from demersal fisheries in Indonesian waters, which calculated from the national fisherman exchange rate index (NTN).

3. RESULTS AND DISCUSSION

Analysis of Sustainability Window (SuWi) of coral reef fisheries activities at the coastal area of Ternate Island were obtained based on the result of indexing of sustainability parameters from ecological dimensions (number of catches), economy (production value), and social (fisherman exchange rate, NTN), within a period of six years from 2012 to 2017. The result of SuWi index was then compared with the SuWi index from the coral reef fisheries at the provincial and national level.

The result shows that the window changes in the maximum ($SWCRF_{max}$) and minimum ($SWCRF_{min}$) threshold for coral reef fisheries sustainability at the coastal areas of Ternate Island in the period 2012 until 2017 tended to increase (Figure 1). The maximum value of SuWi index of coral reef fisheries at the coastal area of Ternate Island from 2012 to 2017 tends to increase, and range from 0 to 0.17 (Table 1). Meanwhile, the minimum threshold value of SuWi index

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tends to change, where there was an increase in 2012 to 2014, but then decrease in 2015 and increase again in the next year, within index values ranging between 0 to 0.09 (Table 1).

The result for the Sustainability Window (SuWi) index for the development of coral reef fisheries at the North Maluku Province (SWCRFPv) show a value that tends to increase between 2012 and 2016, but decreased in 2017 for the maximum threshold with the index value range between 0 to 1.09 (Table 1 and Figure 2). The result for the minimum threshold produce by the coral reef fisheries at the provincial level tends to increase from 2012 to 2017, within the index value that ranges between 0 to 0.47 (Table 1). The SuWi analysis result for national demersal fisheries (SWNDF) shows that there is a change in the index value (Figure 3), where the maximum threshold tends to be in the period 2012 to 2015, then decline in the next years, with the index value ranging from 0 to 2.84 (Table 1). Meanwhile, the minimum threshold for SWNDF value tends to increase, although it experienced a decline in 2015 within index values ranging from 0 to 0.47 (Table 1).

Table 1 The result of the maximum and minimum value of Sustainability Window (SuWi) index for coral reef fisheries activities in the coastal area of Ternate Island, North Maluku Province, and national demersal fisheries in the period 2012 to 2017

SuWi	2012	2013	2014	2015	2016	2017	Max	Min
$SWCRF_{max}$	0.00	0.06	0.09	0.12	0.15	0.17	0.00	0.17
$SWCRF_{min}$	0.00	0.01	0.07	0.01	0.05	0.09	0.00	0.09
$SWCRFPv_{max}$	0.00	0.00	0.26	0.71	1.09	0.59	0.00	1.09
$SWCRFPv_{min}$	0.00	0.02	0.00	0.27	0.47	0.47	0.00	0.47
$SWNDF_{max}$	0.00	0.67	0.92	2.84	1.88	1.70	0.00	2.84
$SWNDF_{min}$	0.00	0.22	0.62	0.56	1.35	1.33	0.00	1.35

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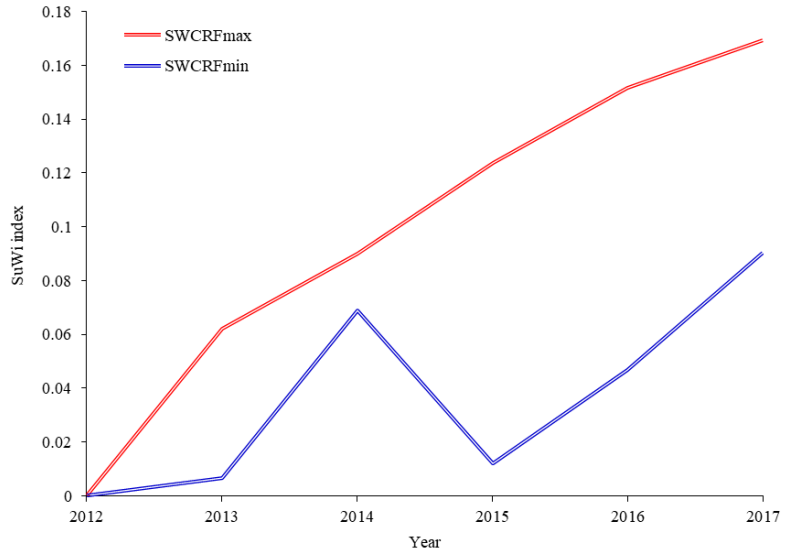

Figure 1 The changes in the value of maximum ($SWCRF_{max}$) and minimum ($SWCRF_{min}$) threshold of Sustainability Window (SuWi) index of coral reef fisheries in coastal area of Ternate Island (SWCRF) from 2012 to 2017

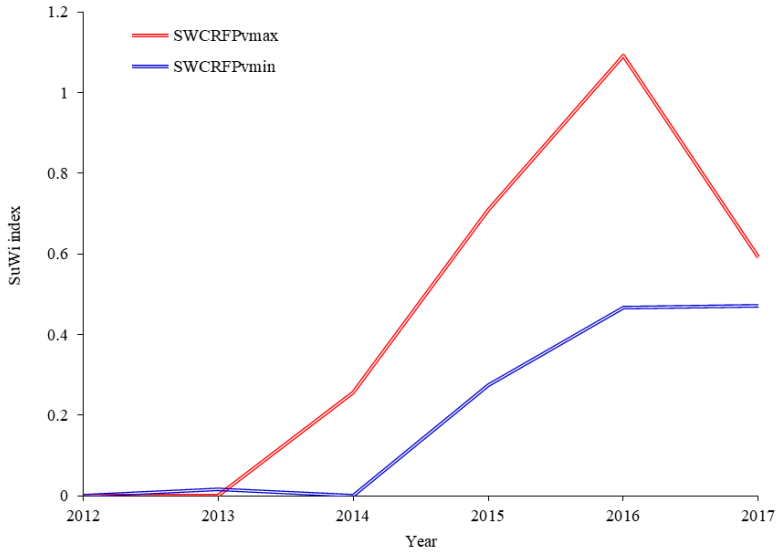

Figure 2 The changes in the value of maximum ($SWCRFPv_{max}$) and minimum (($SWCRFPv_{min}$) threshold of Sustainability Window (SuWi) index of coral reef fisheries in North Maluku Province (SWCRFPv) from 2012 to 2017

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Figure 3 The changes in the value of maximum ($SWNDF_{max}$) and minimum ($SWNDF_{min}$) threshold of Sustainability Window (SuWi) index of national demersal fisheries (SWNDF) from 2012 to 2017

The width of Sustainability Window (SuWi) for coral reef fisheries management at the coastal area of Ternate Island which is generated from the difference between the maximum and minimum value of SuWi index, show that the window for sustainable management tends to fluctuate (Table 2 and Figure 4a), where the width tends to increase in the period between 2012 to 2013, but decreased in 2014, then increased significantly in 2015, but again decreased in the next year. For the coral reef fisheries in North Maluku Province, it also had a fluctuated condition (Table 2 and Figure 4b), where the width of SuWi had experienced a significant increase between the period of 2014 to 2016, but then decreased again in 2017.

Table 2 The changes in the width of Sustainability Window for coral reef fisheries activities in the coastal area of Ternate Island, North Maluku Province, and national demersal fisheries in the period 2012 to 2017

Width of SuWi	2012	2013	2014	2015	2016	2017
WSWCRF	0.00	0.06	0.02	0.11	0.10	0.08
WSWCRFPv	0.00	-0.02	0.25	0.44	0.62	0.12
WSWNDF	0.00	0.46	0.30	2.29	0.53	0.36

WSWCRF = Width of Sustainability Window of coral reef fisheries in Ternate Island, WSWCRFPv = Width of Sustainability Window of coral reef fisheries in North Maluku Province, and WSWNDF = Width of Sustainability Window of national demersal fisheries.

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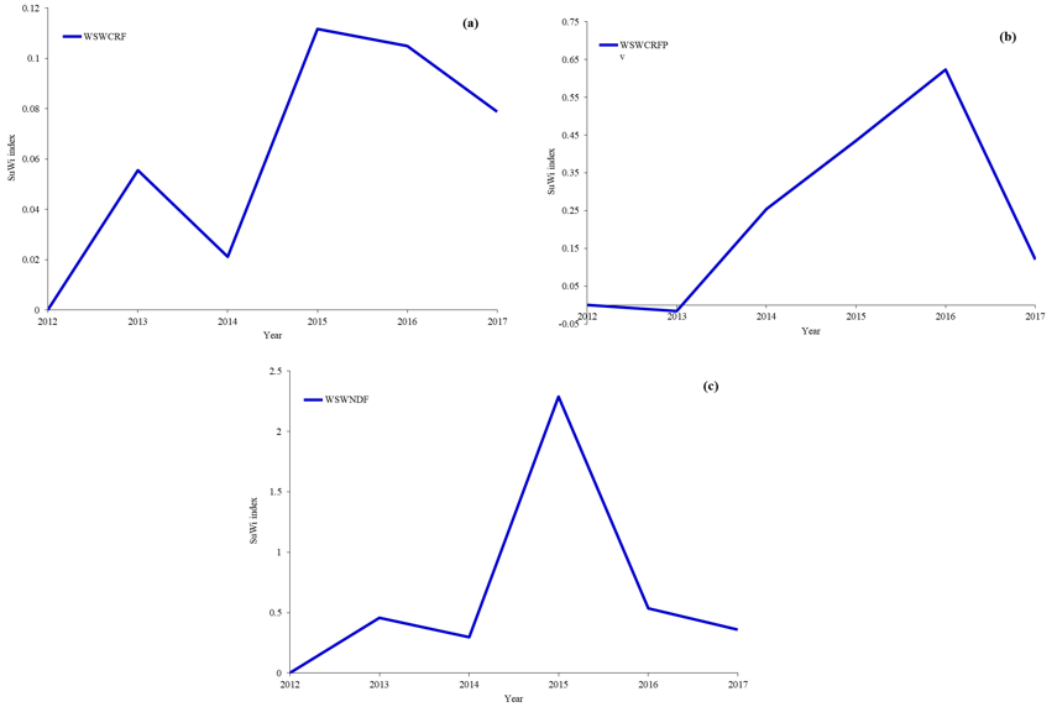

Figure 4 The changes in the width of the Sustainability Window in the coral reef fisheries in period 2012 to 2017. (a) coral reef fisheries in Ternate Island, (b) coral reef fisheries in North Maluku Province, and (c) national demersal fisheries

Meanwhile, the width of SuWi for national demersal fisheries shows the same pattern as found in coral reef fisheries in Ternate Island (Figure 4c). This result shows that the national policy in catch fisheries management in 2012 until 2017, especially for demersal and coral reef fisheries, has a negative impact on the sustainable development and management of coral reef fisheries at the coastal area of Ternate Island. Comparison of the width of sustainability window between the management of coral reef fisheries at the coastal area of Ternate Island with the width of sustainability window of coral reef fisheries management in North Maluku Province and the national demersal fisheries were presented in Figure 5.

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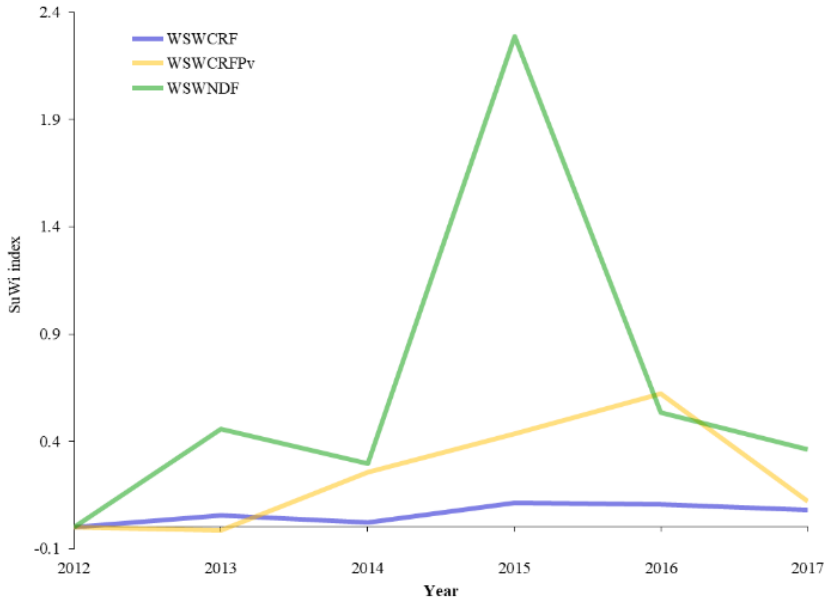

Figure 5 The comparison of the width of sustainability window between coral reef fisheries in the coastal area of Ternate Island (WSWCRF) with the coral reef fisheries in North Maluku Province (WSWCRFPv), and the national demersal fisheries (WSWNDF)

Important research related to sustainable development has been carried out to test sustainable development from the perspective of its application through evaluation models that analyze the sustainability of environmental, economic, and social, which serve as a reference point in increasing the regional capacity of sustainable development (Liang *et al*., 2017). How to obtain appropriate and objective evaluation methods on sustainability is one of the fundamental issues in research on sustainability (Zhang *et al*., 2014; Shaker and Zubalsky, 2015; Silvestre *et al*., 2015; Tan and Lu, 2016).

The capacity of economic development in sustainability is related to the economic elements of the study of regional development sustainability capacity. On one hand, economic development is the basis for regional social development, while on the other hand, economic growth sometimes sacrifices social development for a long period and impacts on unsustainable development (Yang *et al*., 2016). To understand the picture at regional economic level, the capacity of regional economic sustainability must include all existing and potential economic capacities. The environmental sustainability capacity is ecologically related to environmental elements of sustainable development capacity, which not only focused on the ability to develop environmental protection regionally but must also include the ability to coordinate and develop

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the regional environment and its resources. The capacity of social sustainable development is related to the social factors of regional sustainable development capacity, which generally focused on the impact of sustainable development to community social-life, and include the influence of society development, level of education, and daily life-style of the community (Dempsey *et al*., 2011). Due to the overlapping components of the economy-environmental-social complicated systems (Böhringer & Jochem, 2007; Salvati & Carlucci, 2014), the resulting system is multi-level, multi-functional and complex dynamic systems that include environmental, economic, and social structures. Each sub-system in this complex relationship influences each other, resulting in a chain-like structure in the regional sustainable development capacity evaluation system.

According to De Brucker *et al*., (2013), sustainable development considerations, meaning simultaneous attention devoted to economic, social and environmental goals, may be important in complex project evaluation, which then faces three challenges. First, project evaluation by definition entails making choices, whereby not all projects considered contribute equally to sustainable development. Large-scale project evaluations nearly always involve trade-offs among multiple objectives, such as narrow-scope economic goals, broader social objectives and environmental considerations. Second, in complex cases, specific subsets of objectives typically reflect the interests of stakeholder groups, such as project developers, consumers, and third parties affected by the project. These interests must ultimately be aligned to guarantee effective project implementation. Third, in most cases, the selection of specific projects typically has distributional consequences, with different stakeholder groups affected in an idiosyncratic way, and becoming 'winners' or 'losers', i.e., enjoying net benefits or incurring net costs as a result of project implementation. Often this also implies an excessive weight given to narrow-scope economic considerations, at the expense of the social and environmental elements.

4. CONCLUSION

In the developing countries there are numerous problems in the management of MSW such as lower collection efficiency, awareness and knowledge regarding waste reduction and MSW management. Due to the lack of proper legislation all the waste are openly dumped that result in several public health and environmental consequences. There are several treatment options for the sustainable management of MSW including composting, incineration, gasification,

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pyrolysis, biological treatment and recycling. However, for each technology there are several important steps that need to incorporate in formulating the strategy for MSW such as waste stream characterization, LCA study for each management strategy, capacity building to educate the stakeholders with skills and research and identification and incorporation the gap between the problem areas. Similarly, suitability of each MSW management plan should be assess in term of economic perspectives both at micro and macro-level, social acceptability and environmental aspects to protect the environment and human from the consequences of the management processes.

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