Journal of Environmental Science and Sustainable Development

Volume 2 | Issue 1 Article 3

7-31-2019

TRANSITION OF PRIMARY FOREST TO SECONDARY FOREST AND THE IMPACT FOR WATER RESOURCES CONSERVATION

Mahawan Karuniasa
School of Environmental Science Universitas Indonesia, mahawan.karuniasa11@gmail.com

Priyaji Agung Prambudi
School of Environmental Science Universitas Indonesia

Journal of Environmental Science and Sustainable Development
Volume 2, Issue 1, Page 15–25
ISSN: 2655-6847
Homepage: http://jessd.ui.ac.id/

TRANSITION OF PRIMARY FOREST TO SECONDARY FOREST AND THE IMPACT FOR WATER RESOURCES CONSERVATION

Mahawan Karuniasa* **and Priyaji Agung Pambudi**
School of Environmental Science, Universitas Indonesia, Central Jakarta 10430, Indonesia

*Corresponding author: e-mail: mahawan.karuniasa11@ui.ac.id

(Received: 27 June 2019; Accepted: 25 July 2019; Published: 31 July 2019)

Abstract
In recent decades, water resources shrink at an alarming rate in some areas both nationally and internationally. Water resources are directly proportional to the growth in human population. The higher demand for settlement and agriculture are considered to be important factors responsible for the degradation in water quality and resource functions. The aim of this study was to analyze the diversity of vegetation in the water resources area, as well as the level of human participation in the conservation efforts. The study was conducted using a mixed method based on observation and interviews of the local community. The plant diversity in the study area, Dandang water resource, consisted of medium category tree habitus (h'= 1.42); bush habitus (h'= 1.61); and herb habitus (h'= 2.29), there are 27 species from 15 families comprising 9 trees, 6 bushes, and 12 herbs. The level of human participation is still at the whim with limited operational support strength (0.80%). The social capital including communications between parties and organizing resources is a sufficient advantage (58%). However, the involvement of community and village governments in the conservation efforts is still weak (38%). The situation is aggravated by the lack of policies and regulations implemented by the village government (38%). Policy interventions and regulations are important, along with socialization and mentoring programs for the conservation of Dandang water resource area.

Keywords: community participation; conservation; diversity of vegetation; water resources

1. Introduction

River watershed (RW) is a unified ecosystem with a dynamic interaction pattern and is influenced by biotic and abiotic factors. RW cannot be separated from the other water resources (Li, Farooqi, Jiang, Liu, & Sun, 2019). However, in the last decades, we observed water scarcity and drought in many water resource areas (Hovenden, Newton, & Wills, 2014; Fang, Yu, Zhou, Zhou, & Dai, 2016). This situation increases the risk and stress among living organisms, especially plants and humans, for fulfilling their daily needs (Neumann, Zhao, Kindermann, & Hasunauer, 2018). The total water available for human consumption is very low and is getting worse by the degradation of water resource area.

Water resources and watersheds play a major role in fulfilling water supply needs of human beings. Therefore, the management in realizing the sustainability of water resources to restore river watershed ecosystems for life safety and welfare support (Yang & Lu, 2019). Water resources are one of the clean water providers in the world which has a vital role and supports sustainable development (Biggs et al., 2015). Water resources can directly and indirectly be associated with clean water needs. It is directly proportional to human population growth. This situation threatens the clean water supply, especially the unwise usage of water (Bennett, Peterson, & Gordon, 2009; Sallata, 2015). Besides, the functional shift in forest vegetation also raises the risk of extinction of water resources, which has a direct impact on the erosion of fertile soils, causing landslides, river siltation and critical land (Robo, Pawitan, Tarigan, & Dasanto, 2018). The conversion of forest into agricultural land is not only triggering erosion and sedimentation, but also causes flood and drought (Divinsky, Becker, & Bar, 2017). Efforts to preserve water resources can be made to minimize the problem. An effective, efficient and comprehensive management system is needed through the involvement of all stakeholders to develop an appropriate water conservation model for the society and environment (Sallata, 2015; Ostovar, 2019). Groundwater conservation with a vegetation-based approach is the right, cheap and easy strategy for all parties (Fan & Shibata, 2015). Therefore, preservation of water resources is a key factor that must be carried out by all parties so that it can be managed well to provide livelihood to humans and other living organisms.

The issue of sustainability of water resources has basically been around for a long time and has become a real problem that has not been resolved because of inappropriate land use (Gao et al., 2017; Northey, Mudd, Werner, Haque, & Yellishetty, 2019). This is also related to the environment with a very high plant diversity that gives rise to a period of water shortage and excess water that is very clear and tangible. Indonesia which is geographically located in the tropics receives water from rains. In addition, Indonesia's geographical and topographical conditions, which are predominantly dominated by hilly and mountainous areas, causes rainfall in the upstream to be generally higher than in the downstream (Hansen & DeFries, 2007). Higher rainfall in a short period of time is accompanied by ineffective rate of infiltration resulting in water being released as a surface runoff which in turn causes flooding (Hejazi et al., 2014). On the other hand, low rainfall and the inability for rainwater harvesting and conservation efforts raises the risk of drought (Baharsjah, 2012; Shi et al, 2013). Because of these characteristics, the existing water resources should be well managed especially based on vegetation conservation and society's participation so that their existence is sustainable. If this is not done, various problems related to scarcity of water resources and degradation of environmental quality will happen.

Greening is one of the strategic steps in the management of water resources to maintain the availability of ground water in the dry season and to maintain the stability of infiltration rates during rainy season. Greening or conservation of vegetation needs to be integrated with other measures that support conservation efforts for the results to be more optimal (Nelson et al., 2009). Maintaining the sustainability of these water resources is widely part of the indicator of success of river watershed management (Serpa et al., 2015). Therefore, this study aims to identify the diversity of vegetation in water resource areas and the level of community participation in conservation efforts.

2. Methods

The conservation of water resources was done to maintain sustainability, which played a major role in supporting sustainable water resources supply. Proper maintenance of sustainable water sources is absolutely necessary so that the agricultural land can be optimally managed. This study used quantitative approach with mixed methods through observation and interview with the local people. This study was performed in February-April 2019 in Dadapan Village, Wajak Sub-district, Malang Regency, East Java Province (Figure 1). This study involved with the society who directly or indirectly intersected with the water resources. Therefore, the respondents were 85 land owners and/or the locals who lived near the water resources. This study also involved village government as the respondents included village head, village chief and RT Chairperson.

Vegetation condition around Dandang water resource was observed by using plot squared in a total of seven plots and each plot consisted of three observation plot categories as suitable with the concept from Odum (1993) it was the tree habitus of 10×10 m, bush 5×5 m, and herbs 1×1 m as shown in Figure 2. The society sample was decided based on purposive sampling with the following criteria: (1) land owners around water springs and/or, (2) the locals who lived near the water springs, (3) village government which had the authority over the water resources. Related to the matter, village government which was become respondents was Dadapan Village Head, Jangkung Village Chief, RT 33 Chairperson, and RT 32 Chairperson.

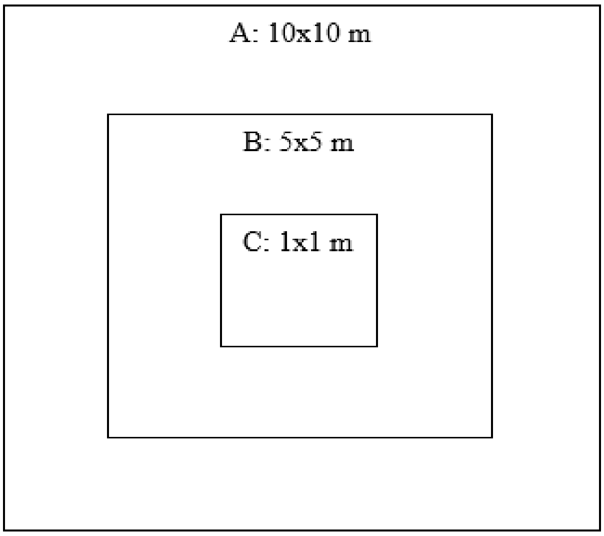

Figure 1. Quadrants plot
(Source: Odum, 1993)

The observation result was analyzed using Important Value Index (IVI) and Shannon-Wiener Index (h′) to find the abundance and evenness of the species present. Then the result was analyzed used descriptive statistics to find the pattern of water resource management which could accommodate social, economic and ecologic aspects.

$$\mathrm{Di} = \frac{\textit{Total number of individuals for type i}}{\text{Total habitat area sampled}} \quad (1)$$

$$\mathrm{RD} = \frac{\text{Type density of i}}{\text{Density of all type}} \quad (2)$$

$$\mathrm{F} = \frac{\text{Total of plots (samples) found i}}{\text{Total of all plots (samples)}} \quad (3)$$

$$\mathrm{R_f} = \frac{\text{Frecuency of type i}}{\text{Total frequency of all types}} \quad (4)$$

$$\text{IVI} = \text{Relative density of type i} + \text{Relative frequency of type I} \quad (5)$$

DOI: https://doi.org/10.7454/jessd.v2i1.34

$$h' = -\frac{Total\ of\ individual\ type\ i}{Total\ of\ individual\ found}\ log\ \frac{Total\ of\ individual\ type\ i}{Total\ number\ of\ individual\ found} \quad (6)$$

Shannon-Wiener Index has the following indicators (Odum, 1993):

$h' < 1$ = low variety level

$1 \leq h' \geq 3$ = medium variety level

$h' > 3$ = high variety level

The plants observed in this study are categorized into three groups—trees, bushes, and herbs. The plants were validated using plant taxonomy websites—The Plant List, The Catalogue of Life, and Integrated Taxonomic Information System (ITIS). Plants can be grouped into three categories according to Odum (1993):

a. Tree habitus have a characteristic true woody stem, the main stem grows upright supporting the canopy, the stem is hard, and the plant is complex (roots, stems, leaves).
b. Bush habitus have a characteristic less woody stem but have many lower branches. The plant height is ≤1.5 m, the stem is softer and green, and branches and leaves are clustered.
c. Herb habitus have a characteristic of watery soft stems and are not woody.

3. Results and Discussion

3.1 Topography Condition and Informant Profile

Wajak is one of the 33 sub-districts in the Malang Regency area, East Java Province. Astronomically, Wajak Sub-district is located between 112,4218 until 112,4800 East Longitude and 8,0956 until 8,0425 South latitude (Central Bureau of Statistic of Malang Regency, 2016). Wajak Regency is located in the southeast of Malang Regency and directly adjacent to the Bromo Tengger Semeru National Park (TNBTS). One of the villages potentially related to national resources in the Wajak Regency is the Dadapan village. This village has an agricultural land and forest area of 521 ha with main crops such as rice and corn. Dadapan village has water resource that supplies the water needs of the village and other sub-districts. The biggest and potential water resource in this area is Dandang water resource. However, the Dandang water resource is experiencing drought due to the conversion of surrounding forest ecosystem to agricultural land. This condition is affected by the lack of conservation efforts surrounding the water resource and the society's less concern in managing and utilizing the water resource (Sallata, 2015; Robo et al., 2018). The water resource area that should be protected by vegetation cover is converted for the cultivation of seasonal crops. This is not separated from the land around the water resource area which is a private property of the society that is exacerbated by the absence of government intervention efforts to encourage the society to conserve and maintain the vegetation cover in this region.

3.2 Vegetation Structure in the Water Source Area

We found 26 species of plants from 15 families comprising 9 species of trees, 6 species of shrubs, and 13 species of herbs. Table 1 presents the plants found around water resource area.

Table 1. Types of plants found around water resources*

No	Family	Species	IVI	h′
Tree Habitus				
1	Malvaceae	*Hibiscus tiliaceus* L.	0.179	0.316
2	Moraceae	*Artocarpus heterophyllus* Lam.	0.026	0.103
3	Lamiaceae	*Tectona grandis* L.f.	0.189	0.280
4	Leguminosae	*Albizia chinensis* (Osbeck) Merr.	0.648	0.061
5	Poaceae	*Bambusa multiplex* (Lour.) Raeusch. Ex Schult.	0.095	0.232
6	Poaceae	*Bambusa vulgaris* Schrad.	0.189	0.103
7	Poaceae	*Gigantochloa apus* (Schult.) Kurz.	0.052	0.165
8	Anonaceae	*Anona muricate*	0.242	0.103
9	Moraceae	*Ficus septica*	0.379	0.061
Total			**2**	**1,42**
Bush Habitus				
8	Compositae	*Chromolaena odorata* (L.) R.M.King & H. Rob	0.362	0.295
9	Leguminosae	*Mimosa pudica* L.	0.444	0.307
10	Leguminosae	*Mimosa pigra* L.	0.138	0.188
11	Poaceae	*Pennisetum purpureum* Schumach.	0.642	0.368
12	Poaceae	*Imperata cylindrica* (L.) Raeusch.	0.291	0.291
13	Verbenaceae	*Lantana camara* L.	0.122	0.161
Total			**1,99**	**1,61**
Herbs Habitus				
14	Amaranthaceae	*Amaranthus* spp	0.043	0.049
15	Brassicaceae	*Brassica rapa* L.	0.119	0.159
16	Compositae	*Ageratum conyzoides* (L.) L.	0.283	0.313
17	Cyperaceae	*Cyperus rotundus* L.	0.224	0.224
18	Euphorbiaceae	*Euphorbia hirta* L.	0.036	0.020
19	Oxalidaceae	*Oxalis barrelieri* L.	0.144	0.145
20	Poaceae	*Oryza sativa* L.	0.124	0.219
21	Poaceae	*Axonopus compressus* (Sw.) P. Beauv.	0.113	0.203
22	Poaceae	*Eleusine indica* (L.) Gaertn.	0.344	0.311
23	Poaceae	*Ischaemum rugosum* Salisb.	0.083	0.152
24	Poaceae	*Cynodon dactylon* (L.) Pers.	0.253	0.25
25	Phyllanthaceae	*Phyllanthus niruri* (L.)	0.101	0.121
26	Phyllanthaceae	*Murdannia nudiflora* (L.) Brenan	0.130	0.112
Total			**1,99**	**2,29**

*IVI: Important Value Index; h′: Shannon-Wienner Index

Based on the observations, we found that all types of habitus, including trees, shrubs, and herbs have a moderate level of diversity where the tree habitus has the Shannon-Wiener h diversity index of 1.42; habitus bush h′=1.61, and herbal habitus h′=2.29. However, it can be seen that herbaceous vegetation has the highest diversity as it contains 13 different vegetation types. The area around the water resource shows that it has been intervened by humans and a large number of forest areas being converted into agricultural lands for the cultivation of *Oryza sativa, Brassica rapa, Amaranthus spp*, and *Pennisetum purpureum*. The conversion of forest to agricultural land is carried out by the community for cultivating food crops, vegetables, and animal feed. On the other hand, the plants found in the region are not primary forest plants, but invasive plants and a majority of bush and herbaceous plants.

Tree species existing in this water resource area is quite interesting as there are no primary forest plants. Therefore, conservation efforts need to be carried out by planting tree species that have the ability to absorb and store large amounts of water (Ostovar, 2019). The limited existence of trees seems to have a direct impact on ground water storage. A decrease in the number of trees resulted in a decrease in ground water (Neumann et al., 2015). If this condition is not immediately resolved, the possibility is that the water resource will turn drought and will not be able to provide life support for the community and the surrounding environment.

Basically, herbs and shrubs have poor water absorption capacity compared with trees (Northey et al., 2019). However, herbs and shrubs do not have a strong root system to bind to the soil (Bennett et al., 2009). Therefore, the dominance of herbs and shrubs accompanied by the lack of primary forest trees is at risk of potential landslides and erosion. Nevertheless, the existence of three different types of bamboos in this area is quite helpful for water storage (Serpa et al., 2015). This mechanism will be more optimal if there are primary forest plants that have a large capacity to store water and a strong ability to bind to the soil, for example, plants belonging to the family Moraceae are specific habitats of this region. The presence of herbs and shrubs needs to be minimized and rehabilitated by using these primary forest plants.

The higher density of grasses and other herbaceous plants indicate that the Dandang water resources area has become a secondary forest, and is no longer the primary forest as it should be for water resources under ideal conditions. If no measures are taken immediately to conserve in a few years, the risk of a water deficit that will lead to the loss of water resources is likely to occur. This situation has occurred in many other water resources in the Malang Raya Regency which is now no longer able to store water. Degradation of the water resource area of primary forest to secondary forest and crop areas annuals into some very significant causal factor (Nirwana, Hijri, & Kamil, 2019). This condition must be avoided to save the existence of water resources which is the source of livelihood for the community. Therefore, appropriate conservation strategies need to be implemented so that the process of reforestation is done to provide optimal results.

Appropriate conservation strategies should be carried out to conserve this area by planting woody plants (Ekhuemelo, 2016). It is important to optimize the ecological suitability, where the water resource will always in primary forest area. The existence of primary forest in the water resources area will be supportive for sustainability because the plant population can absorb and store water in large quantities. This view is also supported by Kumari & Singh (2016) who stated that the best solution for conservation of water resources is by utilizing various types of plants that have the capability to store large amounts of water and growing ecological compatible plants in the study area including *Ficus benjamina*, *Ficus Elastica*, *Artocarpus elasticus*, *Artocarpus communis*, *Garcinia mangostana*, and *Alstonia scholaris*. Through reforestation, there would be optimal land cover and water will be absorbed through plant roots. This will provide enormous benefit for the environment and the surrounding community and provide sustainable conservation of water resources for the community.

3.3 Community Participation in the Efforts of Conservation

The conservation of vegetation in the water resource area has not been practiced yet. The community converts forest ecosystems into agricultural lands. At present, there is only 2000 m^2 of land that is not being used for agriculture as the topography of the slope is quite steep. This area is dominated by *Ficus septica* with Important Value Index (INP) value of 0.379 and *Albizia chinensis* with INP value of 0.648. Both types of plants have the highest INP values for tree habitus and reflect that in this water resource area there is no primary forest. Even though the water resource area is in the middle of a primary forest, it is important to support the stability of the hydrological cycle.

The stability of the hydrological cycle is very important for the surrounding community, because all communities in the three villages (Dadapan, Sukolilo, and Patok Picis) utilize water resource directly for their daily needs and to irrigate agricultural land. The high dependency and access to water resources, in reality, is not balanced with the efforts and participation of the community in conservation efforts. The opposite is true in this area; about 50 m from the center of the water source of the forest ecosystem is converted into seasonal commodity agricultural land *(Oryza sativa, Brassica rapa, and Amaranthus spp)*. While in areas with fairly steep slopes are planted with *Albizia chinensis*. On the other hand, invasive plant species dominate in this region. The three most dominant types of invasive plants are *Eleusine indica* (INP 0.344), *Ageratum conyzoides* (INP 0.283), and *Cynodon dactylon* (INP 0.253). These invasive plants normally do not grow in primary forest areas, and conversion of forest into agricultural land can actually introduce these plants in the region and become dominant (Nelson et al., 2009). The dominance of these plants in the water resource area basically has a negative impact, because herbal habitus plants neither have a strong root system nor the ability to absorb and store water in optimal quantities. It is different from invasive plants that have a very massive ability to spread in degree, so vegetation cover becomes huge (Monteiro et al., 2013). Of course, this can inhibit the regeneration of trees, because when the seedlings begin to grow, the high dominance of invasive plants inhibits seedling growth and risks causing death (Biggs et al., 2015). If this is left unchecked for a long time, the degradation of the quality and function of the ecosystem will be significant.

The risk of degradation in the quality and function of ecosystems caused by the presence of invasive plants and deforestation is exacerbated by low levels of community participation in the conservation efforts. Natural factors and human factors must be considered during the conservation process. Table 2 presents information on the level of community participation in the efforts to conserve water resources.

From the interviews conducted, we found that the local village community and government have a strong will and operational ability (economic) (80%) in terms of conservation. However, in reality, the involvement of local village community and government in the conservation process is still very low (35%). This is exacerbated by weak policies and regulations related to conservation (35%). The community and village government have sufficient capital (58%) in terms of communication and organizing resources. This means that the local village community and government already have social capital to mobilize and optimize the conservation process. Social capital is the most important factor in the efforts to manage the environment including conservation of water resources (Yang & Lu, 2017). In such cases, the research areas for understanding that people still have to do something starts from community leaders (headman).

Table 2. Community participation level in the efforts of water source conservation

No.	Indicator of Participation	Percentage (%)
1.	Participation awareness	62
2.	Willingness of the community in conservation efforts	87
3.	Involvement in conservation activities	35
4.	Communication between parties	58
5.	The resources organizing	58
6.	Operational capability of the community and village government	80
7.	Strength of policies and regulations	35

Deforestation is a barrier to the conservation process and the local government has not looked at this issue strategically, so as not to be a priority. Only in 2015, the local government took an initiative in collaboration with the environmental government agencies and planted about 1000 seedlings of perennials such as *Syzygium aqueum*, *Anona muricata*, *Garcinia mangostana*, and *Artocarpus heterophyllus*. However, from a total of 120 heads of household who were invited to contribute, only 23 people (20%) actively participated in the reforestation effort. Based on the results through in-depth interviews, we found that a majority of people have low confidence in the village government leadership, and show less participation in the programs. These results support the views by Apipalakul, Wirojangud, & Keow (2015) who stated that public confidence in the leader and government determines the level of participation in government programs. Thus, the quality and integrity of government influence the level of community participation to achieve desirable outcomes from these programs.

The lack of public confidence in the local leader is the issue that resulted in environmental degradation, which is becoming increasingly worse. Ideally to resolve such issues, an environmental crisis deficit based on bottom-up approach should be co-created with the help of the local community since people who work and live in the region know more about the environmental conditions. In other words, people are more sensitive to changes in environmental signals. The sensitivity should continue at a higher level by drafting a program or programs submitted to the government that is authorized to make a policy. With the help a government policy for the conservation of water resources supported by public participation (co-creative), the environmental problems can be resolved. As shown by Martini & Buffa (2017), the bottom-up and co-creative mechanisms is a part of an important solution for managing the environment. Concrete measures have to be taken for massive conservation by strengthening policies and regulations for future collective agreements to preserve water resources in that region.

4. Conclusion

Vegetation diversity in the water resource area of Dandang village comprises tree habitus (h′=1.42); bush habitus (h′=1.61); and herbal habitus (h′=2.29). Invasive plants such as *Eleusine indica* (INP 0.344), *Ageratum conyzoides* (INP 0.283), and *Cynodon dactylon* (INP 0.253) form the most dominant species in the region. The community participation in the water conservation process is still limited to the level of willingness and operational capability, and the community involvement in conservation efforts is still weak. This situation is exacerbated by weak policies and regulations of the village government for conserving water resources. However, the community has sufficient social capital to implement this water resource conservation. A strong intervention from the village government is required to make policies and regulations prohibiting the use of land around water resources, and conducting regular mentoring programs to the community so that their massive conservation efforts are carried out. In essence, conservation will succeed if the community has environmental awareness and the government is committed to maintaining its sustainability policy.

References

Apipalakul, C., Wirojangud, W., & Keow, T. (2015). Development of Community Participation on Water Resource Conflict Management. *Procedia - Social and Behavioral Sciences*, *186*, 325–330. https://doi.org/10.1016/j.sbspro.2015.04.048

Ayu, I. W., Prijono, S., & Soemarno. (2013). Evaluasi Ketersediaan Air Tanah Lahan Kering di Kecamatan Unter Iwes, Sumbawa Besar. *Jurnal Pembangunan Dan Alam Lestari*, *4*(1), 18–25. Retrieved from https://jpal.ub.ac.id/index.php/jpal/article/view/113

Baharsjah, J. S. (2012). *Long-term National Strategy for Water Resources Management Facing the Sustainable Prospects of Global Climate Change.* Jakarta.

Bennett, E. M., Peterson, G. D., & Gordon, L. J. (2009). Understanding relationships among multiple ecosystem services. *Ecology Letters*, *12*(12), 1394–1404. https://doi.org/10.1111/j.1461-0248.2009.01387.x

Biggs, E. M., Bruce, E., Boruff, B., Duncan, J. M. A., Horsley, J., Pauli, N., McNeill, K., Neef, A., Ogtrop, F. V., Curnow, J., Haworth, B., Duce, S., & Imanari, Y. (2015). Sustainable development and the water-energy-food nexus: A perspective on livelihoods. *Environmental Science and Policy*, *54*, 389–397. https://doi.org/10.1016/j.envsci.2015.08.002

Cavender-Bares J., Balvanera, P., King E., & Polasky, S. (2015). Ecosystem service trade-offs across global contexts and scales. *Ecology and Society*, *20*(1), 21–26. http://dx.doi.org/10.5751/ES-07137-200122

Central Bureau of Statistic Malang Regency. (2016). *Malang Regency in Number 2016.* Malang. Retrieved Mei 12, 2019, https://malangkab.bps.go.id/publication/2016.html

Divinsky, I., Becker, N., & Bar, P. (2017). Ecosystem service tradeoff between grazing intensity and other services a case study in Karei-Deshe experimental cattle range in northern Israel. *Ecosystem Services,* *24*, 16–27. https://doi.org/10.1016/j.ecoser.2017.01.002

Ekhuemelo, D. O. (2016). Importance of Forest and Trees in Sustaining Water Supply and Rainfall. *Nigeria Journal of Education, Health and Technology Research (NJEHETR)*, 273–280.

Fan, M., & Shibata, H. (2015). Simulation of watershed hydrology and stream water quality under land use and climate change scenarios in Teshio River watershed, northern Japan. *Ecological Indicators*, *50*, 79–89. https://doi.org/10.1016/j.ecolind.2014.11.003

Fang, X. M., Yu, D. P., Zhou, W. M., Zhou, L., & Dai, L. M. (2016). The effects of forest type on soil microbial activity in Changbai Mountain, Northeast China. *Annals of Forest Science*, *73*, 473–482. https://doi.org/10.1007/s13595-016-0540-y

Gao, P., Li, P., Zhao, B., Xu, R., Zhao, G., Sun, W., & Mu, X. (2017). Use of double mass curves in hydrologic benefit evaluations. *Hydrological Processes*, *31*(26), 4639–4646. https://doi.org/10.1002/hyp.11377

Hansen, A. J., & DeFries, R. (2007). Ecological mechanisms linking protected areas to surrounding lands. *Ecological Applications*, *17*(4), 974–988. https://doi.org/10.1890/05-1098

Hejazi, M.I., Edmonds, J., Clarke, L., Dvies, E., Chaturvedi, V., Wise, M., Patel, P., Eom, J., & Calvin, K. (2014). Integrated assessment of global water scarcity over the 21st century under multiple climate change mitigation policies. *Hydrology and Earth System Sciences*, *18*, 2859–2883. https://doi.org/10.5194/hess-18-2859-2014

Hovenden, M. J., Newton, P. C. D., & Wills, K. E. (2014). Seasonal not annual rainfall determines grassland biomass response to carbon dioxide. *Nature*, *7511*, 583–586. https://doi.org/10.1038/nature13281

Kumari, M., & Singh, J. (2016). Water Conservation : Strategies and Solutions. *International Journal of Advanced Research and Review*, 1(4): 75–79.

Li, X., Farooqi, T.J.A., Jiang, C., Liu, S., & Sun, O. J. (2019). Spatiotemporal variations in productivity and water use efficiency across a temperate forest landscape of Northeast China. *Forest Ecosystems*, *6*(22), 1–13. https://doi.org/10.1186/s40663-019-0179-x

Martini, U., & Buffa, S. N. (2017). Community Participation, Natural Resource Management and the Creation of Innovative Tourism Products : Evidence from Italian Networks of Reserves in the Alps. *Sustainability*, *7*, 1–16. https://doi.org/10.3390/su9122314

Monteiro, A.T., Fava, F., Concavales, J., Huete, A., Guesmorali, P., Porolo, G., & Boochi, S. (2013). Landscape context determinants to plant diversity in the permanent meadows of Southern European Alps. *Biodiversity Conservation*, *22*, 937–958. https://doi.org/10.1007/s10531-013-0460-1

Nelson, E., Mendoza, G., Regetz, J., Polasky, S., Tallis, H., Cameron, D., Chan, K.M.A., Daily, G. C., & Goldstein, J., Kareiva, P.M., Lonsdorf, E., Naidoo, R., Ricketts, T.H., Shaw, M. (2009). Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment*, *7*(1), 4–11. https://doi.org/10.1890/080023

Neumann, M., Zhao, M. S., Kindermann, G., & Hasenauer, H. (2015). Comparing MODIS net primary production estimates with terrestrial national forest inventory data in Austria. *Remote Sensing*, *7*, 3878–3906. https://doi.org/10.3390/rs70403878

Nirwana, E. E. K. A., Hijri, Y. S., & Kamil, M. (2019). Government Cooperation In Malang City And Malang Regency Government In Management Water Resources Wendit. *Logos: Journal of Local Government Issues, 2*(1).

Northey, S. A., Mudd, G. M., Werner, T. T., Haque, N., & Yellishetty, M. (2019). Sustainable water management and improved corporate reporting in mining. *Water Resources and Industry*, *21*(October 2018), 100104. https://doi.org/10.1016/j.wri.2018.100104

Odum, E. P. (1993). *Fundamental Ecology (Dasar-dasar Ekologi): Third Edition*. Jogjakarta: Gadjah Mada University Press.

Ostovar, A. L. (2019). Investing upstream: Watershed protection in Piura, Peru. *Environmental Science and Policy*, *96*(July 2018), 9–17. https://doi.org/10.1016/j.envsci.2019.02.005

Robo, S., Pawitan, H., Tarigan, S. D., & Dasanto, B. D. (2018). Projections of changes in land use and its impact on the hydrological response of the Upper Ciliwung Watershed. *Jurnal Teknologi Rekayasa*, *3*(2), 157. https://doi.org/10.31544/jtera.v3.i2.2018.157-166

Sallata, M. K. (2015). Conservation and management of water resources based on their existence as natural resources. *EBONI Journal*, 75–86.

Serpa, D., Nunes, J. P., Santos, J., Sampaio, E., Jacinto, R., Veiga, S., Lima, J. C., Moreira, M., C.-, Real, J., Keizer, J. J., & Abrantes, N. (2015). Impacts of climate and land use changes on the hydrological and erosion processes of two contrasting Mediterranean catchments. *Science of The Total Environment*, *538*, 64–77. https://doi.org/10.1016/j.scitotenv.2015.08.033

Shi, Z., Ai, L., Li, X., Huang, X., Wu, G., & Liao, W. (2013). Partial least-squares regression for linking land-cover patterns to soil erosion and sediment yield in watersheds. *Journal of Hydrology*, *498*(18), 165–176. https://doi.org/10.1016/j.jhydrol.2013.06.031

Susilawati, S. (2009). Konservasi Tanah Dan Air di Daerah Semi Kering Propinsi Nusa Tenggara Timur. *Jurnal Teknik Sipil Unika Soegijapranata*, *3*(1), 33–43. Retrieved from http://ced.petra.ac.id/index.php/jts/article/view/16904

Yang, K., & Lu, C. (2017). Evaluation of land-use change effects on runoff and soilerosion of a hilly basin the Yanhe River in the Chinese Loess Plateau. *Land Degradation and Development*, *28*(1), 59–78. https://doi.org/10.1002/ldr.2873