ISSN 0258-2724

西南交通大学学报

JOURNAL OF SOUTHWEST JIAOTONG UNIVERSITY

2024年2月 第59卷 第1期
Vol. 59 No. 1 February 2024

EI Compendex
Scopus 收录
全国中文核心期刊
中国科技论文统计源期刊
中国科学引文数据库来源期刊

1
2024

Editorial Team

西 南 交 通 大 学 学 报

第 56 卷 第 6 期
2021 年 12 月

JOURNAL OF SOUTHWEST JIAOTONG UNIVERSITY

Vol. 56 No. 6
Dec. 2021

ISSN: 0258-2724 DOI：10.35741/issn.0258-2724.56.6.23

Research article

Earth Sciences

HYDROLOGY CHARACTERISTICS IN KRUKUT RIVER RIPARIAN BUFFER ZONE

克魯庫特河沿岸緩衝區的水文特徵

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Received: September 27, 2021 ▪ Review: October 28, 2021 ▪ Accepted: November 25, 2021 ▪ Published: December 24, 2021

Abstract

This research aims to investigate the characteristic of hydrology in the Krukut River. However, it studies an interesting floodplain like the riparian buffer zone (RBZ). RBZ is close adjacent to the river waters, generally accompanied by shrubs and the other crops along a river. It is useful for stabilizing the streams and minimizing the flood damages. The development of a region will impact the surrounding ecosystem that has been a developed human activity along the river, one of which is the Krukut River. The methodology consists of hydrological analysis for finding the characteristic of hydrology. The hydrology is analyzed using the water discharge data of Krukut River headwater. However, the maximum water discharge frequency is analyzed by using two models that are a) Log Pearson distribution and b) Gumbel distribution. The observations are made during the survey reveal that RBZs and floodplain areas are dominated by human habitation on both banks. The result of the analysis showed that human habitation accounts for 77.5% and 22.5% respectively, different types of vegetation such as shrubs account for 10.5%, shrubs – for 5%, and erosion – for 7%, so the environmental conditions of the river are directly disturbed due to excessive human activities. The result indicates that in order to stabilize the river banks, the riparian can be cropped by humans for a specific aim, reducing water loss by the evaporation and reducing the flood damage risk in low-lying areas that may be the location near to the water.

Keywords: Krukut River, Riparian Buffer Zone, Floodplain, Hydrologic Engineering Center River Analysis System, Quantum GIS

摘要 本研究旨在調查克魯庫特河的水文特徵。然而，它研究了一個有趣的洪氾區，如河岸緩衝區。河岸緩衝區緊鄰河水，一般沿河有灌木和其他作物。它有助於穩定河流並最大限度地減少洪水損失。一個地區的發展將影響沿河人類活動發展起來的周邊生態系統，克魯庫特河就是其中之一。該方法包括用於發現水文特徵的水文分析。水文分析使用克魯庫特河源頭的排水數據。但是，最大排水頻率是通過使用兩個模型來分析的：日誌皮爾遜分佈和甘貝爾 分佈。調查期間的觀察結果表明，河岸緩衝區和洪氾區地區以人類居住為主。分析結果表明，人類居住地分別佔 77.5%和 22.5%，不同類型的植被如灌木佔 10.5%，灌木佔 5%，侵蝕佔 7%，因此河流的環境條件因過度的人類活動而直接受到干擾。結果表明，為了穩定河岸，人類可以針對特定目的對河岸進行耕作，減少蒸發造成的水分流失，降低可能靠近水的低窪地區的洪水災害風險。

关键词: 克鲁库特河、河岸缓冲区、洪泛区、水文工程中心河流分析系统、量子地理信息系统

I. Introduction

Riparian buffer zones are between the terrestrial and aquatic systems, and there are complex and dynamic environments with some benefits and purposes. The hydro-ecological benefits of riparian zones include stabilizing the soil, protecting the water quality, preventing the pollutants and sediment delivery to streams, reducing erosion, and reducing the surface water flow rates [1, 2]. The riparian buffer zones are divided into two buffer zones consisting of the reserve zone and the management zone [3]. Human development, agriculture, and forestry operations are restricted in the reserve zone, and only ecologically acceptable forestry operations can be applied in the management zone [4]. The riparian buffer zones width is varied and based on the type of water bodies, beneficial uses, and terrain conditions [5]. Humans historically lived in harmony with watercourses. However, it disturbed the riparian buffer zones after land use was developed. Flooding impacts RBZ [6, 7]. In order to minimize adverse human impacts on the water quality, biodiversity, and stream stability, the communities are increasingly developing protected buffers around the riparian areas and along the streams in the river. Stream buffers benefit a variety of habitats and biodiversity, stream stability, water quality, and financial saving. RBZ can help by protecting stream stability against flood, stabilizing streambeds and streambanks, and maintaining the streamflow. Streamside vegetation also provides steadier rainwater infiltration, which "stabilizes runoff flows as water is stored in the soil profile, moves into groundwater supplies, or is taken up by plants and used in photosynthesis and evapotranspiration" and then stream buffers provide a zone that can accommodate floodwaters so that they do not interfere with or impact built structures [8]. Riparian buffers help stabilize streambanks and streambeds with roots of plants, especially trees, provide increased erosion resistance as fine roots bind with the soil. Root structures also help armor the river bank from erosion [8]. Riparian buffers also reduce stream channel erosion by reducing runoff and streambed scour caused by excessive flows. The buffers also reduce the effects of the drought by storing water, maintaining groundwater levels, and maintaining the stream base flow during low flow periods [9].

Several factors influence the buffer; the width of buffer and vegetation are most easily influenced. Buffer effectiveness is also strongly influenced by watershed land use will have a greater impact on surface runoff than others. For example, a high percentage of the impervious region, such as pavement or roofing, will result in a larger volume and higher velocity of surface runoff. Determining the width of the riparian buffer zones can be used DEM (Digital Elevation Models). It can define the delineated flood area and water surface area, sediment yield, water quality, and hydraulic networks. In previous studies, the riparian buffer zone starts from the edge of the water bodies [10]. The main objective of this study was to determine the width of RBZ around a sample Krukut River based on a hydro-ecological approach using GIS technology.

II. Materials And Methods

A. Study Area

Krukut is one of the rivers that flow through the central part of Jakarta. The main river length is ± 30 km. The river flows through 3 areas (as presented in Figure 1): Central Jakarta, South Jakarta, and Bogor City. The study was conducted on a selected reach of the Krukut River in the central zone, mainly in South Jakarta. The bounding geographical coordinates of the study area are $6^0$18'25.95"- $6^0$17'47.04" south latitudes and $106^0$48'4.32"-$106^0$48'56.13" east longitudes (Figure 1). The catchment area in the Krukut River is 84 km^2. The Krukut River has seasonality with a low enough discharge in the dry season and a high rainy season. However, the highest discharge happened in 2014 – 19.43 m^3/sec [10]. Based on the flooding in 2002-2018, the regions where are often flooding were Cipete urban Village, Petogogan, Mampang, Bangka, and Ciganjur [11].

B. Land Cover Typology in South of Jakarta

A typology of land cover was designed based on a literature review of mechanisms degrading or maintaining the stream ecological status [12] and based on the analysis of relationships between land cover and stream conditions [13, 14] make a result of six thematic classes such as "water surfaces areas," agricultural areas," "urban areas," "forested areas," "semi-natural herbaceous vegetation" (meadow and pasture land) and "natural bare soil." Water surfaces and natural bare soil categories were defined for delineating the river water bodies (stream bed and stream banks). The urban and agricultural areas are considered the two categories that cause the main alteration of stream ecological status. Besides that, urbanization leads to enhanced runoff, channel erosion, and reduced water quality. The typology of land cover in the South of Jakarta is bare natural soil, water surface areas, agricultural areas, and urban areas.

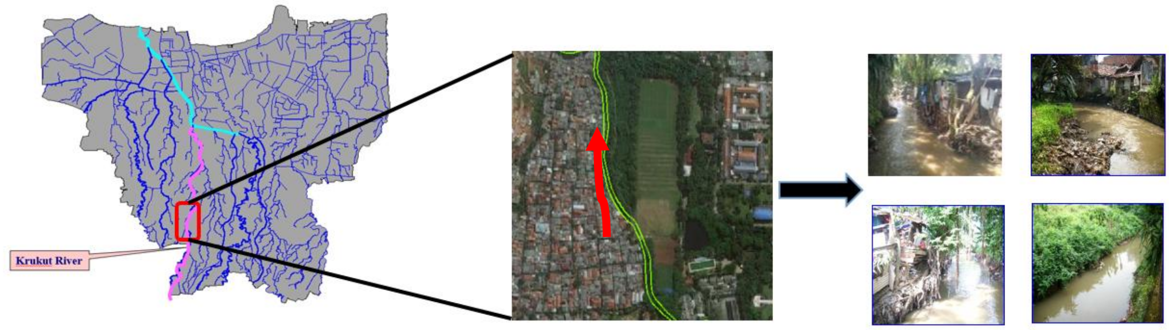

Figure 1. Location of the study area in the South of Jakarta

C. Data

The study requires high spatial resolution imagery data considering the spatial extent of riparian areas and the diversity of land cover types [15]. The available data on the whole Krukut River territory were collected: aerial photographs (5×5 km²) with 0.5 m spatial resolution and spectral information in the visible bands were collected for good detection of riparian land cover objects.

The hydrologic were conducted using water discharge data of headwater of Krukut River. The maximum water discharge frequency was analyzed using a) Log Pearson distribution and b) Gumbel distribution. The chi-square and Smirnov-Kolmogorov tests were employed to determine the suitable distribution type.

D. Model Approach

In this study, the Hydrologic Engineering Center River Analysis System (HEC-RAS) flood model approach was adopted. An overview of the model approach and a case study is using the low-resolution DEM. In HEC-RAS, 1D and 2D approaches are combined and allowed simulation of water flow in river reaches as well as river-bank overflow and flow at flood plains. In this research, only the 2D module was activated since the DEM mesh element size is smaller than the channel width. The water movement in the HEC-RAS approach is described by the finite difference approximation, which allows only the use of rectangular mesh. Any DEM as being used in the HEC-RAS approach has to be based on the raster, and the topographic representations of a vector DEM in flood modelling are not further discussed.

The data requirements for floodplain modelling can be categorized into data input for analysis, calibration, and verification. The analysis part mainly requires geometric information such as the cross-section area of channel and floodplain DEM, friction coefficients, boundary, and initial conditions. The calibration and verification stages require independent observed flow characteristics: inundation area, flow discharge, depth, and velocity.

Simulations performed in this study therefore serve for model comparison when DEM's of different resolutions are used. For the Krukut River as especially south of Jakarta, a DEM was created with 1M, where data acquisition was performed during the low flow season when river water depths are assumed negligible as compared to water depths during high flows. Data could thus be used without any modification for the elevation of the channel area as covered by water.

For representation as partially objects in Krukut River, roughness values of 0.025 for the bank river and 0.030 for channel in Krukut River, buildings are assumed to have the same surface roughness values as other features in the floodplain. The possible representations of buildings for flood modelling and the associated possible flow vectors are illustrated in Figure 2. In any simulation, surface roughness values of 0.025 for the floodplain and 0.013 for the channel are used. In hydraulic flood modelling, initial and mathematical boundary conditions must be defined. The initial conditions represent the hydraulic state of the system prior to the actual model simulation. It can be estimated by interpolation of the observations from available gauges.

Flood modelling also requires the specification of upstream and downstream boundary conditions. Here, an upstream condition is based on stage hydrograph, and in the downstream boundary IS based on normal depth. We set up the flood inundation model at the mesh, which implies that exposure and hazard must be assessed at the scale of individual elements at risk that are buildings or infrastructure. The flood model must, therefore, represent flows at this targeted spatial scale. The domain was discretized accordingly by an unstructured computational mesh at a very high spatial resolution, with mesh sizes of 1 m in the built-up areas and the river body and between 5 and 10 m in the urban areas. The element size is smaller than the critical length scale, and there is determined by building dimensions and building separation distances [16].

III. Results and Discussion

A. Status of Riparian Buffer Zone

During the investigation, it was found that the riparian buffer zone is dominated by the human habitation that contributes about 77.5% and 22.5% respectively, the different types of vegetation like shrubs cover about 10.5%, bushes about 5%, and erosion about 7% in the study area. The major classes of riparian buffer zone have been categorized through the remotely sensed data using the Quantum GIS software, and it was indicated that the RBZ of the selected reach of Krukut River was disturbed (Figure 2).

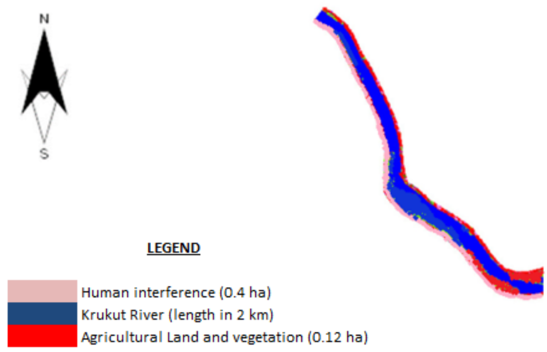

Figure 2. Status of riparian buffer zone in the study area

Floodplains are flat land adjacent to a stream or river that experiences occasional or periodic flooding. Floodplain areas were found in the study area, and it was observed that the flood plain areas were disturbed due to the human activities. On both banks of the floodplain, areas that had already been cultivated and functionally disappeared were recorded. The Krukut River had a width of 16 meters, and it is currently only 2 meters, so the current drainage capacity is only around 30 percent of the planned flood that makes the Krukut River as frequent flooding.

B. Hydrology Connectivity, Flood Risk, and Land Use

The area of land use on the Krukut watershed can be seen with the largest percentage filled by settlements, which is equal to 75%. The biggest type of land use on the combined watershed is residential areas (Figure 2). The CN (curve number) value for residential areas ranges 51-91. The CN value of the residential area accounts for runoff larger surface compared to the other land uses. It can be concluded that the biggest contributor to surface runoff in the watershed was observed as a residential area (Figure 3).

The shape, size, and land use of the watershed affect watershed runoff. The shape of the Krukut watershed is getting bigger downstream. It can slow down water travel time to downstream. The usage of the largest land in the Krukut watershed is residential areas by 75%. Surface watershed runoff will vary depending on rainfall falling into the watershed. Climate factor becomes initial determinants of differences in surface runoff that occur in certain regions. The soil type located in the watersheds determines the surface runoff because it determines how long the water is infiltrated. The percentage of watershed area is the last factor that influences the occurrence of surface runoff because certain forms of watershed with the area of the watershed large can slow down the discharge time to downstream. So that it can minimize the runoff surface that occurs.

The Krukut watershed produces the largest surface runoff of 35% of the watershed area in Jakarta. This situation can make the Krukut watershed that accounts for the largest surface runoff in Jakarta.

The results of Krukut watershed land use analysis that is based on the land use map as shown in the figure above shows that the changes in the forest land area and plantation area are very varied while the changes in the residential land area is continued to increase by about 21% in 1990 to 2000 namely from 9.086 km^2 to 12.948 km^2, then increasing again by 23% in 2000 to 2011, from 12.948 km^2 to 16.876 km^2, then increasing by 45%, in 2011 to 2017 from 16.876 km^2 to 25.085 km^2. As for the green open spaces, which include the rice fields, dryland agriculture, and shrubs for gardens, they are decreasing every year. The decrease is in the area of paddy fields, influenced by a large number of residential areas around the study area. The results show in a shift in the function of land use, from paddy fields to residential land.

Based on the changes in the land cover in the Krukut River basin, there are the changes in the flood discharge of the Krukut River. For a 2-year return period, it was 104.01 m^3/sec in 2000 and 108.25 m^3/sec in the observation year 2017.

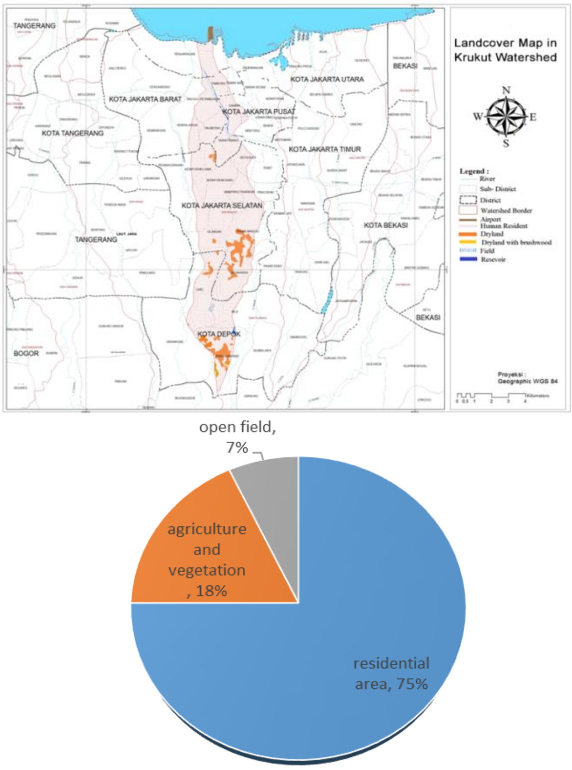

Figure 3. Krukut watershed land use map in 2017

Figure 4. Existing condition in Krukut River

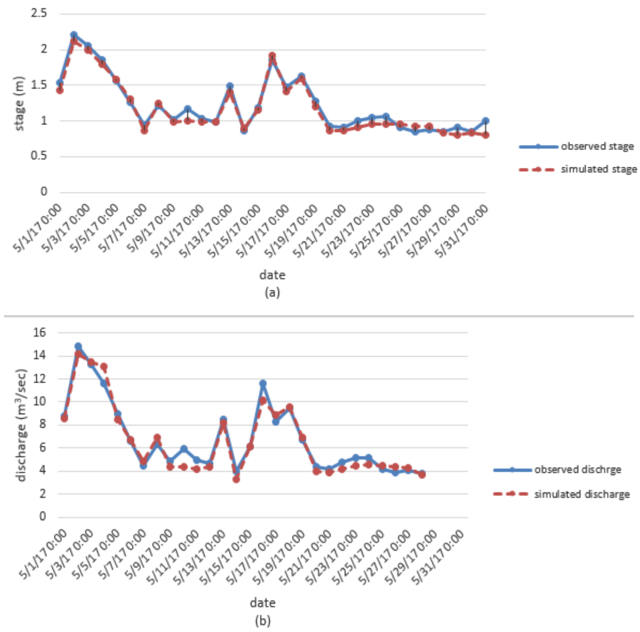

Figure 5. Calibration of stage/discharge for upstream and downstream gage station

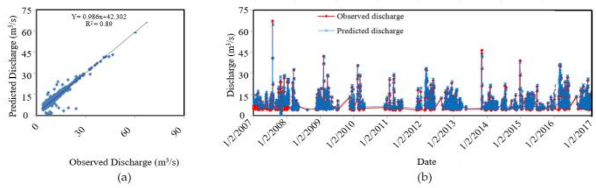

Figure 6. The plot of predicted vs. observed discharge: (a) validation of the rating curve; (b) for the period of 1 February 2007 to 1 February 2017

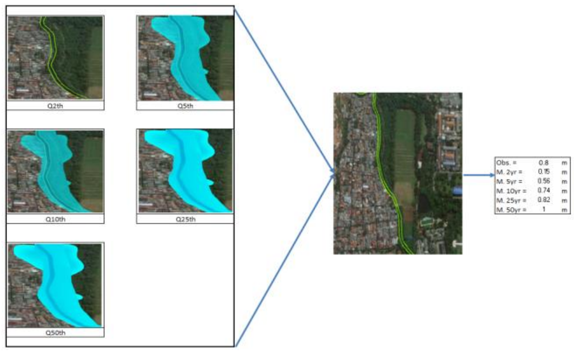

Figure 7. Comparison between observed and modeling inundation in South of Jakarta area: a) modeled, b) observed

There is a 2-year return period of about 104.01 m^3/sec in 2000 and 108.25 m^3/sec in 2017. A 5-year return period was 163.17 m^3/sec in 2000 and became 168.66 m^3/sec in the year of observation in 2017. The 10-year return period was 183.87 m^3/ sec in 2000 and became 188.81 m^3/sec in the year of 2017 observations. For the return period of 25 years, the existing flood discharge was 194.73 m^3/sec in 2000 and 198.87 m^3/sec in 2017. The return of 50 years of flood discharge on the Krukut River in 2000 was 200.64 m^3/sec and increased to 204.92 m^3/sec. In the return period of 100 years in 2000, this amounted to 204.61 m^3/sec and changed to 206.93 m3/sec in 2017.

The results of the flood discharge calculation showed that the flood discharge has increased from 2000 to 2017. It is happened due to the value of curve number (CN) that increased the quite large value from 2000 to 2017, so even though the intensity value decreased from 2000 to 2017 but the discharge resulting is increasing. The above shows that the value of CN affects the results of the flood discharge calculation. However, another variable that also influences the results of the flood discharge calculation is the intensity of rain.

From the graph above, it can be seen that the pattern of changes in flood discharge between the data measurement and it is based on the calculation results has the same pattern. Based on the land use, it shows that there is AN increase in discharge from 2000 to 2017. It is caused by several things: the condition of residential land area continues to increase while the area of forest or paddy fields has decreased so that the average flow coefficient is 0.679 in 2000 increased to 0.685 in 2017. In addition, the relatively high rainfall intensity based on the analysis of design rain from 2003 to 2017 affected the increase in discharge generated in 2017 (as presented in Figures 5, 6, and 7).

In order to find the correlation coefficient of land use and flood discharge, the multiple regression analysis is used so that the combined correlation coefficient value of 0.01562 can be obtained. For the linear trend, the relationship between land use and flood discharge is approached by the equation y = a + bx1 + cx2, where: y = discharge (m^3); x1 = residential land area; x2 = vegetation area. So, for the linear trend, the land use relationship with flood discharge is obtained by the equation: y = -13,069.32979 + 6.1989779 x1 + 6.28456 x2

In this research, the three possible causes are identified. Firstly, at the micro-scale or mesh, the topology between DEM and the topography river at the computational mesh in a high spatial resolution is characterized by a high number of mesh nodes. Thus, the flow depths of the mesh nodes have to be interpolated in some way to assign the flow depth to around the river. As the flow depth attribution method can significantly influence the outcomes of flood loss analyses, we recommend that the chosen method be explicitly described in future studies. Secondly, the mesh should be designed based on the detailed topographic characteristics. So that it fits with the flow depth attribution method. Thirdly, at larger mesh elements of flow direction delineation becomes more arbitrary specific when rectangular mesh structure is applied that is also specific to the HEC-RAS flood model approach. The overall conclusion of this study is that accurate simulation of topography has a significant effect on the flood simulation results.

IV. CONCLUSION

This study evaluates the applicability of detailed land cover data to riparian zones for improving how river types are described and how hydro morphological reference conditions of rivers are established. Rivers are dynamic systems created by processes and the mutual interaction of processes and forms. It makes the channel width is decreasing, and the average depth increase causes the condition of RBZs and floodplain areas to be alarming and need some sustainable conservation.

The result shows that human habitation contributes 77.5% and 22.5%, respectively. However, the different types of vegetation like shrubs covers contributes in amount of 10.5%, bushes in amount of 5%, and erosion in amount of 7%. It shows that the ecological conditions of the river are directly disturbed due to the excessive human activities.

The recommendations for restoration of riparian buffer zone in selected reach of Krukut River are:

1. Humans can plant the riparian for a specific purpose, such as stabilizing the river banks, reducing the water loss through evaporation, and reducing the risk of flood damage in low-lying areas that may be located close to the water.
2. The floodplains activity should be noted and monitored.

ACKNOWLEDGEMENTS

The authors would also like to thank Balai Besar Wilayah Sungai Ciliwung-Cisadane for providing all the necessary data for this study and encouragement to conduct such studies for the benefit of science and society.

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DROLOGY_CHARACTERISTICS_IN_KRUKUT_RIVER_RIPARIAN_BUFFER_ZONE.pdf

by karya Ilmiah 2 ftsp

Submission date: 27-Aug-2024 08:10AM (UTC+0700)
Submission ID: 2438758596
File name: DROLOGY_CHARACTERISTICS_IN_KRUKUT_RIVER_RIPARIAN_BUFFER_ZONE.pdf (911.34K)
Word count: 5079
Character count: 22680

西南交通大学学报

第 56 卷第 6 期
2021 年 12 月

JOURNAL OF SOUTHWEST JIAOTONG UNIVERSITY

Vol. 56 No. 6
Dec. 2021

ISSN: 0258-2724

DOI：10.35741/issn.0258-2724.56.6.23

Research article

Earth Sciences

HYDROLOGY CHARACTERISTICS IN KRUKUT RIVER RIPARIAN BUFFER ZONE

克鲁庫特河沿岸緩衝區的水文特徵

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Received: September 27, 2021 ▪ Review: October 28, 2021
▪ Accepted: November 25, 2021 ▪ Published: December 24, 2021

Abstract

This research aims to investigate the characteristic of hydrology in the Krukut River. However, it studies an interesting floodplain like the riparian buffer zone (RBZ). RBZ is close adjacent to the river waters, generally accompanied by shrubs and the other crops along a river. It is useful for stabilizing the streams and minimizing the flood damages. The development of a region will impact the surrounding ecosystem that has been a developed human activity along the river, one of which is the Krukut River. The methodology consists of hydrological analysis for finding the characteristic of hydrology. The hydrology is analyzed using the water discharge data of Krukut River headwater. However, the maximum water discharge frequency is analyzed by using two models that are a) Log Pearson distribution and b) Gumbel distribution. The observations are made during the survey reveal that RBZs and floodplain areas are dominated by human habitation on both banks. The result of the analysis showed that human habitation accounts for 77.5% and 22.5% respectively, different types of vegetation such as shrubs account for 10.5%, shrubs – for 5%, and erosion – for 7%, so the environmental conditions of the river are directly disturbed due to excessive human activities. The result indicates that in order to stabilize the river banks, the riparian can be cropped by humans for a specific aim, reducing water loss by the evaporation and reducing the flood damage risk in low-lying areas that may be the location near to the water.

Keywords: Krukut River, Riparian Buffer Zone, Floodplain, Hydrologic Engineering Center River Analysis System, Quantum GIS

摘要 本研究旨在調查克魯庫特河的水文特徵。然而，它研究了一個有趣的洪氾區，如河岸緩衝區。河岸緩衝區緊鄰河水，一般沿河有灌木和其他作物。它有助於穩定河流並最大限度地減少洪水損失。一個地區的發展將影響沿河人類活動發展起來的周邊生態系統，克魯庫特河就是其中之一。該方法包括用於發現水文特徵的水文分析。水文分析使用克魯庫特河源頭的排水數據。但是，最大排水頻率是通過使用兩個模型來分析的：日誌皮爾遜分佈和甘貝爾 分佈。調查期間的觀察結果表明，河岸緩衝區和洪氾區地區以人類居住為主。分析結果表明，人類居住地分別佔77.5%和 22.5%，不同類型的植被如灌木佔 10.5%，灌木佔 5%，侵蝕佔 7%，因此河流的環境條件因過度的人類活動而直接受到干擾。結果表明，為了穩定河岸，人類可以針對特定目的對河岸進行耕作，減少蒸發造成的水分流失，降低可能靠近水的低窪地區的洪水災害風險。

关键词: 克鲁库特河、河岸缓冲区、洪泛区、水文工程中心河流分析系统、量子地理信息系统

I. Introduction

Riparian buffer zones are between the terrestrial and aquatic systems, and there are complex and dynamic environments with some benefits and purposes. The hydro-ecological benefits of riparian zones include stabilizing the soil, protecting the water quality, preventing the pollutants and sediment delivery to streams, reducing erosion, and reducing the surface water flow rates [1, 2]. The riparian buffer zones are divided into two buffer zones consisting of the reserve zone and the management zone [3]. Human development, agriculture, and forestry operations are restricted in the reserve zone, and only ecologically acceptable forestry operations can be applied in the management zone [4]. The riparian buffer zones width is varied and based on the type of water bodies, beneficial uses, and terrain conditions [5]. Humans historically lived in harmony with watercourses. However, it disturbed the riparian buffer zones after land use was developed. Flooding impacts RBZ [6, 7]. In order to minimize adverse human impacts on the water quality, biodiversity, and stream stability, the communities are increasingly developing protected buffers around the riparian areas and along the streams in the river. Stream buffers benefit a variety of habitats and biodiversity, stream stability, water quality, and financial saving. RBZ can help by protecting stream stability against flood, stabilizing streambeds and streambanks, and maintaining the streamflow. Streamside vegetation also provides steadier rainwater infiltration, which "stabilizes runoff flows as water is stored in the soil profile, moves into groundwater supplies, or is taken up by plants and used in photosynthesis and evapotranspiration" and then stream buffers provide a zone that can accommodate floodwaters so that they do not interfere with or impact built structures [8]. Riparian buffers help stabilize streambanks and streambeds with roots of plants, especially trees, provide increased erosion resistance as fine roots bind with the soil. Root structures also help armor the river bank from erosion [8]. Riparian buffers also reduce stream channel erosion by reducing runoff and streambed scour caused by excessive flows. The buffers also reduce the effects of the drought by storing water, maintaining groundwater levels, and maintaining the stream base flow during low flow periods [9].

Several factors influence the buffer; the width of buffer and vegetation are most easily influenced. Buffer effectiveness is also strongly influenced by watershed land use will have a greater impact on surface runoff than others. For example, a high percentage of the impervious region, such as pavement or roofing, will result in a larger volume and higher velocity of surface runoff. Determining the width of the riparian buffer zones can be used DEM (Digital Elevation Models). It can define the delineated flood area and water surface area, sediment yield, water quality, and hydraulic networks. In previous studies, the riparian buffer zone starts from the edge of the water bodies [10]. The main objective of this study was to determine the width of RBZ around a sample Krukut River based on a hydro-ecological approach using GIS technology.

II. Materials And Methods

A. Study Area

Krukut is one of the rivers that flow through the central part of Jakarta. The main river length is ± 30 km. The river flows through 3 areas (as presented in Figure 1): Central Jakarta, South Jakarta, and Bogor City. The study was conducted on a selected reach of the Krukut River in the central zone, mainly in South Jakarta. The bounding geographical coordinates of the study area are $6^0$18'25.95"- $6^0$17'47.04" south latitudes and $106^0$48'4.32"-$106^0$48'56.13" east longitudes (Figure 1). The catchment area in the Krukut River is 84 km^2. The Krukut River has seasonality with a low enough discharge in the dry season and a high rainy season. However, the highest discharge happened in 2014 – 19.43 m^3/sec [10]. Based on the flooding in 2002-2018, the regions where are often flooding were Cipete urban Village, Petogogan, Mampang, Bangka, and Ciganjur [11].

B. Land Cover Typology in South of Jakarta

A typology of land cover was designed based on a literature review of mechanisms degrading or maintaining the stream ecological status [12] and based on the analysis of relationships between land cover and stream conditions [13, 14] make a result of six thematic classes such as "water surfaces areas," agricultural areas," "urban areas," "forested areas," "semi-natural herbaceous vegetation" (meadow and pasture land) and "natural bare soil." Water surfaces and natural bare soil categories were defined for delineating the river water bodies (stream bed and stream banks). The urban and agricultural areas are considered the two categories that cause the main alteration of stream ecological status. Besides that, urbanization leads to enhanced runoff, channel erosion, and reduced water quality. The typology of land cover in the South of Jakarta is bare natural soil, water surface areas, agricultural areas, and urban areas.

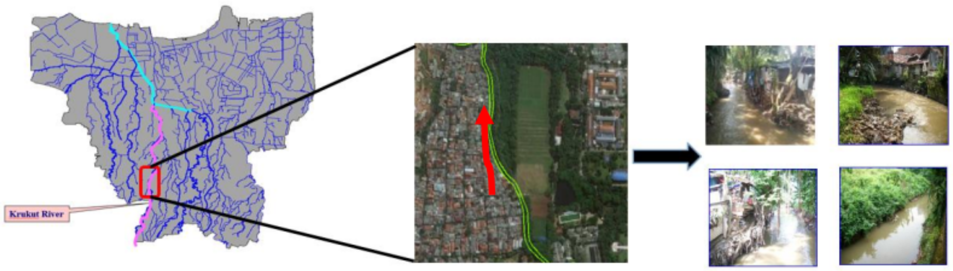

Figure 1. Location of the study area in the South of Jakarta

C. Data

The study requires high spatial resolution imagery data considering the spatial extent of riparian areas and the diversity of land cover types [15]. The available data on the whole Krukut River territory were collected: aerial photographs (5×5 km^2) with 0.5 m spatial resolution and spectral information in the visible bands were collected for good detection of riparian land cover objects.

The hydrologic were conducted using water discharge data of headwater of Krukut River. The maximum water discharge frequency was analyzed using a) Log Pearson distribution and b) Gumbel distribution. The chi-square and Smirnov-Kolmogorov tests were employed to determine the suitable distribution type.

D. Model Approach

In this study, the Hydrologic Engineering Center River Analysis System (HEC-RAS) flood model approach was adopted. An overview of the model approach and a case study is using the low-resolution DEM. In HEC-RAS, 1D and 2D approaches are combined and allowed simulation of water flow in river reaches as well as river-bank overflow and flow at flood plains. In this research, only the 2D module was activated since the DEM mesh element size is smaller than the channel width. The water movement in the HEC-RAS approach is described by the finite difference approximation, which allows only the use of rectangular mesh. Any DEM as being used in the HEC-RAS approach has to be based on the raster, and the topographic representations of a vector DEM in flood modelling are not further discussed.

The data requirements for floodplain modelling can be categorized into data input for analysis, calibration, and verification. The analysis part mainly requires geometric information such as the cross-section area of channel and floodplain DEM, friction coefficients, boundary, and initial conditions. The calibration and verification stages require independent observed flow characteristics: inundation area, flow discharge, depth, and velocity.

Simulations performed in this study therefore serve for model comparison when DEM's of different resolutions are used. For the Krukut River as especially south of Jakarta, a DEM was created with 1M, where data acquisition was performed during the low flow season when river water depths are assumed negligible as compared to water depths during high flows. Data could thus be used without any modification for the elevation of the channel area as covered by water.

For representation as partially objects in Krukut River, roughness values of 0.025 for the bank river and 0.030 for channel in Krukut River, buildings are assumed to have the same surface roughness values as other features in the floodplain. The possible representations of buildings for flood modelling and the associated possible flow vectors are illustrated in Figure 2. In any simulation, surface roughness values of 0.025 for the floodplain and 0.013 for the channel are used. In hydraulic flood modelling, initial and mathematical boundary conditions must be defined. The initial conditions represent the hydraulic state of the system prior to the actual model simulation. It can be estimated by interpolation of the observations from available gauges.

Flood modelling also requires the specification of upstream and downstream boundary conditions. Here, an upstream condition is based on stage hydrograph, and in the downstream boundary IS based on normal depth. We set up the flood inundation model at the mesh, which implies that exposure and hazard must be assessed at the scale of individual elements at risk that are buildings or infrastructure. The flood model must, therefore, represent flows at this targeted spatial scale. The domain was discretized accordingly by an unstructured computational mesh at a very high spatial resolution, with mesh sizes of 1 m in the built-up areas and the river body and between 5 and 10 m in the urban areas. The element size is smaller than the critical length scale, and there is determined by building dimensions and building separation distances [16].

III. Results and Discussion

A. Status of Riparian Buffer Zone

During the investigation, it was found that the riparian buffer zone is dominated by the human habitation that contributes about 77.5% and 22.5% respectively, the different types of vegetation like shrubs cover about 10.5%, bushes about 5%, and erosion about 7% in the study area. The major classes of riparian buffer zone have been categorized through the remotely sensed data using the Quantum GIS software, and it was indicated that the RBZ of the selected reach of Krukut River was disturbed (Figure 2).

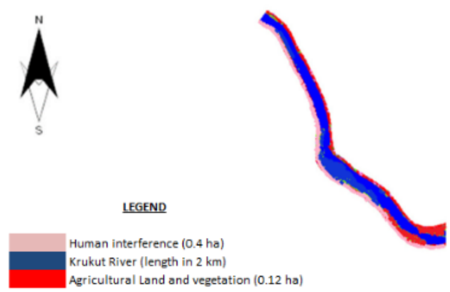

Figure 2. Status of riparian buffer zone in the study area

Floodplains are flat land adjacent to a stream or river that experiences occasional or periodic flooding. Floodplain areas were found in the study area, and it was observed that the flood plain areas were disturbed due to the human activities. On both banks of the floodplain, areas that had already been cultivated and functionally disappeared were recorded. The Krukut River had a width of 16 meters, and it is currently only 2 meters, so the current drainage capacity is only around 30 percent of the planned flood that makes the Krukut River as frequent flooding.

B. Hydrology Connectivity, Flood Risk, and Land Use

The area of land use on the Krukut watershed can be seen with the largest percentage filled by settlements, which is equal to 75%. The biggest type of land use on the combined watershed is residential areas (Figure 2). The CN (curve number) value for residential areas ranges 51-91. The CN value of the residential area accounts for runoff larger surface compared to the other land uses. It can be concluded that the biggest contributor to surface runoff in the watershed was observed as a residential area (Figure 3).

The shape, size, and land use of the watershed affect watershed runoff. The shape of the Krukut watershed is getting bigger downstream. It can slow down water travel time to downstream. The usage of the largest land in the Krukut watershed is residential areas by 75%. Surface watershed runoff will vary depending on rainfall falling into the watershed. Climate factor becomes initial determinants of differences in surface runoff that occur in certain regions. The soil type located in the watersheds determines the surface runoff because it determines how long the water is infiltrated. The percentage of watershed area is the last factor that influences the occurrence of surface runoff because certain forms of watershed with the area of the watershed large can slow down the discharge time to downstream. So that it can minimize the runoff surface that occurs.

The Krukut watershed produces the largest surface runoff of 35% of the watershed area in Jakarta. This situation can make the Krukut watershed that accounts for the largest surface runoff in Jakarta.

The results of Krukut watershed land use analysis that is based on the land use map as shown in the figure above shows that the changes in the forest land area and plantation area are very varied while the changes in the residential land area is continued to increase by about 21% in 1990 to 2000 namely from 9.086 km^2 to 12.948 km^2, then increasing again by 23% in 2000 to 2011, from 12.948 km^2 to 16.876 km^2, then increasing by 45%, in 2011 to 2017 from 16.876 km^2 to 25.085 km^2. As for the green open spaces, which include the rice fields, dryland agriculture, and shrubs for gardens, they are decreasing every year. The decrease is in the area of paddy fields, influenced by a large number of residential areas around the study area. The results show in a shift in the function of land use, from paddy fields to residential land.

Based on the changes in the land cover in the Krukut River basin, there are the changes in the flood discharge of the Krukut River. For a 2-year return period, it was 104.01 m^3/sec in 2000 and 108.25 m^3/sec in the observation year 2017.

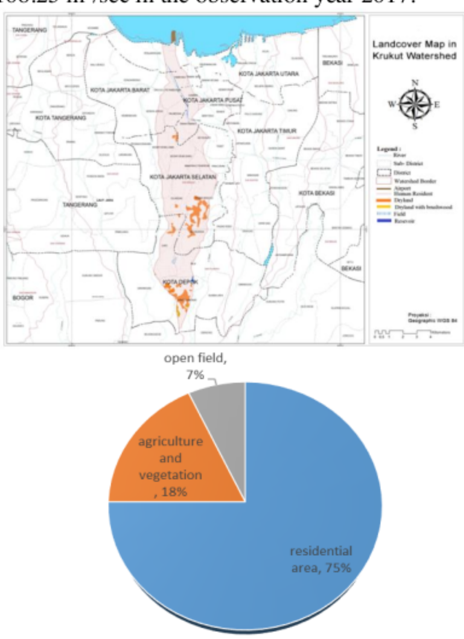

Figure 3. Krukut watershed land use map in 2017

Figure 4. Existing condition in Krukut River

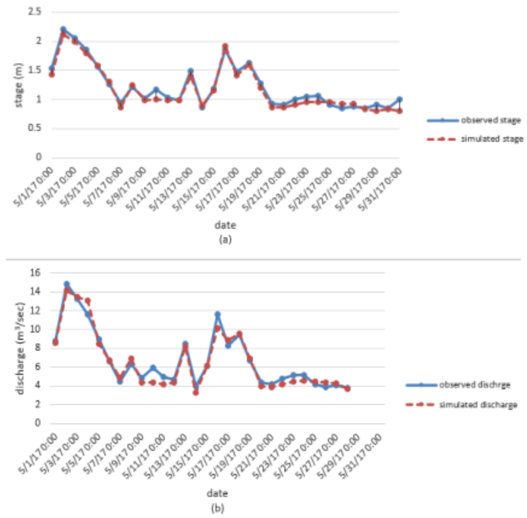

Figure 5. Calibration of stage/discharge for upstream and downstream gage station

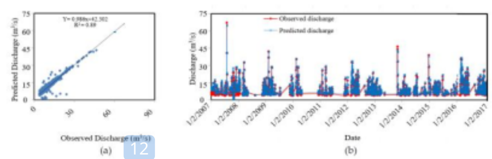

Figure 6. The plot of predicted vs. observed discharge: (a) validation of the rating curve; (b) for the period of 1 February 2007 to 1 February 2017

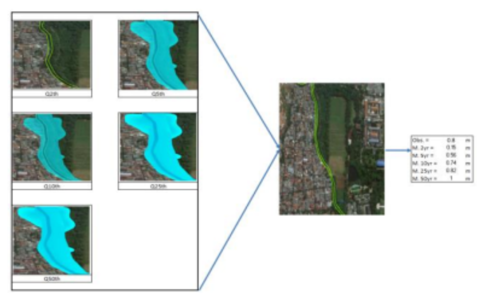

Figure 7. Comparison between observed and modeling inundation in South of Jakarta area: a) modeled, b) observed

There is a 2-year return period of about 104.01 m^3/sec in 2000 and 108.25 m^3/sec in 2017. A 5-year return period was 163.17 m^3/sec in 2000 and became 168.66 m^3/sec in the year of observation in 2017. The 10-year return period was 183.87 m^3/ sec in 2000 and became 188.81 m^3/sec in the year of 2017 observations. For the return period of 25 years, the existing flood discharge was 194.73 m^3/sec in 2000 and 198.87 m^3/sec in 2017. The return of 50 years of flood discharge on the Krukut River in 2000 was 200.64 m^3/sec and increased to 204.92 m^3/sec. In the return period of 100 years in 2000, this amounted to 204.61 m^3/sec and changed to 206.93 m3/sec in 2017.

The results of the flood discharge calculation showed that the flood discharge has increased from 2000 to 2017. It is happened due to the value of curve number (CN) that increased the quite large value from 2000 to 2017, so even though the intensity value decreased from 2000 to 2017 but the discharge resulting is increasing. The above shows that the value of CN affects the results of the flood discharge calculation. However, another variable that also influences the results of the flood discharge calculation is the intensity of rain.

From the graph above, it can be seen that the pattern of changes in flood discharge between the data measurement and it is based on the calculation results has the same pattern. Based on the land use, it shows that there is AN increase in discharge from 2000 to 2017. It is caused by several things: the condition of residential land area continues to increase while the area of forest or paddy fields has decreased so that the average flow coefficient is 0.679 in 2000 increased to 0.685 in 2017. In addition, the relatively high rainfall intensity based on the analysis of design rain from 2003 to 2017 affected the increase in discharge generated in 2017 (as presented in Figures 5, 6, and 7).

In order to find the correlation coefficient of land use and flood discharge, the multiple regression analysis is used so that the combined correlation coefficient value of 0.01562 can be obtained. For the linear trend, the relationship between land use and flood discharge is approached by the equation y = a + bx1 + cx2, where: y = discharge (m^3); x1 = residential land area; x2 = vegetation area. So, for the linear trend, the land use relationship with flood discharge is obtained by the equation: y = -13,069.32979 + 6.1989779 x1 + 6.28456 x2

In this research, the three possible causes are identified. Firstly, at the micro-scale or mesh, the topology between DEM and the topography river at the computational mesh in a high spatial resolution is characterized by a high number of mesh nodes. Thus, the flow depths of the mesh nodes have to be interpolated in some way to assign the flow depth to around the river. As the flow depth attribution method can significantly influence the outcomes of flood loss analyses, we recommend that the chosen method be explicitly described in future studies. Secondly, the mesh should be designed based on the detailed topographic characteristics. So that it fits with the flow depth attribution method. Thirdly, at larger mesh elements of flow direction delineation becomes more arbitrary specific when rectangular mesh structure is applied that is also specific to the HEC-RAS flood model approach. The overall conclusion of this study is that accurate simulation of topography has a significant effect on the flood simulation results.

IV. Conclusion

This study evaluates the applicability of detailed land cover data to riparian zones for improving how river types are described and how hydro morphological reference conditions of rivers are established. Rivers are dynamic systems created by processes and the mutual interaction of processes and forms. It makes the channel width is decreasing, and the average depth increase causes the condition of RBZs and floodplain areas to be alarming and need some sustainable conservation.

The result shows that human habitation contributes 77.5% and 22.5%, respectively. However, the different types of vegetation like shrubs covers contributes in amount of 10.5%, bushes in amount of 5%, and erosion in amount of 7%. It shows that the ecological conditions of the river are directly disturbed due to the excessive human activities.

The recommendations for restoration of riparian buffer zone in selected reach of Krukut River are:

1. Humans can plant the riparian for a specific purpose, such as stabilizing the river banks, reducing the water loss through evaporation, and reducing the risk of flood damage in low-lying areas that may be located close to the water.
2. The floodplains activity should be noted and monitored.

Acknowledgements

The authors would also like to thank Balai Besar Wilayah Sungai Ciliwung-Cisadane for providing all the necessary data for this study and encouragement to conduct such studies for the benefit of science and society.

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