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Research Paper

Spatiotemporal differentiation pattern of Chaohu Lake shoreline and the impact of human activity and natural factor: a remote sensing and statistical analysis*

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Abstract Changes in lake shorelines can significantly impact its ecological environment and lead to the erosion of wetland soils. Accurate extraction and continuous monitoring of lake shorelines are critically important for protecting and managing these ecosystems. To characterize the evolution of Chaohu Lake shoreline from 2000 to 2020, we used Landsat remote sensing imagery in combination with the modified normalized difference water index (MNDWI) and the digital shoreline analysis system (DSAS). The spatiotemporal changes of the shoreline were quantified using the end point rate (EPR) and linear regression rate (LRR) metrics. Results indicate that between 2000 and 2020, the surface area of Chaohu Lake shrank by 2.38 km^2 and its shoreline length decreased by 2.89 km, following a pattern of initial expansion followed by contraction. The most rapid shoreline retreat (6.63 km) occurred between 2005 and 2011. There was significant spatial variability in the shoreline change, especially in areas such as Hongshi Bay and Jindou Donglu, where the highest erosion and accretion rates were -22.09 m/a (EPR) and 20.72 m/a (LRR), respectively. Notably, the western part of the lake (near Hefei) experienced greater human disturbance and correspondingly higher annual shoreline change rates (EPR: 0.73 m/a; LRR: 0.91 m/a) than the eastern part (EPR: 0.60 m/a; LRR: 0.47 m/a). Overall, these findings provide a scientific basis for ecological restoration and sustainable shoreline management of Chaohu Lake.

Keyword: Chaohu Lake; Landsat imagery; digital shoreline analysis system (DSAS); lake shoreline

1 INTRODUCTION

As important components of the hydrosphere, lakes are closely tied to the water cycle. The spatial distribution of lakes often reflects the distribution and utilization of inland water resources (Qi et al., 2020). Inland lakes serve as critical ecological barriers and resource reservoirs, playing an irreplaceable role in regulating regional climate, maintaining biodiversity, and ensuring the availability for productive and domestic uses in neighboring communities (Zhang et al., 2019). As transitional zones between terrestrial and aquatic ecosystems, lake shorelines serve as a sensitive reactor to lake dynamics and a pivotal interface between ecological conservation and resource exploitation (Tan et al., 2019). In recent years, however, lakes of China have faced severe challenges under dual pressures from climate change and human activities, including water eutrophication (Ji et al., 2017), pronounced lake shoreline morphological changes (Luo et al., 2017),

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and wetland degradation (Zekarias et al., 2020). Precise delineation and dynamic monitoring of lake shorelines are therefore critical for their effective utilization and science-guided management.

Traditional lake shoreline monitoring has relied on field surveys, which suffer from high costs, low efficiency, and limited capacity to capture large-scale changes (Ribas et al., 2020). With advances in remote sensing, integration of multi-source satellite data with spatiotemporal fusion technology now enables long-term and high-accuracy lake shoreline monitoring (Cheng et al., 2020). For example, the normalized difference water index (NDWI) and supervised classification methods are widely used for water body extraction (Liuzzo et al., 2020; Chowdhury et al., 2023), whereas the digital shoreline analysis system (DSAS) quantifies spatiotemporal heterogeneity in lake shoreline evolution using metrics such as end point rate (EPR) and linear regression rate (LRR) (Ding et al., 2018). Furthermore, machine learning approaches (e.g., random forest, logistic regression) facilitate analysis of relationships between lake shoreline dynamics and driving factors, including meteorological influences and anthropogenic activities (Gu et al., 2020; Qi et al., 2021). The integrated approach employed in this study-combining modified normalized difference water index (MNDWI) for shoreline extraction with DSAS for change-rate analysis-provides a more efficient, accurate, and robust framework for long-term shoreline monitoring than traditional field-based methods.

Chaohu Lake, the fifth-largest freshwater lake in China, is located in Anhui Province and has a watershed area of ~13 000 km^2. It serves as a crucial ecological barrier in the middle and lower reaches of the Changjiang (Yangtze) River, and its water quality directly affects regional ecological security (Tian et al., 2025). Accelerated urbanization and industrialization in recent decades have intensified ecological challenges in the Chaohu Lake Basin, making environmental management a critical concern. Existing studies have explored multiple aspects of the lake dynamics, such as shoreline collapse and morphological changes (Gao et al., 2005), and land-use evolution in the surrounding areas (Jia et al., 2025). However, systematic analyses of spatiotemporal shoreline morphodynamics remain scarce. As the interface between terrestrial and aquatic ecosystems, lake shoreline dynamics reflect ecosystem stability and human-nature interaction. Most prior studies focus on lake-wide trends or single-factor drivers, while the quantitative assessments of lake shoreline heterogeneity and multi-scale driving forces are notably absent.

Therefore, using Landsat remote sensing data (2000–2020), this study integrates the MNDWI and the DSAS to quantitatively characterize the spatiotemporal differentiation of Chaohu Lake shoreline through EPR and LRR metrics, and explores the combined effects of natural and anthropogenic driving factors. The objective is to provide a scientific foundation and theoretical basis for ecological restoration and sustainable shoreline management of Chaohu Lake. For clarity, we define “shoreline” in this study as the instantaneous land-water boundary at the time of each satellite overpass, following established shoreline change methodologies (Maiti and Bhattacharya, 2009). This boundary is delineated automatically and consistently using MNDWI, and shifts in its position over time are analyzed to infer long-term geomorphological changes in the littoral zone.

2 MATERIAL AND METHOD

2.1 Study area

Chaohu Lake (31°25′N–31°42′N, 117°17′E–117°50′E) is one of the five largest freshwater lakes in China. It is situated in central Anhui Province, spanning the jurisdictions of Hefei City, Chaohu City, Feidong County, Feixi County, and Lujiang County. The lake has a surface area of 780 km^2, with an average depth of 2.5 m and a maximum depth of 5 m. Chaohu Lake is divided into eastern and western parts by the Zhongmiao-Mushan-Qitou line (Chen and Liu, 2015). The western part borders Baohe District and Feixi County of Hefei City, whereas the eastern part adjoins Chaohu City and Lujiang County (Fig.1). The Chaohu Lake experiences a typical subtropical monsoon climate with distinct seasonal variation. The mean annual temperature ranges from 15 to 16 °C, and annual precipitation averages about 1 000 mm, mostly occurring in the summer months (He et al., 2021).

2.2 Data source and preprocessing

In this study, we utilized Landsat satellite imagery from 2000–2020 to systematically monitor shoreline evolution and perform quantitative analyses. Multi-temporal images were obtained from the Geospatial Data Cloud (http://www.gscloud.cn) and the USGS Earth Explorer platform

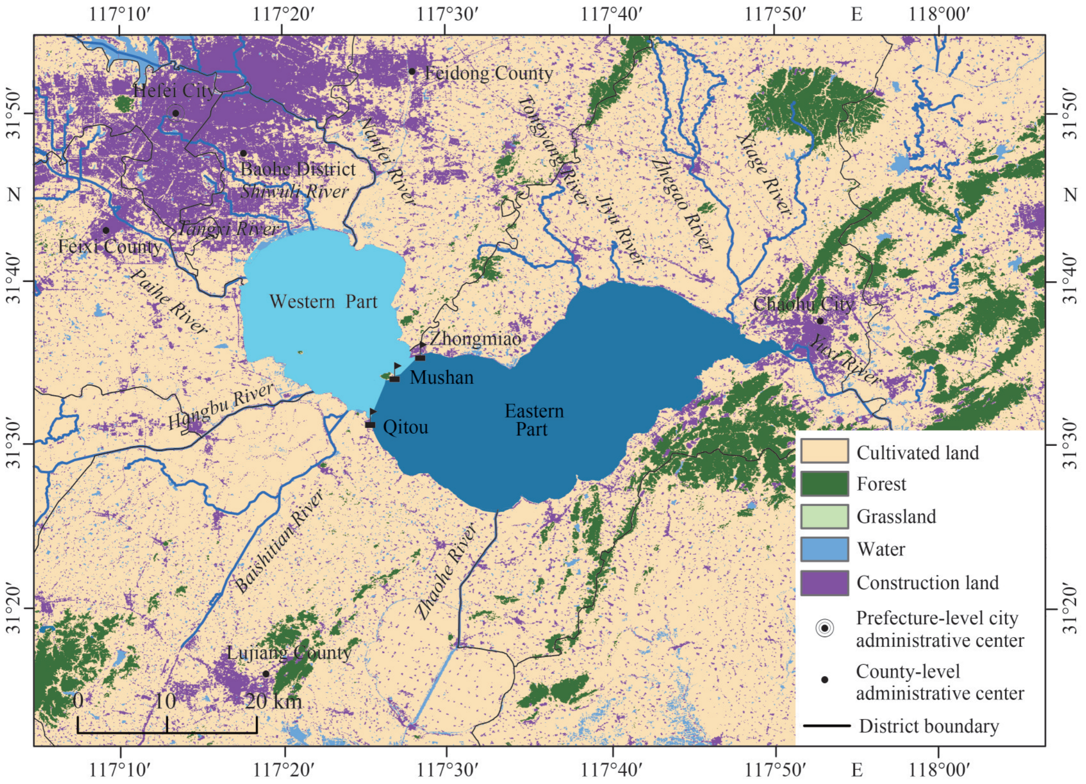

Fig.1 Geographical location of Chaohu Lake

(https://earthexplorer.usgs.gov), prioritizing scenes with <10% cloud cover and high radiometric quality. Five years (2000, 2005, 2011, 2015, 2020) were selected for analysis. Notably, the 2010 dataset was replaced by a 2011 image due to a Landsat 7 sensor malfunction that caused striping noise. To minimize the influence of seasonal water-level fluctuations, all images were acquired during the relatively stable hydrological period of September–October (Table 1). The extracted “shoreline” corresponds to the apparent land-water interface at the time of each satellite pass. Although instantaneous lake levels can affect this position, using images from a consistent season minimizes variability and aligns with methodologies in other regional studies (Li et al., 2024).

Table 1 Remote sensing data used in the study

No.	Satellite and sensor	Acquisition date (yyyy-mm-dd)	Total band	Spatial resolution (m)
1	Landsat 5 TM	2000-09-15	7	30
2	Landsat 5 TM	2005-10-31	7	30
3	Landsat 5 TM	2011-09-14	7	30
4	Landsat 8 OLI	2015-10-11	11	30
5	Landsat 8 OLI	2020-10-24	11	30

Image preprocessing followed standard procedures: 1. radiometric calibration: convert raw digital numbers to surface reflectance; 2. atmospheric correction: apply the FLAASH model to reduce aerosol and other atmospheric effects; 3. geometric correction: perform coordinate transformation to align imagery to the WGS84 datum (Fig.2). Additionally, USGS-recommended cross-calibration coefficients were applied to adjust Landsat 5 TM reflectance data to match the Landsat 8 OLI spectral response baseline. This integrated preprocessing approach effectively corrected radiometric and

Fig.2 Preprocessed satellite image of Chaohu Lake

Please see Fig.1 for geographic details.

geometric distortions, providing a robust foundation for subsequent lake shoreline extraction and change analysis.

2.3 Research method

2.3.1 Natural lake shoreline delineation

Water-index-based methods are widely used for delineating natural lake shorelines and are particularly effective for large-scale and long-term monitoring. In this study, MNDWI was employed, which is an enhanced version of NDWI that uses the green and mid-infrared (MIR) bands to reduce interference from built-up shadows in water extraction. The index is defined as:

$$\text{MNDWI}=(\text{green}-\text{MIR})/(\text{green}+\text{MIR}). \tag{1}$$

In this formula, green denotes the green spectral band, and MIR represents the mid-infrared band.

2.3.2 DSAS analysis

Shoreline evolution encompasses changes in lake area and shoreline geometry, as well as positional change rates over time. To quantify these changes, perpendicular transects were cast at 500-m intervals along the lake shoreline. These spacing balances the need to capture significant local changes against the need to avoid clutter from overly dense transects. After generating the transects, manual quality control was performed to remove any transects intersecting large permanent structures. Ultimately, 350 valid transects were retained for detailed spatiotemporal analysis of shoreline dynamics.

Two metrics were used to quantify shoreline change: EPR and LRR. EPR provides a rapid assessment of short-term change between two discrete shoreline positions, while LRR identifies long-term trends from multiple shoreline positions over time. Both metrics were calculated using DSAS, and the results were considered significant at the 95% confidence level.

EPR is computed as the net shoreline displacement between two time points, divided by the time interval (in years):

$$E_{ij}=(d_j-d_i)/(t_j-t_i), \tag{2}$$

where d_i and d_j are the perpendicular distances from a fixed baseline to the shoreline at times t_i and t_j (m), and t_j-t_i is the time interval between those observations (years).

LRR characterizes long-term trends by fitting a least-squares line to a series of shoreline positions; the slope b of this line is the average annual change rate:

$$z=a+bx, \tag{3}$$

where z is the shoreline position (distance from the baseline, m) at time x (year), b is the slope (LRR, in m/a), and a (m) is the intercept.

3 RESULT

3.1 Shoreline length and areal dynamics of Chaohu Lake

The spatiotemporal evolution of Chaohu Lake's shoreline from 2000 to 2020 was analyzed using continuous time-series boundary data. Between 2000 and 2020, the surface area of Chaohu Lake showed a persistent shrinking trend (Fig.3), with a total reduction of 2.38 km^2. A turning point occurred in 2005, when the lake reached a peak area of 782.77 km^2, followed by sustained shrinkage thereafter. This period can be divided into three phases: an expansion phase from 2000 to 2005 (area increase of 1.88 km^2, from 780.90 to 782.77 km^2), a stabilization phase from 2005 to 2011 (minor net decrease of 0.07 km^2, to 782.70 km^2), and an accelerated contraction phase from 2011 to 2020 (area loss of 4.15 km^2, down to 778.55 km^2).

The shoreline length of Chaohu Lake also declined overall from 2000 to 2020 (Fig.3), with a net reduction of 2.89 km. Notably, the shoreline length initially increased and later decreased during this period. The most rapid expansion occurred between 2000 and 2005, when shoreline length grew from 194.96 to 200.45 km (a gain of 5.49 km). The sharpest contraction followed from 2005 to 2011, shrinking the shoreline to 193.82 km (a loss of 6.63 km). A brief recovery between 2011 and 2015 added 3.06 km (reaching 196.88 km), before a

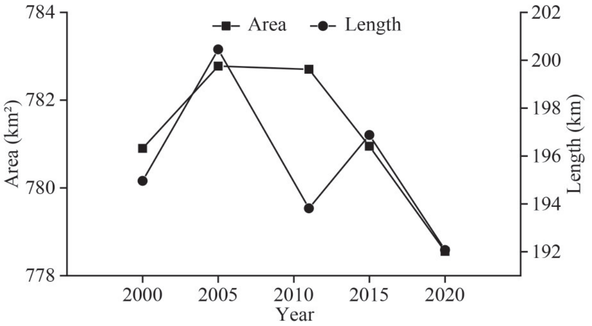

Fig.3 Changes in area extent and shoreline length of Chaohu Lake (2000–2020)

renewed contraction from 2015 to 2020 removed 4.81 km, reducing the length to 192.07 km.

3.2 Long-term shoreline dynamics of Chaohu Lake

Shoreline changes from 2000 to 2020 were further analyzed with EPR and LRR metrics (Fig.4). Overall, the lake shoreline exhibited an accretionary tendency, but with strong spatial heterogeneity in erosional and depositional patterns. Most shoreline segments showed minimal movement, whereas certain locations experienced pronounced changes (e.g., Guihua Tai (Terrace), Hongshi Bay, Dongkoumen, Hubian Village, Wuhe Village, Xiapaihe, Jindou Donglu). Jindou Donglu had the highest accretion rate, while Hongshi Bay suffered the most rapid erosion. On average, the shoreline shifted about 0.64 m/a (EPR) or 0.62 m/a (LRR) between 2000 and 2020. The maximum accretion rates were 18.50 m/a (EPR) and 20.72 m/a (LRR), and the maximum erosion rates were -22.09 m/a (EPR) and -16.97 m/a (LRR).

In the eastern part of the lake, the average change rate was 0.60 m/a (EPR) and 0.47 m/a (LRR). The maximum accretion in the eastern shore reached 17.21 m/a (EPR) and 16.95 m/a (LRR), and its maximum erosion reached -12.73 m/a (EPR) and -10.30 m/a (LRR). In the western part, the average change rate was higher, at 0.73 m/a (EPR) and 0.91 m/a (LRR). The western shore's maximum accretion was 18.50 m/a (EPR) and 20.72 m/a (LRR), while the maximum erosion was -22.09 m/a (EPR) and -16.97 m/a (LRR).

According to the EPR spatial distribution map (Fig.5), most of the shoreline experienced slow accretion or slight retreat between 2000 and 2020. Areas near the Hangbu River estuary, Jindou Donglu, and Dongkoumen showed relatively rapid accretion (up to 18.50 m/a). Conversely, shorelines near Xiapaihe, Hongshi Bay, and Hubian Village underwent accelerated erosion, with rates up to -22.09 m/a.

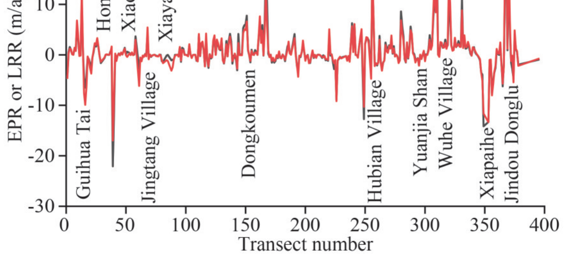

Fig.4 EPR and LRR distribution along Chaohu Lake's shoreline (2000–2020)

The LRR spatial distribution (Fig.6) reveals a similar pattern: most shoreline segments had only minor accretion or retreat. Notably, accelerated accretion occurred near Wuhe Village, Jindou Donglu, and Dongkoumen (the peak at 20.72 m/a), whereas pronounced erosion was observed near Xiapaihe, Guihua Tai, Hongshi Bay, Jingtang Village, and Hubian Village (with a maximum of -16.97 m/a).

3.3 Interannual shoreline variability in Chaohu Lake

Interannual shoreline variability was examined by calculating EPR over four sub-periods: 2000–2005, 2005–2011, 2011–2015, and 2015–2020 (Fig.7). Frequent fluctuations occurred throughout 2000–2020, with each interval exhibiting distinct spatial patterns of accretion and erosion, as summarized below:

1. 2000–2005: the average shoreline change rate was -1.70 m/a (EPR), indicating net erosion. Most segments showed only slow accretion or minor retreat, but significant changes occurred near Hongshi Bay, Jingtang Village, Dongkoumen, Hubian Village, Yuanjia Shan (Hill), Wuhe Village, and Xiapaihe. Shorelines near Jingtang Village, Dongkoumen, and Yuanjia Shan had high accretion rates (>20 m/a EPR), with the fastest progradation at Yuanjia Shan (67.43 m/a). In contrast, shorelines near Hongshi Bay, Hubian Village, Wuhe Village, and Xiapaihe experienced rapid erosion (approximately -30– -80 m/a), with the fastest retreat at Hongshi Bay (-78.78 m/a). The eastern part averaged -1.19 m/a (erosion-dominated; max accretion 33.75 m/a, max erosion -55.66 m/a), while the western part averaged -2.72 m/a (erosion-dominated; max accretion 67.43 m/a, max erosion -78.78 m/a).

2. 2005–2011: the average change rate was -0.80 m/a, indicating continued net erosion. Most segments had moderate fluctuations, but intense changes were noted near Guihua Tai, Xiaohu Village, Xiayang Village, Yuanjia Shan, and Wuhe Village. Yuanjia Shan and Wuhe Village exhibited the fastest accretion (43.32 and 55.18 m/a, respectively), while Guihua Tai, Xiaohu Village, and Xiayang Village suffered severe erosion (~-30– -70 m/a), with Xiayang Village eroding fastest

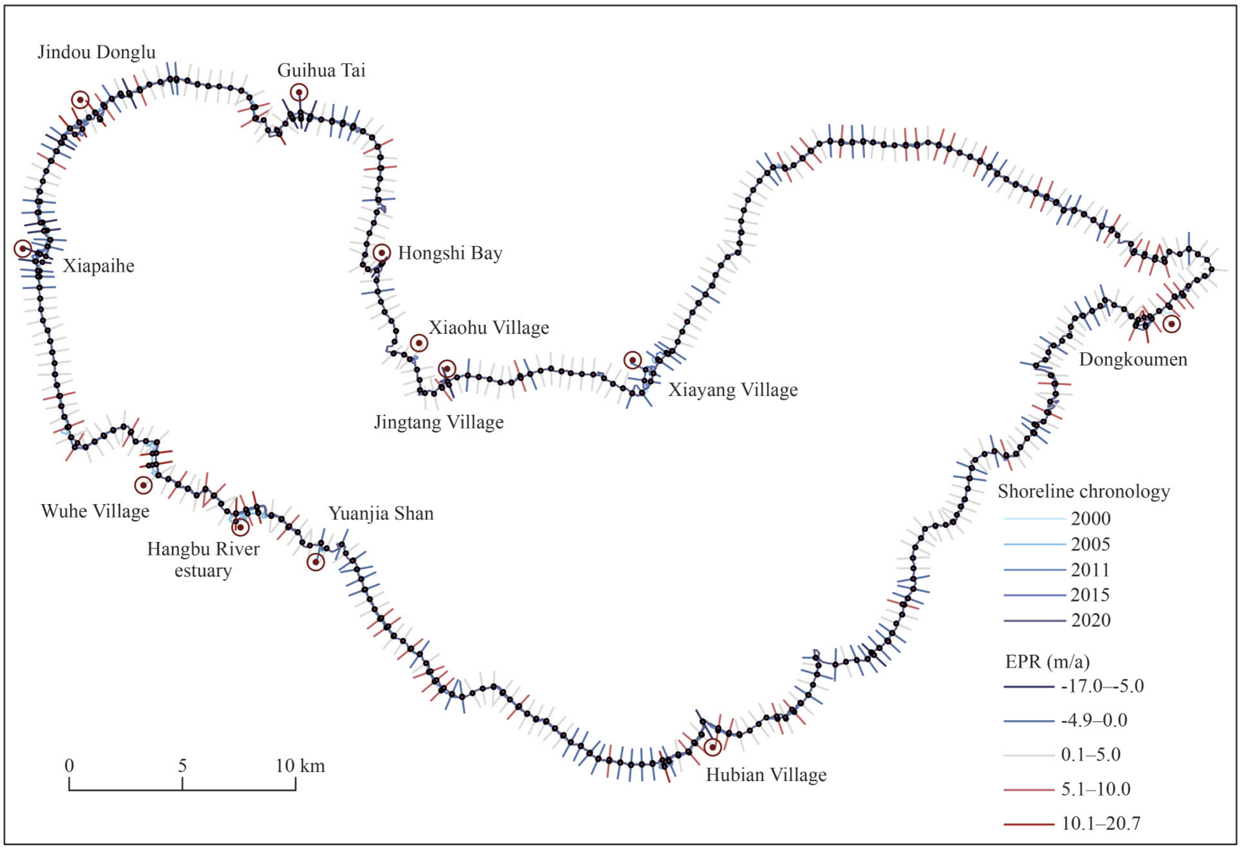

Fig.5 Spatial distribution of EPR (2000–2020) for the shorelines of Chaohu Lake

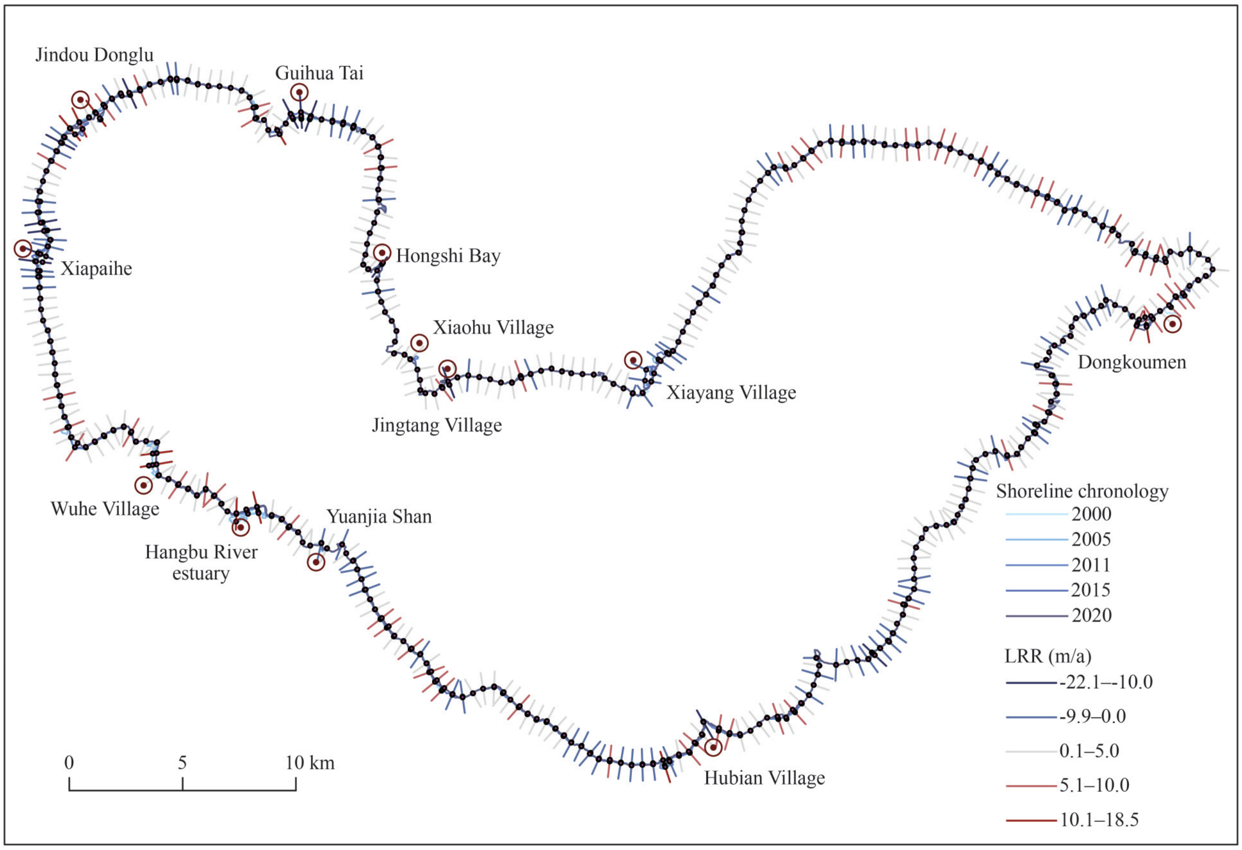

Fig.6 Spatial distribution of LRR (2000–2020) for the shorelines of Chaohu Lake

(-65.38 m/a). The eastern part averaged -1.23 m/a (erosion-dominated; max accretion 9.90 m/a, max erosion -63.58 m/a). The western part had a slight accretion tendency (average +0.05 m/a; max accretion 55.18 m/a, max erosion -40.51 m/a).

3. 2011–2015: the average change rate was +3.07 m/a, indicating a shift to net accretion. Significant shoreline advances occurred near Guihua Tai, Xiaohu Village, Xiayang Village, Hubian Village, and Jindou Donglu (all >40-m/a accretion), with Xiayang Village achieving the highest progradation (95.34 m/a). Jingtang Village was an outlier with notable erosion (-55.31 m/a). The eastern part averaged +2.26 m/a (accretion-dominated; max accretion 95.34 m/a, max erosion -55.31 m/a), while the western part averaged +4.65 m/a (accretion-dominated; max accretion 88.47 m/a, max erosion -24.77 m/a).

4. 2015–2020: the average change rate was +2.79 m/a, continuing an overall accretion trend. Most shoreline segments showed moderate accretion, but rapid changes were concentrated near Guihua Tai, Dongkoumen, Wuhe Village, and Jindou Donglu. Shorelines at Guihua Tai, Dongkoumen, and Wuhe Village showed accelerated accretion (>30 m/a), with the fastest advance at Dongkoumen (84.72 m/a). In contrast, Jindou Donglu experienced notable erosion (-24.21 m/a). The eastern part averaged +3.26 m/a (accretion-dominated; max accretion 84.72 m/a, max erosion -3.56 m/a), while the western part averaged +1.85 m/a (accretion-dominated; max accretion 42.88 m/a, max erosion -24.21 m/a).

4 DISCUSSION

Shoreline dynamics at Chaohu Lake are governed by multiple interacting factors, both natural and anthropogenic. From 2000 to 2020, the Chaohu Basin underwent rapid urbanization and land-use changes, which profoundly altered the morphology and ecosystem integrity of the lake shoreline. Urban areas expanded markedly (especially on the western shore near Hefei City) while croplands and woodlands declined significantly (Li et al., 2018). These changes led to altered surface runoff patterns, increased sediment and nutrient inputs, and reduced riparian vegetation buffers, thereby accelerating shoreline erosion in vulnerable areas such as Hongshi Bay and Xiapaihe. Meanwhile, sediment carried by inflow rivers has formed bird-foot and fan-shaped deltas at river mouths, driving lake shoreline progradation and morphological alterations. The deltaic sedimentation reduced the lake depth and volume (Yang et al., 2010). Consequently, the lake surface area continued to shrink after 2005, accompanied by complex shoreline morphological

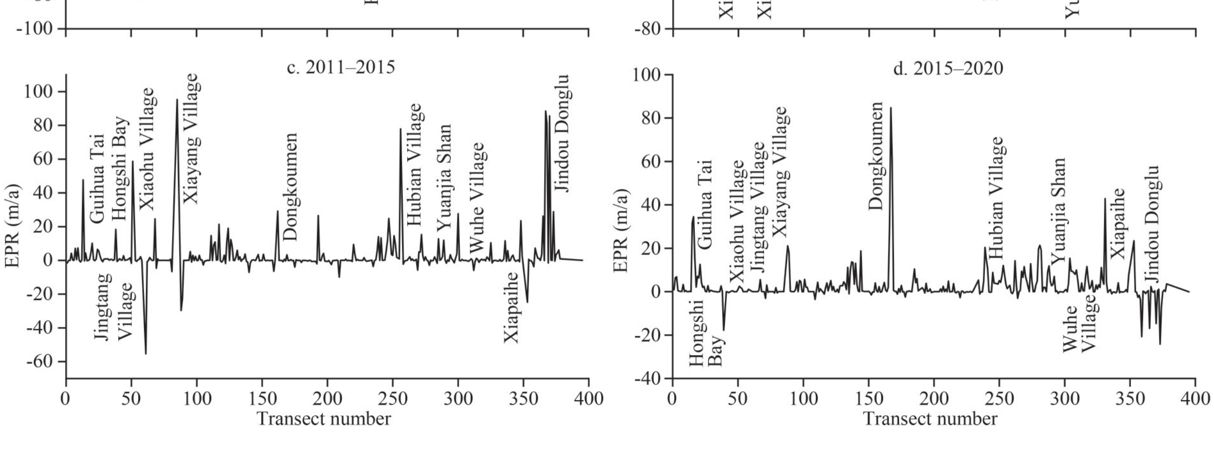

Fig.7 EPR values and spatial distribution for each period (2000–2020)

adjustments. For example, the Nanfei River (an urban wastewater conduit) and the Fengle River (affected by agricultural runoff) delivered substantial sediments and pollutants into the lake, leading to siltation and shoreline instability (Yang and Li, 2019). Since the early 2010s, ecological restoration policies (e.g., converting farmland to lake, wetland rehabilitation) have partially mitigated these impacts, contributing to localized shoreline stabilization and ecological recovery-particularly evident at Guihua Tai and Hongshi Bay after 2015 (Zhang et al., 2022).

In parallel, global warming and climate variability have placed additional pressure on lake hydrology worldwide (Chen et al., 2023). Rising regional temperatures intensify evaporation, exacerbating water loss and shoreline contraction (Zhang et al., 2024). Precipitation anomalies, such as more frequent extreme rainfall and prolonged droughts, further disrupt the lake water balance, causing water-level fluctuation, and episodic shoreline advance or retreat (Alifujiang et al., 2025). These climatic shifts often interact with human impact. For instance, urban expansion and deforestation reduce soil infiltration, amplifying flood-driven sediment delivery during heavy rains, while drought-induced low water levels expose more shoreline to wind-wave erosion. Such compounding effects of climate and anthropologic agents underscore the complexity of the shoreline dynamics.

Geographically, the western part of Chaohu Lake (influenced by the metropolitan expansion of Hefei City) showed higher shoreline change rates (EPR: ~0.73 m/a; LRR: ~0.91 m/a) compared to the eastern part (EPR: ~0.60 m/a; LRR: ~0.47 m/a). This disparity reflects differing human pressures. The western part experienced intensive industrial and residential development, port construction, and tourism infrastructure growth, whereas the eastern part was nourished by natural rivers like the Baishitian River with larger forest cover, thus remained relatively undisturbed (Li, 2019). The rapid shoreline progradation near Jindou Donglu during 2011–2015 could be linked to land reclamation and urban construction projects in Baohe District. Additionally, the western lake is relatively shallow (~2.5-m mean depth) with limited hydrodynamic exchange, making it highly susceptible to wind-wave erosion. Shoreline changes in the west are strongly influenced by fluvial sediment inputs (Bai et al., 2024). The development of Hefei City has undoubtedly placed intense pressures on the western shoreline. Although ecological restoration initiatives have begun in recent years, their effects often lag in time (Li et al., 2024). In contrast, the eastern shore, bordering southwestern Wuwei City and Hanshan County, benefits from its remoteness, lower human disturbance, higher forest/grassland cover, and proactive conservation planning. These factors have enabled more pronounced environmental improvements on the eastern side (Tang et al., 2020). Consequently, shoreline dynamics have been significantly more pronounced in the western part of the lake.

Based on these findings, differentiated management strategies should be implemented for Chaohu Lake shoreline:

Western sector (Hefei side): enforce strict limits on shoreline development and strengthen management of the Nanfei and Fengle River basins. Establish ecological buffer zones in high-erosion areas (e.g., Hongshi Bay) to protect against further degradation.

Eastern sector: preserve the relatively undisturbed state through preventive conservation measures. Protect natural wetland systems (e.g., the Baishitian River inflows) to maintain the area’s high ecological quality.

High-change zones: prioritize sections with drastic change for monitoring and restoration. In particular, address excessive sedimentation near Jindou Donglu and severe erosion near Hongshi Bay with nature-friendly restoration and continuous monitoring.

Lake shoreline evolution is shaped by the interplay between natural processes and anthropogenic influences. Urbanization, for instance, has intensified soil erosion and increased sediment delivery into the lake via riverine networks. These sediments accumulate at river mouths, forming new mudflats that can subsequently facilitate further land reclamation and urban expansion (McVey et al., 2023). Nonetheless, accurately disentangling and quantifying the relative contributions of these drivers remains a challenge.

While this study offers a comprehensive assessment of shoreline changes in Chaohu Lake, several limitations warrant acknowledgment. First, the operational definition of the shoreline—as the apparent land-water boundary derived from remote sensing imagery—effectively captures large-scale changes but may overlook subtle morphological shifts. Secondly, although Landsat’s 30-m spatial resolution is adequate for detecting broad trends, it restricts the detection of fine-scale shoreline dynamics. Thirdly, the absence of synchronized daily water level records limits our ability to evaluate the short-term hydrological influences on apparent shoreline position quantitatively. Furthermore, although key natural and anthropogenic agents were identified, their individual contributions could not be precisely quantified without higher-resolution hydrological and socioeconomic datasets. Lastly, the 2000–2020 study window may not fully reflect long-term cyclical patterns in shoreline behavior. Future research should incorporate higher-resolution satellite imagery, detailed sediment transport records, and extended temporal datasets to better unravel the complex, multi-scale mechanisms underlying shoreline evolution.

5 CONCLUSION

1. From 2000 to 2020, Chaohu Lake's surface area shrank by 2.38 km^2 and its shoreline length shortened by 2.89 km, following a pattern of initial expansion followed by contraction. Specifically, the shoreline expanded by 5.49 km during 2000–2005, then rapidly contracted by 6.63 km from 2005 to 2011. High-intensity change zones were mainly concentrated at Hongshi Bay and Jindou Donglu. The maximum erosion rates reached -22.09 m/a (EPR) and -16.97 m/a (LRR), while the peak accretion rates were 18.50 m/a (EPR) and 20.72 m/a (LRR).

2. Significant spatial disparities in shoreline dynamics were observed between the lake's eastern and western parts. From 2000 to 2020, the western shoreline had a higher annual change rate (EPR: 0.73 m/a; LRR: 0.91 m/a) than the eastern side (EPR: 0.60 m/a; LRR: 0.47 m/a). The western part, adjacent to Hefei, experienced rapid urbanization, pollution inputs, agricultural runoff, and engineering projects, all of which intensified shoreline fluctuations. In contrast, the eastern part benefited from better ecological conditions and minimal human interference.

3. Chaohu Lake's shoreline evolution has been driven by both anthropologic activity and climate change. Urbanization, land reclamation, and pollution inputs directly altered shoreline structure, while global warming and precipitation variability influenced lake water levels and evaporation, exacerbating patterns of shoreline retreat and advance. These findings highlight the need for holistic management strategies that combine human impact mitigation with climate adaptation measures to ensure the sustainable development of the shoreline ecosystem of Chaohu Lake.

6 DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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