Sriwijaya Journal of Environment
Article
ojs.pps.unsri.ac.id

Optimizing the Utilization of Swamp Lands for Urban Settlements in Kertapati District, Palembang

Maulana Yusuf[1], Nurhayati Damiri[1,2*], Ardiyan Saptawan[3], Syafrul Yunardy[4], Nur Aslamiah Supli[3]

[1]Doctoral Program of Environmental Science, Graduate School, Universitas Sriwijaya, Jl. Padang Selasa No. 524, Bukit Besar, Palembang, South Sumatra, Indonesia
[2]Department of Plant pests and diseases, Faculty of Agriculture, Universitas Sriwijaya. Jl. Raya Palembang-Prabumulih Km 32, Indralaya, Ogan Ilir 30662, South Sumatra, Indonesia
[3]Faculty of Social and Political Science, Universitas Sriwijaya, South Sumatra, Indonesia
[4]South Sumatra Provincial Forestry Office, Indonesia
**Corresponding author's e-mail: nurhayati@fp.unsri.ac.id*

Article history

Received	Received in revised form	Accepted	Available online
1 August 2023	24 August 2023	9 September 2023	8 September 2023

Abstract: The water crisis caused by floods and droughts has become an urgent problem in many regions worldwide. To address these challenges, the provision of empty spaces for rainwater harvesting has been a focus of attention as a potential solution to reduce the adverse impacts of these extreme phenomena. The objective of this study is to explore and propose effective strategies for optimizing the utilization of swamp lands for urban settlements in the Kertapati District of Palembang. The research methodology involves quantitative and qualitative analyses of hydrological data and land use on a property in Bukit Lama IB I, Palembang, South Sumatra, which has implemented the rainwater harvesting system. The hydrological data includes rainfall, roof catchment area, yard area, and rainwater accumulation rates. The results of the study show that the provision of empty spaces for rainwater harvesting can significantly reduce the risks of floods and droughts. When heavy rainfall occurs, this system can retain excess rainwater, thereby reducing surface runoff volume and slowing the flow toward rivers. Additionally, the harvested water can serve as a reserve to cope with drought during the dry season. The research also identifies several critical factors influencing the effectiveness of the rainwater harvesting system, including infrastructure design and surrounding land use. In this context, collaboration between the government, communities, and the private sector becomes crucial in implementing this system widely and sustainably. In conclusion, the provision of empty spaces for rainwater harvesting has proven to be an effective approach to reducing the risks of floods and droughts. Facing increasingly complex climate change, it is essential for communities, governments, and other stakeholders to adopt and implement this system as part of a comprehensive strategy to manage water resources sustainably and protect the environment.

Keywords: maintaining balance, wetland environment, urban development, rainwater harvesting

1. Introduction

The regular appearance of floods in the watershed region is influenced not only by upstream factors, like changes in land use and land cover but also by extreme weather conditions that result in heavy rainfall in specific parts of Indonesia's archipelago. The occurrence of floods caused by environmental disruptions is becoming a significant issue both in Indonesia and worldwide [1-3].

Cities along the east coast of South Sumatra, and many other places in Indonesia, are situated on wetlands. Cities like Palembang, Kayu Agung, and Indralaya are examples of cities that have extensive wetland areas. In Palembang alone, more than 50 percent of the city's total area, which is approximately 40,000 hectares, consists of vast wetlands. According to [4], in the year 2015, the wetland area in Palembang was about 22,000 hectares. Until now, for housing developments, commercial buildings, and other constructions, people are still extensively filling in the wetlands. It is not surprising that by the beginning of the 21st century, specifically in the year 2010, the wetland area in Palembang was reduced to less than 40 percent of the city's total area.

The decreasing wetland areas in urban areas always lead to flooding or inundation during prolonged and heavy rainfall, especially in the rainy season. Flooding occurs whenever there is intense and prolonged rainfall, adding to the suffering of residents in areas that are constantly submerged. The increasing risk of flooding or inundation in urban areas is due to the proliferation of economic and social activities. The high flood risk in urban areas is believed to be a result of global climate change [5;6]. Building for various urban needs without considering the natural balance of wetlands is another cause of increased inundation risk, in addition to the activities of the community in various forms [7].

Considering an effort to maintain the natural balance of wetlands as a means of absorbing and storing rainwater is an alternative to adapting to the wetland environment. Balance should also be considered in relation to river water levels rising due to upstream flooding or the influence of tidal waters. An adaptive alternative to the wetland environment is to provide empty spaces for harvesting rainwater or tidal water from rivers nearby.

Since several decades ago, many countries around the world have collectively recognized the importance of preparing empty spaces for harvesting rainwater or tidal water. This is done to accommodate the water that accumulates during the rainy season and to provide water during droughts, and water shortages, as well as to mitigate floods and droughts [8]. The significance of planning for the provision of empty spaces for rainwater harvesting as a form of water conservation awareness has been reported by [9] Studies and planning for the provision of empty spaces for rainwater harvesting have been conducted at the campus of Diponegoro University in Semarang. The development of the campus, which transformed approximately 50 percent of the university campus area into buildings, has been acknowledged by researchers to have led to a reduction in green open spaces for rainwater absorption, resulting in floods and waterlogging during the rainy season and water shortages during droughts.

Experts have introduced the concept of sustainable water use, including providing water to communities based on their actual needs. Identifying alternative water sources for human needs should be done using the principles of sustainable water resource management and ideally meeting drinking water standards [10]. Wetlands are areas that receive abundant water during the rainy season, both from river overflow and rainfall. The plentiful rainwater should be seen as a blessing, but it is often blamed for causing disasters that inconvenience communities, such as floods [11].

According to [11], in the city of Palembang, there are more than 40 areas prone to waterlogging. These areas include 11 locations along various roads, such as Jenderal Sudirman Street in front of Sintera Hotel, R Sukamto Street in front of RM Pindang Meranjat, Basuki Rahmat Street at Polda intersection, Demang Lebar Daun Street between Angkatan 45 Street - RS Siti Khodijah, R Suprapto Street in front of Unsri, and along Macan Lindungan Street. Also, Yos Sudarso Street in front of SPBU, RE Martadinata Street in front of the Lurah 2 Ilir Office, Jakabaring area along 16 Ulu, A Yani Street Naga Swidak, Sentosa Street, and between the Gerong River Bridge to the Kedukan Bridge. In Kenten, along May Ruslan Street and Pentolan Bambang Utoyo, and at Adawiyah School. Furthermore, in Veteran Street in front of the Mitsubishi Dealer, as well as H Burlian and Kasnariansyah Streets.

The extensive utilization of wetland areas in Palembang is one of the causes of waterlogging. This utilization has resulted in a high percentage of built-up areas in the city, leading to a reduction in wetland areas. On the other hand, the water cycle in Palembang does not function smoothly due to the large number of areas covered by buildings and roads. This article aims to report on the study of the effectivity of the provision of empty spaces to mitigate floods and drought: an effective approach for water management. The impact of this imbalance is disrupted water cycles, leading to waterlogging during the rainy season and water scarcity during the dry season. Policy recommendations will be provided

2. Material and Methods

The study was conducted in a premise and its yard owned a person was known as rainfall harvesting house from January and March 2023. The materials used was the rainfall facilities that were available in the premise namely fishpond, swimming pool, infiltration wells, glass measuring, bucket, plastic bags, measuring device etc. Rain was measured in each area of rainfall harvesting sites namely rainfall that fallen into the swimming pool, fish pond, rainfall tank, and infiltration wells. Data collected from the observation in each rainfall harvesting areas was predicted and observed.

Figure 1. Three rainwater harvesting areas in the rainwater harvesting house.

The experiment conducted to study the effectivity of empty spaces in harvesting the rain and tidal water was arranged as follows. Land arrangement involved preparing a 60 m x 23 m area (1,380 m²). This area was organized with a 30 m x 10 m (21.74 percent) front portion excavated, and the excavated soil was used to fill the space that covers 75 percent of the entire land area for the future house and yard. The empty space in this section, without rain, measured 30 m x 10 m x 2 m = 600 m². The soil that was derived from the digging of the front land was used to pill up the other area. Next, a space of 35 m² was prepared for building a swimming pool with a height of 1.22 m (an empty space of 42 m²).

The empty space for the rainwater tank is 12 m², and for the soak pit, it was 5 m². The remaining area was for the backyard, right side, front, and left side of the house. All areas were designed to direct rainwater from the 100 m² roof to the swimming pool, from a 65 m² area to the rainwater tank, and from a 125 m² area to the soak pit. Rainwater from the grass roof and front terrace was collected in the yard and guided through pipes or open gutters to the fishpond in front of the house. In this study, a literature review was conducted to study the categories of wetland in Palembang city.

3. Results and Discussion

The construction of the houses have been aligned with the rainwater harvesting system. The roofs of the houses were made of ceramic and zinc tiles. Multiple observations had shown that the rainwater harvesting system, which included creating empty spaces from the roofs leading to the swimming pool, fishpond, soak pit, and rainwater tank, never exceeds the capacity of each rainwater harvesting device. The swimming pool could efficiently collect rainwater falling from the middle and rear parts of the roof. Similarly, the rainwater tank accommodated rainwater from the left side of the house's roof. The soak pit was able to collect rainwater from the right side of the neighboring building's roof, as well as the roof of the kitchen and warehouse. Additionally, rainwater from the grass roof, front terrace, and front yard was effectively collected by the swimming pool.

Based on the observations and calculations made for the runoff from the roof area of a person's house and the courtyard with the rainwater harvesting system, the following results were obtained. The study observed four different rainfall intensities: 5 mm, 25 mm, 38 mm, and 72 mm/hour.

Since the research conducted, it was revealed that rainfall, regardless of its intensity, generates a significant amount of rainwater. Even the lowest intensity of rainfall fills up the empty spaces for rainwater storage in the swimming pool, tanks, and fishpond. The accumulated rainwater in the fishpond and all other storage containers during four rainfall events was 96.5 m³, with an average of 24 m³ per rainfall event (Table 1). This quantity does not cause the pool to overflow because there is daily evaporation, ranging from 3 to 5 percent per day [13]. The presence of evaporation caused the stored rainwater in all storage methods to decrease gradually over time.

Reportedly, the rainwater harvesting house used in the study never experiences water shortages. With this rainwater harvesting system, there is an annual savings of clean water ranging from 30 to 50 percent. There are several reasons why providing empty spaces for rainwater harvesting is crucial for water conservation [14].

Table 1. Increase in water volume in the three rainwater storage areas in the rainwater harvesting house.

Rainfall (mm)	Area I (m3)	Area II (m3)	Area III (m3)	SD (%)
5	1,25	0,75	5	12
25	6,25	1,75	15	13
38	9,25	3,1	38	11
72	18	6,5	72	14

Firstly, the increasing demand for water leads to higher groundwater extraction, resulting in a reduction of groundwater reserves. Providing empty spaces for rainwater harvesting offers numerous benefits as an alternative solution. Secondly, the availability of water from sources like lakes, rivers, and groundwater is fluctuating. Collecting and storing rainwater in various ways can serve as a solution when the quality of surface water, such as lake or river water, is low (i.e., turbid) during the rainy season, as is often the case in many places. Thirdly, other water sources are usually located far from homes or communities.

Collecting and storing water near homes and even within residential areas can improve access to water supply, positively impacting health, and strengthening the users' sense of ownership of this alternative water source. Fourthly, water supplies can be contaminated by industrial activities or human waste, such as the influx of heavy metals and/or harmful minerals like arsenic, salt, or fluoride. In contrast, rainwater quality is generally good, especially in large quantities, and rain is a frequent occurrence. Consequently, the rainwater harvesting system provides multiple advantages, including water conservation, stable water supply, and improved water quality.

The rainwater harvesting described earlier in this paper has proven to be an effective adjustment to the wetland environment through the construction of several empty spaces in the house and its surroundings, in the form of fish ponds, swimming pools, rainwater tanks, and soak pits. In reality, rainwater harvesting is the wisest alternative. On one side, the utilization of wetlands for housing can be well-implemented, while on the other side, the wetland's function as a water reservoir during the rainy season remains sustainable. Similarly, during the dry season, when water seemingly disappears from the wetland area, it is always present and sufficient to meet various needs for clean water, such as watering plants, cleaning vehicles, and serving as a habitat for various types of fish.

Through rainwater harvesting, various fruit trees such as longan, durian, avocado, banana, guava, jackfruit, mango, papaya, and grapes flourish in rainfall harvesting house's courtyard, nourished by rainwater irrigation. This practice not only supports sustainable housing in the wetland area but also ensures an adequate and consistent supply of clean water for various purposes.

Overall, rainwater harvesting has proven to be an effective and sustainable approach to maintain the balance of the wetland environment while meeting the water needs of the community. It enables the coexistence of residential development and the preservation of wetland functions, allowing the area to thrive and support various plant and animal life throughout the year.

Based on the result of the study above, the adjustment of stakeholders to the wetland environment in developing ideal wetland areas should involve a series of activities: firstly, stakeholders must adhere to existing regulations; secondly, stakeholders should understand the characteristics of wetlands; thirdly, stakeholders need to maintain environmental balance in wetland areas by implementing a system to provide empty spaces in urban built-up areas.

The Government of the Republic of Indonesia is committed to effectively managing wetlands through the issuance of Indonesia Government Regulation (GR) no. 3 year 2013 about Wetlands. Several key points outlined in the GR include: (1) The purpose of Wetland Damage Control Efforts is to prevent, address, and restore damages to both the wetland itself and its surrounding areas, to avoid causing harm to life, (2) The designation of wetlands must ensure that development activities within productive wetlands do not impact wetlands with protective functions. Thus, the overall balance and sustainability of wetland functions remain within the river basin, preserving the hydrological integrity of the wetland, (3) A wetland information system needs to be established and implemented to support wetland management, forming part of the water resource information network. This system must be regularly updated to meet the needs, open in nature, and accessible to everyone.

In the city of Palembang, all existing wetlands fall under the category of non-tidal swamp land, known as lebak wetlands. This means that these wetlands are not directly influenced by the waves and flow of seawater. Subagyo (2006) classified wetlands based on the duration and depth of inundation into three types: (1) Pematang Wetland, (2) Middle Wetland, and (3) Deep Wetland.

Several characteristics of wetlands must be recognized by stakeholders to differentiate between wetlands and rivers [15]. These specific features of wetlands include: 1) Wetlands have water with a pH ranging from acidic to neutral and appear brown to blackish in colour. 2) Wetlands are commonly found in inland areas as well as in coastal regions. 3) Coastal wetlands are influenced by the tides of the sea. 4) During high tide, the surface of the wetland will have higher water levels compared to low tide, where there may be little to no water. 5) Wetlands located near the coastline are often covered with mangrove trees, while those inland are characterized by palm or nipah trees.

Pematang wetlands are relatively more beneficial naturally compared to Middle Wetlands and Deep Wetlands. However, there is still a possibility of experiencing drought or water shortages during the dry season. Pematang wetlands are utilized by the community for settlements, home gardens, fruit orchards, and rice fields located behind villages, and they are part of the river embankment area and the hinterland wetland area. Floodwater in pematang wetlands usually lasts less than 3 months, or at least one month per year. The average floodwater height is less than 50 cm. Because the floodwater is always shallow, this part of the wetland is often referred to as "Shallow Wetlands."

Middle Wetlands are areas that never experience drought and are used for rice fields, crops, and vegetables on terraced fields located further away from the villages. The water depth is deeper, between 50 to 100 cm, lasting less than 3 months or between 3 to 6 months. It is still considered part of Middle Wetlands if the water depth is deeper, more than 100 cm, but the duration of flooding is relatively short, less than 3 months.

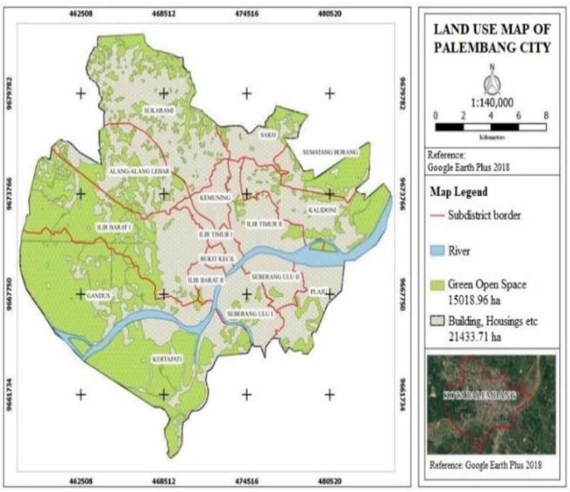

Figure 2. Land Use Map of Palembang City

Deep Wetlands (Lebak Dalam) are the wetland areas with the deepest water and are challenging to dry out, except during long dry seasons. They are also known as "lebak lebung," a place for preserving fish caught when floodwaters recede. The water level in Deep Wetlands generally exceeds 100 cm, lasting for 3 to 6 months or more than 6 months. They are still considered Deep Wetlands if the water depth is shallower, between 50-100 cm, but the duration of flooding is approximately more than six consecutive months in a year.

According to [16-17], human adaptation to the environment, including wetland environments, involves an understanding that humans are gifted with four powers: 1) Physical strength, which gives humans physical abilities (body organs and senses). 2) Life force, which enables humans to develop and adapt to the environment, as well as sustain their lives in facing challenges. 3) Intellectual power, which allows humans to possess knowledge and technology. 4) Heart power, which enables humans to have morals and appreciate beauty.

The focus of this paper is on the integrated efforts to maintain the wetland's function as a water balance controller. The adjustment approach involves creating empty spaces for rainwater harvesting in the residential environment within the wetland area. The following are the steps proposed by [18;8] for adjusting to the wetland environment by constructing rainwater harvesting houses.

4. Conclusion

Based on the study results and discussion, it can be concluded as follows: a) We collected rainwater using different structures like ponds, pools, tanks, and gardens. About 20% of the land (270 m2) was used for fish ponds, while the rest (274 m2) was for homes, a pool (35 m2), rainwater tank (10 m2), soak pit (5 m2), and the rest for gardens and sports. b) We made sure no rainwater was wasted in ponds or other storage. This helped adjust to the wetland environment. c) In wetlands, building needs to fit the environment to avoid problems. They made spaces for rainwater in houses and yards, but not in protected wetlands. d) Making spaces for rainwater is good. It helps stop floods and droughts. With climate change, it's important for communities and governments to use this system to manage water and protect nature. e) Leaders should make rules. Places in wetlands, like homes and shops, should have rainwater harvesting through the making of empty spaces. This keeps wetlands working and cities safe from floods. These rules help nature and cities thrive together.

Acknowledgement

This research was funded by the Doctoral Dissertation Research Program, Directorate of Research, Technology and Community Service Directorate General of Higher Education, Research and Technology with contract number 059/E.5/PG.02.00.PT/2023.

References

[1] Wells, J.A., Wilson, K. A., Abram N. K., Nunn, M., Gaveau, D. L. A., Runting, R. K., Tarniati N., Mengersen, K. L., Meijaart. E. 2016. *Rising floodwater: Mapping* impacts and perceptions of flooding in Indonesia Borneo. Environ. Res. Lett, 11, pp.064016.

[2] Kadri, T. and Kurniyaningrum, E. 2019. *Impact of land use on frequency of floods in upper Bekasi watershed, Indonesia*, *Int. J. Sci. Technol. Res.*, 8, pp. 3328–3334.

[3] Faradiba, F. 2022. *The impact of climate on flood disasters in Indonesia*. Int. J. Progress Sci. Technol, 31, pp.363-371.

[4] Nursito, C. D. 2015. Hidrologi dan Lingkungan: Studi kasus di Kota Palembang, Sumatera Selatan. Banjarmasin: Universitas Lambung Mangkurat.

[5] Coumou and Rahmstorf. 2012. A Decade of Weather Extreme. *Nature Climate Change*, 2(7), pp. 491–496.

[6] Cea, L. and Costabile. 2022. *Flood risk in urban areas: Modelling, management and adaptation to clime change. A review*. Hydrology, 9(3), pp.50.

[7] Rahim, S. E., Damiri, N and Zaman, Ch. 2018. *Pemanen air hujan dan prediksi aliran permukaan dari atap dan halam rumah sebagai alternatif penyediaan air bersih* in *Prosiding Seminar Nasional Hari Air Dunia 2018*.

[8] Rahim, S. E. 2013. Pengendalian erosi tanah dalam rangka pelestarian lingkungan hidup. PT. Bumi Aksara. Jakarta.

[9] Nurrohman, F., S.W.E., Paksi, S., Sangkawati & Sugiyanto. 2015. Perencanaan panen air hujan sebagai sumber air alternatif di Kampus Universitas Diponegoro. Jurnal Karya Teknil Sipil, 4 (4), pp.283-292.

[10] Yulistyorini, A. 2011. *Pemanenan air hujan sebagai alternatif pengelolaan sumberdaya air perkotaan. Teknologi dan Kejuruan*, 34(1),

pp. 105–114.

[11] Afriyanto, S.S.T.B and Suskiyatno, B. 2015. Metoda *Rain water harvesting" untuk kebutuhan air bersih dormitory Unika Soegijapranata sebagai solusi teknologi yang ekologis*. Prosiding SNST ke-6 Tahun 2015. Fakultas Teknik Universitas Wahid Hasyim Semarang.

[12] Siregar, S. M., Sakir, M. I., Helmizuryani, S. N., Aida, and Saleh, E. 2019. 'Pengelolaan Rawa Perkotaan (Kasus Banjir Di Kota Palembang)', in *Prosiding Seminar Nasional Hari Air Dunia 2019*.

[13] Tyas, M. W., Sutan A. T., Haji and Wirosoedarmo. R. 2014. *Analisis nomografi suhu, laju penguapan dan tekanan udara pada alat desalinisasi tenaga surya dengan pengaturan vakum*. Jurnal sumberdaya alam dan Lingkungan. Universitas Brawijaya, Malang. pp.55-61.

[14] Worm, Janette, Hattum, Tim van. 2006. *Rainwater harvesting for domestic use*. First edition. Agromisa Foundation and CTA, Wageningen.

[15] Subagyo, H. 2006. 'Klasifikasi Dan Penyebaran Hutan Rawa', *Karakteristik Dan Pengelolaan Lahan Rawa, Pertama*. Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian. Badan Penelitian dan Pengembangan Pertanian. Departemen Pertanian.

[16] Koentjaraningrat. 1987. *Kebudayaan, Mentalitas & Pembangunan*. PT Gramedia.

[17] Aryadi, M. 2011. Community Forests, the Phenomenon of Cultural Adaptation by Society. Published by the Publishing Center of Muhammadiyah University Malang.

[18] Rahim, S. E. 2007. Rumah dengan sistem panen hujan, *https://bebasbanjir2025.wordpress.com*.