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Application of Flow Coefficients to Support High Economical Plant Cultivation (Case Study: Kwanyar Bangkalan, Indonesia)

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Abstract: The initial study that we carried out regarding the Kwanyar sub-district area, Bangkalan, East Java, shows the need to optimize land productivity and analyze the potential for farming to build the welfare of the people of the Kwanyar subdistrict. Preliminary spatial data analysis related to the topography as a result of Digital Elevation Model (DEM) data processing shows that: the Kwanyar sub-district is dominated by flat slopes (0-8°) compared to the northern region of the Kwanyar sub-district, while runoff water analysis shows a low flow coefficient (0- 0.25) which means that most of the Kwanyar area has low absorption capacity and a high potential for stagnant water. In addition, the Kwanyar region has a Regosol soil type. Regosol soil has a coarse texture and low organic matter, which makes it unable to properly hold water and minerals for plants, so it tends to be infertile. The initial study then became the basis for this research.

Keywords: Agriculture; Cultivation; Runoff; Slope; Vegetation

Introduction

Cultivating food crops in the Kwanyar sub-district faces various challenges, one of which is land degradation (Yunianti et al., 2022). Intensive agricultural and plantation cultivation can reduce soil fertility, especially a decrease in soil organic matter content (Wihardjaka et al., 2020), which is an essential element in the soil (Wihardjaka et al., 2022). The organic matter content in the soil greatly influences soil physical properties such as the stability of soil structure, soil density, and also water holding capacity (Arpino et al., 2023; Jiao et al., 2020; Luna Juncal et al., 2023). The availability of organic matter can increase the availability of macro- and micro-nutrients, as well as increase the cation exchange capacity, so that nutrients can be available to plants (Dhaliwal et al., 2019; Kizuka et al., 2023; Yorlano et al., 2022). The availability of organic matter also supports the activity of soil microorganisms to secrete enzymes that play an important role in the availability of plant nutrients such as N, P, and K (Debele, 2020; Lu et al., 2020; Ndabankulu et al., 2022). Decreasing soil fertility without being offset by adequate return of organic matter in the long term can result in land degradation and have an impact on decreasing crop productivity (Kopittke et al., 2019; Purwanto & Alam, 2020).

One of the parameters that affect the level of soil fertility is the slope and flow coefficient (Utama et al., 2022). The slope's slope shows the flow direction based on the height and pitch of the hill with the upstream to the downstream system. The coefficient of flow or water runoff shows the percentage of stagnant water absorbed into the soil. Both of these parameters indirectly affect soil erosion, where erosion is one of the causes of land

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degradation (Andrade et al., 2021; Kopittke et al., 2019; Y. Liang et al., 2020; Yang et al., 2022).

This research was conducted to determine the effect of the slope of the slope on the runoff of the research area with the existing conditions of the area being developed for agriculture in high economical plant cultivation (Ahmad Zubairi et al., 2022; K. Liang et al., 2023; Sabzi et al., 2022). Thus, the further development of this research becomes significant in the analysis of decision making regarding the development and management of agricultural land for the cultivation of high-economy crops.

Method

The research area is in Bangkalan Regency, especially in Kwanyar District. The following details the research location Figure 1. Next, determine the flow direction to determine the direction of flow on the surface. The coefficient of land flow is obtained from the slope of the land.

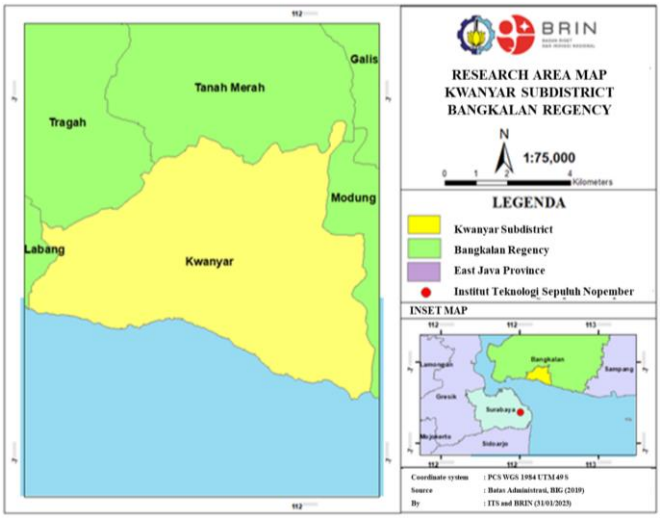

Figure 1. The boundaries of the research area use administrative boundaries

Slope Classification

Clip DEM, generate slope, reclassify, dissolve SHP, and continue with slope classification analysis are all slope classification steps that are performed after the coordinate system conversion. Data are converted to UTM by the coordinate system. Clipping DEM is the process of combining SHP data from the research site with DEM data. Reclassification is a step in the classification method. The disintegration procedure converts the reclassified data into shapefile data. Using color settings as symbols for each category, data from the dissolve operation is organized (Marin et al., 2020; Setyoko, 2019).

Flow Coefficient Classification

The coefficient of water flow on the surface of the land was estimated using data regarding land cover and slope. Using the straightforward model shown below, the flow coefficient is computed:

$$C = \frac{Lbl}{L\,T}\ x\ score \qquad (1)$$

with C as the flow coefficient, Lbl as the area (km2) of a specific land class, and LT as the total study area (km2). This method processes the intersection, including the calculation. The results of intersection processing provide information for the classification of flow coefficients (Ayu Saputri et al., 2018; Bujung, 2020; Indriatmoko & Wibowo, 2018; Nganro et al., 2019).

Result and Discussion

Preliminary studies that have been conducted show that based on slope and flow coefficient data processing it is found that Kwanyar sub-district is dominated by low-lying areas, compared to other areas in the northern part of Bangkalan district, as shown in Figure 2.

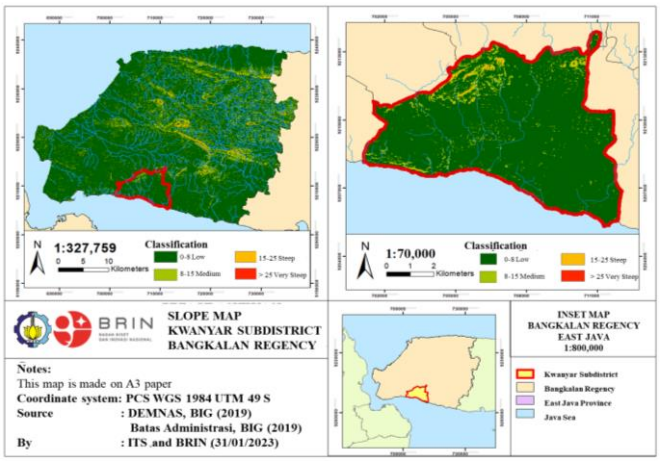

Figure 2. Slope classification map

In addition, the results of analysis of runoff water show that 100% of the water in the zone flows to the ground surface and 0% of the water is absorbed into the soil surface (Rugendo et al., 2023; Spangler et al., 2019a). Based on the slope, most of the flow coefficient in the study area is 0.2. The flow coefficient value indicates that 20% of the water flows to the ground surface and 80% of the water is absorbed or infiltrated into the soil. This shows that most of the flow coefficients are low with low absorption and high potential for waterlogging, as shown in Figure 2 (Indriani & Utama, 2023).

If viewed from the water runoff map in Figure 3, the northern region has a high runoff value, namely with an interval of 0.5-0.75. In this area has a land

classification, namely fields. If viewed from the results obtained, the water will run off faster so that the water absorbed on the land is quite a bit. On average, the kwanyar area has land with a low slope so that a low flow coefficient is obtained. In addition, the land is used for rice fields (Abas et al., 2022; Page et al., 2023; Zhang et al., 2021). So that the rice fields in the Kwanyar sub-district act as rain-fed rice fields. However, this has a weakness in the dry season, the lack of water distribution. In addition, land with steep slopes and high flow coefficients has the potential for high-level land degradation, so that it can affect the thickness of the soil layer getting thinner (Cui et al., 2020; Spangler et al., 2019b). The thickness of the soil layer is getting thinner can indicate the level of soil fertility is decreasing (Chen et al., 2023; Guo et al., 2021).

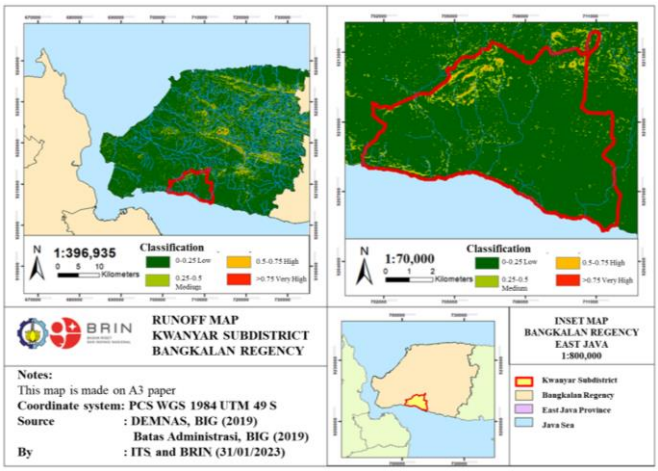

Figure 3. Runoff classification map

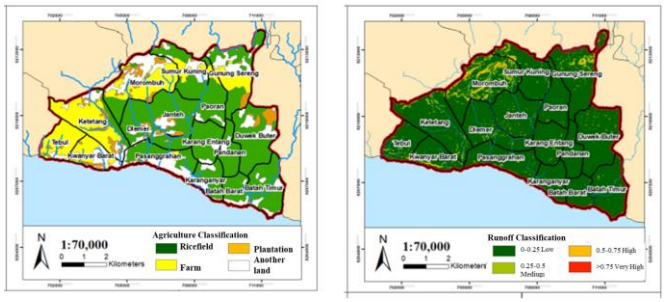

Figure 4. Agricultural classification maps and water runoff maps

In the future, with development, this value will increase significantly which means in controlling water in the area (Ayu Saputri et al., 2018; Bujung, 2020; Indriatmoko & Wibowo, 2018; Nganro et al., 2019). This research was conducted to determine the effect of the slope of the runoff of the research area with the existing conditions of the area being developed for agriculture in high economical plant cultivation. Thus, the further development of this research becomes significant in the analysis of decision making regarding the development and management of agricultural land for the cultivation of high-economy crops based on Figure 4 (Arpino et al., 2023; Ordonez et al., 2020).

Conclusion

Most of the kwanyar area has land with a low slope so that a low flow coefficient is obtained. In addition, the land is used for rice fields. So that the rice fields in the Kwanyar sub-district act as rain-fed rice fields. However, this has a weakness in the dry season, the lack of water distribution. In addition, land with steep slopes and high flow coefficients has the potential for high-level land degradation, so that it can affect the thickness of the soil layer getting thinner. The thickness of the soil layer is getting thinner can indicate the level of soil fertility is decreasing. In the future, with development, this value will increase significantly which means in controlling water in the area. This research was conducted to determine the effect of the slope of the slope on the runoff of the research area with the existing conditions of the area being developed for agriculture in high economical plant cultivation. Thus, the further development of this research becomes significant in the analysis of decision making regarding the development and management of agricultural land for the cultivation of high-economy crops.

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Author Contributions

The author's contributions include Widya Utama, Anicetus Wihardjaka, Nourma Al Viandari, Dwa Desa Warnana, Wien Lestari, and Eki Komara: focus on methdology and review on writing, and so on; Sherly A. Garini, Rista F. Indriani, Dhea P. N. Putra, and Annisa R. Varhana: collect data, process data, analyze data, and write original drafts.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

References

Abas, K., Brisson, J., Amyot, M., Brodeur, J., Storck, V., Montiel-León, J. M., Duy, S. V., Sauvé, S., & Kõiv-Vainik, M. (2022). Effects of plants and biochar on the performance of treatment wetlands for removal of the pesticide chlorantraniliprole from agricultural runoff. *Ecological Engineering*, *175*(October 2021). https://doi.org/10.1016/j.ecoleng.2021.106477

Ahmad Zubairi, N. A., Takaijudin, H., Ab Ghani, A., Goh, H. W., & Day, W. A. (2022). Assessment of imidacloprid removal from agricultural runoff by the bioretention treatment train system. *Environmental Advances*, *7*, 100156. https://doi.org/10.1016/j.envadv.2021.100156

Andrade, V. S., Gutierrez, M. F., Regaldo, L., Paira, A. R., Repetti, M. R., & Gagneten, A. M. (2021). Influence of rainfall and seasonal crop practices on nutrient and pesticide runoff from soybean dominated agricultural areas in Pampean streams, Argentina. *Science of the Total Environment*, *788*, 147676. https://doi.org/10.1016/j.scitotenv.2021.147676

Arpino, M., Stryker, J., Hanzas, J., Winchell, M., Thomas, M. A., Schleier, J., & Meals, D. (2023). Effectiveness of side-inlet vegetated filter strips at trapping pesticides from agricultural runoff. *Science of the Total Environment*, *879*(March), 162881. https://doi.org/10.1016/j.scitotenv.2023.162881

Ayu Saputri, D., Ridwan, R., Amin, M., & Asmara, S. (2018). Analisis Koefisien Aliran Permukaan Pada Berbagai Bentuk Penggunaan Lahan Dengan Swat. *Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering)*, *7*(1), 1. https://doi.org/10.23960/jtep-l.v7i1.1-8

Bujung, C. A. (2020). Studi Densitas Lineament dan Pola Aliran Permukaan Daerah Manifestasi Geotermal Di Sekitar Danau Tondano. *Jurnal FisTa: Fisika dan Terapannya, 1*(1), 1-5. Retrieved from https://eurekaunima.com/index.php/fista/article/view/55

Chen, X., Deng, S., Ji, B., Wu, S., & Chang, J. (2023). Seasonal purification efficiency, greenhouse gas emissions and microbial community characteristics of a field-scale surface-flow constructed wetland treating agricultural runoff. *Journal of Environmental Management*, *345*(June), 118871. https://doi.org/10.1016/j.jenvman.2023.118871

Cui, N., Zhang, X., Cai, M., Zhou, L., Chen, G., & Zou, G. (2020). Roles of vegetation in nutrient removal and structuring microbial communities in different types of agricultural drainage ditches for treating farmland runoff. *Ecological Engineering*, *155*(June), 105941. https://doi.org/10.1016/j.ecoleng.2020.105941

Dhaliwal, S. S., Naresh, R. K., Mandal, A., Singh, R., & Dhaliwal, M. K. (2019). Dynamics and transformations of micronutrients in agricultural soils as influenced by organic matter build-up: A review. *Environmental and Sustainability Indicators*, *1–2*(May), 100007. https://doi.org/10.1016/j.indic.2019.100007

Guo, T., Campbell-Arvai, V., & Cardinale, B. J. (2021). Why does the public support or oppose agricultural nutrient runoff regulations? The effects of political orientation, environmental worldview, and policy specific beliefs. *Journal of Environmental Management*, *279*(November 2020), 111708. https://doi.org/10.1016/j.jenvman.2020.111708

Gurmu, G. (2019). Soil organic matter and its role in soil health and crop productivity improvement. *Forest Ecology and Management, 7*(7), 475-483. https://doi.org/10.14662/ARJASR2019.147

Indriani, R. F., & Utama, W. (2023). Physiographic Study for Hydrology of Benowo Region Surabaya. *IOP Conference Series: Earth and Environmental Science*, *1127*(1), 012019. https://doi.org/10.1088/1755-1315/1127/1/012019

Indriatmoko, R. H., & Wibowo, V. E. (2018). Aplikasi Sistem Informasi Geografi Untuk Penghitungan Koefisien Aliran Daerah Aliran Sungai (Das) Ciliwung. *Jurnal Air Indonesia*, *3*(2), 182–190. https://doi.org/10.29122/jai.v3i2.2339

Jiao, S., Li, J., Li, Y., Xu, Z., Kong, B., Li, Y., & Shen, Y. (2020). Variation of soil organic carbon and physical properties in relation to land uses in the Yellow River Delta, China. *Scientific Reports*, *10*(1), 1–12. https://doi.org/10.1038/s41598-020-77303-8

Kizuka, T., Mikami, H., Kameyama, S., Ono, S., & Suzuki, H. (2023). Hydrological environment affects the nutrient retention and runoff function of naturally re-wetted agricultural peatland in lowland river floodplain. *Science of the Total Environment*, *857*(March 2022), 159483. https://doi.org/10.1016/j.scitotenv.2022.159483

Kopittke, P. M., Menzies, N. W., Wang, P., McKenna, B. A., & Lombi, E. (2019). Soil and the intensification of agriculture for global food security. *Environment International*, *132*(May), 105078. https://doi.org/10.1016/j.envint.2019.105078

Liang, K., Li, T., He, B., & Qian, T. (2023). Dynamics of dissolved organic carbon in runoff discharge under different rainfall patterns in a representative agricultural catchment. *Journal of Hydrology*, *617*(PC), 129079. https://doi.org/10.1016/j.jhydrol.2023.129079

Liang, Y., Wei, D., Hu, J., Zhang, J., Liu, Z., Li, A., & Li, R. (2020). Glyphosate and nutrients removal from

simulated agricultural runoff in a pilot pyrrhotite constructed wetland. *Water Research*, *168*, 115154. https://doi.org/10.1016/j.watres.2019.115154

Lu, X., Mahdi, A. K., Han, X. zeng, Chen, X., Yan, J., Biswas, A., & Zou, W. xiu. (2020). Long-term application of fertilizer and manures affect P fractions in Mollisol. *Scientific Reports*, *10*(1), 1–12. https://doi.org/10.1038/s41598-020-71448-2

Luna Juncal, M. J., Masino, P., Bertone, E., & Stewart, R. A. (2023). Towards nutrient neutrality: A review of agricultural runoff mitigation strategies and the development of a decision-making framework. *Science of the Total Environment*, *874*(October 2022), 162408. https://doi.org/10.1016/j.scitotenv.2023.162408

Marin, R. J., García, E. F., & Aristizábal, E. (2020). Effect of basin morphometric parameters on physically-based rainfall thresholds for shallow landslides. *Engineering Geology*, *278*(October), 105855. https://doi.org/10.1016/j.enggeo.2020.105855

Ndabankulu, K., Egbewale, S. O., Tsvuura, Z., & Magadlela, A. (2022). Soil microbes and associated extracellular enzymes largely impact nutrient bioavailability in acidic and nutrient poor grassland ecosystem soils. *Scientific Reports*, *12*(1), 1–11. https://doi.org/10.1038/s41598-022-16949-y

Nganro, S., Trisutomo, S., Barkey, R. A., & Ali, M. (2019). Analisis Koefisien Limpasan Permukaan Kota Makassar Dengan Metode Cook. *Tataloka*, *21*(2), 285. https://doi.org/10.14710/tataloka.21.2.285-292

Ordonez, D., Valencia, A., Elhakiem, H., Chang, N. Bin, & Wanielista, M. P. (2020). Adsorption thermodynamics and kinetics of Advanced Green Environmental Media (AGEM) for nutrient removal and recovery in agricultural discharge and stormwater runoff. *Environmental Pollution*, *266*, 115172. https://doi.org/10.1016/j.envpol.2020.115172

Page, B., Badiou, P., & Steele, O. (2023). Nutrient retention of newly restored wetlands receiving agricultural runoff in a temperate region of North America. *Ecological Engineering*, *195*(January), 107060. https://doi.org/10.1016/j.ecoleng.2023.107060

Purwanto, B. H., & Alam, S. (2020). Impact of intensive agricultural management on carbon and nitrogen dynamics in the humid tropics. *Soil Science and Plant Nutrition*, *66*(1), 50–59. https://doi.org/10.1080/00380768.2019.1705182

Rugendo, M. K., Gichimu, B. M., Mugwe, J. N., Mucheru-Muna, M., & Mugendi, D. N. (2023). Surface runoff and soil erosion from Nitisols and Ferralsols as influenced by different soil organic carbon levels under simulated rainfall conditions. *Heliyon*, *9*(7), e17684. https://doi.org/10.1016/j.heliyon.2023.e17684

Sabzi, B. D., Yazdi, N., & Maleki, A. (2022). Technological solutions for adaptation with Iran's water resources crisis. In *Urban Climate Adaptation and Mitigation*. Elsevier Inc. https://doi.org/10.1016/B978-0-323-85552-5.00002-6

Setyoko, T. B. (2019). *Pemetaan Kemiringan Lereng Menggunakan Pengindraan Jauh Dengan Citra Dem Untuk Pembangunan Perumahan Di Kecamatan Pule Dalam Bentuk 3D*. Retrieved from https://rb.gy/8ya2q

Spangler, J. T., Sample, D. J., Fox, L. J., Owen, J. S., & White, S. A. (2019a). Data on floating treatment wetland aided nutrient removal from agricultural runoff using two wetland species. *Data in Brief*, *22*, 756–761. https://doi.org/10.1016/j.dib.2018.12.037

Spangler, J. T., Sample, D. J., Fox, L. J., Owen, J. S., & White, S. A. (2019b). Floating treatment wetland aided nutrient removal from agricultural runoff using two wetland species. *Ecological Engineering*, *127*(December 2018), 468–479. https://doi.org/10.1016/j.ecoleng.2018.12.017

Utama, W., Hafiizh Immaduddin, M., & Indriani, R. F. (2022). Physiographic Study for Hydrology of Embung Hendrosari Region, Gresik Regency. *IOP Conference Series: Earth and Environmental Science*, *1095*(1). https://doi.org/10.1088/1755-1315/1095/1/012004

Wihardjaka, A., Harsanti, E. S., & Ardiwinata, A. N. (2022). Effect of fertilizer management on potassium dynamics and yield of rainfed lowland rice in Indonesia. *Chilean Journal of Agricultural Research*, *82*(1), 33–43. https://doi.org/10.4067/S0718-58392022000100033

Wihardjaka, A., Pramono, A., & Sutriadi, M. T. (2020). Peningkatan Produktivitas Padi Sawah Tadah Hujan Melalui Penerapan Teknologi Adaptif Dampak Perubahan Iklim. *Jurnal Sumberdaya Lahan*, *14*(1), 25. https://doi.org/10.21082/jsdl.v14n1.2020.25-36

Yang, Y. Y., Tfaily, M. M., Wilmoth, J. L., & Toor, G. S. (2022). Molecular characterization of dissolved organic nitrogen and phosphorus in agricultural runoff and surface waters. *Water Research*, *219*(February), 118533. https://doi.org/10.1016/j.watres.2022.118533

Yorlano, M. F., Demetrio, P. M., & Rimoldi, F. (2022). Riparian strips as attenuation zones for the toxicity of pesticides in agricultural surface runoff: Relative influence of herbaceous vegetation and terrain slope on toxicity attenuation of 2,4-D. *Science of the*

Total Environment, *807*. https://doi.org/10.1016/j.scitotenv.2021.150655

Yunianti, I. F., Al Viandari, N., Jumari, Supraptomo, E., & Sutriadi, M. T. (2022). Peningkatan Hasil Padi Melalui Penerapan Pengelolaan Hara Spesifik Lokasi di Lahan Sawah Tadah Hujan. *Biota : Jurnal Ilmiah Ilmu-Ilmu Hayati*, *7*(1), 11–18. https://doi.org/10.24002/biota.v7i1.5425

Zhang, K., Zhuang, D., Yang, J., Liu, X., Fu, X., Jiang, B., Luo, H., Xue, R., Li, M., Mo, Y., Huang, B., Li, L., Fan, L., Chen, W., Cheng, L., Chen, J., Chen, F., Ma, D., & Zhang, X. (2021). Performance on horizontal flow and folded plate denitrification bioreactor recycling waste sawdust and municipal sludge for continuously treating simulated agricultural surface runoff. *Journal of Cleaner Production*, *316*(March), 128299. https://doi.org/10.1016/j.jclepro.2021.128299