UDC 633; DOI 10.18551/rjoas.2022-08.14

ESTIMATION OF AGROFORESTRY LAND EROSION BASED ON THE WATER EROSION PREDICTION PROJECT (WEPP) APPLICATION

Triwanto Joko*, **Muttaqin Tatag**, **Waskitho Nugroho Tri**, Researchers
Prasetyo Yoga Eko, Student
Department of Forestry, Faculty of Agriculture and Animal Husbandries,
Muhammadiyah Malang University, Indonesia
*E-mail: joko.fpumm@gmail.com

ABSTRACT
The existence of land productivity is decreasing day by day, this is caused by the rate of erosion. The characteristics of agroforestry land those are not suitable for its designation will also result in decreased land productivity. Increasing the rate of erosion can make sedimentation in rivers and reservoirs more and more. Villages in the Pujon Malang sub-district include villages that are in landslide-prone areas and most of them are at high risk of landslides, droughts, and flash floods. This study aims to identify the value of erosion on agroforestry land based on the WEPP application and to identify the value of the classification of erosion hazard classes resulting from the erosion estimation using the WEPP application. Primary data collection in the field includes soil sample data in the form of soil texture, soil depth, albedo, percentage of sand, percentage of clay, percentage of organic matter, value, exchange capacity, % rock, and albedo. Secondary data in the form of rainfall data, topography, soil types, and land use. The total value of the erosion rate that occurred was 657,700 tons/ha. The total erosion value comes from 364.715 tons/ha for agricultural land, 8.898 tons/ha for agroforestry land as much as 283,200 tons/ha for settlements, and forest land for as much as 0.882 tons/ha. The total value of soil erosion that occurred was 657,700 tons/ha. The erosion value belongs to the Erosion Hazard Class V including very heavy erosion.

KEY WORDS
Erosion, water erosion prediction project (WEPP), agroforestry.

Soil erosion is one of the most serious environmental problems worldwide and in the long term increased erosion and runoff can lead to decreased soil fertility in rapidly eroded lands and loss of vegetation in the area (Kyarikunda et al, 2017). Agricultural land processing on the same land as ecologically sustainable, geographical areas of land sharing, agroforestry system science, land processing potential, and conservation practices (Jhariya et al, 2015). Incorrect land use can cause an increase in the rate of erosion in a region (Febrani, 2014). Based on Pratiwi (2013) Land characteristics that are suitable for their designation will result in increased land productivity. Land productivity will increase if the characteristics of the land are used properly, will reduce the risk of failure and protect the soil from erosion and reduce the need for fertilizers due to the recycling of crop residues (Kumar & Tiwari, 2017).

An increase in the existing erosion rate can make sedimentation in rivers or reservoirs even greater (Brandt et al 2012). Sedimentation that occurs can have an impact on the usability of reservoirs and the presence of rivers decreases. Indirectly, the existing sedimentation can trigger floods and droughts (Aryani, 2016). The increase in the existing erosion rate can make sedimentation in rivers or reservoirs even greater (Mahyudin et al, 2015). The increase in the rate of erosion has an impact on the increasing sedimentation of reservoirs and rivers (Marganingrum & Dyah, 2013). Sedimentation that occurs can affect the usability of reservoirs and rivers decreases. Indirectly the existing sedimentation can trigger floods and droughts (Naharuddin et al, 2018). The role of agroforestry in influencing soil water quality, climate change mitigation, and species diversity (Zamora & Udawatta, 2016). The contribution of agroforestry to environmental sustainability is very significant through its contribution to environmental, economic, and social functions and does not create negative impacts on the environment (Dollinger & Jose, 2018).

Water Erosion Predict Project (WEPP) is an application that can be used for estimating the value of the rate of soil erosion. Enter data for WEPP namely soil, topography, climate, and land use. Outputs such as erosion, sedimentation, and run-off values make WEPP superior to erosion estimation using other methods (Delgado & Canters, 2012).

Continuous monitoring is carried out to make environmental management policy decisions, so research is needed on erosion rates in various lands based on four parameters, including slope, soil, climate, and plant management that can cause erosion impacts (Brandt et al, 2012). The purpose of this study is to identify the value of erosion on land in Pujon District based on the WEPP application and identify the value of the classification of erosion hazard classes resulting from the erosion estimation using the WEPP application.

METHODS OF RESEARCH

This research was conducted in Pujon District, Malang Regency, East Java Province, Indonesia. Research measuring tools using, GPS, ArcGIS 9.3, WEPP version 2012, and, Microsoft Office. Primary data uses soil sample data (soil texture, soil depth, % sand, % clay soil, % organic matter, cation exchange capacity value, % rock, and albedo), topography (slope length (m), and land slope (%)) and land use. The secondary data used is the required climatic data, namely the maximum and minimum temperature data, rainfall, geographical location, and elevation of the rain station.

RESULTS AND DISCUSSION

The results of the erosion estimation based on the WEPP erosion estimate are 364.715 tons/ha/year for agricultural land, 8,898 tons/ha/year for agroforestry land, 283,200 tons/ha/year for settlement, and 0.882 tons/ha/year for forest land in Figure 1. The total erosion value in Pujon District is 657,700 tons/ha/year.

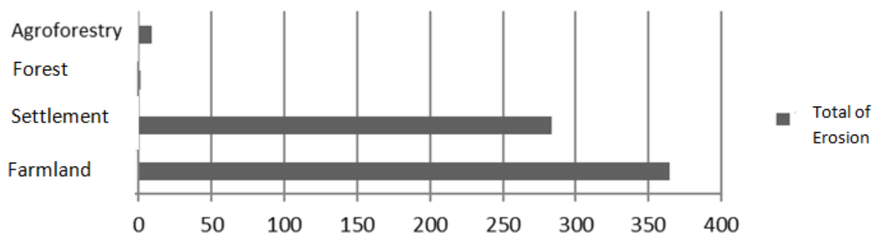

Figure 1 – Total of Erosion

Table 1 – Classification of Erosion Hazard

Erosion Hazard Class	Erosion Rate (ton/ha/year)	Description
I	< 15	Slight
II	15 - 60	Light
III	60 - 180	Moderate
IV	180 - 480	Severe
V	> 480	Extremely Severe

Source: Suripin (2004).

This farmland has crops such as shallots, cabbage, and leeks. These plants have a distance not too far from the ground. Walidatika and Sigit (2017) This low distance makes the rainwater hit the ground hard so that splash erosion occurs which will eventually become grooves will create a large erosion rate value of 362.175 tons/ha/year. This forest land is planted with Pinus (*Pinus merkusii*) and *Eucalyptus degulpta*. These two plants are often found in some forest lands. This tree has the ability to withstand the blow of rainwater to the ground. Branches and leaves will make rainwater fall slowly to the ground, so that the resulting erosion value is small, which is around 0.882 tons/ha/year. Suripin (2004) erosion hazard class is presented in Table 1.

Destianto & Pigawati (2014) Agroforestry land planted with annual crops and seasonal crops (*Eucalyptus deglupta* and vegetables), has a lower erosion value than agricultural land, which is 8.898 tons/ha/year. This is presumably due to the presence of *Eucalyptus deglupta* trees that can withstand rainwater with leaves or twigs (Wilman et al, 2013). In general, the yard does not have trees, or the yard is cemented, so rainwater will directly fall to the ground, causing high erosion on residential land, which is 283,200 tons/ha/year.

DISCUSSION OF RESULTS

Pratiwi (2013) the amount of rainfall, intensity, and speed of rainfall determine the crushing strength of soil aggregates, amount, and the strength of surface runoff. The intensity of rain in the Pujon District is classified as low rainfall intensity. According to the classification of rainfall intensity (Arsyad, 2012), low rainfall intensity is still capable of producing an erosion rate of 657,700 tons/ha/year. This shows that the value of the erosion rate is difficult to reach the lowest point (zero), even though humans are trying to suppress the value of the erosion rate.

The topography in Pujon District varies with different slope lengths and land slopes. The length of the slope or the steep slope of the land creates a large erosion value as well. According to Dewi et al (2012) and Rini (2018) the length of the slope plays a role in the amount of erosion that occurs, the longer the slope, the greater the volume of runoff that occurs. The slope of slope has a major influence on the erosion that occurs, because it greatly affects the speed of surface runoff. The greater the value of the slope, the opportunity for water to enter the soil (infiltration) will be hampered so that the volume of surface runoff is greater which results in the danger of erosion.

Pratiwi (2013) stated that land cover vegetation plays an important role in the process of interception of falling rain and transpiration of water that is absorbed by roots. According to Mutiono (2013) and Kongsager et al (2016) land with good cover has the ability to reduce the kinetic energy of rain, thereby minimizing the occurrence of splash erosion, reducing the flow coefficient, thereby increasing the possibility of rainwater absorption, especially on land with thick solum.

Soil erodibility or sensitivity is the ability of the soil to erode. Soil erodibility values are strongly influenced by data on soil structure, organic matter, texture, and soil permeability (Delgado & Canters, 2012). This organic material is obtained from twigs or leaves of plants (Murthy et al, 2013). The soil texture in the form of clay and sand makes the value of, the erosion rate arises. Soil permeability affects the size of erosion, rainwater that is difficult to enter the soil makes the value of the erosion rate large (Smith et al, 2012).

Soil erodibility, or soil erosion sensitivity factor, which is a soil's resistance to both release and transport, mainly depends on soil properties, such as texture, aggregate stability, shear strength, infiltration capacity, organic matter content, and chemical properties also depend on topographic position, slope and human disturbance (Gil et al, 2015).

Land use will be appropriate if the land is used according to its natural capabilities (Divya, & Solomon, 2016). This capability is determined by the nature and characteristics of the land itself (Supriyadi et al, 2016). Incorrect management and utilization can cause land damage (Achmad, 2012). Land use is used as an erosion control strategy that pays attention to land cover factors as protection (Zamora and Udawatta, 2016). Currently, trees and shrubs commonly used to protect against soil erosion have a positive effect on ecosystem functions and services (Kanzler et al, 2019). Agroforestry lands can be the most effective way to reduce erosion and carbon application (Saha et al, 2018) Increasing soil surface roughness to reduce water flow velocity, protect water quality, and increase biodiversity, for aesthetics and species conservation (Munsel & Chamberlain, 2019). Existing land will be used optimally for community life without causing negative impacts (Jhariya, 2015).

CONCLUSION

The value of the rate of soil erosion that occurs in the Pujon District is 657,700 tons/ha/year. The total erosion value comes from 364.715 tons/ha/year for agricultural land, 8,898 tons/ha/year for agroforestry land, 283,200 tons/ha/year for settlements and 0.882 tons/ha/year for forest land. The value of the rate of soil erosion that occurs in the Pujon District is 657,700 tons/ha/year. The value of the erosion rate belongs to the Erosion Hazard Class V, which is very heavy.

The erosion value of 657,700 tons/ha/year can create a natural disaster in Pujon District so that the authorities can carry out activities such as socializing vegetative soil and water conservation such as agroforestry systems. There needs to be counseling and an introduction about the benefits and importance of erosion prevention plants.

REFERENCES

1. Achmad, R. 2012. Kajian Strategi Optimalisasi Pemanfaatan Lahan Hutan Rakyat Di Provinsi Sulawesi Selatan (Study on Optimalisation Strategy of Private Forest Land Utilization in South Sulawesi). Jurnal Penelitian Sosial dan Ekonomi Kehutanan Vol. 9 No. 4 Desember 2012, Hal. 216 – 228.
2. Arsyad,S. 2012. Konservasi Tanah dan Air. Institut Pertanian Bogor Press: Bogor.
3. Aryani, D. 2016. Turnover Bahan Organik Tanah Di Bawah Tegakan Pinus(Pinus Merkusii Jungh. Et De Vriese)Dan Damar(Agathis Lorantifolia Salisb.) Di Resort Bodogol Taman Nasional Gunung Gede Pangrango. Departemen Ilmu Tanah dan Sumberdaya Lahan Fakultas Pertanian Institut Pertanian Bogor. Bogor.
4. Brandt, R., Zimmermann, H., Hensen, I., Mariscal Castro, J. C., & Rist, S. (2012). Agroforestry Species Of The Bolivian Andes: An Integrated Assessment of Ecological, Economic and Socio-Cultural Plant Values. Agroforestry Systems, 86(1), 1–16. http://doi.org/10.1007/s10457-012-9503-y.
5. Delgado, M. E. M., & Canters, F. (2012). Modeling the Impacts of Agroforestry Systems on the Spatial Patterns of Soil Erosion Risk In Three Catchments of Claveria, The Philippines. Agroforestry Systems, 85, 411–423. https://doi.org/10.1007/s10457-011-9442-z.
6. Destianto, R., & Pigawati, B. (2014). Analisis Keterkaitan Perubahan Lahan Pertanian terhadap Ketahanan Pangan Kabupaten Magelang Berbasis Model Spatio Temporal Sig. Geoplanning, 1(1), 21–32. Retrieved from http://ejournal.undip.ac.id/index.php/geoplanning.
7. Dewi, I. G. A. S. U., Ni Made, T., Tatiek K. 2012. Prediksi Erosi dan Perencanaan Konservasi Tanah dan Air pada Daerah Aliran Sungai Saba. Jurnal Agroekoteknologi Tropika ISSN: 2301-6515 Vol. 1, No. 1.
8. Dollinger. J & Jose, S (2018) Agroforestry for Soil Health Agroforest Syst (2018) 92:213–219 https://doi.org/10.1007/s10457-018-0223-9.
9. Febriani, N. A. (2014). Implementasi Etika Ekologis dalam Konservasi Lingkungan: Tawaran Solusi dari Al-Qur’an. Kanz Philosophia : A Journal for Islamic Philosophy and Mysticism, 4(1), 28. http://doi.org/10.20871/kpjipm. http://doi.org/10.20871/kpjipm.v4i1.53
10. Gil, J., Siebold, M., & Berger, T. (2015). Adoption and Development of Integrated Crop-Livestock-Forestry Systems in Mato Grosso, Brazil. Agriculture, Ecosystems and Environment, 199, 394–406. http://doi.org/10.1016/j.agee.2014.10.008.
11. Jhariya, M.K; Bargali, S.S and Raj, A (2015). Possibilitie and Perspectives of Agroforestry in Chhattisgarh. Chapter http://dx.doi.org/10.5772/60841.
12. Kanzler, M; Cristian, B; Mirck, J; Schmitt, D; Veste. M. (2019). Microclimate Effects on Evaporation and Winter Wheat (Triticum Aestivum L.) Yield Within a Temperate Agroforestry System. Agroforest Syst (2019) 93:1821–1841. https://doi.org/10.1007/s10457-018-0289-4 (0123456789.
13. Kongsager, R., Locatelli, B., & Chazarin, F. (2016). Addressing Climate Change Mitigation and Adaptation Together: A Global Assessment of Agriculture and Forestry Projects. Environmental Management, 57(2), 271–282. http://doi.org/10.1007/s00267-015-0605-y.

14. Kumar, V & A.Tiwari (2017). Importance of Tropical Homegardens Agroforestry System. International Journal of Current Microbiology and Applied Sciences ISSN: 2319-7706 Volume 6 Number 9 (2017) pp. 1002-1019 Journal homepage: http://www.ijcmas.com.
15. Kyarikunda, M., Nyamukuru, A.; Mulindwa, D, and Tabuti, J. R. S. (2017). Agroforestry and Management of Trees in Bunya County, Mayuge District, Uganda. International Journal of Forestry Research Volume 2017, Article ID 3046924, https://doi.org/10.1155/2017/3046924.
16. Mahyudin, Soemarno, Prayogo, T.B. (2015). Analisis Kualitas Air dan Strategi Pengendalian Pencemaran Air Sungai Metro di Kota Kepanjen Kabupaten Malang. Jurnal Pembangunan dan Alam Lestari. Vol. 6, No. 2. Universitas Brawijaya.
17. Marganingrum dan Dyah. (2013). Diferesiasi Sumber Pencemar Sungai Menggunakan Pendekatan Metode Indeks Pencemar (IP) (Studi Kasus: Hulu DAS Citarum). Riset Geologi dan Pertambangan. Vol. 23. No. 1. Hal 37-48.
18. Munsell, J. F and Chamberlain, J.L (2019) Agroforestry for a vibrant future: connecting people, creating livelihoods, and sustaining places. Agroforest Syst (2019) 93:1605–1608
19. https://doi.org/10.1007/s10457-019-00433-0.
20. Murthy,IK; Gupta, M; Tomar, S; Munsi M, Tiwari R, (2013). Carbon Sequestration Potential of Agroforestry Systems in India. J Earth Sci Climate Change 4: 131. doi:10.4172/2157-7617.1000131.
21. Mutiono. 2013. Pengelolaan Hutan Rakyat Berbasis Agroforestry. Retrieved 1 Desember 2016, from http://fmscipb.blogspot.co.id/2012/03/pengelolaan hutan-rakyat-berbasis.html
22. Naharuddin, Rukmi, Wulandari, R., & Paloloang, A. K. (2018). Surface runoff and erosion from agroforestry land use types. JAPS: Journal of Animal & Plant Sciences, 28 (3): 875-882.
23. Pratiwi, V. 2013. Aplikasi Model WEPP untuk Pendugaan Erosi di Sub Daerah Aliran Sungai Tinalah. Skripsi tidak diterbtkan. Fakultas Kehutanan Universitas Gadjah Mada: Yogyakarta.
24. Rini, F. 2018. Prediksi Erosi pada Lahan Petani Agroforestri di DAS Ciliwung Hulu Provinsi Jawa Barat. Jurnal Agrosains dan Teknologi Vol. 3 No 1 13-18.
25. Saha, S; Sharmin, A; Biswas, R and Ashaduzzaman, Md. (2018). Farmers' Perception and Adoption of Agroforestry Practices in Faridpur District of Bangladesh. International Journal of Envronment, Agriculture and Biotechnologi (IJEAB). Vol-3. Issue-6. Nov-Des 2018. ISSN: 2456-1878http://dx.doi.org/10.22161/ijeab/3.6.5.
26. Smith, J., Pearce, B. D., & Wolfe, M. S. (2012). Reconciling Productivity With Protection Of The Environment: Is Temperate Agroforestry The Answer? Renewable Agriculture And Food Systems, 28(1), 1–13. Http://Doi.Org/10.1017/S1742170511000585.
27. Supriyadi., Sri Hartati., N. Machfiroh & R. Ustiatik. (2016). Soil Quality Index in The Upstream of Bengawan Solo River Basin According to The Soil Function In Nutrient Cycling Based on Soybean Production in Agroforestry. Agrivita Journal of Agricultural Science Volume 38 No. 1 February-2016 Issn : 0126 – 0537.
28. Suripin. 2004. Sistem Drainse Perkotaan yang Berkelanjutan. Andi offset: Yogyakarta.
29. Walidatika, N dan Sigit, A.A (2017). Estimasi Evapotranspirasi melalui Analisis Metode Kesetimbangan Energi di Kabupaten Bantul Tahun 2015 dengan Memanfaatkan Citra Landsat Skripsi, Universitas Muhammadiyah Surakarta.
30. Wilman, T; Wardah & Rahmawati. (2013). Sifat Fisik Tanah pada Hutan Primer, Agroforestri dan Kebun Kakao Di Subdas Wera Saluopa Desa Leboni Kecamatan Pamona Puselemba Kabupaten Poso. WARTA RIMBA Volume 1, Nomor 1 Desember 2013.
31. Zamora, D and Udawatta, R. P (2016) Agroforestry as a Catalyst for on-Farm Conservation and Diversification. Cross Mark Agroforest Syst (2016) 90:711–714. DOI 10.1007/s10457-016-0013-1.