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Morphology Evolution of Lower Jeneberang River, Indonesia

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Abstract: River works affecting channel morphology and fluvial processes can be quite varied. The timing of any anthropogenic effects relative to previous modifications along with the magnitude of the effect is important when trying to predict the future estuary evolution. This paper presents a case study investigating the impact of river regulation works for the assumption that rivers are self-supporting morphological systems, which adjust themselves to modify conditions. We compared the longitudinal section and cross section of Jenneberang River, South Sulawesi, prior to the river improvement work with the results of our topographic survey in December 2014. The channel cross-sections were morphometrically analyzed according to their channel widths, and cross-sectional areas. We find considerable changes in the cross sections. East of the segment river tends to be influenced by the rubber dam cross-sectional. Cross sectional 4 seems to erode 2 sides, left and right bank. Left river bank erosion, which is the outer side of the bend of the river, caused by upstream water flow. The left side of the mouth of the river is more exposed from the seaward. Propagation of ocean waves radiating into the right side of the river; eroded riverbanks causing abrasion widen the river cross section. Long section show, downstream near mouth elevation is lower than before, the slope of the river becomes 0.274% and the gradient of the river had increased. Factors that affect long-term morphology changes: change in watershed land use, channelization, river works, in-stream sand or gravel mining, diversion of water in or out of streams, natural lowering of the entire system. River regulation had modify the amount and timing of flows in the downstream Jeneberang River, where Bili-bili reservoir located on the river, holds 375,000,000 m3 of water flow. Hydraulic geometry and cross sectional characteristics of the lower Jeneberang River are influenced by natural processes of fluvial systems and human interventions.

Keywords: *Morphology, Lower Jeneberang River, fluvial processes, anthropogenic effects, Indonesia.*

1. Introduction

Anthropogenic effects are a major agent which influences the morphology of an estuary. This effect can be either directly by means of engineering works and/or indirectly by modifying the physical processes in an estuary. Changes rarely had an instant effect; changes in the governing process caused by intervention in the past may not fully work through the system before further modifications were made to increase the complexity of the interaction. The timing of any anthropogenic effects relative to previous modifications along with the magnitude of the effect is important particularly when the prediction of future estuary evolution will be conducted (DEFRA, 2008).

Since designated as a major city for Eastern Indonesia development in the second 5-Year Plan (1974~1978), Makassar was propelled to be the industrialization and its urban development plan. The flood control has become a pressing issue in regards to establishing the foundation for sound living environment and economic activities. Against this background, the project was to conduct river improvements for the Jeneberang River, in order to provide flood protection of Makassar. Improvements Lower Jeneberang River work covered dredging, excavation, embankment and 9600 m revetment constructions section between the mouth of the Jeneberang River and the Sungguminasa Bridge (JICA, 2001).

Development activities that have been conducted in the Jeneberangan to support the growth of Makassar include: River Improvement (1993), Long Storage / Closure North Estuary (1994), Jeneberang Rubber Dam (1999), and Bili-Bili Multi-Purpose Dam (1999). Beside to reduce flood damage, The Bili-billy Dam also strengthens supplies of raw water by installing a water transmission pipe to the PDAM water treatment plant, leading to the response to water demand from Makassar and the surrounding area.

Human activities affecting channel morphology and fluvial processes can be quite varied. Indirect influences, including changes of land-use and management of the catchment, urbanization and land drainage, can modify runoff and sediment yield. A wide range of direct impfacts influences the river itself: e.g., dams, reservoirs and grade control structures, canalization, artificial cutoffs and rectification,

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dredging, installation of groins, artificial bank stabilization etc.(Nelson, 1997). Land management and organization usually change basin hydrology and lead to result flood risk (Stover and Montgomery, 2001).

The cross-sectional shape of the river in any location is a function of the discharge, the quantity and character of sediment transport, the property of materials making up the bed and banks of the river. River not only carries sediment, but change over laterally, keep on the average a constant river cross section by deposition at the other bank. In an alluvial channel, an equilibrium between erosion and deposition can be maintained so that the form of cross section is “stable” eventhough the orientation of the channel is not (Leopold. et al., 1964).

The present paper aims to evaluate the morphological (long-section and cross-section) changes caused by different types of river regulation works on the selected Lower Jeneberang River in order to find evidence for the assumption that rivers are self-supporting morphological systems, which adjust themselves to modify conditions.

2. Study Area

The Lower Jeneberang River is located in the southern of Makassar, Indonesia, flowing from east to west across the province (Fig.1). Originating from Mt. Bawakaraeng (2,833 m), it flows to the Makassar Strait. The river is 90 km long with a catchment area of 727 km2. The main tributary is the Jenelanta River (220 km2). Forest covers about 69% of the total basin area. There are two reservoirs, which have constructed in the catchment, the Bili-bili reservoir located on the Jeneberang River, holds 375,000,000 m3 water flow and the Jenelanta Reservoir located on the tributary Jenelanta River. In the rainy season (October-April), floods are normally caused by rainstorms, and often short floods are seasoned. There is a productive land for paddy rice and the area under irrigation area is 17,400 ha.

The Jeneberang river mouth had formed a delta, which divided the river into two river mouths, the north river mouth and the south river mouth (Fig. 2). Between these river mouths, the coastal of Jeneberang estuary had developed. The Northern river mouth has been closed.

Lowland occupies almost the entire lower part of the Jeneberang Watershed is in the western part of the southern coast of the island of South Sulawesi, which consists of swampy areas, tidal areas, fluvial and river delta areas that are low slope (<2%) and is covered by alluvium and coastal sediments.

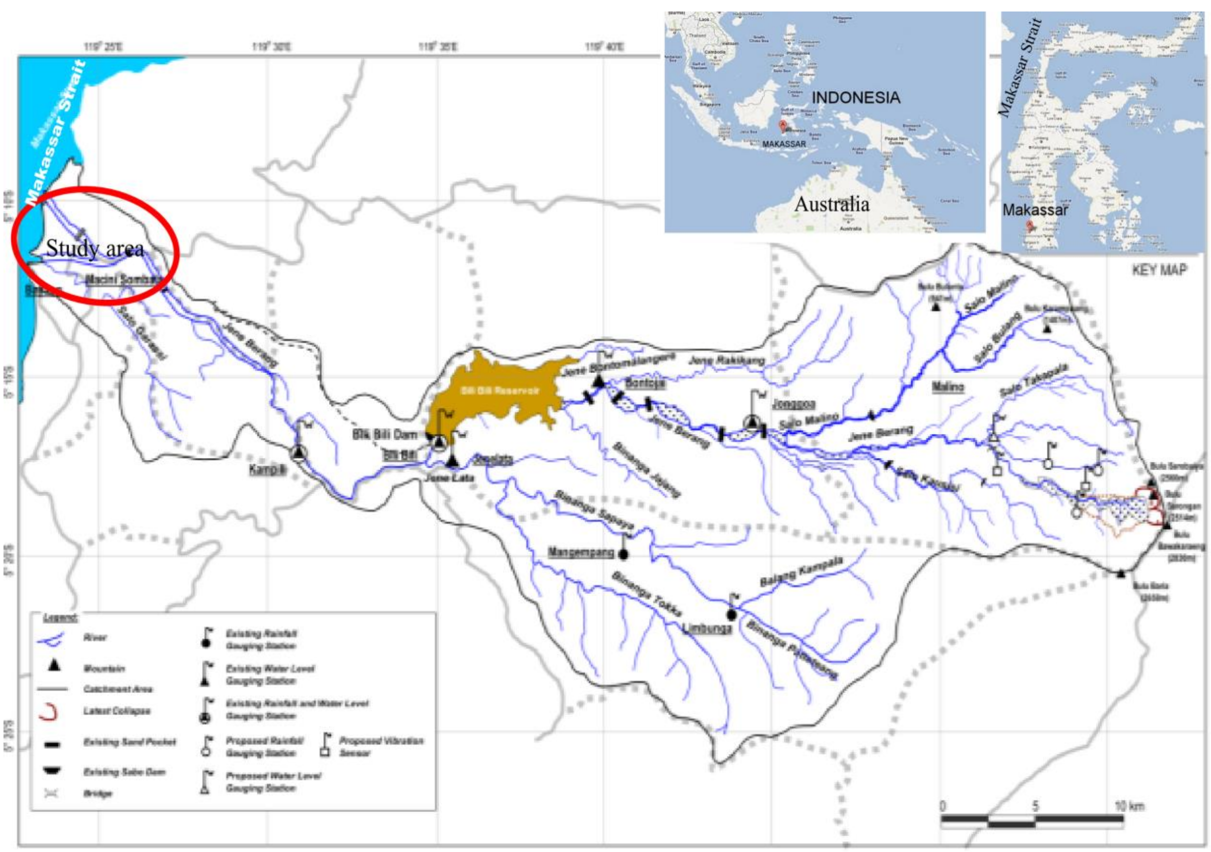

Figure1: *Jeneberang River watershed*

Figure2: *Study area (Google earth image 2015)*

3. Methods

Long section change was detected from topographic survey maps for design Lower Jeneberang Urgent Flood Control Works. Topographic surveying was done to determine the elevation and coordinate locations of geomorphic features within the river channel using a theodolite (Trimble Det-2 Spectra Precision) and global positioning system (GPS-Garmin 60CSx). The river was mapped in December 2014. The survey was carried out on existing survey points to provide controls along the access of the canal. These controls were used to detail the canal and all existing features within the area to be surveyed.

Subsequently, the centerline and inflection points of the studied reach were determined by measuring and halving the distance between bank-lines. Based on these long section parameters, such as slope, and mean channel width was evaluated.

Measuring cross-sectional parameters were alleviated by a reference-point which established by the Balai Sungai Jeneberang-Pompengan in Intake-gate PDAM / long storage and the Jeneberang Rubber Dam. The fixed survey points were installed on the banks or the levees, along the river from rubber dam to the mouth. Several parameters of the Lower Jeneberang River were measured, including: width (w), mean depth (dmean), maximum depth (dmax), width/mean depth ratio (w/d) and cross-sectional area (A).

In order to delineate geomorphic channel responses to Jeneberang River Improvement work, and related river bed and bank protection measures, we compared channel cross-sections and long section before Jeneberang River improvement with the results of topographic survey in December 2014. The channel cross-sections were morphometrically analyzed according to their channel widths, depths and cross-sectional areas.

4. Result

Before Jeneberang River Improvement Project and rubber dam constructed, the plan form of the Lower Jeneberang River was different from that of today. The survey showed that a little sinuous meandering pattern and a wide bed are found in the Lower Jeneberang River (Fig. 3).

Downstream rubber dam elevated when construction processes were conducted. The river bed becomes higher than previously due to the process. The Rubber dam reduced the channel-forming flows resulting post dam channel became narrower. This changed involves in width, depth, and bed level of the channel and, as a secondary effect, the change in slope. The general form of the long profile is a concave upward curve. The degree of concavity however, varies considerably depending on the overall steepness of the gradient. The degree of regularity of the concave curve varies between different segments of the river, but most of long profiles show irregularities as shown Fig. 4.

Variations in the channel cross sections as well as plan form over about 15 years (1999 to 2014), indicate that such changes are more likely to be caused by human interventions rather than by normal processes of adjustment of channel properties to the discharge. The Bili-bili Dam and the Jeneberang Rubber Dam have a major influence on the flow and sediment regimes of rivers as they significantly reduce the downstream flux of water and sediments which further involve geomorphic channel changes.

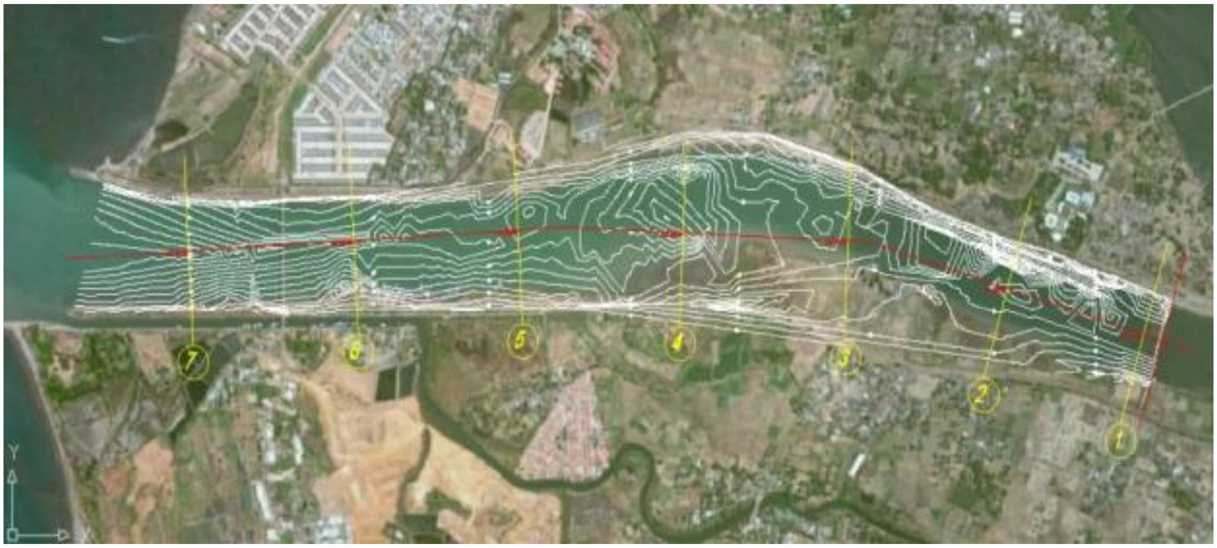

Figure3: *Plan form and tophographic contour, survey December 2014*

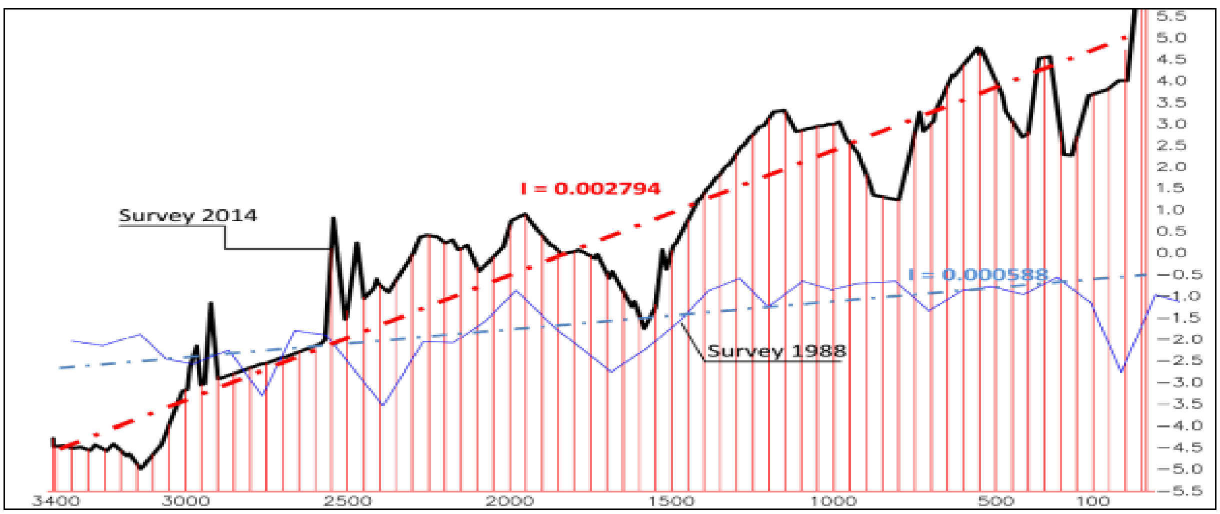

Figure4: *Longitudinal profile of downstream Jeneberang Rubber Dam, based on topographic survey 1988 and 2014*

The actual width ranged is from a minimum of 210 m (cross section 1) to a maximum of 385 m (cross section 4). Channel change and variation in channel cross sections were measured at seven sites downstream rubber dam to the mouth of the river. Cross section (CS) 1 and 2 are the cross profiles on near the rubber dam site (100 m and 500 m from the rubber dam site). The right bank is nearly vertical while the left bank shows somewhat deviations from near vertical nature. Though insignificant the cross sections show a tendency of erosion along the right bank. CS 3 asymmetry was confined to the pools on the right side, as was any helical flow. Areas of cross-section asymmetry were associated with narrow zones in the channel, downstream from sharp curvature changes (D.J. Anthony and Harvey, 1990).

From CS 1 to CS 4 finds considerable changes in the cross sections. CS 1 tends to be influenced by the rubber dam cross-sectional. Cross sectional 4 seems to erode 2 sides, the left and the right banks. The left river bank erosion, which is the outer side of the bend of the river, is caused by upstream water flow. The left side of the mouth of the river is more exposed from the seaward. Propagation of ocean waves radiating into the right side of the river eroded riverbanks causing abrasion widen the river cross section.

CS 5 to 7 CS is located on a straight segment of the Lower Jeneberang River. This segment protected on the left and the right side to control bank erosion by armor rock revetment, forming the jetty to the mouth. The cross section was symmetrically shaped, has been much influenced by coastal hydrodynamics such as wave and tidal. The existence of 5 piers and abutment the Barombong Bridge also influences the bed river shape on the river segment, especially on the cross-section between CS 6 and CS 7. When water in a river flows past an obstacle such as a bridge pier, piles, or boundary roughnesses, there are accompanying momentum and energy losses, and the water level is different upstream and downstream of the obstacle (Fenton, 2008).

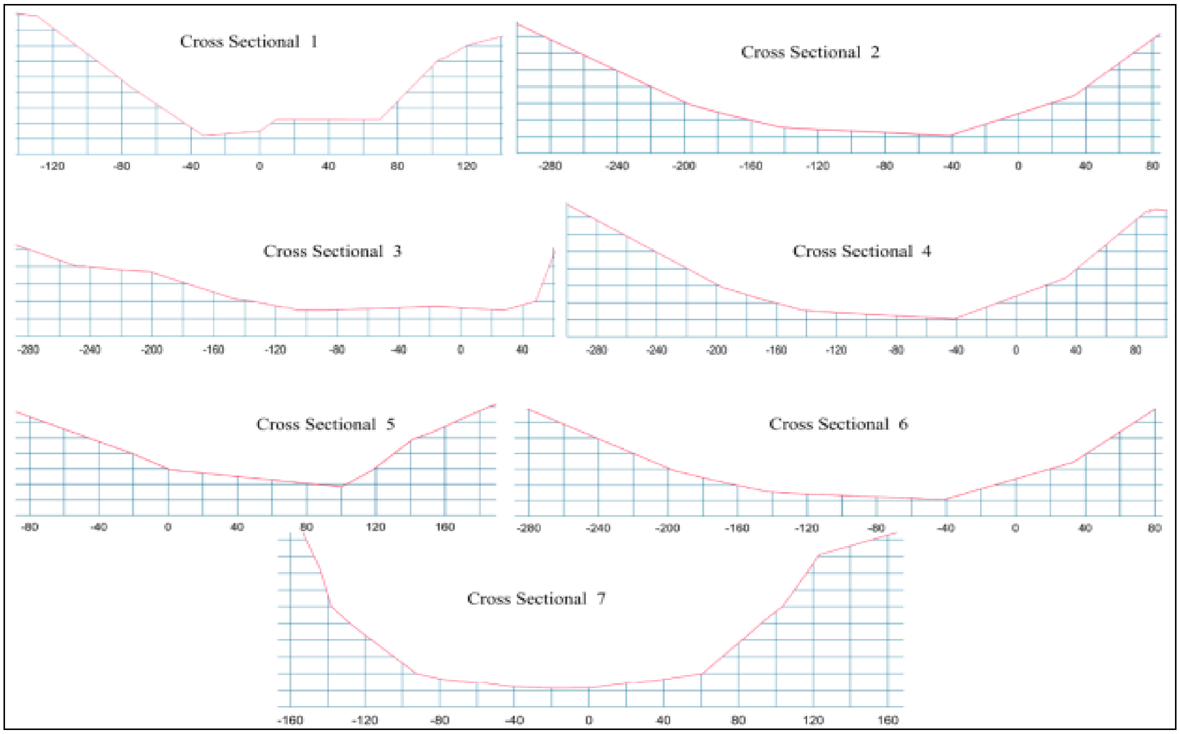

Figure5: *Cross section, based on topographic survey 2014*

Long term bed elevation change and cross sectional variation, as result of change in watershed land use, channelization, engineering river work, in-stream sand or gravel mining, diversion of water in or out of streams, and natural lowering of the entire system. Bili-bili Dam, PDAM intake, and northern river mouth had modified the amount and timing of flows in the downstream Jeneberang River. In addition, the dam reduces the magnitude of the high flow events that historically reshape and rejuvenate the channel through erosion and deposition of sediment. Incoming sediment carried by the river from its watershed is trapped in the reservoir behind the dam. The resulting impact on the river below a dam is often a dramatic change in the quality of the sediments. The finer sediments (sand, silt, and clay) are washed downstream and only the coarser gravels and cobbles remain. Consequently, floodplain building may cease below the dam, yet channel and bank erosion may continue, resulting in entrenched channels that are much lower than the floodplain and flood it less frequently (Pop. et.al., 2013).

5. Conclusion

River regulation had modified the amount and timing of flows in the downstream Jeneberang river, where Bili-bili reservoir located on the river, holds 375,000,000 m^3 of water flow. Long section and cross sectional characteristics of the lower Jeneberang River was different from that of today and was influenced by natural processes of fluvial systems and human interventions. Bili-bili Dam and Jeneberang rubber dam influences discharge and sediment input rate to Lower Jeneberang as they significantly reduce the downstream flux of water and sediments which further involves geomorphic channel changes. The left river bank erosion caused by upstream water flow, but the left side abrasion had eroded by wave propagation from the mouth.

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