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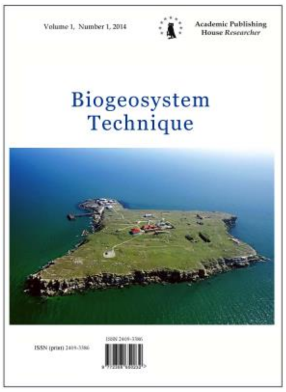

Articles

Dynamics of the Red River Bed in the Hanoi Region

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Abstract

The article substantiates the need to study the fluctuations of the area of the Red riverbed in the area of the city of Hanoi in certain historical periods. A methodology proposed for studying the river, including methods of remote sensing of the Earth (remote sensing) and Geographic Information System (GIS).During each historical period, the Red Riverbed changes in the direction of a gradual balance of bends, erosion of the banks and growth between the two banks. The influence of climate change on spatial changes in the riverbed analyzed using a superimposed map and ceilings. Explosive fluctuations in the area of the riverbed detected during periods of peak floods and greatest droughts. The results of the research formed the basis for creating a spatial security corridor and planning operational and environmental solutions on both banks of the river.

Keywords: Vietnam, Hanoi, Red river, dynamicsof the river, GIS, Lo river, Thao river, Da river, Red river city, historical flood, historic low water lever.

1. Introduction

The length of the Red River in Vietnam is about 560 km. Red River is the second largest river system (after the Mekong catchment) which flows through Vietnam to the South China Sea (Bravard et al., 2013; Bravard et al., 2014; Thi Kim Oanh Ta et al., 2012). The Red River comprises three main tributaries: Da, Lo, and Thao (Wysocka, Swierczewska, 2003; Luu Thi Nguyet Minh et al., 2010). It is also the largest river in the North of Vietnam, flowing in a natural state with a, difference between two main water seasons (Dang et al., 2010; Kort, Booij, 2007). A large amount of sediment draining into the river due to alluvial deposits on the catchment (Brunier et al., 2014; Thi Kim Oanh Ta et al., 2002). Therefore, the Red River system is very complex. There are constant

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changes in water flow and erosion, which causes great difficulties in the use of the river, as well as in the use of coastal land (Phan Cao Duong et al., 2017; Thi Phuong Quynh Le et al., 2007).

Urban environmental management in the Hanoi region has attracted increasing interest in recent years, as evidenced by a large number of studies (Taylor, Wright, 2001), both in Hanoi and other cities. However, these studies focus mainly on environmental pollution. Changes in the soil cover of the Hanoi region can be studied using satellite images (Lan Pham Thi et al., 2013; Hung Vuong Pham et al., 2018). This technique is widely used for environmental monitoring of territories (Boateng, 2012; Duong Du Bui et al., 2011).

In 2006–2007, the city of Hanoi, with the assistance and support of the city of Seoul (South Korea), worked out a basic planning project for the development of the Red River through Hanoi. The study of spatial changes in the section of the Red River canal that passes through Hanoi between 1999 and 2013 conducted with the aim of creating a scientific basis for the development, implementation, evaluation and construction of the "Red River City" project.

Remote sensing and its methods were used to study fluctuations in the Red Riverbed (Nguyen Hoang Hiep et al., 2018). The remote sensing methods, as well as GIS methods, are widely used for monitoring the quality of inland waters (Haddeland et al., 2006; Prathumratana et al., 2008). Water changes can be effectively studied using Landsat images (Nektarios, Karatzas, 2011). In our study, we applied these modern powerful tools to study the process of Red River bed fluctuation.

To control the state of water bodies simultaneously with space survey, the express methods of the monitoring is used (Nguyen Hoang Hiep et al., 2018; Lan Pham Thi et al., 2013). This helps to clarify a number of important points not fully detectable by ground surveying of the territory.

2. Methods

2.1. Photo data used

Within the scope of the study, the Landsat TM and Landsat 8 images data of 1999, 2003, 2007, 2008, 2009 and 2013 where used. The data borrowed at the US Geological Department's website http://glovis.usgs.com. The position of the image collected Path/Row: 127/45 and are in the coordinate system WGS 84, zone 48N. The images selected in the study of changes in the riverbed were from 1999, 2003, 2007 and 2013. The images collected the days with equivalent river water level of 850 cm (according to the data of Hanoi hydrographic station).This helps easily compare the fluctuations in riverbed area over time (Thilakarathne, Sridhar, 2017; Dongnan et al., 2017). Two images collected during the historical flood (August 2008) and historical drought (November 2009) were recorded on the Red River to compare the fluctuations of the river bed due to impacts of the climate change (Table 1).

Table 1. List of satellite imagery

№	Date/Year	Path/Row	Sensor
1	20.09.1999	127/45	ETM+
2	05.05.2003	127/45	ETM+
3	08.11.2007	127/45	ETM+
4	30.08.2008	127/45	ETM+
5	05.11.2009	127/45	TM
6	18.12.2013	127/45	TM

The equipment with hybrid photodetectors (Boateng, 2012) and photosensitive sensors were used for the image acquisition (Lan Pham Thi et al., 2013).

Landsat TM and ETM+ images consist of component images of 7 channels, each band corresponding to a range of values of light wavelength. To represent Landsat image, use composite image of 3 channels (red, blue and blue). Here is the background information about the tapes of Landsat.

Channel 1 (0.45-0.52 µm, Blue): This is a short wavelength band, light canpenetrate water. This tape is used to study objects in water, submerged ecosystems. Use tape 1 to study alluvial flows, coralreefs, water depths.

Channel 2 (0.52-0.60 µm, Green): This tape quality is almost the same as Band 1, and was chosen for vegetation study because the wavelength of light exhibits a green color close to that of vegetation.

Channel 3 (0.63-0.69 µm, Red): The wavelength range of this band is absorbed by plants (this band is called chlorophyll absorption band). Band 3 is used to distinguish between plants and soil. Used to study plants (good forest, badforest).

Channel 4 (0.76-0.90 µm, NearInfrared): Band 4 is absorbed by water, so its image of the water surface is black, showing that the reflected light from the water surface isveryweak. This tape is used to distinguish between water and land.

Channel 5 (1.55-1.75 µm, Mid-Infrared): This band is very sensitive to moistures, it is used to study vegetation and soil moisture. Band 5 is also used in the study of clouds and snow.

Channel 6 (10.40-12.50 µm, Thermal Infrared): This is Thermal Infrared tape, used to study ground temperature. Applications of this channel include studying geology, calculating the absorption of heat by plants, studying the influence of clouds on ground temperature.

Channel 7 (2.08-2.35 µm, Far Infrared): This band isalsoused to study vegetation moisture like Channel 5, it is used to study geology and soil. The bands are combined according to the Different ratios and color combinations to highlight research objects for image interpretation.

2.2. Image processing method

The Figure 1 shows a progress of research. After acquisition, the Landsat image was calibrated and corrected, then it was necessary to eliminate noise, sharpen the image, and adjust the spectrum. For extraction at the waterline, the image is displayed in a 5/2 channel format. An imaging helps to characterize land cover using a classification algorithm with a minimum distance test.

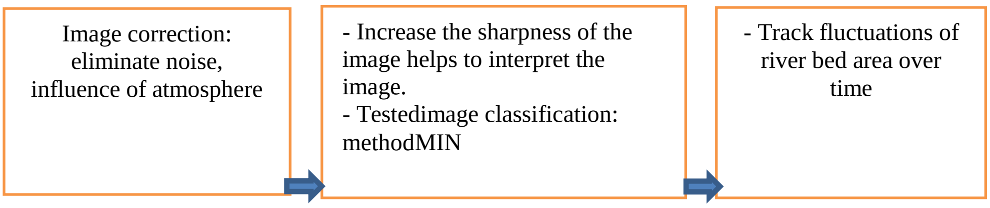
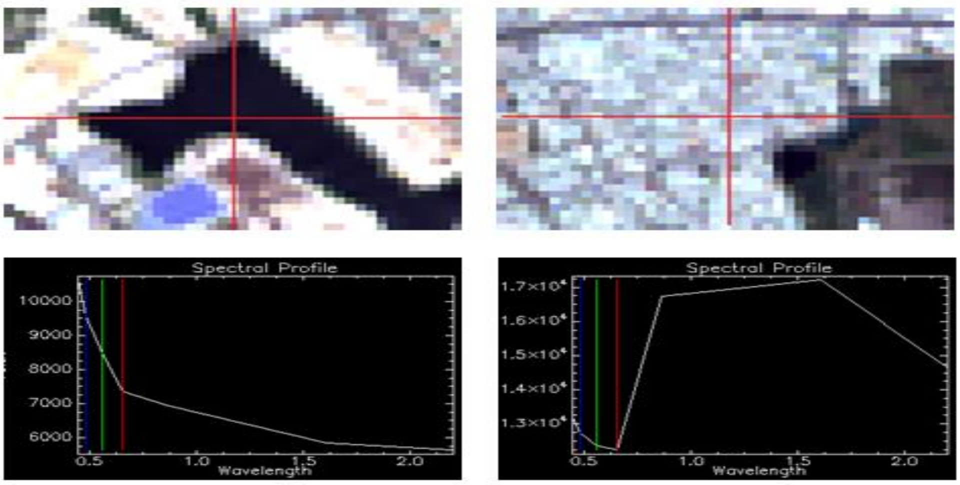


Fig. 1. Research progress

In this study, two objects need classification: river surface area and coastal area. Based on the spectral reflection characteristics of each object type (Figure 2), the keys for classification identified as follows:



River surface area Coastal area

Fig. 2. Real color composite photos of sample objects and the corresponding spectrum graph

Landsat TM images with artificial color combination are made up of three channels 4 (Red), 3 (Green) and 2 (Yellow), through basic processing and band selection to minimize the image. Clouds and silt affect the appearance of objects in the image. The color of the objects shown in the image is a fake color. The Red River bed area and the coastal area after classification presented in the Figure 3.

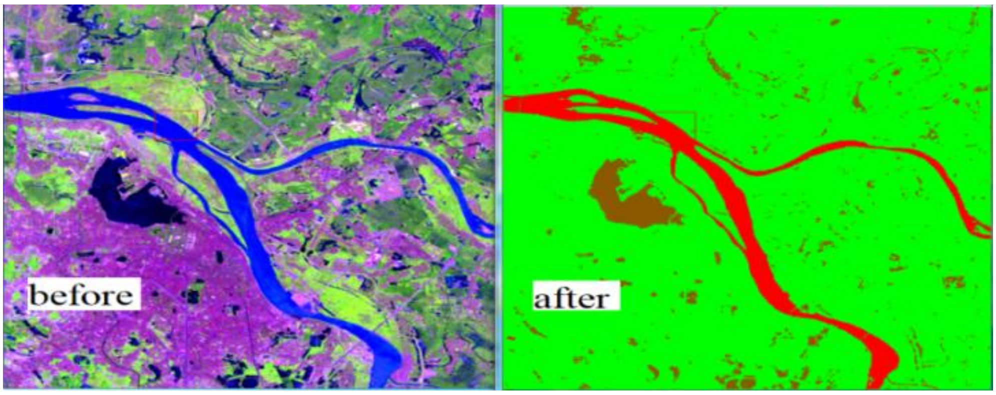


Fig. 3. Results before and after sorting using the image processing method

2.3. Mapping volatility method

The map overlay is a convenient spatial analysis tool and an important factor behind the development of GIS technology. Overlapping is a collection of spatial data and attributes of two or more data layers, and the tool is one of the most popular and powerful data analysis in GIS.

In the project, the water information layers on the research river section from Landsat image data were transformed into the separate layers in GIS. Then the map overlay method to display and calculate volatility used.

3. Results

3.1. Fluctuation of Red River bed

Fluctuation of Red River bed space over time is shown in Figures 4-6.

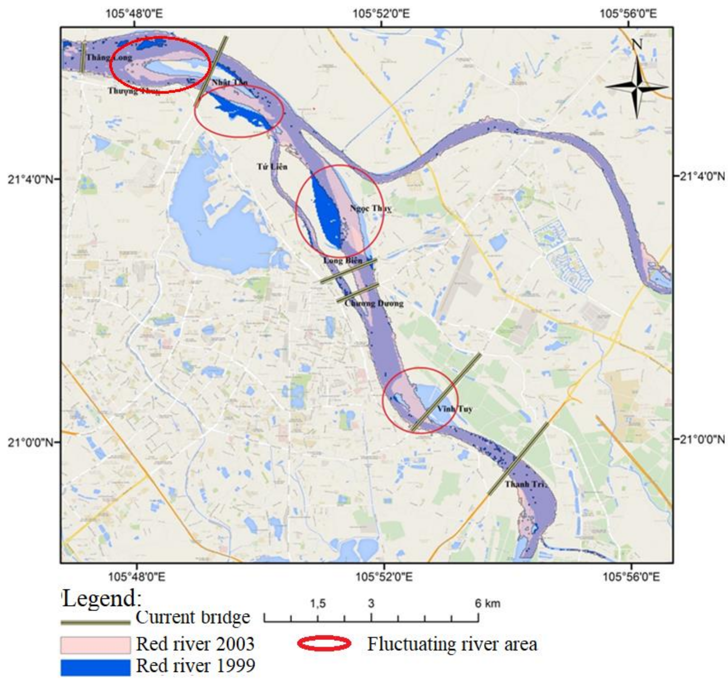


Fig. 4. Fluctuation of Red River bed space over time: 1999–2003

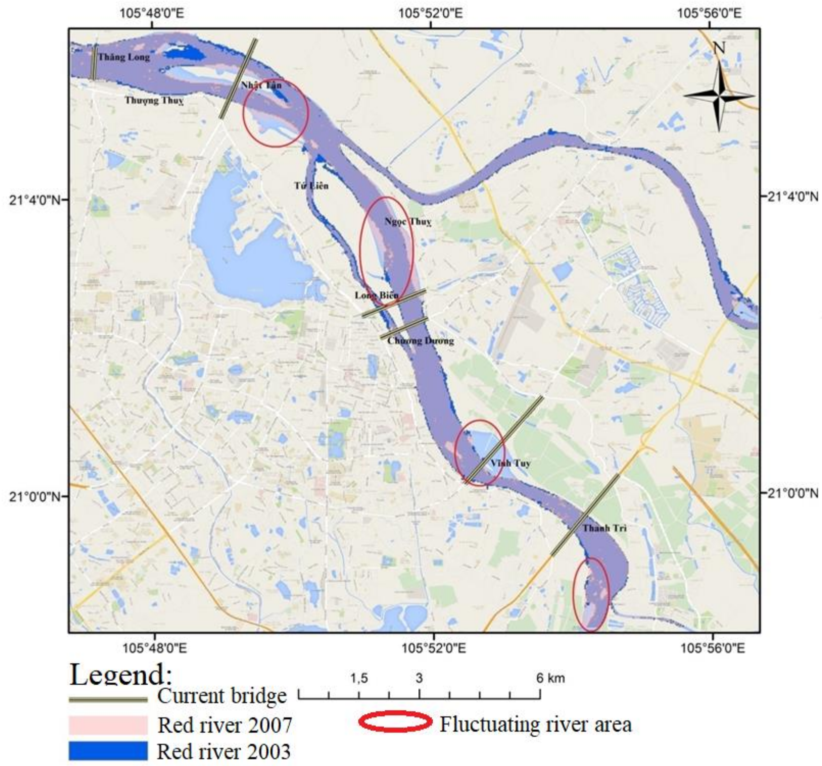


Fig. 5. Fluctuation of Red River bed space over time: 2003–2007

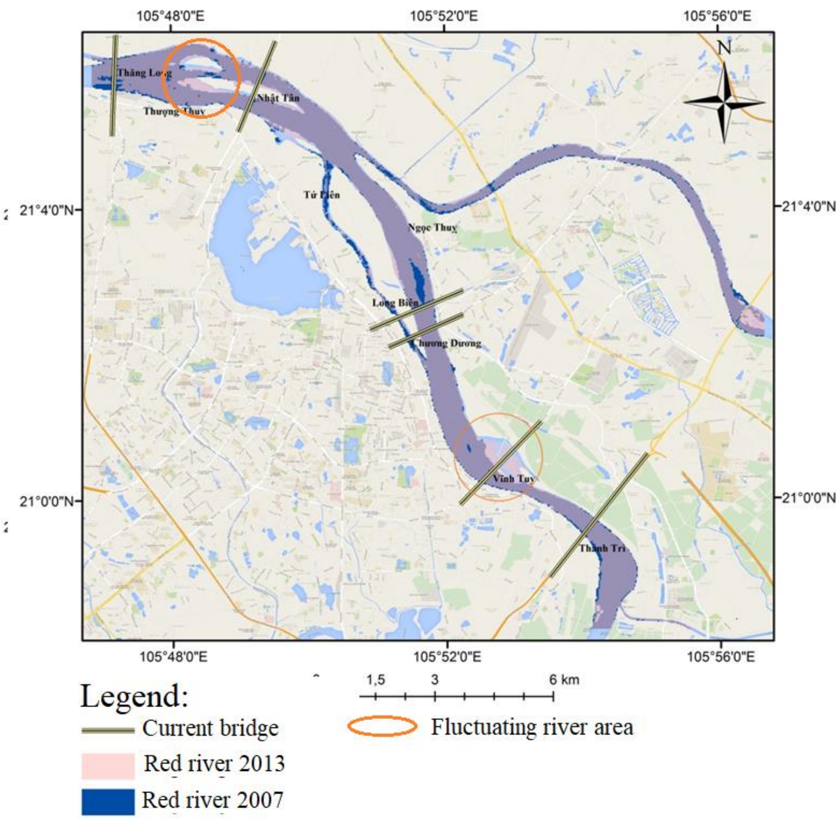


Fig. 6. Fluctuation of river bed space over time: 2007–2013

When the maps in Figures 4-6 overlap the fluctuations in 1999 and 2003, the fluctuations become more pronounced. When compared by this period, the river bed in 2003 tended to shift to the Northeast. Tu Lien area narrowed and moved to the Northeast more than 600 m. Sand dunes in Nhat Tan bridge area and Tu Lien are getting smaller and smaller.

In the 2003–2007 period, the river seemed to be more stable than the previous period. The Tu Lien alluvial area was expanded to more than 600 m compared to about 500 m in 2003.

In the 2007–2013 period, most changed area was the foot of VinhTuy bridge, the river bed expanded suddenly from nearly 600 m in 2007 to more than 1100 m in 2013 to the Northeast.

3.2. The river bed space fluctuation due to climate change

The left part of the Figure 7 shows the space of the Red River on August 30, 2008, the end of the historical 2008 flood. Heavy rains pushed the Red River high. During this flood, the Red River bed expanded to more than 1.6 km and distributed to the southwest.

At the end of 2009, a severe drought affected the Red River. The central part of the Figure 8 shows the space of the Red River bed on November 5, 2009. The river bed seems to be narrowed to the utmost, Tu Lien beach is connected to the mainland, the branching line creating Tu Lien area disappears.

Spatial fluctuations in the section of the Red River passing through Hanoi during the historical flood (30/08/2008) and historical drought (05/11/2009) are shown in Figure 9 on the right.

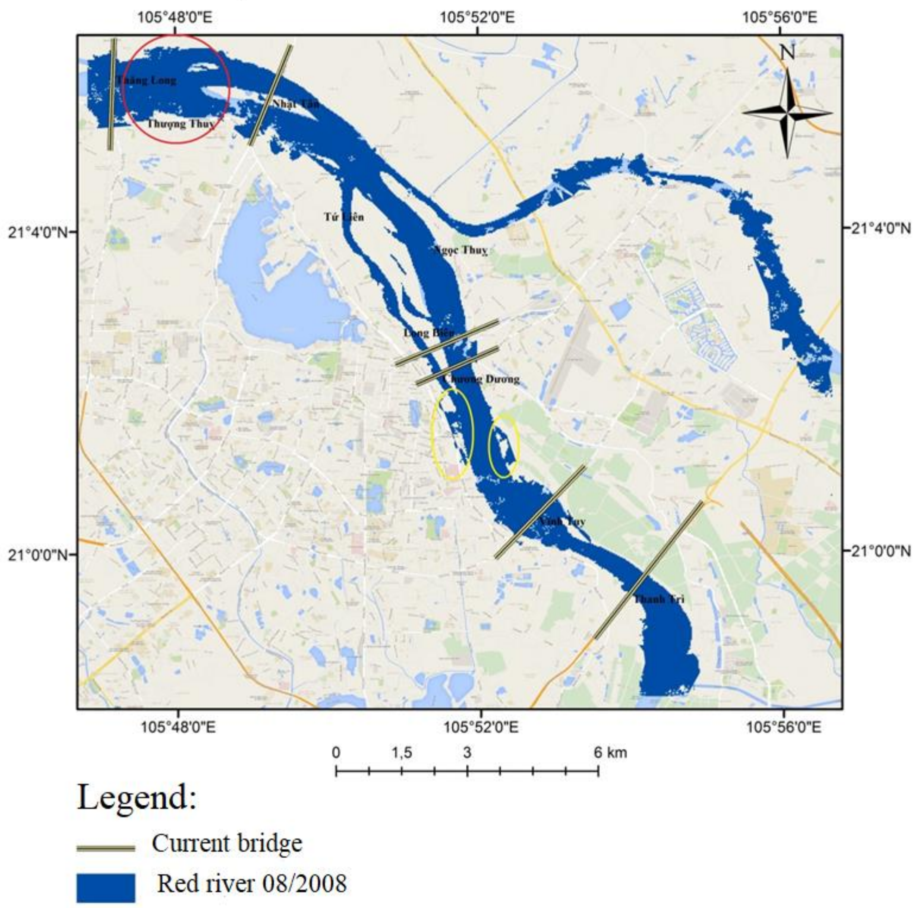


Fig. 7. Fluctuation of the Red River during the historical flood in 30/08/2008

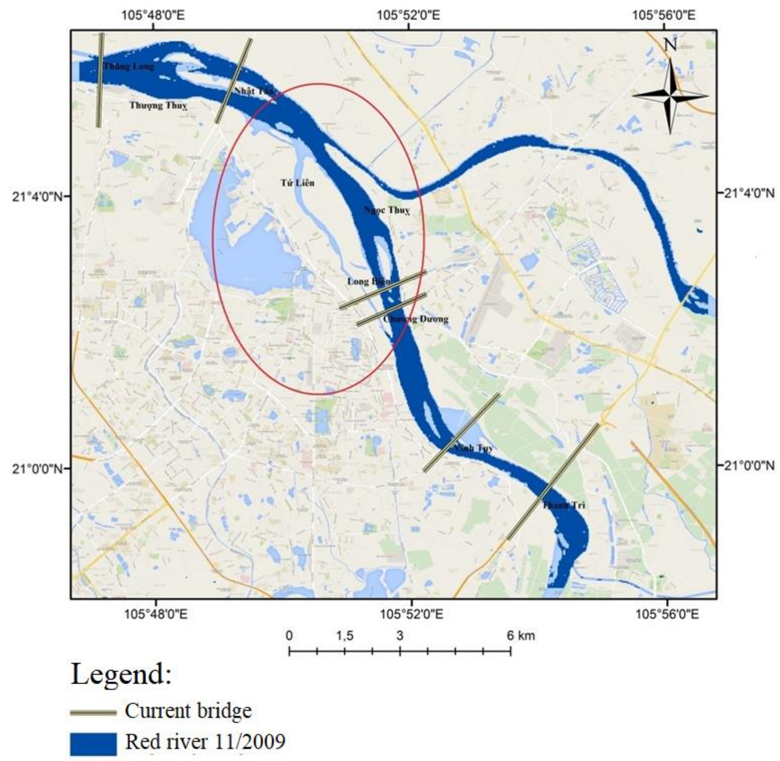


Fig. 8. Fluctuation of the Red River during the historical drought in 05/11/2009

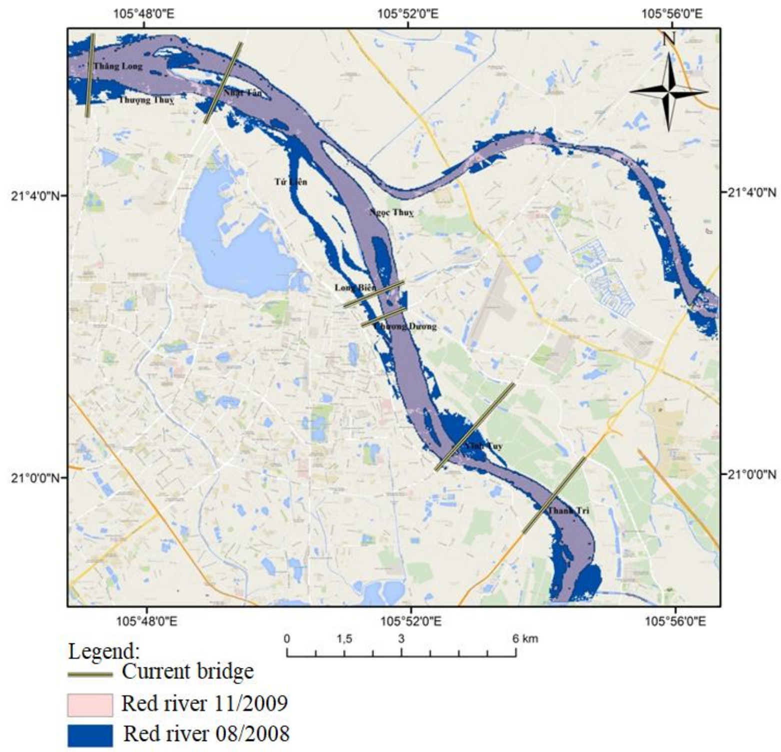


Fig. 9. Fluctuation of the Red River during the historical flood in 30/08/2008 and the historical drought in 05/11/2009

4. Conclusion

The section of the Red River flowing through Hanoi plays a particularly important role in supplying and draining water to the city, adjusting the microclimate and providing a natural living environment for the people of the city. This river section also plays an important role in waterway transport in Vietnam.

In the period of 1999–2013, the Red River section flowing through Hanoi had many changes in the position and space of the river bed. For each historical period, the river bed changed in the direction of gradual balance of bends, erosion of the river banks and accretion between the two sides, especially the mudflats and sand between the rivers.

In order to build a scientific basis for the implementation of the city's planning project for the Red River bank, it is necessary to take into consideration the historical fluctuations of the river bed space to ensure that the river bed is developing normally to minimize damage to the river's natural ecosystem.

Studying the spatial changes of the Red River in times of extreme natural disasters such as historical floods, historical droughts it is necessary to have appropriate solutions to conserve riverbeds and build safety corridors in the future.

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