MULTIPLE
Journal of Global and Multidisciplinary
https://journal.institercom-edu.org/index.php/multiple
Volume 1 Number 2 (2023) E-ISSN 2988-7828
RESEARCH PAPER

Flood Risk Modeling in Buru Island, Maluku Province, Indonesia using Google Earth Engine

Susan E Manakane[1], Philia Christi Latue[2], Glendy Somae[3], Heinrich Rakuasa[4]
[1,2]Program Studi Pendidikan Geografi, Universitas Pattimura, Indonesia
[3,4]Departemen Geografi, Universitas Indonesia, Indonesia

Article Info:

Submitted:	Accepted:	Approve:	Published:
12 July 2023	23 July 2023	18 August 2023	24 August 2023

Corresponding uthor:
Susan E Manakane,
Universitas Pattimura,
Indonesia.
Jl. Ir. M. Putuhena, Poka, Kec. Tlk. Ambon, Kota Ambon, Maluku

Email:
uchanmanakane@rocketmail.com

Abstrack. Flood Risk Modeling in Buru Island, Maluku Province, Indonesia using Google Earth Engine has made a significant contribution to addressing flood threats in the region. Through the integration of satellite imagery, topographic, and hydrological data, this analysis maps flood-prone areas and models their potential impacts. Data processing and analysis were conducted in Google Earth Engine. The results show that the area prone to flooding in the low class is 195,501.88 ha or 23.18%, the area in the medium risk class is 496,182.06 ha or 58.84% and the area at high risk of flooding is 151,599.17 ha or 17.98%. The modeling results provide insights into flood patterns and intensity, enabling the development of more effective mitigation strategies. The use of Google Earth Engine also enables the development of data-driven solutions to increase public awareness and contribute to holistic disaster management. This research not only impacts Buru Island, but also provides valuable guidance for flood risk mitigation efforts in similar areas.
Keywords: Buru, Flood Risk, Google Earth Engine.

INTRODUCTION

Floods are one of the natural disasters that have serious impacts on communities and the environment around the world (BNPB, 2021). Among the various threats of natural disasters that often occur in Indonesia, floods have emerged as a serious problem that can disrupt community welfare, damage infrastructure, and endanger the environment (Lianxiao & Morimoto, 2019) (Ku, 2021). Maluku Province, with Buru Island as one of its islands, is not immune to the increasing risk of flooding (Latue, P. C., & Rakuasa, 2032). Floods often cause huge economic losses and threaten human safety (Tzioutzios & Kastridis, 2020)(Muin, A., & Rakuasa, 2023b). In recent decades, the frequency and impact of floods on Buru Island have shown a significant increase (Gibson & Shelley, 2020). Factors such as global climate change, high rainfall intensity, rapid land use change and uncontrolled urbanization growth have exacerbated the flood risk situation (Rokaya et al., 2022) (Muin, A., & Rakuasa, 2023c) (Hehanussa, F. S., Sumunar, D. R. S., & Rakuasa, 2023).

According to (Latue, 2023), Buru Island's unique geography and environmental conditions make it vulnerable to the impacts of natural disasters, particularly flooding. The varied topography and complex hydrological characteristics contribute to flood risk in different areas of the island (Muin, A., & Rakuasa, 2023a). Factors such as rainfall intensity, river flow volume, and high sea levels can potentially cause flooding in the region (Hossain & Meng, 2020). In the face of these challenges, flood risk modeling is essential to identify flood-prone areas, anticipate possible impacts and formulate effective mitigation strategies. One approach that can help address flood risk is hydrological modeling (DeVries et al., 2020). By utilizing artificial intelligence (AI) technology in the geospatial field, especially Google Earth Engine (GEE), flood risk modeling can be done more accurately and efficiently (Li & Demir, 2023).

Google Earth Engine is a platform that enables geospatial data analysis at scale (Onisimo Muntaga, 2019). With access to satellite imagery and other geospatial data, the platform enables researchers, environmentalists and governments to analyze environmental changes and respond to disaster threats, including floods (Hamidi et al., 2023). Google Earth Engine's strength lies in its ability to integrate data from multiple sources and perform complex spatial analysis quickly (Cui et al., 2023). Analyzing flooding on Buru Island with Google Earth Engine provides important information in designing effective mitigation and adaptation strategies. With a better understanding of flood patterns, flood scenarios, and flood-prone areas, mitigation policies and programs can be designed in a more targeted manner (Sugandhi, N., Rakuasa, H., Zainudin, Z., Abdul Wahab, W., Kamiludin, K., Jaelani, A., Ramdhani, R., & Rinaldi, 2023). In addition, the resulting flood risk maps can also be used as a communication tool to communities, helping them understand the threats and take appropriate actions (Heinrich Rakuasa , Glendy Somae, 2023).

Through this modeling, it is hoped that a better understanding of flood patterns, possible expansion of flood areas, and their impacts on communities and the environment will be created (Sugandhi, N., Rakuasa, H., Zainudin, Z., Abdul Wahab, W., Kamiludin, K., Jaelani, A., Ramdhani, R., & Rinaldi, 2023). This research not only provides important information for policy makers and researchers, but also empowers local communities to contribute to flood risk reduction through increased preparedness and participation in disaster mitigation programs. Based on the above background, this research aims to determine flood-prone areas in Buru Island, Maluku Province, Indonesia using Google Earth Engine.

LITERATURE REVIEW

1. Flood Risk

Flood risk is a situation where the threat of flooding in an area can have a detrimental impact on people, the environment, and infrastructure (Chuang et al., 2020). Flooding is a natural phenomenon that occurs when water overflows from a river channel, lake, or sea, exceeding its normal limits and submerging the surrounding area (Ballerine, 2017) (Heinrich Rakuasa, Daniel A Sihasale , Marhelin C Mehdila, 2022). Flood threats are often caused by natural factors such as heavy rainfall, high tides, or overflowing rivers due to heavy rainfall upstream (Rakuasa, H., Helwend, J. K., & Sihasale, 2022). Flood risk involves complex elements, including physical, social, economic and environmental aspects (Riadi et al., 2018). Flood impacts can include physical damage to buildings, infrastructure and agricultural crops (Latue, P. C., Imanuel Septory, J. S., Somae, G., & Rakuasa, 2023). In addition, flood risk can also threaten the safety of people and animals, and potentially result in loss of life. Flood risk is not a threat that can be ignored. With a deeper understanding of the triggering factors and effective mitigation measures, communities and governments can work together to maintain safety and resilience against flood threats (Mudashiru et al., 2021) (Muin, A., Somae, G., & Rakuasa, 2023)

2. Google Earth Engine

Google Earth Engine is an innovative platform developed by Google for conducting large-scale geospatial and remote sensing analysis (Gorelick et al., 2017). It combines cloud computing capabilities with access to multiple sources of satellite imagery and geospatial information, allowing users to run complex analyses without the need for expensive hardware and software (Ermida et al., 2020). By utilizing Google Earth Engine for flood risk analysis, environmental experts, governments and communities can have a better understanding of flood threats and develop more targeted mitigation measures (Onisimo Muntaga, 2019). In an era of climate change and environmental complexity, utilizing this technology is key in building resilience to flood risks

METHOD

This research was conducted in Buru Island, Maluku Province, Indonesia. The research used JRC Global Surface Water Mapping Layers data, v1.4, NASA SRTM Digital Elevation 30m data, USGS Landsat 8 Level 2, Collection 2, Tier 1 data and research location boundary data. This research uses variables Permanent water, Distance from water, Elevation data, NDVI and NDWI. Processing and analysis of research data is fully carried out in the Google Earth Engine (https://earthengine.google.com/) using a modified script from previous researchers (Figure 1). The results of the analysis of flood-prone areas on Buru Island were then classified into three classes, namely low, medium and high class.

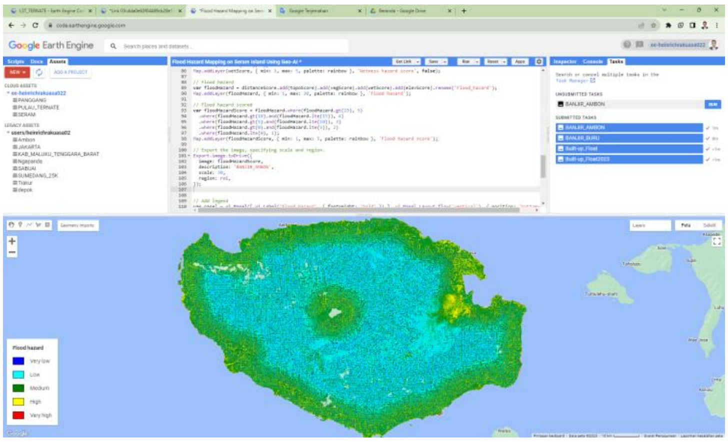

Figure 1. Display of the Flood Risk Management Process in Google Earth Engine

RESULTS AND DISCUSSION

Flood risk areas are areas that have a high potential to experience flooding due to heavy rainfall, high tides, overflowing rivers, or other factors that can cause water immersion. These areas tend to have higher levels of vulnerability to flood threats, which can impact infrastructure, the environment and human safety. It is important to accurately identify and map flood risk areas as a first step in flood risk planning and mitigation. Flood risk maps usually include several factors, such as topography, land use, rainfall and water flow patterns. Through geospatial data analysis and hydrological modeling, areas prone to flooding can be identified and ranked based on their level of risk. Information on flood risk areas is essential for governments, policymakers and communities to plan spatial plans, develop flood-resilient infrastructure, design early warning systems and take other mitigation measures. By understanding and managing flood risk areas, efforts to reduce flood impacts and protect communities and the environment can be more effective.

The results showed that the area prone to flooding in the low risk class is 195,501.88 ha or 23.18%, the area in the moderate risk class is 496,182.06 ha or 58.84% and the area at high risk of flooding is 151,599.17 ha or 17.98%. Flood risk on Buru Island is then classified based on district administrative boundaries where in the low flood risk class Buru Regency has an area of 119,130.45 ha and South Buru Regency has an area of 86,414.56 ha, in the medium flood risk class Buru Regency has an area of 286,498.61 ha and South Buru Regency has an area of 209,683.45 ha and in the high flood risk class Buru Regency has an area of 86,437.49 ha and South Buru Regency has an area of 65,161.68 ha. Details of flood risk on Buru Island can be seen in Figure 2.

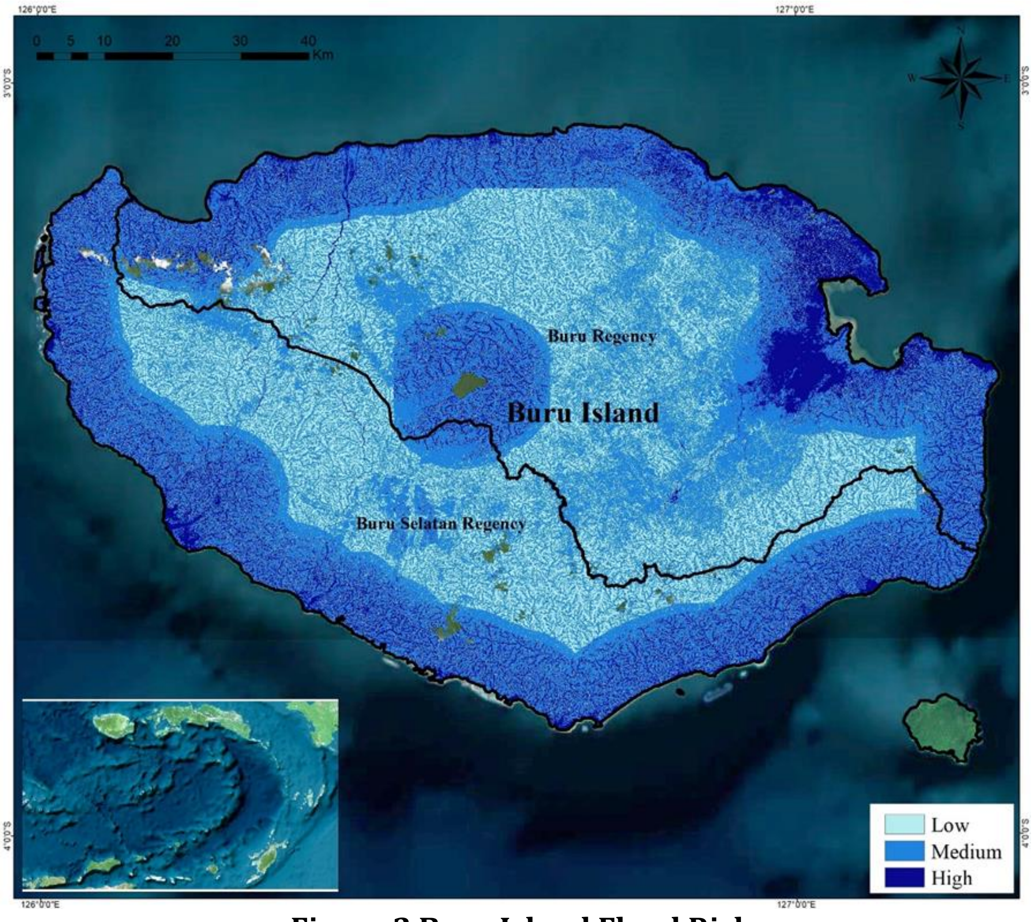

Figure 2 Buru Island Flood Risk

Based on Figure 2, it can be seen that the risk of flooding in the low class is in areas that have topography, hills and mountains and have a high vegetation density index (NDVI) and are far from water bodies, while the risk of flooding in the high and medium classes is in areas with flat and sloping topography, close to water bodies including rivers, and have a low vegetation index or have land cover consisting of open land, shrubs, grasslands and settlements and also high rainfall.

Flood risk analysis on Buru Island brings a range of benefits that are essential for flood hazard management and impact reduction. Firstly, the analysis enables accurate identification of flood-prone areas. This allows the government and stakeholders to focus on locations that require special attention in disaster management efforts. Secondly, flood risk analysis enables a deeper understanding of the factors that cause flooding such as land use, topography, river flow patterns, and rainfall. This information forms the basis for designing effective mitigation strategies.

Thirdly, with inundation and impact modelling, flood risk analysis provides a real picture of how flooding will affect the affected areas. With a better understanding of the depth of water, the extent of submerged areas, and the potential impacts on infrastructure and communities, mitigation measures can be more accurately designed. Fourth, the results of the analyses form the basis for developing more targeted mitigation plans. Flood-resistant infrastructure, improved drainage systems, land use management and early warning systems can be designed and implemented more efficiently. Fifth, flood risk analysis helps in more effective resource allocation, especially by focusing on high-risk areas. This allows for faster response and proper prioritisation.

Sixth, communities can be empowered through the flood risk information they receive. A higher awareness of risk allows them to take proactive measures in the face of flood threats. Seventh, the results of the analysis can be integrated in more sustainable development planning. This helps avoid development in areas that are highly vulnerable to flooding. Eighth, flood risk analysis creates a database that is essential for better decision-making. Decisions based on accurate data and information will be more effective in dealing with flood threats.

By implementing a flood risk analysis on Buru Island, the government and stakeholders can better plan mitigation measures, keep people and the environment safe, and build a more resilient region against flood threats.

CONCLUSION

Flood risk modeling in Buru Island, Maluku Province, Indonesia using Google Earth Engine has had a significant impact on efforts to understand and deal with flood threats in the region. The results show that the area prone to flooding in the low class is 195,501.88 ha or 23.18%, the area in the medium risk class is 496,182.06 ha or 58.84% and the area at high risk of flooding is 151,599.17 ha or 17.98%. Flood risk on Buru Island is then classified based on district administrative boundaries where in the low flood risk class Buru Regency has an area of 119,130.45 ha and South Buru Regency has an area of 86,414.56 ha, in the medium flood risk class Buru Regency has an area of 286,498.61 ha and South Buru Regency has an area of 209,683.45 ha and in the high flood risk class Buru Regency has an area of

86,437.49 ha and South Buru Regency has an area of 65,161.68 ha. The use of this technology provides a better understanding of flood-prone areas, enables the development of more targeted mitigation strategies, and provides a solid basis for data-driven decision-making with more accurate and efficient analysis, better equipping governments and stakeholders going forward

REFERENCE

Ballerine, C. (2017). *Topographic wetness index urban flooding awareness act action support*. Will & DuPage Counties.

BNPB. (2021). *Indeks Risiko Bencana Indonesia (RBI) Tahun 2021*. Pusat Data, Informasi dan Komunikasi Kebencanaan Badan Nasional Penanggulangan Bencana.

Chuang, M.-T., Chen, T.-L., & Lin, Z.-H. (2020). A review of resilient practice based upon flood vulnerability in New Taipei City, Taiwan. *International Journal of Disaster Risk Reduction*, *46*, 101494. https://doi.org/10.1016/j.ijdrr.2020.101494

Cui, J., Guo, Y., Xu, Q., Li, D., Chen, W., Shi, L., Ji, G., & Li, L. (2023). Extraction of Information on the Flooding Extent of Agricultural Land in Henan Province Based on Multi-Source Remote Sensing Images and Google Earth Engine. *Agronomy*, *13*(2), 355. https://doi.org/10.3390/agronomy13020355

DeVries, B., Huang, C., Armston, J., Huang, W., Jones, J. W., & Lang, M. W. (2020). Rapid and robust monitoring of flood events using Sentinel-1 and Landsat data on the Google Earth Engine. *Remote Sensing of Environment*, *240*, 111664. https://doi.org/10.1016/j.rse.2020.111664

Ermida, S. L., Soares, P., Mantas, V., Göttsche, F.-M., & Trigo, I. F. (2020). Google Earth Engine Open-Source Code for Land Surface Temperature Estimation from the Landsat Series. *Remote Sensing*, *12*(9), 1471. https://doi.org/10.3390/rs12091471

Gibson, S., & Shelley, J. (2020). Flood disturbance, recovery, and inter-flood incision on a large sand-bed river. *Geomorphology*, *351*, 106973. https://doi.org/10.1016/j.geomorph.2019.106973

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment*, *202*, 18–27. https://doi.org/10.1016/j.rse.2017.06.031

Hamidi, E., Peter, B. G., Munoz, D. F., Moftakhari, H., & Moradkhani, H. (2023). Fast Flood Extent Monitoring With SAR Change Detection Using Google Earth Engine. *IEEE Transactions on Geoscience and Remote Sensing*, *61*, 1–19. https://doi.org/10.1109/TGRS.2023.3240097

Hehanussa, F. S., Sumunar, D. R. S., & Rakuasa, H. (2023). Pemanfaatan Geogle Earth Engine Untuk Identifikasi Perubahan Suhu Permukaan Daratan Kabupaten Buru Selatan Berbasis Cloud Computing. *Gudang Jurnal Multidisiplin Ilmu*, *1*(1), 37–45.

Heinrich Rakuasa , Glendy Somae, P. C. L. (2023). Pemetaan Daerah Rawan Banjir di Desa Batumerah Kecamatan Sirimau Kota Ambon Menggunakan Sistim Informasi Geografis. *ULIL ALBAB : Jurnal Ilmiah Multidisiplin*, *2*(4), 1642–1653. https://doi.org/10.56799/jim.v2i4.1475

Heinrich Rakuasa, Daniel A Sihasale , Marhelin C Mehdila, A. P. W. (2022). Analisis Spasial Tingkat Kerawanan Banjir di Kecamatan Teluk Ambon Baguala, Kota Ambon. *Jurnal*

Geosains Dan Remote Sensing (JGRS), *3*(2), 60–69. https://doi.org/10.23960/jgrs.2022.v3i2.80

Hossain, M. K., & Meng, Q. (2020). A fine-scale spatial analytics of the assessment and mapping of buildings and population at different risk levels of urban flood. *Land Use Policy*, *99*, 104829. https://doi.org/10.1016/j.landusepol.2020.104829

Ku, C.-A. (2021). Simulating future land use exposure to extreme floods in metropolitan areas based on an integrated framework. *Urban Climate*, *35*, 100738. https://doi.org/10.1016/j.uclim.2020.100738

Latue, P. C. (2023). Spatial Analysis of Flood Prone Areas in Fena Leisela Subdistrict, Buru Regency. *Journal of Innovation Information Technology and Application (JINITA)*, *5*(1), 65–73. https://doi.org/10.35970/jinita.v5i1.1865

Latue, P. C., & Rakuasa, H. (2032). Identification of Flood-Prone Areas Using the Topographic Wetness Index Method in Fena Leisela District, Buru Regency. *Journal Basic Science and Technology*, *12*(2). https://doi.org/10.35335/jbst.v12i1.3673

Latue, P. C., Imanuel Septory, J. S., Somae, G., & Rakuasa, H. (2023). Pemodelan Daerah Rawan Banjir di Kecamatan Sirimau Menggunakan Metode Multi-Criteria Analysis (MCA). *Jurnal Perencanaan Wilayah Dan Kota*, *18*(1), 10–17. https://doi.org/10.29313/jpwk.v18i1.1964

Li, Z., & Demir, I. (2023). U-net-based semantic classification for flood extent extraction using SAR imagery and GEE platform: A case study for 2019 central US flooding. *Science of The Total Environment*, *869*, 161757. https://doi.org/10.1016/j.scitotenv.2023.161757

Lianxiao, & Morimoto, T. (2019). Spatial Analysis of Social Vulnerability to Floods Based on the MOVE Framework and Information Entropy Method: Case Study of Katsushika Ward, Tokyo. *Sustainability*, *11*(2). https://doi.org/10.3390/su11020529

Mudashiru, R. B., Sabtu, N., Abustan, I., & Balogun, W. (2021). Flood hazard mapping methods: A review. *Journal of Hydrology*, *603*, 126846. https://doi.org/10.1016/j.jhydrol.2021.126846

Muin, A., & Rakuasa, H. (2023a). Evaluasi Rencana Tata Ruang Wilayah Kota Ambon Berdasarkan Aspek Kerawanan Banjir. *ULIL ALBAB : Jurnal Ilmiah Multidisiplin*, *2*(5), 1727-1738. https://doi.org/10.56799/jim.v2i5.1485

Muin, A., & Rakuasa, H. (2023b). Pemanfaat Geographic Artificial Intelligence (Geo-AI) Untuk Identifikasi Daerah Rawan Banjir Di Kota Ambon. *Gudang Jurnal Multidisiplin Ilmu*, *1*(2), 58-63. https://doi.org/10.59435/gjmi.v1i2.24

Muin, A., & Rakuasa, H. (2023c). Pemetaan Daerah Rawan Banjir di Desa Lokki Kecamatan Huamual Kabupaten Seram Bagian Barat. *Gudang Jurnal Multidisiplin Ilmu*, *1*(2), 47–52. https://doi.org/10.59435/gjmi.v1i2.22

Muin, A., Somae, G., & Rakuasa, H. (2023). Analisis Potensi Genangan Banjir di Kecamatan Siwalalat, Kabupaten Seram Bangian Timur berdasarkan Topographic Wetness Index. *ULIL ALBAB: Jurnal Ilmiah Multidisiplin*, *2*(5), 1800–1806. https://doi.org/DOI: https://doi.org/10.56799/jim.v2i5.1502

Onisimo Muntaga, L. K. (2019). Google Earth Engine Applications. *Remotesensing*, 11–14. https://doi.org/10.3390/rs11050591

Rakuasa, H., Helwend, J. K., & Sihasale, D. A. (2022). Pemetaan Daerah Rawan Banjir di Kota Ambon Menggunakan Sistim Informasi Geografis. *Jurnal Geografi: Media Informasi Pengembangan Dan Profesi Kegeografian*, *19*(2), 73–82. https://doi.org/10.15294/jg.v19i2.34240

Riadi, B., Barus, B., Widiatmaka, Yanuar, M. J. P., & Pramudya, B. (2018). Identification and delineation of areas flood hazard using high accuracy of DEM data. *IOP Conference Series: Earth and Environmental Science*, *149*, 012035. https://doi.org/10.1088/1755-1315/149/1/012035

Rokaya, P., Lindenschmidt, K.-E., Pietroniro, A., & Clark, M. (2022). Modelling of ice jam floods under past and future climates: A review. *Journal of Hydrology X*, *15*, 100120. https://doi.org/10.1016/j.hydroa.2022.100120

Sugandhi, N., Rakuasa, H., Zainudin, Z., Abdul Wahab, W., Kamiludin, K., Jaelani, A., Ramdhani, R., & Rinaldi, M. (2023). Pemodelan Spasial Limpasan Genangan Banjir dari DAS Ciliwung di Kel. Kebon Baru dan Kel. Bidara Cina DKI Jakarta. *ULIL ALBAB : Jurnal Ilmiah Multidisiplin*, *2*(5), 1685-1692. https://doi.org/10.56799/jim.v2i5.1477

Tzioutzios, C., & Kastridis, A. (2020). Multi-Criteria Evaluation (MCE) Method for the Management of Woodland Plantations in Floodplain Areas. In *ISPRS International Journal of Geo-Information* (Vol. 9, Issue 12). https://doi.org/10.3390/ijgi9120725