Assessment of Watershed Carrying Capacity for the Aesesa Flores Watershed Management, East Nusa Tenggara Province of Indonesia

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ABSTRACT

The Aesesa Flores (AF) watershed has an important role for the community in the district of Ngada and Nagekeo, East Nusa Tenggara Province of Indonesia. However, in recent years, over exploitation of natural resources in the AF watershed has caused severe land degradation in the region. This study analyzed the carrying capacity of the AF watershed. The assessment of the AF watershed carrying capacity in this study was done according to the Indonesian Ministry of Forestry Regulation Number P.61/2014 that regulates the monitoring and evaluation of watershed management. The main objectives of this study were to assess the carrying capacity of the AF watershed, and evaluate the suitability of the aforementioned regulation to its condition. The results of carrying capacity analysis showed that the upstream region of the AF watershed was categorized to have a low carrying capacity condition, while both the middle and downstream region of the watershed were categorized to have a moderate carrying capacity condition. These results indicated that there was a need to prioritize the rehabilitation and land management in the upstream region of the AF watershed, in order to improve its condition.

1. INTRODUCTION

Watersheds are complex land and water systems, and a natural resource management unit that cannot be limited by government administrative boundaries (Paimin et al., 2012). Watershed management is a human effort in regulating the reciprocal relationship between natural and human resources in the watershed and all its activities in order to achieve the sustainability and harmony of the ecosystems as well as increasing the usefulness of natural resources for humans in a sustainable manner (Indonesian Government Regulation No. 37/2012). Watershed management is defined as the formulation and implementation of a series of activities related to natural and human resources in a watershed taking into account the social, political, economic and institutional factors that exist in the watershed and its surroundings to achieve specific social goals (Paimin et al., 2012). The management effort needs to consider the complexity of social, economic, cultural and institutional aspects operating inside and outside the watershed (Asdak, 2010). One of the ways to manage natural resources in the watershed is to consider the carrying capacity of the environment through an ecological area approach of the watershed area (Suryanto, 2007). A previous study by Brontowiyono et al. (2009) was done to assess the carrying capacity of the Oyo Watershed in Gunung Kidul, Yogyakarta, Indonesia, and was based on the water resources carrying capacity. Another study by Rahadi et al. (2014) assessed the water resources carrying capacity in the Brantas Watershed of Batu, Indonesia. Both of these studies focused on the physical aspect of watershed carrying capacity, which is the water resources, including annual water yield and annual water flow. To have a better understanding of the complete watershed carrying capacity, not only the physical aspect of the watershed, but also the socio-economic and governance aspects of watershed need to be considered.

The Indonesian Minister of Forestry Regulation Number P.60/Menhut-II/2014 (Kemenhut, 2014a) advises the needs of monitoring and evaluation of Watershed Management. In Indonesia, the watershed carrying capacity is needed before planning the watershed management by the Provisional Government. By the Indonesian law, the assessment of watershed carrying capacity must be done according to the Indonesian Minister of Forestry Regulation Number P.61/Menhut-II/2014 concerning Watershed Classification (Kemenhut, 2014b). Both regulations explain the criteria for assessing the condition of watershed carrying capacity based on land conditions, water management, socio-economic conditions, water construction investment and use of regional space. The study of water resource and the watershed carrying capacity can offer comprehensive information on the socio-economic system of watershed, and how the socio-economic system is both supported and affected by the dynamics in the water resource system (Yang et al., 2015).

The AF watershed is one of the priority watersheds in the province of East Nusa Tenggara (NTT) which has an area of 129,005 ha and display ±87 km from upstream in Bajawa, the capital of Ngada Regency, and its downstream in Mbay the capital of Nagekeo District. Besides having a lot of potential natural and environmental resources, the management of the AF watershed is still faced with various technical challenges, namely: 1) the very high percentage of critical land which is 75.05%; 2) the very low percentage of closing coverage is 17.60%; low rainfall, especially in the downstream region which is only four months of rain and the dangers of drought and land fires; 3) unstable yearly watershed hydrology condition where the discharge from 2007 to 2017 reached a maximum in 2009 of 587.98 (m^3/s) and the lowest in 2011 was 8.10 (m^3/s); and 4) the welfare level of the population is still low. Namely, 45.10% of the 18,918 households in the AF Watershed are Poor Families (BPDAS Benain Noelmina, 2013; Noywuli et al., 2017).

The dynamics that occur in the Aesesa Flores (AF) watershed result from both human activities and the natural process of physical and biotic environment (Arrow et al., 1995). The dynamics changes in the watershed create pressure on the carrying capacity of the watershed. If the pressure exceeds the carrying capacity of the watershed, it can lead to environmental problems such as drought, floods, erosion, sedimentation, landslides, and other environmental problems that ultimately affect the level of community welfare. The watershed problems generally occur due to the utilization of natural resources that exceeds the carrying capacity. The carrying capacity of the watershed is an important aspect of the study in watershed management and can be used to analyze the watershed's ability to support the socio-economic system. Unlimited population growth in a watershed cannot be achieved due to limited resources; hence the carrying capacity of the watershed is a measure of these limitations (Hui, 2006).

In order to provide a foundation for the sustainable watershed management of the AF watershed, it is necessary to study and evaluate the inherent carrying capacity of each AF watershed region. The main objectives of this study were to evaluate and classify the carrying capacity of AF watershed based on the Regulation of the Indonesian Minister of Forestry Number P.61/Menhut-II/2014 (Kemenhut, 2014a) regarding the Watershed Management Monitoring and Evaluation Criteria. The specific objectives of this study are to evaluate the carrying capacity of the AF watershed in five specific criteria. The criteria are: 1) land resource management in the AF watershed; 2) water resource management in the whole region of the AF watershed; 3) socio-economic condition in the AF watershed; 4) water-related infrastructure that support the water management in the AF watershed; and 5) the regional spatial utilization in the AF watershed. This study also evaluated the suitability of the carrying capacity assessment based on the Regulation P.61/Menhut-II/2014 to the specific condition of AF watershed.

2. METHODOLOGY

2.1 Location

This research was carried out in the Aesesa Flores watershed in March-April 2018. The Aesesa Flores watershed is geographically located at positions 120º56'48"-121º22'42"BT and 8029'01"LS-8049'41"LS and in this Aesesa Flores watershed administration included in the two administrative districts in the Central Island of Flores, NTT Province. The upstream region and a small part of the central region are in the administration area of the Ngada Regency government, whereas the central and downstream regions are in the Nagekeo District administration. AF Watershed covers an area of 129,005 ha with a length of 87 km, as presented in Figure 1.

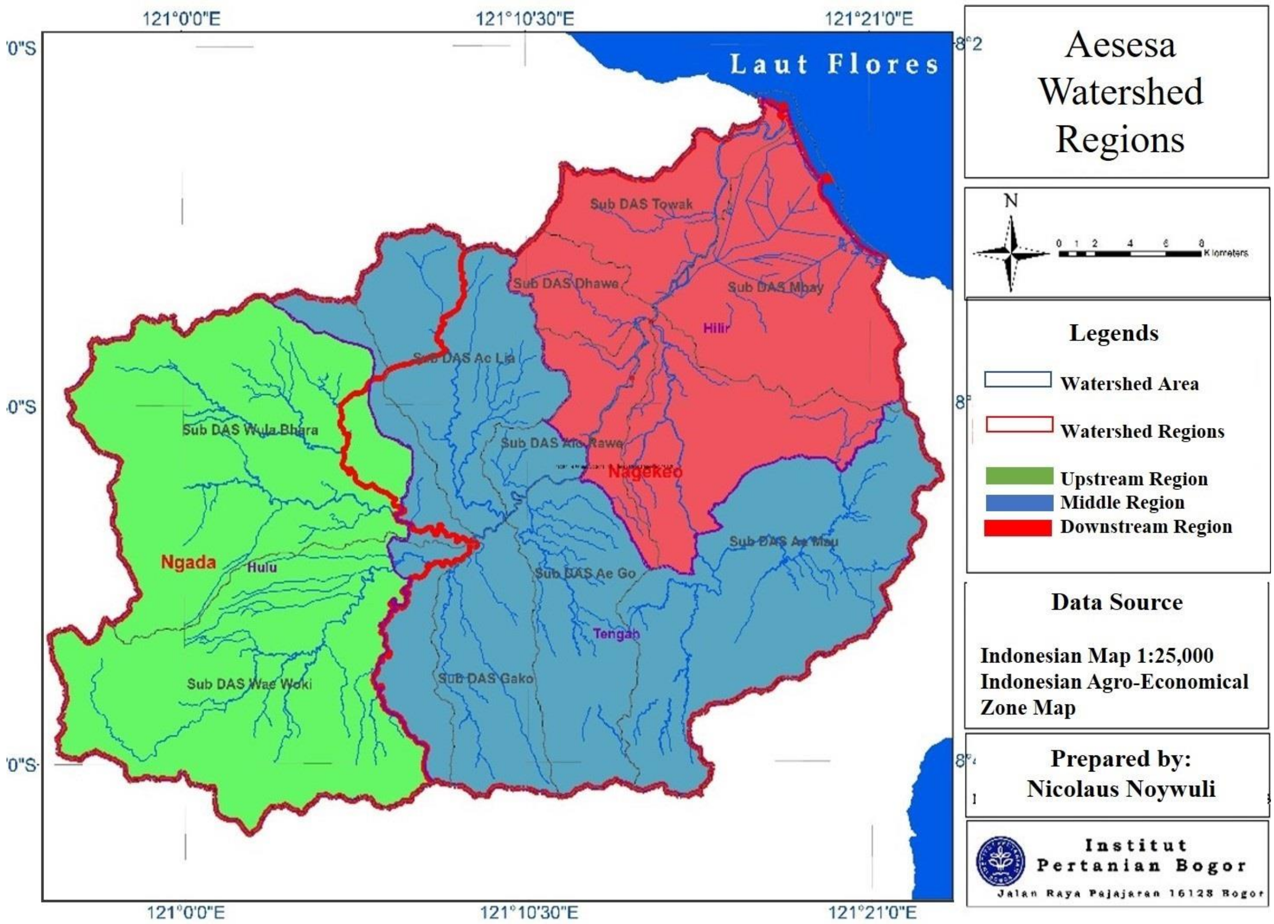

Figure 1. Aesesa Flores watershed region

Climatologically, the watershed AF belongs to a semi-arid region with low rainfall. The rainy season and wet months are generally short, around three to four months, namely December to March. The dry season lasts between six to nine months, namely the period April to November. In June-September, the region receives wind currents originating from Australia that do not contain a lot of water vapor resulting in a dry season. Conversely in December-March many wind currents contain water vapor originating from Asia and the Pacific Ocean so that the rainy season occurs. Rainfall is a climate parameter that is very important in the inventory the biophysical characteristics of AF watersheds, because it will directly affects the amount of erosion that may occur in the region and the total water yield in the AF watershed. The lowest rainfall (0-1,000 mm/year) only occupies an area of 5,318 ha in the lower reaches (downstream area). The highest rainfall (1,251-2,500 mm/year) occurs in the middle and upstream part of the AF watershed, which occupies a total area of 64,346 ha. The highest rainfall occurred in the upstream area of AF watershed as expected, which was recorded between 1,501-2,500 mm/year.

2.2 Data source

The evaluation and classification of AF watershed carrying capacity were done based on the Regulation of the Indonesian Minister of Forestry Number P.61/Menhut-II/2014 (Kemenhut, 2014a). The evaluation and classification of AF watershed carrying capacity were based on the primary and secondary data of the five criteria in the regulation of the Indonesian Minister of Forestry Number P.61/Menhut-II/2014. Each criterion in the regulation consists of different parameters that need to be evaluated. The detail for data analysis will be explained further below.

The primary data used in this study includes the sediment data, flood information, conservation activities, land use, and the value of water construction investment in the AF watershed for each region. The sedimentation data was collected directly from the main streams in each AF watershed regions during the rainy and dry season. The collection of sediment sampling was done in the wet season (February) in each main stream point of the AF watershed regions, and there were two sampling points in each region, hence there were six sampling events (Figure 2). The calculation of sedimentation is as follow:

$$Qs = \frac{k \times Cs \times Q}{\text{total area (ha)}} \quad (1)$$

where Qs is total seasonal sedimentation in (ton/ha); k is constant (0.0864); Cs is sedimentation load from direct measurement; and Q seasonal water debit.

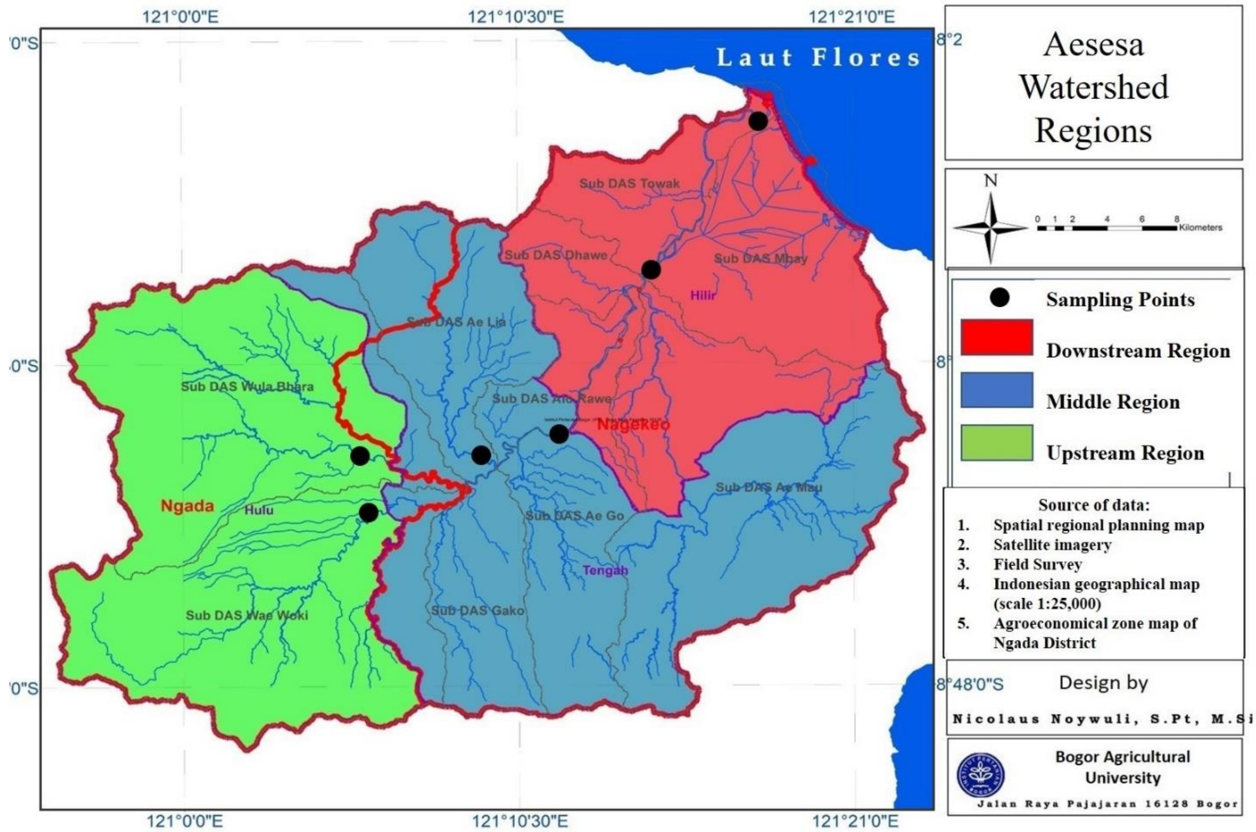

Figure 2. Sampling point of sedimentation analysis

The data and information on flooding, conservation norms and the value of investment in building water infrastructure are the result from the community interviews and information from relevant agency officials. The flooding occurrence was recorded when there are flooding in the area (water load from river that inundate the area in 24 h). The conservations norms recorded including whether farmers in the respective area (upstream, middle and downstream) are practicing the conservation techniques such as terrace, mulching, organic fertilizer, agroforestry practices and crop rotation techniques. The investment in building water infrastructure was used proxy of the value (in Rupiah) of water related infrastructure (dams, river channel, irrigation channel) in the area.

The land use data was based on an interpretation of satellite imagery data. The field survey and interview were conducted using purposive sampling and the questionnaire to 127 respondents, including local government bodies (head village chiefs) and multiple stakeholders in the AF watershed, including community groups, farmers groups and Non-Government Organization (NGO). The secondary data collection includes literature review, and other reports from the relevant government institution involved in the AF watershed management (e.g., regional agricultural agency, regional environmental protection agency and district government) (Table 1).

Table 1. Primary and secondary data used in this study

Primary data	Secondary data
• Sedimentation data • Flooding occurrence • Conservation activities • Water related investment	• Annual river debit data (obtained from Regional Watershed Agency in East Nusa Tenggara) • Annual rainfall data (obtained from the Meteorological Agency in East Nusa Tenggara) • Population data (obtained from the local Ngada and Nagaeko District Government) • Socio-economic data (obtained from the local Ngada and Nagaeko District Government) • Thematic maps including administrative area, land use and land cover map, degraded area map (obtained from the Indonesian Central Map Agency and the Regional Watershed Agency)

2.3 Data analysis

This study was a quantitative descriptive and based on the results of the study provide an overview of the condition of the carrying capacity of the watershed of each region in the AF watershed. Increased competence in the area of watershed management, based on parameters measured quantitatively by the AF watershed ecological approach. The data analysis procedure system is carried out based on the Minister of Forestry Republic of Indonesia Regulation Number P.61/Menhut-II/2014 concerning Monitoring and Evaluation Criteria for Watershed Management (Kemenhut, 2014a). The analysis of the condition of the carrying capacity of the AF watershed is carried out in an integrated manner against the five criteria: land, water management, socio-economic, water related infrastructure, and regional spatial utilization. Each sub-criteria has its own parameters, and the evaluation-classification process was done by categorizing each parameters (from primary and secondary data) into relevant scoring and classes. The detail of parameters for each criteria are described in Table 2.

Table 2. Criteria and sub-criteria of carrying capacity assessment

Criteria	Sub-criteria	Definition	Approach
Land resource carrying capacity	Percentage of degraded land (PLK)	Area with high soil erosion, steep slope, low productivity	Percentage of degraded land (from the regional map) in the watershed
	Percentage of land cover (PPV)	Area with high land cover percentage is considered not degraded	Percentage of land covered (plant) in the watershed
	Erosion index (Crop and Management index-CP)	Index of erosion based on the type of crop and agricultural management	Using the crop-index and agricultural management-index based on the Universal Soil Loss Equation (USLE)
Water resource carrying capacity	Flow regime coefficient (KRA)	Maximum flow coefficient	Calculation based on the Regulation Number P.61/Menhut-II/2014
	Yearly flow coefficient (KAT)	Yearly flow coefficient	
	Sedimentation load (MS)	Yearly sedimentation load	
	Flood occurrence	Yearly flood occurrence	
	Water utilization index (IPA)	Ratio of water utilization in the area and the yearly flow coefficient	

Table 2. Criteria and sub-criteria of carrying capacity assessment (cont.)

Criteria	Sub-criteria	Definition	Approach
Socio-economic carrying capacity	Land availability index (IKL)	Ratio of available agricultural land and the total of farmers in the area	Calculation based on the Regulation Number P.61/Menhut-II/2014
	Welfare index (TKP)	Ratio of poor household to the total household in the area. Household with income less than IDR 12 million	
	Regulation and governance	Any regional regulation that concerning conservation of watershed	
Water related infrastructure	City classification	Classification of type of city based on the Indonesian Regulation	Data from secondary data from the regional government
	Water related infrastructure (IBA)	Investment by the regional government on any water related infrastructure	
Regional spatial utilization	Protected area (PTH)	Percentage of protected area (an area that solely purpose for conservation), determined by the Indonesian Ministry of Forestry	Data from secondary data from the regional government
	Agriculture-farming area (LKB)	Percentage of productive agriculture area compared to the total area of watershed	

After the values in all criteria and sub criteria are calculated, the values are entered into the class. The class in question is a class with a classification of the carrying capacity of the watershed. Classification of watershed carrying conditions is divided into 5 categories namely very good, good, medium, bad and very bad. The total score per watershed is obtained from the sum of the multiplication between scores and weights for all criteria. Classification of watershed carrying conditions (DDD) is determined based on the value obtained, where $DDD \leq 70$ is categorized as very high, $70 < DDD \leq 90$ is categorized high, $90 < DDD \leq 110$ is categorized as moderate, $110 < DDD \leq 130$ is categorized as low, and $DDD > 130$ categorized as very low. Details of calculations for each criteria are presented in the supplementary material (Supplementary data as follow Table F1, F2, F3, F4, and F5).

3. RESULTS AND DISCUSSION

The results of the analysis of the carrying capacity conditions for the upstream, midstream and downstream regions of the Aesesa Flores watershed (AF) for each region which were carried out in an integrated manner against 5 criteria with 15 sub criteria, indicate that the conditions of the AF watershed carrying capacity in general are in a condition leading to bad. The detail of each criteria analysis is presented in the supplement material. The carrying capacity of water resources is a complex function related to the ecological aspect of water environment, socio-economic condition, and pressure from population, policy and governance in the watershed area (Zhou et al., 2017). The results from the carrying capacity assessment showed that the overall carrying capacity assessment in the upstream region is categorized as having low carrying capacity, while both the middle and downstream region is categorized as moderate condition. The results of the analysis of the condition of the carrying capacity of the AF watershed based on the region and its assessment criteria are presented in Table 3.

The carrying capacity of each AF watershed region above 100 ($DDD \geq 100$), indicates that the carrying capacity of the AF watershed needs to be immediately restored, especially in the upstream region. This is in accordance with the provisions of Indonesian Government Regulation Number 37/2012 and the Indonesian Ministry of Forestry Regulation Number 61/2014, concerning the classification of watersheds. The total average carrying capacity of the whole AF watershed is classified as moderate in the Indonesian Ministry of Forestry Regulation Number 61/2014 (Kemenhut, 2014a). Hence, according to this regulation it is important to prioritize the plan for the AF watershed rehabilitation to avoid further damage and/or degradation.

However, it should be noted that the categorical order of carrying capacity in the Indonesian Ministry of Forestry Regulation number 61/2014 is confusing. In this regulation, carrying capacity of a watershed above 100 is considered bad, where carrying capacity of watershed below 70 is considered good. This categorical order is confusing, because usually a watershed with higher carrying capacity means that the watershed could supply the demand of natural resources in the area. Hence, to avoid further misperception it is important to revise the categorical order of carrying capacity in the Indonesian Ministry of Forestry Regulation number 61/2014.

Table 3. Classification of carrying capacity (DDD) of AF watershed

No.	Criteria-sub criteria	Region and DDD						Average
		Upstream		Middle		Downstream		
		Value	Classes	Value	Classes	Value	Classes	
1	**Land resources**	**47,50**		**50,00**		**50,00**		**49,17**
A	Percentage of degraded land	30,00	Very high	30,00	Very high	30,00	Very high	30,00
B	Percentage of land-cover	12,50	Low	15,00	Very low	15,00	Very low	14,17
C	Erosion index	5,00	Very low	5,00	Very low	5,00	Very low	5,00
2	**Water resources**	**19,50**		**15,50**		**15,50**		**16,83**
A	Water debit flow	2,50	Very low	2,50	Very low	3,75	Low	2,92
B	Annual water debit flow	7,50	Very high	7,50	Very high	6,25	High	7.08
C	Sedimentation load	6,00	Very high	2,00	Very low	2,00	Very low	3,33
D	Flood occurrence	1,50	Low	1,50	Low	1,50	Low	1,50
E	Water utilization index	2,00	Very low	2,00	Very low	2,00	Very low	2,00
3	**Socio-economic**	**26,00**		**23,50**		**21,75**		**25,75**
A	Population pressure	12,50	Low	10,00	High	10,00	Moderate	10,83
B	Welfare	10,50	Very low	10,50	Very low	8,75	Low	9,92
C	Regulations and governance	3,00	Moderate	3,00	Moderate	3,00	Moderate	3,00
4	**Water related infrastructure**	**11,25**		**8,75**		**11,25**		**10,42**
A	City classification	3,75	Low	3,75	Low	3,75	Low	3,75
B	Water related infrastructure	7,50	Very high	5,00	Moderate	7,50	Very high	6,67
5	**Regional spatial utilization**	**6,25**		**5,00**		**6,25**		**5,83**
A	Protected area	2,50	Very high	2,50	Very high	3,75	High	2,92
B	Agriculture area	3,75	Low	2,50	Very low	2,50	Very low	2,91
Average value		110,50	Low	102,75	Moderate	104,75	Moderate	106

The low management performance of each AF watershed region from the five criteria, as presented in Table 2, is caused more by the criteria of land resource, then followed by socioeconomic and institutional, water governance criteria, and water investment criteria. Based on these assessments, the AF watershed is considered to be having low carrying capacity, due to the low land and water resources.

The Regulation of the Indonesian Minister of Forestry Number P.61/Menhut-II/2014 (Kemenhut, 2014a) considers that the water resource carrying capacity in the watershed will determine the capability of the watershed to fulfill demands from the region. However, it should be noted that this regulation only assesses the quantity of water resources in the watershed. The quality of water in the watershed has not been assessed, hence this study suggests to revise the Regulation of the Indonesian Minister of Forestry Number P.61/Menhut-II/2014 to accommodate the water quality assessment. Furthermore, this regulation is using the flood occurrence as one indicator for the water resource carrying capacity. This study found that in the dry climate of AF watershed, flooding has not become an issue, but drought is more relevant in this area. The drought occurrence is not in the indicator of carrying capacity based on the Regulation of the Indonesian Minister of Forestry Number P.61/Menhut-II/2014 (Kemenhut, 2014a). Therefore, looking at the diverse condition of watershed in Indonesia, further studies and research to formulate better comprehensive carrying capacity assessments that look at different climate regimes in Indonesia is important.

The lowest management performance of the five criteria is the criteria for land resources, where the percentage of degraded land for each region is very high, while the percentage of vegetation cover is also very low and only a very low erosion index (Supplementary data as follow Table A1, A2, and A3). The criteria for the use of space in the area showed very good performance, where protected areas are very good and supported by the availability of cultivation areas (Supplementary data as follow Table E1). Of the five criteria for assessing the condition of the carrying capacity of this watershed, the criteria for land, water management, socio-economic and institutional, and investment in water construction must be restored (Supplementary data as follow Table A1, B2, C2, and D1) while the criteria for spatial use need to be maintained (Supplementary data as follow Table E2). The land carrying capacity of vegetation is mostly affected by the hydrological aspect (Guo and Shao, 2003). Thus, it is very important to rehabilitate the degraded land in order to restore the damaged watershed region.

Improvement of the carrying capacity for each region in the AF watershed can be done with emphasis according to the results of the classification of the carrying capacity. According to Indonesian Government Regulation Number 37/2012, the implementation of watershed management activities is adjusted to the condition of its carrying capacity. The results from this study indicated that the carrying capacity of the AF watershed needs to be restored. Recovery activities in the three AF Watershed regions are mainly focused on four criteria, namely land conditions, socio-economic and institutional, and water construction investment, as well as water management. A previous study by Ren et al. (2016) proposed the metabolic theory of water resource and emphasized the needs to evaluate the water resource system, socio-economic system and the ecological system in the process of evaluation water resource carrying capacity. The result from this study showed that the water utilization index (IPA) is categorized as very low (Supplementary data as follow Table B5), however the yearly flow coefficient is categorized as high (Supplementary data as follow Table B2). This result indicated that in the AF watershed should have more water resource, but in reality, people in the AF watershed face a shortage of water during dry season (May-October) (Noywuli et al., 2017). It can be suggested that the distribution and management of water resource in the AF watershed is not efficient, thus there is a need to prioritize improving its water resource capacity. Another study by Lu et al. (2017) who analyze the water environmental carrying capacity of Huaihe river basin in china, also suggested that management of water resource needs to be more efficient and appropriate water management strategies are needed to improve the water resource capacity.

Efforts to restore carrying capacity in the upstream, midstream and downstream regions of the AF watershed are done by optimizing land use in accordance with the function and carrying capacity of the area, and then applying soil and water conservation techniques. Furthermore, managing vegetation for conserving biodiversity, increasing land productivity, ecosystem restoration, and rehabilitation and land reclamation. Ye et al. (2016) suggested that the analysis of environment carrying capacity, in this case the AF watershed carrying capacity, can provide clear information on the pressure of human activities to the environment, hence there is a need to balance the productive economic activities and the protection of ecological-environment condition in the AF watershed. The pressure of socio-economic condition on the carrying capacity of water resource has also been reported elsewhere by Yang et al. (2015) and Shabbir and Ahmad (2016). In addition, important things to do are to develop productive economic activities, increase awareness and role of watershed management agencies, then, develop watershed management institutions to improve coordination, integration, synchronization and synergy across sectors and administrative regions (Hariadi et al., 2004). Genskow and Born (2006) further emphasize the importance of collaborative and partnership-based initiative between multi-stakeholder in the watershed to formulate a better watershed management plan.

Handling the conditions of carrying capacity of the AF watershed with damaged categories in the upstream and medium categories in the middle and downstream regions of the AF watershed, it can be recommended to pass; 1) restoration and conservation (Arsyad, 2010); and 2) mapping and structuring of stakeholders. Restoration and conservation efforts in each region of the AF watershed require synergies from all sectors, both the public, private and community sectors, to carry out these strategic initiatives. Without participation, all sectors are difficult to achieve. Each sector can contribute according to the authority and resources they have. It is important to understand that an effective collaboration of multi-stakeholder is important to achieve the appropriate watershed management and restoration plan (Imperial, 2005). In addition, there must be a synchronization of management policies at the district, provincial and central government levels regarding spatial policies, land use, division of authority between agencies, and others by Reddy et al. (2017).

The private sector can also take a role by making efficient use of water resources and integrating them into their business strategies, undertaking various initiatives to conserve water resources independently and collectively, supporting campaigns for efficient use and conservation of water resources, providing support to community groups including non-governmental organizations that actively make efforts to conserve forest and water resources to increase the scale and impact of their programs, through initiatives of Corporate Service Responsibility (CSR) including co-social investment. On the community side, awareness efforts to community leaders, traditional leaders, religious leaders, youth leaders, women leaders and figures from various stakeholders are needed. The existence of local champions who have an awareness of the problems faced by the AF watershed at the same time as an alternative solution that should be taken will be very helpful in the collective awareness process, both at the community level and at the Aesesa Flores watershed level.

Apart from the restoration and conservation efforts, the efforts of mapping and structuring stakeholders and strategic issues related to the AF watershed with the aim of identifying key actors who have high influence and relevance to be involved in resolving the AF watershed problems, whether government agencies or sectors, private sector, community groups, mass media, academics, NGOs, and other prominent public figures (Noywuli et al., 2018). This was done so that a relevant stakeholder engagement strategy could be made. While academics and watershed management practitioners need to conduct research and awareness processes to government agencies, public officials, community leaders and the media (Noywuli et al., 2018). In addition, it also develops several pilot projects for management, especially in sustainable water resources, such as building infiltration and bio-pore wells, building an artificial-*bana* (wetland) and conservation in the water catchment area, producing and applying the best knowledge to encourage agricultural development, increase farmer income and preservation of the environment. A series of studies and pilot projects are expected to strengthen recommendations for possible conservation and restoration interventions in each AF watershed region and also build awareness from various stakeholder groups, to collectively move together to save the AF watershed ecosystem as a sustainable regional development capital.

The management of watershed in Indonesia is regulated according to the Indonesian Government Regulation Number 37/2012, and the Indonesian Ministry of Forestry Regulation Number 60-61/2014. Regional government (Provincial government) is tasked to arrange a management plan that includes the carrying capacity assessment of watershed before any programs in the watershed management could be funded by the National State

Budget. This study found that the Indonesian Forestry Minister's Regulation Number 61/2014 does not comprehensively assess the carrying capacity of AF watershed. Further studies are needed to improve the carrying capacity assessment of watershed in Indonesia, especially for watershed in dry climate condition.

4. CONCLUSIONS

Based on the Republic of Indonesia's Forestry Minister's Regulation Number 61/2014, the AF watershed was found to have a low carrying capacity in the upper stream area, and moderate both in the middle and downstream area. Based on this result, the AF watershed needs to be restored immediately so that the AF watershed can function properly and sustainably. The restoration-rehabilitation plan could be in the form of: 1) the development of agro-industry, agroforestry and ecotourism; 2) Replanting and rehabilitation of degraded land; 3) the development of bamboo farming; 4) increasing the community involvement in the management of AF watershed; and 5) actively encourage the local customary institution to be involved in the management of AF watershed. This study also evaluated the suitability of carrying capacity assessment based on the Regulation Number 61/2014 to the condition of AF watershed. Several criteria, such as flood occurrence was not suitable for AF watershed, where drought is more prominent. Hence, this study suggested that the Regulation Number 61/2014 needs to be revised to consider dry climate areas in Indonesia.

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