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Riverbank changes along the Mekong River: Remote sensing detection in the Vientiane–Nong Khai area

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Abstract

Riverbank erosion is a natural process, but often human activities can have a significant impact on the rates of morphological change. This paper aims to assess bank erosion problems in the Vientiane–Nong Khai section of the Mekong River, where the Mekong borders Thailand and Lao PDR. The study provides new and more accurate information about recent riverbank movement rates. The bank movement rates are quantified using two Hydrographic Atlases dated 1961 and 1992, derived originally from aerial photos and a field survey, and SPOT5 satellite images acquired on 4 December 2004 and 28 April 2005 with a resolution of 2.5 m in natural colours. Bank erosion and accretion rates on the left (Lao PDR) and right (Thailand) banks of the Mekong are analysed for two time periods: 1961–1992 and 1992–2005, respectively. The quantified average bank erosion rates were found to be slow, ranging from 0.8 to 1.0 m/a for the first and second analysis period, respectively. These average annual erosion rates are only 0.1% of the channel width, which is very low on a global scale. However, erosion rates were much higher for the islands in the river, 2.4 and 4.8 m/a for the two time periods. The quantified accretion for the main banks was 0.4 m/a during 1961–1992 and 0.7 m/a during 1992–2005, which for the islands increased from 0.6 to 6.4 m/a from the first to the second period.

1. Introduction

River channel changes, such as bank erosion, downcutting and bank accretion, are natural processes for an alluvial river. However, developments like sand mining, infrastructure building on the riverbank, artificial cutoffs, bank revetment, construction of reservoirs and land use alterations have changed the natural geomorphological dynamics of rivers (Lane and Richards, 1997; Surian, 1999; Fuller et al., 2003; Rinaldi, 2003; Li et al., 2007). As a consequence, channel stability is often threatened (Fuller et al., 2003; Grant et al., 2003; Kesel, 2003; Rinaldi, 2003). Such human activities could be stronger forces for change than natural events such as floods, droughts and landslides (Surian and Rinaldi, 2003). These human-induced channel changes may result in various environmental and social-economic consequences in navigation, loss of riparian land and infrastructure, flood hazard and the alteration of aquatic and riparian ecosystems. Therefore, a better understanding on river channel changes is of great importance for river engineering and environmental management.

In the Lower Mekong Basin (LMB), i.e. the Mekong basin downstream of China and Myanmar, the river is characterised by large areas of alluvial channel (Gupta and Liew, 2007). The whole Upper Mekong Basin and parts of LMB are categorised as rock-cut channel. It has been reported that bank erosion has become a serious problem for many sites along the lower Mekong River in terms of imperilling nearby settlements and infrastructure (e.g. Pham et al., 2004; Le et al., 2006). Recent damages caused by bank erosion in the Mekong region have been frequently reported. For example, in the lower Mekong delta of Vietnam alone tens of lives were lost, six villages with 2200 houses were eroded and damaged, and numerous

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infrastructure such as bridges, roads, ports and buildings, etc. were destroyed in recent decades (Le et al., 2006). In the Lower Mekong Basin, the impact of bank erosion on humans is a serious problem.

Bank erosion, island growth and attachment of islands to riverbanks are also sensitive transboundary issues as the Mekong River forms a significant length of the border between Lao PDR and Thailand. River channel changes therefore have implications for the position and administration of the border line (Rutherfurd et al., 1996). Especially, it has been reported that the Vientiane–Nong Khai section of the border between the two countries has experienced an increasing bank erosion problem (JICA, 2004). The area has long had a reputation as being one of the most unstable reaches of the river (Rutherfurd et al., 1996). According to Rutherfurd et al. (1996), the average erosion rate was 0.7 m/a during 1959/1961–1988. However, on a global scale this is one magnitude lower than many other large rivers (Van de Wiel, 2003).

This study focuses on this trans-national part of the Mekong in order to assess the above problems and provide information on bank movement rates. The study aims to: (1) assess how much the shape of the river in the Vientiane–Nong Khai section has changed over time as a result of bank movement; (2) discuss the possible causes of the changes in bank erosion rates, especially over the latest 10 years or so; and (3) compare the study section erosion rates to global erosion rates. The paper focuses on assessing changes in bank location by remote sensing. The hydrodynamic EIA 3D Model has been applied to the study area (MRC/WUP-FIN, 2006) but is not presented in more detail in this paper. The social impacts of the bank erosion in Lao PDR side of the study area have also been covered in MRC/WUP-FIN (2006).

2. Study area

2.1. Mekong River

Carrying an average 475 km^3 of water each year from a basin of 795,000 km^2, the Mekong is the world's eighth largest river (Mekong River Commission, 2003; Campbell, 2005). The Mekong originates from China and flows through Myanmar, Lao PDR, Thailand, Cambodia and Vietnam before ending in the South China Sea. The annual monsoon climate dominates the hydrology of the Mekong. The discharge varies greatly between dry and wet seasons, being largest during August–September and smallest in April–May (Mekong River Commission 2005; Kummu and Varis, 2007).

Within the study reach the Mekong River has a slightly sinuous channel planform in accord with the definitions of Leopold and Wolman (1957, p. 60) and Dury (1969, Fig. 9.II.5). In the study area, the channel is divided into two channels of unequal cross-sectional area separated by large permanent islands that are not flooded significantly during the annual high-flow, and which sustain relict mature forest and seasonal agriculture. Most of the islands are elongated. The local presence of multiple channels separated by large islands is typical for an incipient anastomosed channel pattern in a sand-bedded tropical monsoon river and accords with Nanson and Knighton's (1996) Type 2 anastomosed rivers.

2.2. Vientiane–Nong Khai section of the Mekong

The study area is located in the Vientiane–Nong Khai section of the Mekong River, which forms the border between Thailand and Lao PDR (Fig. 1). An overview of the history of the border and agreements between Thailand and Lao PDR is given by Rutherfurd et al. (1996). This section of the river has experienced increasing riverbank erosion over the past years (JICA, 2004) and has been reported to be one of the most unstable reaches of the river being located immediately below the gorge track of the river (Rutherfurd et al., 1996). Gupta and Liew (2007) classified the Mekong altogether into eight River Units based on the geomorphological characteristic of each section. Our study section falls into the River Unit 2a: "Alluvial channel with visible sediment in low flow". The change from "Upper rock-cut channel, wide channel with sediment" (Unit 1d) to Unit 2a occurs just upstream from the study section.

The total length of the studied river section is 49 km and is located between 1544 and 1593 km (kilometres from the mouth of the Mekong in Vietnam). The discharge varies annually from 800 to 14,000 m^3/s, while the total suspended solids (TSS) concentration varies between 50 and 700 mg/l, being highest during August–September as illustrated in Fig. 2 (Kummu and Varis, 2007).

The data used for the analysis of suspended sediment concentration (SSC) and total suspended solids concentration and fluxes in the Mekong mainstream are from the Mekong River Commission's (MRC) databases (Mekong River Commission, 2004). Vientiane station is part of the MRC Water Quality Monitor Network (WQMN), while Nong Khai data is available in the MRC hydrological database (HYMOS) (Kummu and Varis, 2007). The monthly water discharge and suspended sediment concentration averaged from 1993 to 2000 at Vientiane and Nong Khai are also presented in Fig. 2.

3. Data and materials

A number of datasets are needed in order to quantify the riverbank changes. The main datasets used in this study are presented below. All spatial data are projected to UTM Zone 48 and use Indian 1960 datum.

The Hydrographic Atlas of 1961, based on a field survey and aerial photos from 1959 to 1961 (Mekong River Commission, 1961), was used to map the bank location in 1961. The scale of the atlas is 1:20,000. The atlas is available only in hardcopy format (Fig. 3).