No.	Sustainability Attributes				
	Ecology	Economy	Social	Technology & Access	Institution & Governance
5	Agricultural Productivity	Demand on natural resources, market access and agricultural input-output	Community welfare level	Technologies used on land conservation	Local wisdom and custom law
6	Land Conservation	Level of agricultural land ownership	Community education level	Technologies used on soil and water conservation	Agricultural organization
7	Forest Area	Tourism index	Education services	Technologies used on post-harvest	Coordination between Regional Government and Stakeholders
8	Land Conversion Rate	Income from non-agricultural activities	Health services	Agricultural techniques on bamboo	Land rehabilitation decision making
9	Annual water debit	Agricultural workforce	Religion services	Road access to public infrastructures	Financial institution and agricultural market institution
10	Water catchment area conservation	Service sector workforce	Unemployment rate	Education and health public infrastructures	Agricultural and forestry extension officer
11	Increasing Bamboo Area	Farmer's adaptation to the changing in market demand	Social contribution from bamboo	Technologies to make organic fertilizers	Agricultural and forestry extension activities
12	Regional planning (Housing and Coastal)	PDAM (Regional Water Authority) services			Information on Regional Development
13		Regional economic development			Organization in charge of bamboo management
14		Economical contribution from bamboo			
15		Irrigation services			

Table 2: Sustainability index in the RAP-DASAF software.

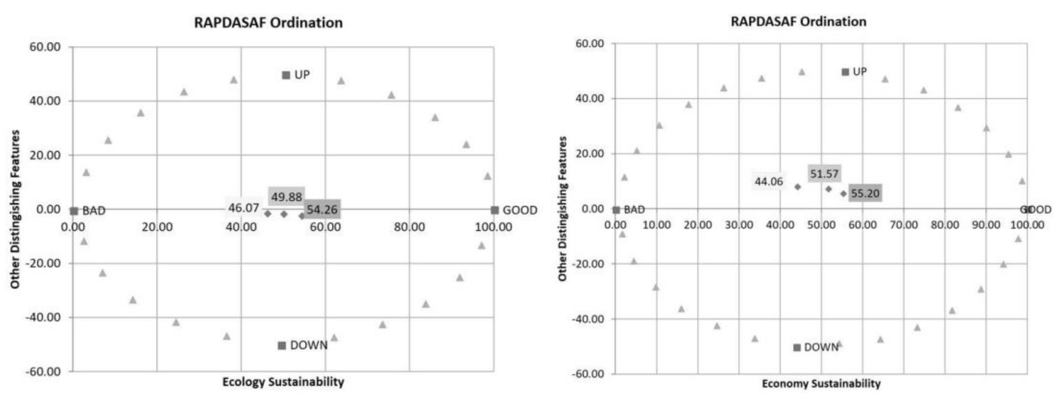
Index	Categorize
0.00 – 24.99	Worse (Unsustainable)
25.00 – 49.99	Bad (Less Sustainable)
50.00 – 74.99	Moderate (Moderate Sustainable)
75.00 - 100	Good (Sustainable)

Results and Discussion

In this study, the sustainability assessment on the AF watershed management was done on three different regions and consists of five dimensions as explained in the methods section. The results from ordination analysis for each sustainable dimension will be explained in the latter section, whereas the sustainable index value ranging from 0 to 100 and correlated to the sustainability status (Table 2). The result from ordination analysis for each dimension will be explained below.

Sustainability Assessment

The result from ordination analysis on the ecology dimension showed that both the upstream and the downstream regions are categorized as less sustainable, while the middle region is categorized as moderate sustainable (Figure 2A). The analysis on the social sustainability dimension showed similar results, where both the upstream and the downstream regions are categorized as less sustainable, while the middle region is categorized as less sustainable (Figure 2C). On the sustainability status of economic dimension, the ordination analysis showed that both the middle and the downstream regions are categorized as moderate sustainable, while the upstream region is categorized as less sustainable (Figure 2B). Similar to that, institution and governance dimension showed that both the middle and the downstream regions are categorized as moderate sustainable, while the upstream region is categorized as less sustainable (Figure 2E). Interestingly, all the regions in the AF watershed are categorized as less sustainable in the technology and accessibility dimension (Figure 2D). The Monte Carlo simulation (Figure 3) showed that the dispersion in the scatter plot of all dimension is not significant (less than 0.25), thus the ordination analysis was in a good fit to the model, and the results of the ordination analysis is reliable to be used as sustainability assessment (Kavanagh & Pitcher 2004).



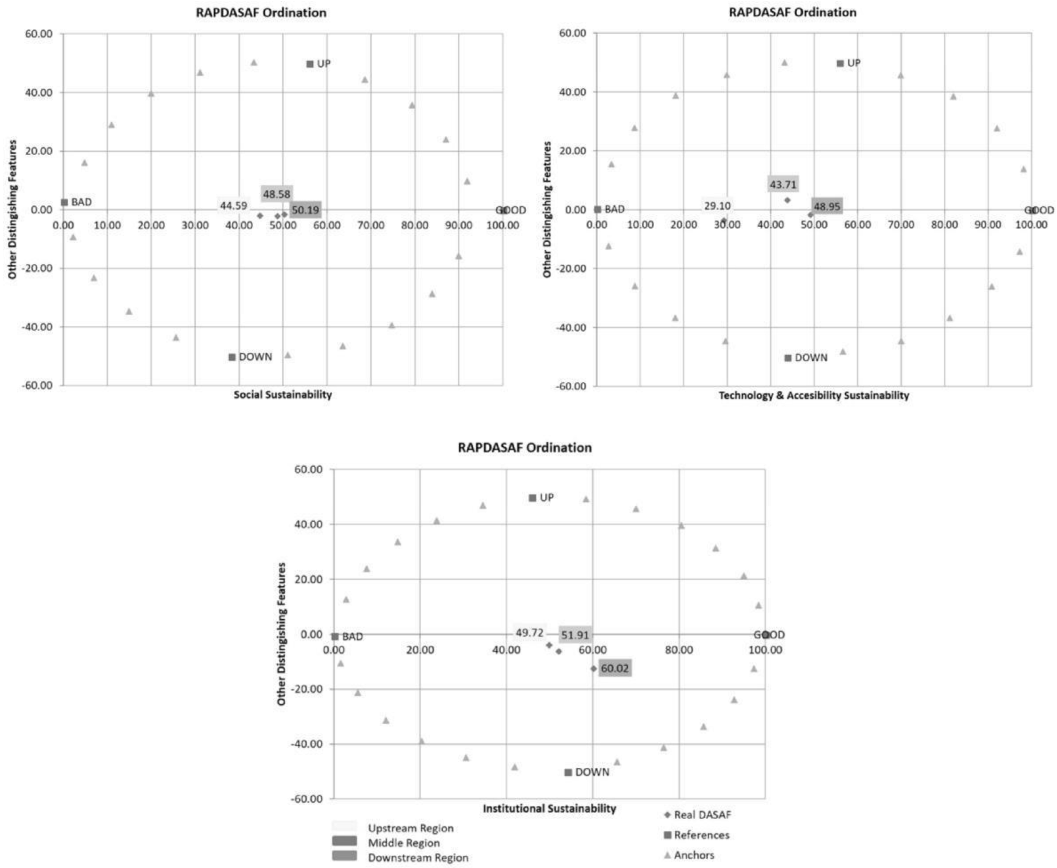
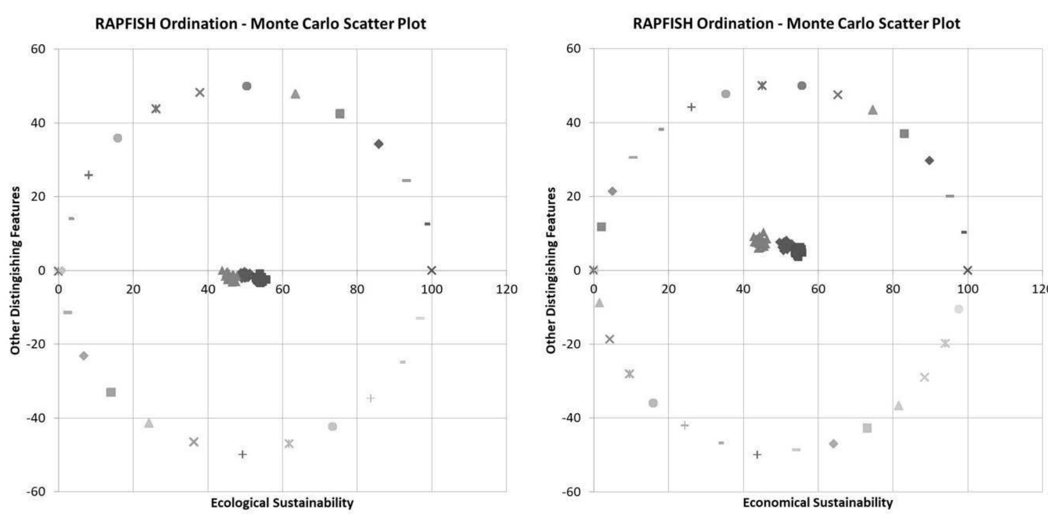


Figure 2: ordination analysis on the sustainability status of AF watershed in A) Ecology; B) Economy; C) Social; D) Technology and Accessibility and E) Institutional and Governance Dimension.



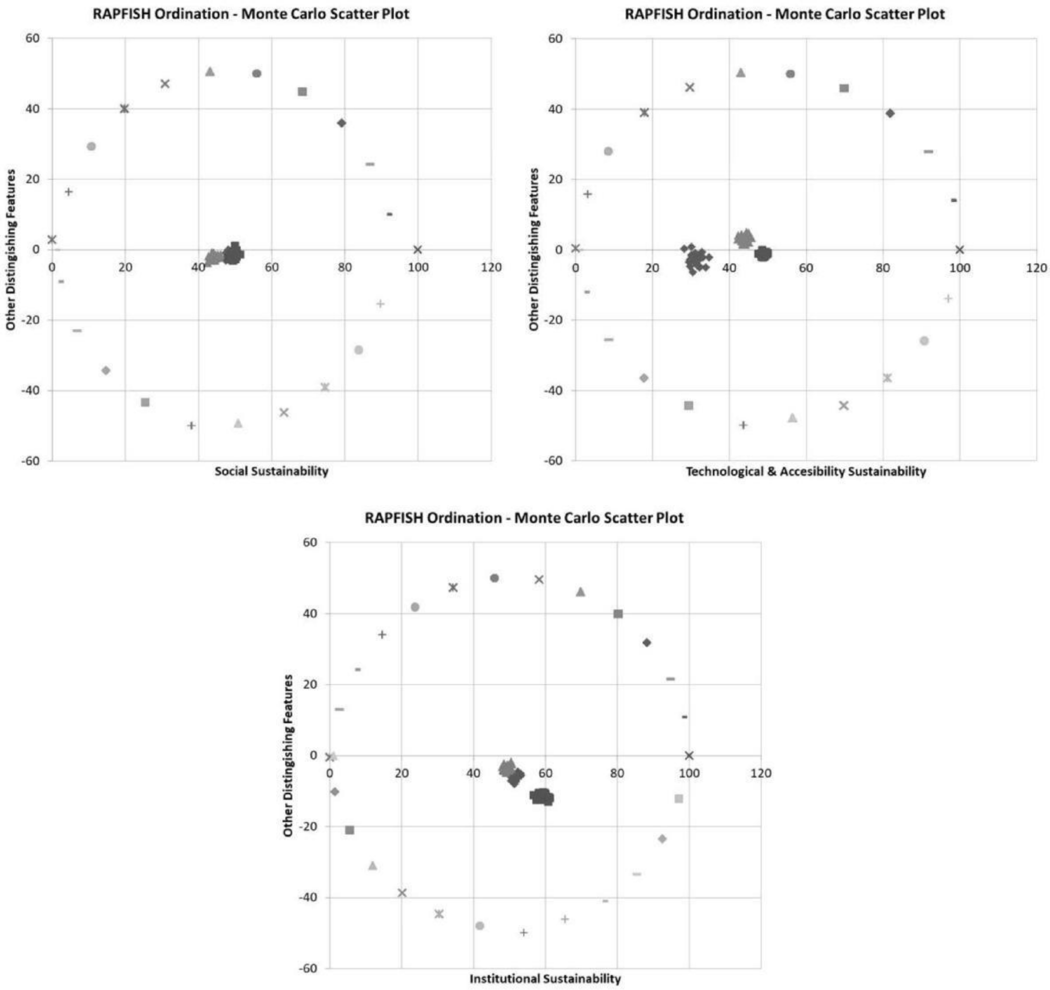


Figure 3: Monte Carlo analysis on the sustainability dimension of watershed management.

Leverage Factor Analysis

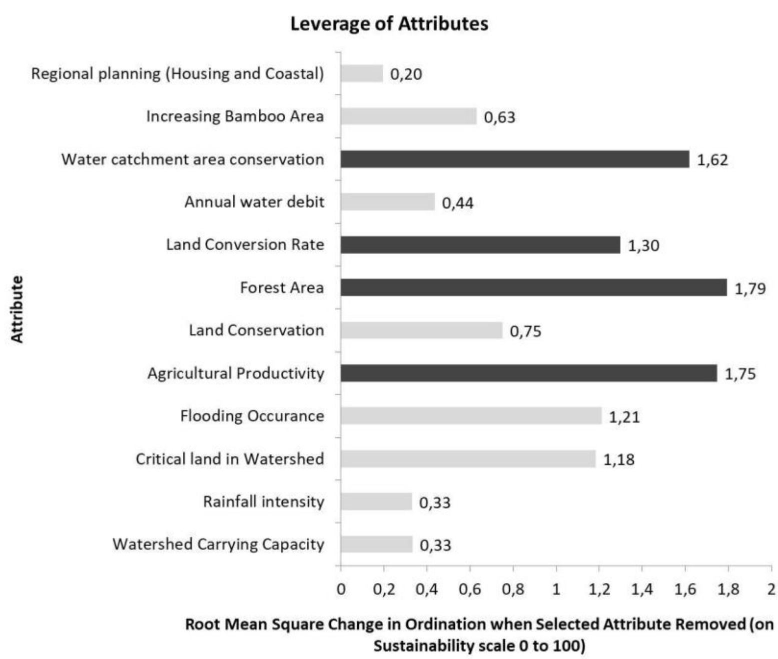
The results from the sensitivity analysis, also known as the leverage analysis, showed that from 11 attributes tested in the ordination analysis, there were four main attributes that sensitive to ecology dimension of sustainability (Figure 4A). Those four attributes are: (1) water catchment area conservation; (2) land conversion rate; (3) forest area and (4) agricultural productivity. Based on the leverage analysis, these four attributes are the main factors that determining the ecological sustainability in the AF watershed. Previous research by Maan *et al.* (2006) reported that the economic pressure results in the degradation of environment in the AF watershed. The typical slash and burn agricultural practices resulted in large-scale deforestation activities in the AF watershed (Maan *et al.*, 2006).

The results from the leverage analysis showed that there were five main attributes that sensitive to economic dimension of sustainability (Figure 4B). Those five attributes are: (1) regional water authority services; (2) service sector workforce; (3) agricultural workforce; (4) tourism index and (5) level of agricultural ownership. These five attributes are the main factors that influenced the economic sustainability in the AF watershed. Water seems to be the main concern in the AF watershed management. Previous analysis showed that the AF watershed is the main water source for economic activities both in Ngada and Nagakeo District. These activities include water provisioning for consumption, and rice production (Maan *et al.*, 2006).

In regard to the social dimension of sustainability, the results from the sensitivity analysis showed there were three main attributes that sensitive to social dimension of sustainability (Figure 4C). Those three attributes are: (1) religion services; (2) community welfare level and (3) community's motivation and participation in the forest and land conservation efforts. One of the proposed strategies to achieved sustainable watershed management in the AF watershed is the collaborative community-based management (Maan *et al.*, 2006). The broad objectives of the proposed strategy are focusing in improving physical watershed condition and to improve the community awareness and participation in the watershed management (Mann *et al.*, 2006).

The results from the sensitivity analysis on the technology and accessibility dimension showed that there were five sensitive attributes (Figure 5A). Those five attributes are: (1) agricultural techniques on bamboo plantation; (2) technologies used on post-harvest activities; (3) technologies used in the soil and water conservation activities; (4) technologies used on land conservation and (5) technologies used on watershed management. Communities in the upstream regions of AF watershed have a lower level of education (Noywuli *et al.*, 2017). The lower level of education in the upstream region could contributing to the less sustainable status.

The results from the sensitivity analysis showed there were six main attributes that sensitive to institution dimension of sustainability (Figure 5B). Those six attributes are: (1) agricultural and forestry extension officer; (2) financial and agricultural market institution; (3) land rehabilitation decision making; (4) coordination between regional government and stakeholders; (5) local wisdom and custom law and (6) ownership regime on the natural resources in the watershed. Mann et al. (2006) emphasized the needs for community collaboration to achieve a sustainable watershed management in the AF watershed. Local wisdom and custom law are important in the AF community watershed management (Maan *et al.*, 2006).



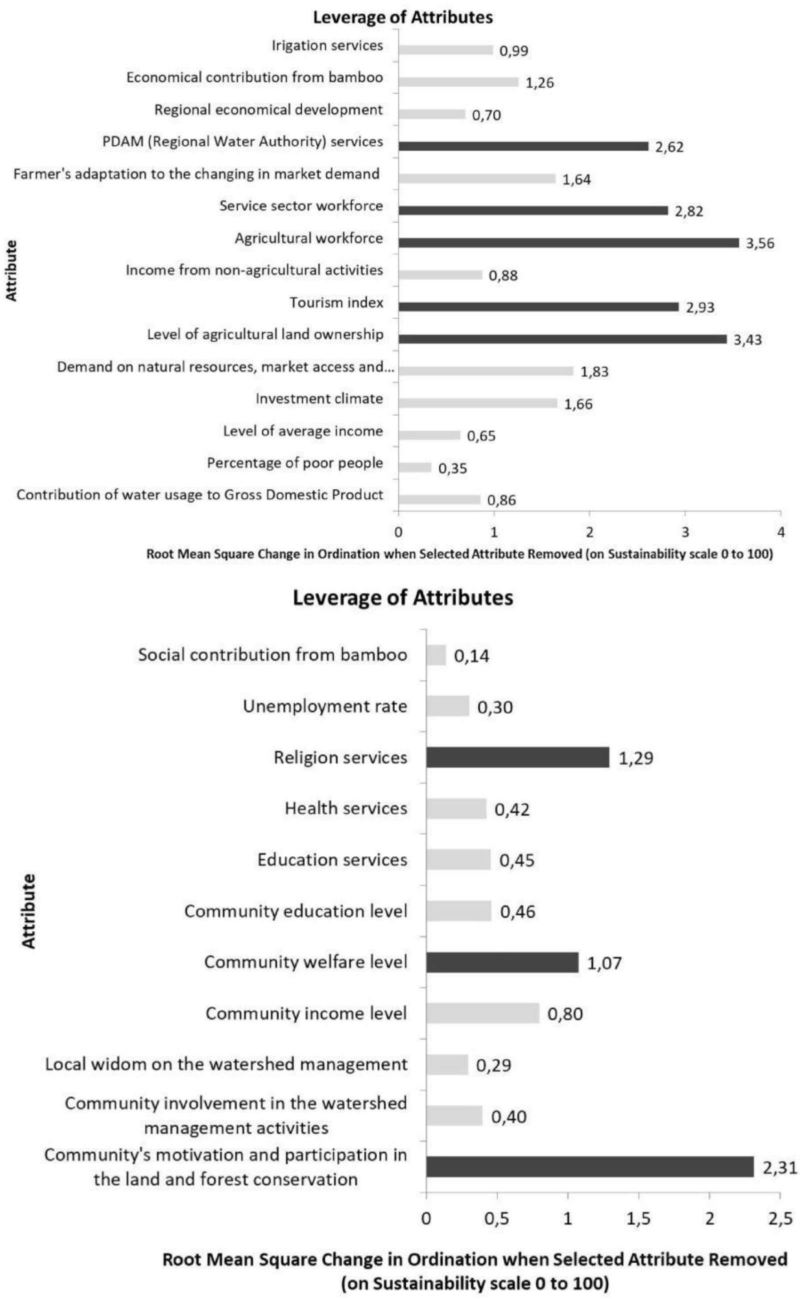
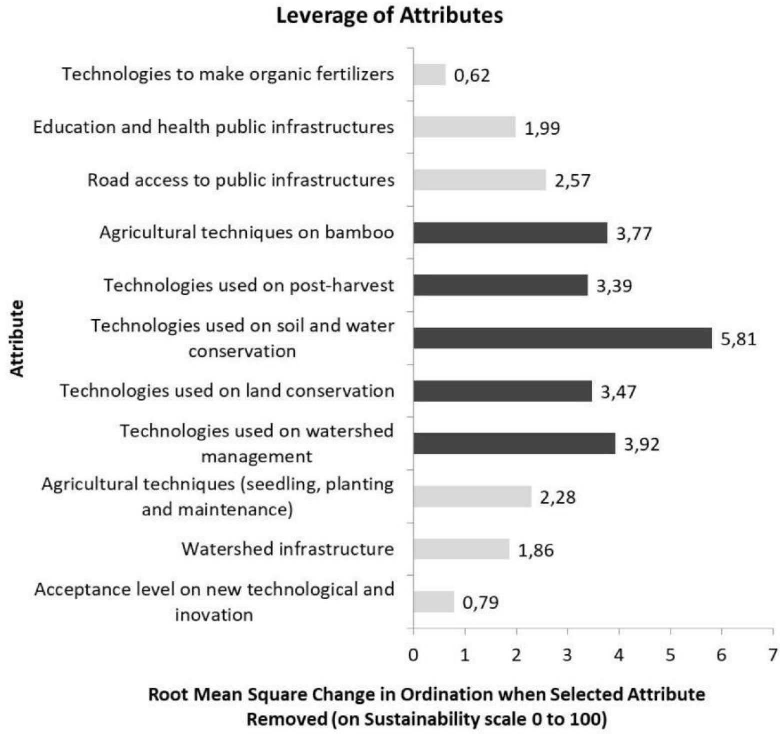


Figure 4: The sensitive attributes that affect the sustainability of AF watershed management on A) Ecological Dimension; B) Economic Dimension; C) Social Dimension.



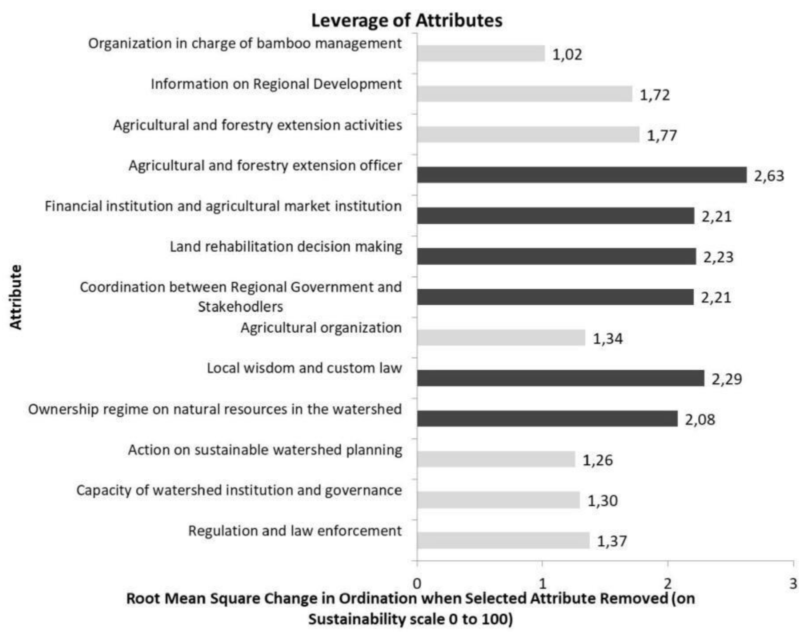


Figure 5: The sensitive attributes that affect the sustainability of AF watershed management on A) Technology and Access Dimension; B) Institution and Governance Dimension

Sustainable Assessment: Multidimensional Sustainability

Based on the ordinal analysis and the generated sustainability index, each region was calculated the overall multidimensional sustainability (Figure 6). In this study, all dimensions were assumed to have the proportional weight of 20%. Based on the multidimensional sustainability assessment (Figure 6 & Table 3), the middle region is categorized as moderate sustainable (53.72%). Both the upstream and downstream regions, however, are in the less sustainable category (49.13% and 42.71%, respectively). The upstream region was observed to have a better ecological sustainability (49.88%) compare to the downstream region (46.07%). However, when looking at the technology and access sustainable dimension, the downstream region was better (43.71%) than the upstream region (29.10%). Surprisingly, the upstream region showed better economic sustainability (51.57%) compared to the downstream region (44.06%).

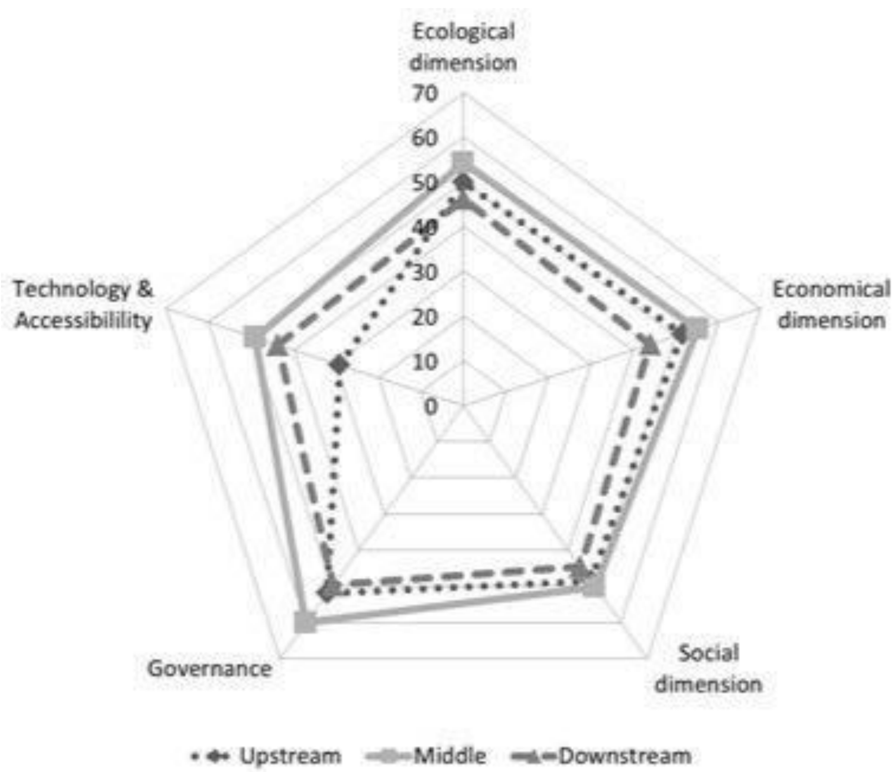


Figure 6: Multidimensional sustainability assessment

Table 3: Sustainability index in each regions (Upstream, Middle, Downstream) of AF watershed

No.	Region	Ecology	Economy	Social	Technology & Access	Institution & Governance
1	Upstream (Sustainability Index)	49.88	51.57	48.58	29.10	51.91
	Squared correlation (R^2)	94.15	95.37	93.77	93.57	94.87
	Stress values (%)	16.29	13,35	16.84	13.35	15.21
	Sustainability Status	Less Sustainable	Moderate Sustainable	Less Sustainable	Less Sustainable	Moderate Sustainable
2	Middle (Sustainability Index)	54.26	55.20	48.58	29.10	51.91
	Squared correlation (R^2)	94.15	95.37	93.77	93.57	94.87
	Stress values (%)	16.29	13.35	16.84	13.35	15.21
	Sustainability Status	Moderate Sustainable	Moderate Sustainable	Moderate Sustainable	Less Sustainable	Moderate Sustainable
3	Downstream (Sustainability Index)	46.07	44.06	44.59	43.71	49.72
	Squared correlation (R^2)	94.15	95.37	93.77	93.57	94.87
	Stress values (%)	16.29	13.35	16.84	13.35	15.21
	Sustainability Status	Less Sustainable	Less Sustainable	Less Sustainable	Less Sustainable	Moderate Sustainable

Looking at the R_2 value of all five sustainability dimensions tested in this study (Table 3), all dimensions showed R_2 value close to 1. This means that the five sustainability dimensions tested in this study are strongly linked to the sustainable assessment of AF watershed. Previous study by Yusuf *et al.* (2016) also reported that the same five dimensions (economic, ecology, social, technology and governance) were acceptable to be used in the sustainability assessment of watershed management.

Conclusion

The sustainability assessment was done on the AF watershed management in the three different regions, and the results showed that both the upstream and downstream regions were categorized as less sustainable, and only the middle region was regarded as moderate sustainable. In overall, of the five sustainability dimensions tested in this study, the social and technological dimensions were fall into less sustainable category. The other three dimensions, namely economic, ecology and institution-governance were regarded as moderate sustainable. The MDS approach was able to provide further sensitivity analysis on attributes that influencing the sustainability status for each dimension in the AF watershed. The results from the sensitivity analysis emphasize the needs of community collaborative watershed management in the AF watershed that involving multiple stakeholders to be involved in the planning, action and monitoring of the watershed management.

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