The sangkarak river watersheds morphometric changes of Maros-Pangkajene Regency

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Abstract. Watersheds morphometric changes occur due to several factors, natural and or anthropogenic activities. The Sangkarak River Watersheds is one of the watersheds in Maros and Pangkajene Regencies with an area of 352.297 Ha, starting in Bantimurung area to the Makassar Strait. Since specific temporal data on the morphometric this watershed is not available and become obstacles for the fisheries management, this study aims to determine the dynamics of the watershed morphometric of Sangkarak river using remote sensing technology and Geographic Information System. The application used in this research is the DSAS (Digital Shoreline Analysis System) tool, which is an ArcGIS tool designed by USGS and ESRI to monitor shoreline movements. The data used in this research is the Landsat image data for 2002, 2008, 2013 and 2018. The results of the analysis of image data from 2002 to 2018 showed that there was a trend of river’s covering area decline up to 12.74 hectares, and presumably due to uncontrolled land uses.

1. Introduction

Sangkarak River Watersheds is one of the waterheds found in Maros-Pangkajene Kepulauan (Pangkep) Regencies, covering area up to 352.297 hectares. The source of Sangkarak River is in Bantimurung, Maros Regency and flow to Makassar Strait through Pangkep regency [1]. This river watersheds, is located in Rammang-Rammang Karst, a part of Maros-Pangkep Karst. Maros-Pangkep Karst, the second largest karst in the world after the one in South-Eastern China area, in part is included in Bantimurung-Bulusaraung National Park in South Sulawesi. Maros-Pangkep Karst is also known as habitat for many endemic species in Wallace region.

Rivers has an important role in the distributing water and nutrients, in water cycling and channeling surface water. In many rivers banks, cities are found since river provide water supplies and transportation. Rivers also provide agricultural lands and as for fisheries, rivers provide habitat and food for many aquatic organisms and source of livelihood. However, according to [2] land use changes of river watershed could cause the increase the amount of sediment deposited in river mouth hence changing the growth and form (river meander) and the speed of river flows. Morphometric changes of river watershed are caused by both natural process and anthropogenic activities such as deforestation, land mining, land uses, high precipitation and so forth [3]. The environmental and water quality changes could impact the aquatic live and its surrounding. In terms of fisheries, Muhtadi et al. (2017) [4] mentioned that changes in the river water quality will affect the fish composition structure of the river. Moreover, Gordon et al (1992) [5] noted that river current, habitat availability and water
temperature will affect functional structure of fish communities, while river substrate structure and width changes will affect taxonomy structure of fish communities.

In accordance with increasing anthropogenic activities within Sangkarak River Watershed for more than two decades and their impact, directly or indirectly might change the morphometric of Sangkarak River, hence affecting the aquatic organisms in it. Therefore, this study aims at analyzing the morphometric changes of the Sangkarak River Watershed using Digital Shoreline Analysis System (DSAS) to provide reference for fisheries management of the area.

2. Research Method

2.1 Site and time
Geographical position of Sangkarak River is on 119° 31’ - 119° 36’ BT dan 4° 53’ - 4° 57’ LS as shown at Figure 1. Field survey and data collection was taken during May to June 2019.

![Figure 1. Research Site](image)

2.2 Data Collection
Landsat Image acquired on year 2002, 2008, 2013 and 2018 were used to map the river morphometric and land use changes, as well as Indonesian Map (Peta Rupa Bumi Indonesia, RBI). Ground truthing, using Global Positioning System (GPS), for validation was done on the sampling point based on Landsat image interpretation. Open interview to the settlers around the river banks was done to support the land uses changes of the watershed history.

2.3 Data Analysis
a. Analysis on morphometric changes of five different years satellite images was done using Digital Shoreline Analysis System (DSAS) of ArcGIS 10.5
b. Land use changes mapping of year 2002 and 2018 using ArcGIS 10.5 was interpreted, covering areas 500 meters to the right and the left of the river
c. Normalized Difference Water Index (NDWI) Analysis, was done to separate water, soil and vegetation wetness, using Algorithm [6] as :

\[
NDWI = \frac{\text{Green-NIR}}{\text{Green+NIR}}
\]

Note:
Green = Green Band of satellite image
NIR = Near Infra-Red Band of satellite image
d. DSAS Analysis: using NSM (Net Shoreline Movement) and EPR (End Point Rate) parameters. In this study, NSM is considered as river line changes. The NSM value was calculated from the distance of old river line to the newest river line in meter. The EPR value was calculated from
NSM value divided by time of old river line to the newest river line, also in meter. The simple calculation of NSM and EPR [7] is as follows:

\[
\begin{align*}
\text{NSM} & = X^1 - X^0 \\
\text{EPR} & = \frac{\text{NSM}}{(t^1 - t^0)}
\end{align*}
\]

**Note:**
- \( \text{NSM} \) = Net River line Movement
- \( X^0 \) = Baseline distance to the old river line
- \( X^1 \) = Baseline distance to the newest river line
- \( \text{EPR} \) = Yearly river line changes
- \( t^0 \) = time of the old river line
- \( t^1 \) = time of the newest river line

The NSM and EPR values were calculated from river line, river baseline and transect. The river line was measured from data of those five different years, having geometric value and coordinate system. As for the river baseline, is the baseline designated as the first point of transect in measuring the river line changes. The transect, also has geometric and coordinate system is put with distance 50 meters between transects and the length of 100 meters and 250 meters, depending on and adapting to the river line form and distance between the baseline and the farthest river line.

c. Analysis of land cover

The analysis was done using unsupervised method and the land cover classification was done twice. The first classification was done using composite band red, green and blue (band 321 on Landsat 7 and band 432 on Landsat 8). The second classification was done using composite band Near Infrared (NIR), SWIR-1, and Red (band 453 on Landsat 7 and band 564 on Landsat 8). This second classification was aiming to identified mangrove distribution [8]. As for land cover accuracy was done through overall accuracy test that is by counting the number of non-error samples divided by the total samples. The formula for the overall accuracy is [9]:

\[
N = \frac{X_n}{X_0}
\]

**Note:**
- \( N \) = overall accuracy
- \( X_n \) = Number of non-error data/samples
- \( X_0 \) = Total number of samples used

3. Result

3.1 River Morphometric Changes

The result showed that from 408 transects, the Sangkarak River has the highest erosion, 44.12% on its right side, while the highest sedimentation, 55.88% was found on its left side. The Sangkarak’s river line changes on the right side of the river are shown at Figure 2.
The highest sedimentation was found in Kecamatan Bontoa during the periods of year 2002-2008, amounted to 30.86 meters. On the other hand, the highest erosion on its right side was found in Kecamatan Pangkajene during year 2013-2018, up to 191.53 meters. The average yearly change on this location for 18 years is 13.28 meter.

The result on the river line changes on the left side of Sangkarak River showed that 66.75% sedimentation and 33.25% erosion has occurred as presented at Figure 3.

The highest erosion was found in Kecamatan Bontoa during the periods of year 2002-2008, amounted to 31.12 meters, with the yearly average (of 18 years) of 0.66 meter. On the other hand, the highest sedimentation on this location was found during year 2013-2018 up to 43.79 meters, with yearly average, during 18 years, of 3.32 meters. Visualization of the Sangkarak River’s line changes for the last 18 years is shown in Figure 4.
3.2 Land cover changes

Landsat image of 2002 and 2018 classified the land cover, within the Sangkarak River covering areas of 500 meters to its each sides, into six classes: 1) open land (lahan terbuka, LT), 2) mangrove vegetation (vegetasi mangrove, VM), 3) non-mangrove vegetation (vegetasi non-mangrove, VNM), 4) settlement (pemukiman, Pm), 5) river (sungai, Sg) and 6) fish ponds (tambak, Tb). During year 2002, vegetation cover, especially mangrove, was distributed nearly evenly from the upper portion of this river to its mouth. However, in 2018 the vegetation distributions become less. Unlike the vegetation cover, during 2002, fish ponds were less and increasing more in 2018. The land use change is presented on Figure 5.
Within 16 years, land cover of the open land, mangrove, non-mangrove vegetation and river classes were decreasing, while the other two classes, i.e. fish ponds and settlement were increasing. The highest area loss was for mangrove with 270.59 hectares or 37.20%; while the highest land cover increased was for fish ponds, up to 347.70 hectares or 47.80%. The conversion of land cover uses 2002 to 2018 is elaborated in matrix shown in Table 1.
Table 1. Matrix of Land Cover Conversion from 2002 to 2018

| Land cover 2018 (Ha) | Land cover 2002 (Ha) |
|---------------------|----------------------|
| LT                  | 154,80               | 193,96               |
| VM                  | 4,35                 | 551,10               |
| NM                  | 6,88                 | 85,95                |
| Pm                  | 13,59                | 12,59                |
| Sg                  | 0,09                 | 322,99               |
| Tb                  | 14,24                | 887,71               |

Based on the above table, the highest conversion was of mangrove into fish ponds amounted to 353.79 hectares.

3.3 Accuracy test
There were 92 sampling points from the total of 803 as results of transect numbers done by DSAS analysis. The value of overall accuracy test was 95%, therefore the map is feasible for further uses, as Anderson et al., (1976) [10] mentioned that the acceptability of the accuracy value in land cover mapping is 85% or 0.85.

4. Discussion

4.1 River morphometric changes
Although the percentage of sedimentation on the Sangkarak river banks was higher than erosion, but sedimentation occurred because there is erosion or there is soil load carried by the river and deposited in the river basin [11]. The land cover data of Sangkarak River pointed out there was a narrowing area of 12.74 hectares due to the present of fish ponds and addition of vegetation along its banks. According to Strand and Pemberton (1982), one of the reason for erosion is land use degradation or damage, which in turn decreasing soil infiltration hence increasing the surface flow and causing erosion and at the end sedimentation.

The highest erosion of Sangkarak River right hand side significantly found at Kecamatan Pangkajene, Pangkep Regency, with yearly average of 13.28 meters and the peak in the period of 2013-2018 due to flash flooding in 2013 [13]. On the other hand, the highest sedimentation was found on Sangkarak River left side at Kecamatan Bontoa within period of 2013 to 2018, amounted to 43.79 meters. Aside from the erosion from the river upper portion, image classification showed there is addition of 4.90 hectares mangrove in that area. Interviews to the settlers confirmed that there was mangrove rehabilitation activity, initiated by the fish ponds owners, to protect their fish ponds. According to Hogarth (2007) [14], mangrove ecosystem could slowing the river flow hence increasing the sedimentation brought by the river current.

4.2 Impacts of land cover changes to river morphometric
Landsat image interpretation year 2002 to 2008 discovered there was conversion of mangrove into fish ponds up to 353.79 hectares. This fact was the reason why sedimentation occurred in this river. Suwoyo et al., (2014) [15] research relate that 35.97% of fish ponds wastes are causing sedimentation to waters body.

Mangrove rehabilitation along the river banks done by fish farmers as well as people living on the river banks as “breakwater” and or for “extending fish ponds area” also has added to more vegetation cover of the Sangkarak River hence impacting the river morphometric.
In turn the sedimentation in this river will affect the water quality and aquatic organisms living in it. Sedimentation causes turbidity and silting of a river and river waters and environmental changes will impacted the composition of fish communities of the river [4].

Aside from those mentioned, cement industry is also present and considered located in Sangkarak River Watershed, that may also has impact on the quality of this river. According to Zuchrufa, (2017) [16], Karst is composed of limestone and has a role in water infiltration and water source. Any disturbance to Karst area (Maros-Pangkep Karst) will affecting the availability of water during dry season and on the other hand become floods potential during wet season [17].

5. Conclusions

1. Sedimentation was the major cause for Sangkarak River morphometric changes, starting 2002 up to 2018. The location of highest sedimentation, 43.79 meters, was found on right side of this river at Kecamatan Pangkajene, Pangkep Regency (119° 34' 6,49" BT dan 4° 55' 34,62" LS); while the highest erosion area (191.53 meters) was on the left side at Kecamatan Bontoa, Maros Regency (119° 32' 59,38" BT dan 4° 53' 21,59" LS).

2. Sedimentation in this river resulted in the narrowing of the river body up to 12.74 hectares or 1.75% within 16 years.

Recommendations

1. The need for further study on community structure of aquatic organisms, particularly on endemic species, due to fact that sedimentation might affect the water and habitat quality of Sangkarak River.

2. River rehabilitation assessment study, especially on the area of heavy sedimentation and erosion.

3. Bathymetry data of this river is still need for better understanding of the changes and its impacts.

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References

[1] KLHK 2019 Webgis Kementrian Lingkungan Hidup dan Kehutanan Kementrian Lingkungan Hidup dan Kehutanan.

[2] Sasmito B and Amarrohman F J 2016 Pemantauan Perubahan Garis Pantai Menggunakan Aplikasi Digital Shoreline Anaysis System (Dsas) Studi Kasus: Pesisir Kabupaten Demak J. Geod. Undip 5 78–89

[3] Kurniawan R, Sutikno S and Sujatmoko B 2017 Analisis Perubahan Morfologi Sungai Rokan Berbasis Sistem Informasi Geografis Dan Penginderaan Jauh

[4] Muhtadi A, Leidonald R, Sibagariang R D and Nurfadillah 2020 Biodiversity of nekton in batangtoru river and its tributaries in North Sumatra, Indonesia Biodiversitas 21 2344–52

[5] Gordon N D, McMahon T A, Finlayson B L, Gippel C J and Nathan R J 1992 Stream hydrology, an introduction for ecologists The University of Chicago Press New York

[6] McFeeters S K 1996 The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features Int. J. Remote Sens.

[7] Himmelstoss E A, Henderson R E, Kratmann, G. M and Farris A S 2018 Digital Shoreline Analysis System (DSAS ) Version 5.0 User Guide (Virginia)

[8] Purwanto A D, Asriningrum W, Winarso G and Parwati E 2014 Analisis Sebaran dan Kerapatan Mangrove Menggunakan Citra Landsat 8 di Segara Anakan, Cilacap Semin. Nas. Penginderaan jauh 2014 232–41

[9] Jesen J R 2005 Introductory Digital Image Processing: A Remote Sensing Perspective
Prentice Hall series in geographic information science (California: Prentice Hall)

[10] Anderson J R, Hardy E E, Roach J T and Witmer R E 1976 A Land Use And Land Cover Classification System For Use With Remote Sensor Data (Washington)

[11] Arsyad S 1989 Konservasi tanah dan air (Bogor: Institut Pertanian Bogor)

[12] Strand R I and Pemberton E L 1982 Reservoir sedimentation technical guidelines for Bureau of Reclamation US Bur. Reclam. 48

[13] Pemerintah Kabupaten Maros 2013 Maros dilanda banjir bandang. Maros.go.id

[14] Hogarth P 2007 The Biology of Mangroves and Seagrasses (New York: Oxford University Press)

[15] Suwoyo H S, Undu M C and Makmur 2014 Laju Sedimentasi Dan Karakterisasi Sedimen Tambak Super Intensif Udang Vaname Proceeding 343–55

[16] Zuchrufa M 2017 Karst, Kerusakan Lingkungan, dan Kelangsungan Hidup Indones. Inst. Sci.

[17] Purwantara S 2015 Dampak Pengembangan Permukiman Terhadap Air Tanah Di Wilayah Yogyakarta Dan Sekitarnya 4 31–40