

Biodiversity conservation in Mts. Arjuno-Welirang-Anjasmoro, East Java: Recent status of Biodiversity conservation and strategy for SDGs achievement

Iwan, Marjono, Qomariyatus Sholihah, Luchman Hakim

Graduate School of Environmental Science, Brawijaya University, Malang, East java,
Indonesia

Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang, East java,
Indonesia

Department of Industrial Engineering, Faculty of Engineering, Brawijaya University,
Malang, East Java

ABSTRACT

The mountains of Mts. Arjuno-Welirang-Anjasmoro in East Java have crucial ecosystem functions. It is especially crucial to support the SDGs programs in an area in adjacent to the mountains. The aims of the research firstly was to describe the bio-physical aspect of the mountains ecosystem of Mts. Arjuno-Welirang-Anjasmoro as a potential resources for SDGs programs, especially for area in adjacent to the mountain ecosystem. Secondly, the paper describes the local government and community perspectives in the potentials values of bio-resources in Mts. Arjuno-Welirang-Anjasmoro ecosystem to accelerate SDGs programs. Thirdly, this paper describes the recommendation for the optimum uses of bio-resources in mountains ecosystem in SDGs achievement. This study confirm that basically the area of Mts. Arjuno-Welirang-Anjasmoro has high level of biodiversity, and therefore it is crucial for conservation programs. The forest ecosystem has crucial contribution in SDGs achievement. Local government and community state that the most contribution was related to the goals 13 (Climates actions), 15 (Life on lands) and 6 (Clean water and sanitation). The significant grows of tourism sectors in the area also contributes to the other goals. Ecotourism is one of the prospective sector of tourism should be developed to ensure the sustainable use of resources in tourism industry. Recommendation for SDGs achievement includes completing data bases and designing scenario for optimum uses of bio resources inside forest ecosystem sustainably. Strengthening conservation programs was crucial, and should be implemented by multi-stakeholder and community support.

Keywords: sustainable development, biodiversity conservation, community development, ecotourism.

Introduction

Mountains ecosystem in East Java is crucial area for biodiversity conservation programs. Compared to the lowlands area, mountain area in East Java are relatively less disturbed as an impact of rapid community settlement growth and industrial area development. The combination of geo-physical, climate, and socio-economical aspects contributes to the limitation for fast industrial development of mountains area (Whitten et al., 1996; Hakim and Soemarno, 2017). The agricultural and tourism sectors, however, shows a significant growth in mountains area. The combination of abundance fertile lands and waters in mountains ecosystem support for rapid agricultural growth.

The community in Java Island viewing mountains as a sacred area, in which it is contributes to preservation of many sites of mountains area in East Java. The spiritual and cultural relationship of people and nature in tropical developing countries has been reported by numerous authors contribute to the harmonious and sustainable uses of natural resources. Understanding such relationship is crucial to develop local community participation in conservation program, especially in area which were appreciated by local culture (Reed, (2008). In east Java, there are numerous sacred area distributed in mountain area. Some respected area were without human interventions. These provides opportunities for mountain area in East Java still has a high number of biodiversity. Mountain forest is crucial habitat for wildlife (Whitten et al., 1996; Hakim and Soemarno, 2017).

The area of Mts. Arjuno-Welirang-Anjasmoro is one of the area with high number of biodiversity. Located in the heart of East Java province, the area has been declared as Grand Forest Conservation area (*Taman Hutan Raya*) in 1992 to protect high number of biodiversity and numerous fragile ecosystems. Prior to the designated as grand forest conservation area, the Mt. Arjuno has been declared as strict nature reserve with the formal name Arjuno Lalijiwo in 1972. These ecosystem areas are especially crucial for numerous ecological process. High level of biodiversity and numerous ecological function inside the Mts. Arjuno-Welirang-Anjasmoro are the significant object for research and education. The area is home to rare and vulnerable plants and animals species Whitten et al., 1996; Van Steenis, eet al., 2006). In the slope of Mt. Arjuno is also hot spot for temple, statue and cultural relict artifacts of the past. Considering potential aspect of the ecosystem as sites for education, in 2015 these area together with Bromo Tengger Semeru was declared as Arjuno Bromo Tengger Semeru Biosphere Reserve (Hakim and Soemarno, 2017).

The ecosystem of Mts. Arjuno-Welirang-Anjasmoro are expected to be able to support local people prosperity, especially community who lived in an adjacent to the area. It is especially relevant with the Sustainable Development Goals (SDGs) targets. The connection of forest ecosystems to achieve SDGS has been discussed (Swamy et al., 2018). Forest especially crucial to achieve the sustainable development program. Scholar point out that decrease and loss of forest contributes to the achievement of SDGs program Krause and Tilker (2022) report that decline and loss of fauna in tropical forest contributes to the SDG issues in objectives 2 (zero hunger), SDG 3 (good health and well-being), SDG 13 (climate action) and SDG 15 (life on land). With the total area c.a. 27,868.30 hectare, the ecosystem of Mts. Arjuno-Welirang-Anjasmoro principally crucial to support sustainable living of local community in adjacent to the forest. As far, there are absent of potential contribution of grand forest in SDGs achievement. Tourism has been growth in some are in the mountains chains ecosystem of Mts. Arjuno-Welirang-Anjasmoro, in which it is potential to support SDGs. There are, however, lack of discussion in the contribution of biodiversity of the mountains

ecosystem to support SDGs implementations. The aims of the research firstly was to describe the bio-physical aspect of the mountains ecosystem of Mts. Arjuno-Welirang-Anjasmoro as a potential resources for SDGs programs. Secondly, the paper describes the local government and community perspectives in the potentials values of bio-resources in Mts. Arjuno-Welirang-Anjasmoro ecosystem to accelerate SDGs programs. Thirdly, the paper describes the potentiality of tourism sector and strategy for sustainable tourism development in the mountains chains area.

Methods

The secondary data sources related to the physical and biological aspect of Mts. Arjuno-Welirang-Anjasmoro were collected. A systematic review of collected document was done to summarize and highlight the important information related to ecosystem biodiversity. Data and information related to the biophysical aspect of the area was collected from data base of office of forestry in Malang and Surabaya.

A field survey was conducted to visit some place in adjacent area to the Mts. Arjuno-Welirang-Anjasmoro. An interviews with local community was implemented to get data and information related to the human and natural resources interaction in Mts. Arjuno-Welirang-Anjasmoro. Interview was focused to the local community knowledge and perception on the forest ecosystem, especially with the role related to SDGs. An interview with the local representative of local government in adjacent to forest ecosystem were implemented to get respondent's perspective to the potential values of forest ecosystem in SDGs achievement. The respondents were representative of local government of Malang, Mojokerto, Pasuruhan, Batu, and Jombang. The responses consist of representative staff in each regency who are responsible for the SDGs issues. Data were analysed descriptively.

Result and Discussion

Geographical feature of the area

Mts. Arjuno-Welirang-Anjasmoro is the complex of active mountains ecosystem in the hearth of East java province. The conservation forest consist of mountains and some hills, stretched from Mt. Arjuno-Welirang in the east to Mt. Anjasmoro in the west. Inside the grand forest area, the mountains area has at least 36 peaks. About nine peaks has high more than 2000 m asl. It is includes Mt. Arjuno (3.339 m.asl.), Mt. Anjasmoro (3.275 m.asl.), Kembar II (3.256 m.asl.), Mt. Welirang (3.156 m.asl.), Mt. Kembar I (3.061 m.asl.), Mt. Baklorbubuk (2.608 m.asl.), Mt. Lalijiwo (2.524 m.asl.), Mt. Ringgit (2.474 m.asl) and Mt. Argowayang (2.198 m.asl). (Fig.1)

relatively poor. It can be found in the top area of mountains Mt. Welirang, one of the most active volcanoes in Mts. Arjuno-Welirang-Anjasmoro chains.

Official document of grand forest state that the forest was home to numerous plant species, with abundances species from families of *Euphorbiaceae* and *Moraceae*. Basically, the mountain flora of Mts. Arjuno-Welirang-Anjasmoro was high, with some species endemic to eastern java area Van Steenis, (2006). There are high number of ferns (*Pteridaceae*). Two species of plants was declared as protected plants according to Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor 106 Tahun 2018, including: *Castanopsis argentea* and *Anaphalis javanica*. The humidity of the mountain area is ideal habitat for orchids. Field survey by Soetopo et al., (2021) report numerous wild orchids species, includes *Appendicula elegans*, *Agrostophyllum* sp, *Bulbophyllum* sp., *Ceratostylis anjasmoroensis*, *Dendrobium nudum*, *Liparis caespitosa*, *Schoenorchis juncifolia*, *Thrixspernum aff subulantuntum*, and *Trichostesia annulata*. There are also *Dendrobium tenellum*, *Eria vericulosa*, *Oberonia similis*, *Pholidota carnea*, and *Appendicula* sp. A reported endemic orchods of the park incluses *Ceratostyliis anjasmoroensis* JJ Wood & J.B. Comber which was firstly reported from Mt. Anjosmoro in 1978 and *Corybas pictus* (Blume) O.K. var dorowatiensis J.J.S. which was reported from Mt. Dorowati.

The birds of Mts. Arjuno-Welirang-Anjasmoro are includes Alap-alap Kawah (*Falco peregrinus*), Bubut Jawa (*Centropus nigrorufus*), Elang Hitam (*Ictinaetus malayensis*), Elang-ular Bido (*Spilornis cheela*), Julang Emas (*Rhyticeros undulatus*), Sempurhujan Rimba (*Eurylaimus javanicus*), Takur Tulung-tumpuk (*Megalaima javensis*), Kipasan Belang (*Rhipidura javanica*), Opor Jawa (*Lophozosterops javanicus*), and Takur Bultok (*Megalaima lineata*). There are also endemic birds of Java, Elang Jawa (*Nisaetus bartelsi*). As far, illegal collection of birds and habitat disturbance becomes crucial threats to the survival of many birds population. Bird has crucial roles in seeds dispersal.

Mammals of the mountains chains includes Kijang muncak (*Muntiacus muntjak*), Rusa timor (*Rusa timorensis*), Kucing kuwuk (*Prionailurus bengalensis*), Landak jawa (*Hystrix javanica*), Lutung budeng (*Trachypithecus auratus*) and Macan Tutul. A survey by Izza and Kurniawan (2014) found five Amphibian found in watu Ondo, namely *Philautus aurifasciatus*, *Leptobrachium hasseltii*, *Limnonectes microdiscus*, *Huia masonii*, and *Duttaphrynus melanostictus*. River, riparians, water spring and waterfall is crucial habitat for amphibians. Declinhe sof such habitat less to the decrease of amphibians diversity.

The ecosystem rich in plants with economical values. Bamboo is one of the important bio-resources for local people living in adjacent to the grand forest. The bamboo species includes *Dendrocalamus asper*, *Gigntochloa apus*, and *Bambusa* spp. Bamboo was crucial in water conservation, especially in water spring ecosystem (Ben-Zhi ett al. 2005). Bamboo was also crucial on global warming mitigation action. Problems with bamboo, however, was illegal collection by local people. Official report of the grand forest authorities state that the main target of bamboo population degradation includes young bamboo shoots. Bamboo is one of the important non wood forest resources. Bamboo has been used for numerous purposes, ranging from civil construction to vegetables. Medical plant grows and easily found in the Mts. Arjuno-Welirang-Anjasmoro. The potentials of medical plants however, less explored.

Potential contribution in SDGs issues

The potential contribution of Mts. Arjuno-Welirang-Anjasmoro ecosystems to support SDGs target was considered important. Respondent's state that basically forest ecosystem was

contributes in SDGs achievement in many goals. Since there are no marine area, there are no statement in the contribution of ecosystem in goal 14, life below water (Table 1).

Table 1. The potential contribution of Mts. Arjuno-Welirang-Anjasmoro ecosystems to support SDGs

No.	Indicators of SDGs	Perceptions (%)				
		LWC	LC	M	SC	VSC
1	No poverty	0	0.5	0.36	0.14	0
2	Zero hunger	0	0.07	0.5	0.36	0.07
3	Good health and wellbeing	0	0.07	0.5	0.5	0.07
4	Quality education	0	0.29	0.36	0.21	0.14
5	Gender equality	0.07	0.14	0.43	0.36	0
6	Clean water and sanitation	0	0.07	0.07	0.5	0.36
7	Affordable and clean energy	0	0.07	0.14	0.72	0.07
8	Decent works and economic growth	0	0	0.22	0.57	0.22
9	Industry, innovation and infrastructure	0	0.14	0.57	0.29	0
10	Reduced inequality	0	0.21	0.5	0.29	0
11	Sustainable cities and communities	0.07	0.14	0.5	0.22	0.07
12	Responsible consumption and production	0	0.07	0.43	0.50	0
13	Climate action	0	0	0	0.21	0.79
14	Life below water	-	-	-	-	-
15	Life on lands	0	0	0	0.21	0.79
16	Peace and justices strong institutions	0	0	0.29	0.71	0
17	Partnership to achieve the goals	0	0	0.07	0.5	0.43

LWC= Lowest contribution, LC=Low contribution, M=Medium, SC= Strong contribution, VSV=very strong contribution

The issues of forest contribution in climates (SDG 13) and Life on lands (SDG 15) received special attention among respondent. The important of Mts. Arjuno-Welirang-Anjasmoro ecosystems in climates changes mitigation related to the potential forest cover and vegetation ability in carbon capture an sequestration mechanism. Abundance of vegetation was main machine to capture and absorb CO₂. The ability of plant to mitigate global warming has been describes by authors. Forest with abundance plants species especially contributes to the global warming mitigation (Malhi et al., 2002; Malhi 2012; Kuma and Shibru, 2015). The conservation of forest therefore crucial to increase ecosystem opportunities in carbon mitigation.

The contribution of ecosystem in SDG 15 was relevant with the function of forest as habitat for numerous living creature in mountains ecosystem. It is especially relevant with the numerous report that conclude Mts. Arjuno-Welirang-Anjasmoro was crucial habitat for fauna Fuadi et al., 2018). The forest area was crucial habitat for *Trachypithecus auratus* (Whitten et al., 1996). Izza & Kurniawan 2014 report that the forest was crucial habitat for Amphibian fauna. Changes of climates and decrease of vegetation was crucial factor for amphibian faun declines and local extinction. There are good understanding of respondents related to the role of forest in global warming mitigation. Respondents argues that campaign of forest conservation inn global warming mitigation has been massive and able to deliver the issues of forest conservation in global warming issues. Poor understanding has been found

among local community. The local community views forest as a place with abundance bioresources for income generating.

Grand forest ecosystem contribution in water issues also crucial as stated by the respondents (SDG 6). Respondents point out that one of the main function of forest ecosystem was providing continuous clean water support. The ecosystem has abundance water spring and rivers. The forest authority confirm that there are 153 water spring found in grand forest area. The importance of forest conservation and water resources management has been widely discusses, and conclude that protecting forest is crucial for water conservation (Supangat et al., 2021).

The forest was crucial habitat of flora and fauna. The similar situation also found in Mts. Arjuno-Welirang-Anjasmoro ecosystems. The significant of Mts. Arjuno-Welirang-Anjasmoro ecosystems as a crucial habitat for wildlife and biodiversity conservation programs led to the declaration of the area as part of the Arjuno Bromo Tengger Semeru Biosphere Reserve. The biosphere reserve is a models of sustainable development of area with high commitment tin biodiversity conservation, education and local community prosperity.

Restoration programs in degraded area in Mts. Arjuno-Welirang-Anjasmoro ecosystems has been considered important. Without the scientific guidelines, however, restoration will goes wrong (Hakim et al., 2018). An introduction of numerous plant into native ecosystem basically disturb the ability of native vegetation succession. The reason behind the introduction of exotic plants species was includes economical aspects to support local community in adjacent to the forest able received benefits from species.

Community perception of the forest was also crucial in determining forest benefits to achieve SDGs program. Prior study by Ambayo (2019) report that basically community understand that forest of Mts. Arjuno-Welirang-Anjasmoro is the protected area system, with strict regulation to protect bio-resources inside the forest. Respondent state that every violation to the forest ecosystem has punishment consequences. Illegal resources collection from forest was prohibited. With the lack of jobs, however, local community surrounding forest collect bio-resources as economic incomes.

Tourism and SDGs in forest area

The abundance of wildlife, luxurious forest and culture are the main resources for tourism development. It is especially crucial for ecotourism development. The development of ecotourism in conservation area has positive impact to economy, social and ecological aspects (Hakim and Soemarno, 2017; Hakim, 2022). The area of Mts. Arjuno-Welirang-Anjasmoro rich in term of beautiful landscapes and natural tourism resources. The natural tourism object includes Cangar hot spring, Watu Ondo waterfall, Watu Lumpang waterfall, Loka Wiyata Surya, Tretes Pengajaran waterfall, Slimpring waterfall, Supit Urang waterfall, Alap-Alap waterfall, Petung Sewu recreation park, Gajah Mungkur recreation park, Tambak Sari jungle tract, Tretes recreation area, Gunung Pundak hiking area, Watu Jengger hiking area, Wonorejo-Lawang mountain trekking. The abundance number of waterfall was influenced by the dominant spring and rivers flows in mountains landscapes. Globally, waterfall is one of the interesting natural tourism object Hudson (1998). Many waterfall has been visited by tourist, and in many case tourism contribute to the pollution of water ecosystem in waterfall recreation sites.

Cangar hot spring is one of the famous recreation sites with high number of tourist in holydays. Problems with the recreation sites was carrying capacity which are potentially destroy the hot spring and its surrounding ecosystem. Vandalism was common in Cangar, destroy the beauty of nature and vegetation. There are abundance of solid waste and plastics. Decline of environmental quality and disturbance of biodiversity lea to the poor destination competitiveness and sustainability Hakim (2017). These sould be special attention in tourism area with a lot of visitor number in Mts. Arjuno-Welirang-Anjasmoro
 In adjacent to the Mts. Arjuno-Welirang-Anjasmoro, some town has been grown as a recreation sites with tourism facility and infrastructure, including Batu, Trawas, and Tretes. Batu has been known as a city tourism, represent the complete attraction, accessibility and amenity of tourism with a lot of tourist number.

Tourism grows significantly, and contributes to the achievement of SDG 3, 8, 16 and 17. Respondens states that there are potential contribution of ecotourism development in SDGs achievement (Table 2). Tourism is especially crucial sector to support local economic growth. According to statistical data, income generated from nature-based tourism in Mts. Arjuno-Welirang-Anjasmoro was significant (Table 2). Respondent state that tourism in Mts. Arjuno-Welirang-Anjasmoro are able to provides numerous jobs related to tourism, ranging from transportation, home stay, restaurant, etc. Proper management of natural resources uses in forest ecosystem will becomes the key for the tourism sustainability.

The relationship of biodiversity and tourism has been identified close. Scholars point out that managing biodiversity is crucial, especially for tourism in fragile area. In east Java, wild life especially crucial to support tourism industry. According to respondent, poor data base in forest ecosystem should be completed. Problems often related to the basic research to determine the characteristic of biodiversity for sustainable uses of resources in tourism industry. Biodiversity data and information are the key for sustainable management of tourism (Hakim and Soemarno, 2017, Hakim L (2022).

Table. 2. Tourism arrivals in Mts. Arjuno-Welirang-Anjasmoro

No	Year	Income generated (IDR)	Number of visitor
1	2018	3,556,974,000	293,606
2	2019	3,525,159,000	294,471
3	2020	2,012,243,000	169,787
4	2021	1,949,180,000	136,272
5	2022	3,246,166,000	187,980

The rapid grows of tourism spatially should be managed through the carrying capacity of recreation sites in mountain forest to accept tourist visitation. Abundance tourist visitation in fragile ecosystem has negative impact, ranging from animal escape to reproduction fails. Respondent state that in some area, birds has been declines as an impact of a lot of tourism activity.

Community participation tourism development was also reported by respondents. Respondents argues that the involvement and participation of community in tourism development are crucial. Ecotourism is one of the potential approach in tourism development

in Mts. Arjuno-Welirang-Anjasmoro. Ecotourism widely recommended as a form of tourism in fragile environment, including mountains area with high number of biodiversity (Nepal, 2002).

Table 2. Potential contribution of ecotourism in SDGs achievement

No.	Indicators of SDGs	Contributions
1	No poverty	Numerous jobs related to tourism industry
2	Zero hunger	Tourism stimulates industry and provides food for destinations system
3	Good health and wellbeing	Tourism program and product contributes to good health and wellbeing
4	Quality education	Tourism require skilled person, therefore tourism stimulates and support educations programs
5	Gender equality	Opportunities for male and female in tourism business
6	Clean water and sanitation	Tourism require clean water, both for consumption and non consumption. Sanitation contributes to the health
7	Affordable and clean energy	Ecotourism promote clean energy as a tourism attraction and material for environmental education
8	Decent works and economic growth	Ecotourism provides various decent works and initiates for economic growth
9	Industry, innovation and infrastructure	Tourism related to numerous business. The success of tourism depend on the innovation and availability o infrastructure.
10	Reduced inequality	Tourism provides numerous benefits to reduce inequality
11	Sustainable cities and communities	Tourism support sustainability action as a basic requirement for competitive tourism industry
12	Responsible consumption and production	Ecotourism related to the local product, health food and proper consumption pattern
13	Climate action	Ecotourism principles support for forest conservation and global warming mitigation
14	Life below water	-
15	Life on lands	Biodiversity support tourism attractiveness
16	Peace and justices strong institutions	Tourism need peace and justice, as a basic requirements for hospitality industry
17	Partnership to achieve the goals	Tourism bringing numerous stakeholders, and there are opportunities for partnership

Conclusion

The ecosystems of Mts. Arjuno-Welirang-Anjasmoro has high level of biodiversity, and therefore it is crucial for conservation programs. There are potential contribution of the forest to achieve SDGs, including goals 13 (Climates actions), 15 (Life on lands) and 6 (Clean water and sanitation). There are opportunities for ecotourism development. The development of ecotourism especially crucial for sustainable use of resources in tourism industry. Completing data bases and designing scenario for optimum uses of bio resources inside forest ecosystem in sustainable manner is crucial. Strengthening conservation programs was crucial, and should be implemented by multi-stakeholder and community support

References

- Ambayoen MA (2019) Persepsi masyarakat desa penyangga kawasan tahura raden soerjo pada fungsi hutan konservasi. In Seminar Nasional Pembangunan Pertanian IV. 7th December 2019. 1.
- Ben-Zhi Z, Mao-Yi F, Jin-Zhong X, Xiao-Sheng Y, Zheng-Cai L (2005) Ecological functions of bamboo forest: research and application. *Journal of Forestry Research* 16(2): 143-147.
- Fuadi AN, Gizano S, Damarmoyo KS, Ari S, Wibowo ECW, Susilo B, Nugroho E (2018) Biodiversity of Avifauna Based on Its Morphology Located in R. Soerjo Forest Park Pasuruan District, Indonesia. In *The Proceeding of 4th International Biology Conference–2018* (p. 9).
- Hakim, L, Soemarno M (2017) Biodiversity conservation, community development and geotourism development in Bromo-Tengger-Semeru-Arjuno biosphere reserve, East Java. *Geojournal of Tourism and Geosites* 20(2): 220-230.
- Hakim L (2017) Managing biodiversity for a competitive ecotourism industry in tropical developing countries: New opportunities in biological fields. In *AIP Conference Proceedings* 1908(1): p. 030008. AIP Publishing LLC.
- Hakim L, Rahardi B, Rachmansyah A (2018) Checklist of flora along tourist trails to Mt. Lamongan, East Java (Indonesia): misconception of restoration and ecotourism programs in mountain region?. *Journal of Degraded and Mining Lands Management* 5(3): 1299.
- Hakim L (2022) Wildlife and tourism in East Java southern coastal area: challenges for ecologically sustainable tourism. *Journal of Marine and Island Cultures* 11(1): 91-102.
- Hudson BJ (1998) Waterfalls resources for tourism. *Annals of Tourism Research* 25(4): 958-973.
- Izza Q, Kurniawan N (2014). Eksplorasi Jenis-Jenis Amfibi di Kawasan OWA Cangar dan Air Terjun Watu Ondo, Gunung Welirang, TAHURA R. Soerjo. *Biotropika: Journal of Tropical Biology* 2(2): 103-108.
- Kuma M, Shibru S (2015) Floristic Composition, Vegetation Structure, and Regeneration Status of Woody Plant Species of Oda Forest of Humbo Carbon Project, Wolaita, Ethiopia. *Journal of Botany* 2015: Article ID 963816. <http://dx.doi.org/10.1155/2015/963816>

Krause T, Tilker A (2022) How the loss of forest fauna undermines the achievement of the SDGs. *Ambio* 51(1): 103-113.

Malhi Y, Meir P, Brown S (2002) Forests, carbon and global climate. *Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences* 360(1797): 1567-1591.

Malhi Y (2012) The productivity, metabolism and carbon cycle of tropical forest vegetation. *Journal of Ecology* 100(1): 65-75.

Nepal SK (2002) Mountain ecotourism and sustainable development. *Mountain research and development* 22(2): 104-109.

Reed, MS (2008). Stakeholder participation for environmental management: a literature review. *Biological conservation* 141(10): 2417-2431.

Soetopo L, Tutik SR, Noorfakhriyah AN (2021) Biodiversity conservation of epiphyte orchids in the natural habitat for sustainable bioeconomy. In *IOP Conference Series: Earth and Environmental Science* 743(1): p. 012085. IOP Publishing.

Supangat AB, Agus C, Wahyuningrum N, Indrawati DR (2021) Soil and Water Conservation Planning Toward Sustainable Management of Upstream Watershed in Indonesia. In *Sustainability in Natural Resources Management and Land Planning*. Springer, Cham. 77-91.

Swamy L, Drazen E, Johnson WR, Bukoski JJ (2018) The future of tropical forests under the United Nations Sustainable Development Goals. *Journal of Sustainable Forestry* 37(2): 221-256.

Van Steenis, CGGJ, Hamzah A, Toha M (2006) *Mountain flora of Java*. Brill.

Whitten AJ, Whitten T, Soeriatmadja RS, Soeriatmadja RE, Afiff SA (1996) *Ecology of Java & Bali (Vol. 2)*. Oxford University Press.