Impacts of Land-use Changes on Lakes in Typical Regions of China

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Wuhan University
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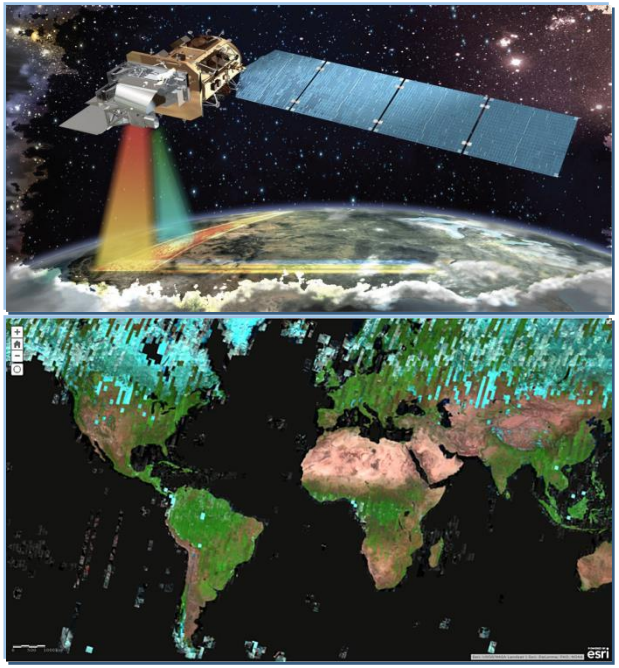
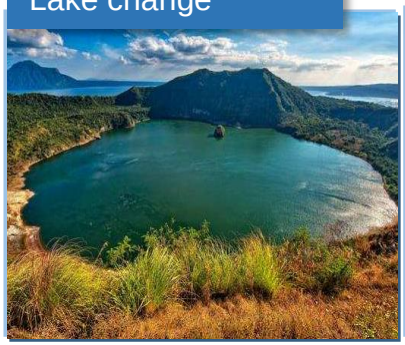
Introduction



Satellite Image

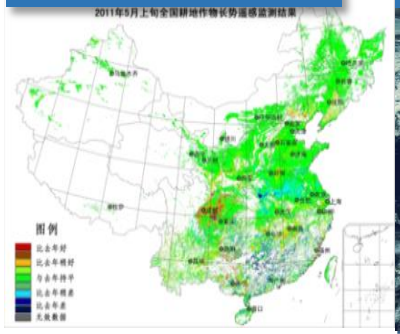
Surface water

Lake change

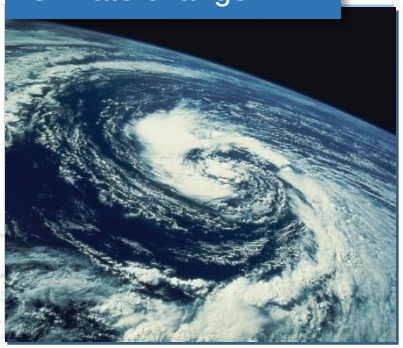


Wetland monitoring

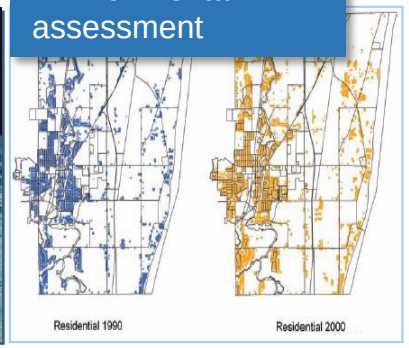
Ecosystem service



Climate change



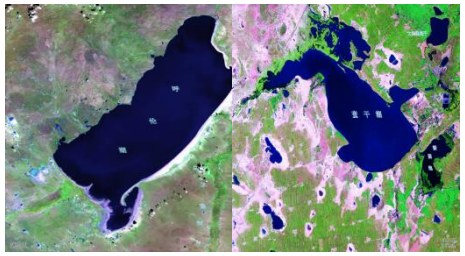
Environmental assessment



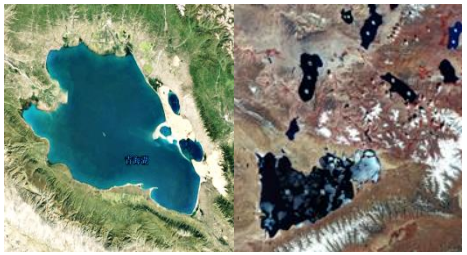
Satellite images can monitor the global or regional surface water change, providing rich information for ecological services, climate change and environmental assessment.

Introduction

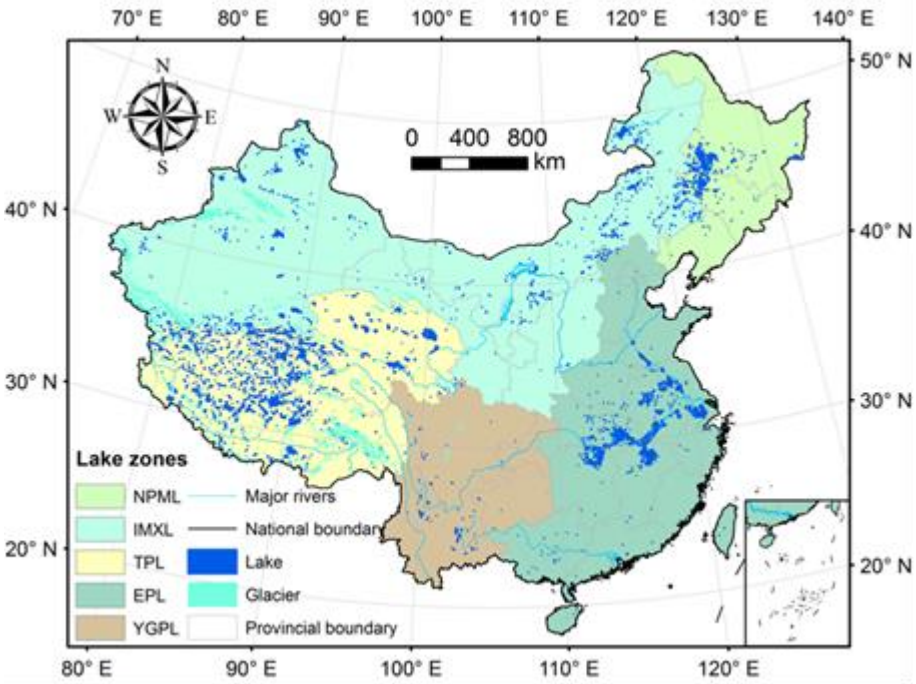
Lakes in China



Freshwater lake

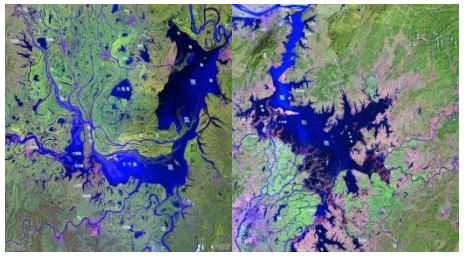


Salt lake



Lakes in populated regions

Urban lake



Freshwater lake

China has a great wealth of lake resources over a great spatial extent. Lakes in populated regions are particularly vulnerable to the influence of various human activities.

01

Introduction

Extensive land-use changes on lakes

Urban expansion

Land reclamation

Fish pond

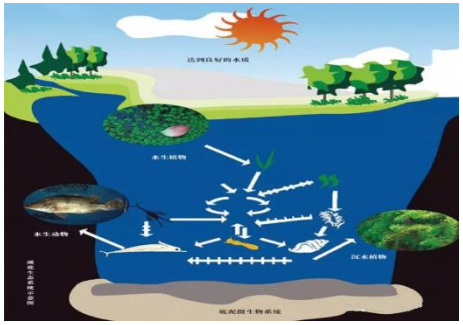
Wetland vegetation

Problems

Lake shrinkage

Sewage discharge

Eutrophication



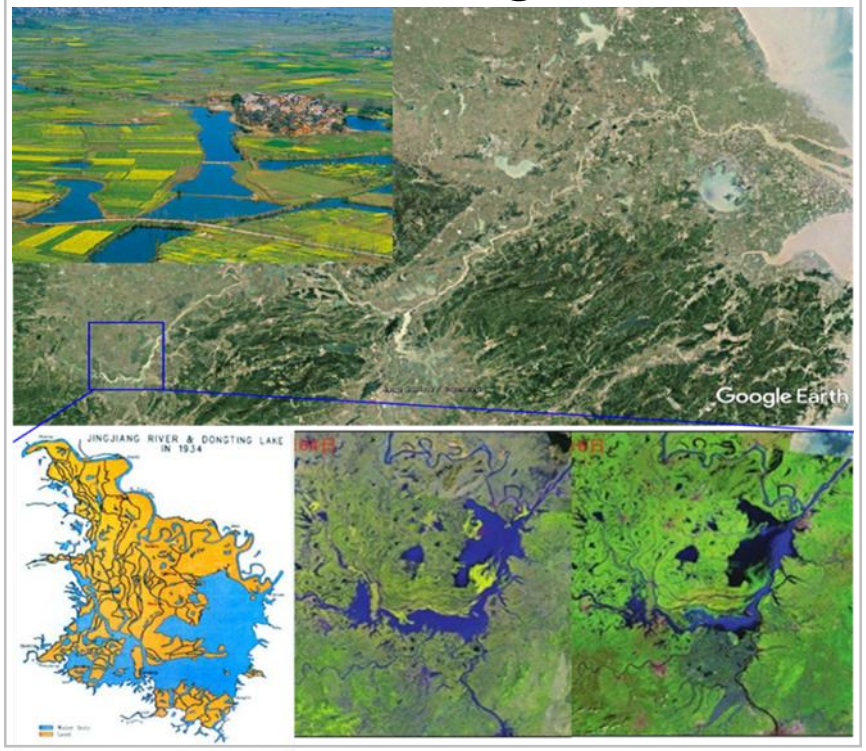
Ecosystem degradation

Lakes in populated regions have been significantly altered by excessive anthropogenic activities, e.g., agricultural irrigation, water diversion projects, and land use changes.

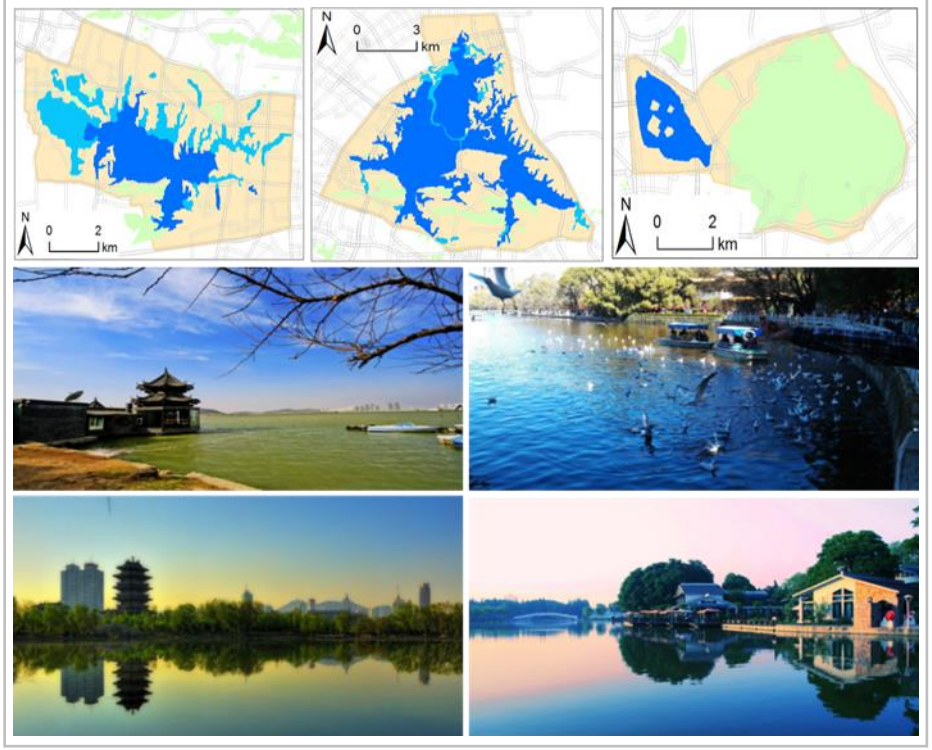
Introduction

☐Lakes in populated regions

Lakes in the Yangtze Basin



Lakes in urban area



Huang *et al*., Impacts of Land-Use Changes on the Lakes across the Yangtze Floodplain in China, *Environmental Science & Technology*, 2017.
Huang *et al*., Spatiotemporal change patterns of urban lakes in China's major cities between 1990 and 2015, *International Journal of Digital Earth*, 2017.
Huang *et al*., Assessing China's lake changes and associated driving forces during 1985–2015, *PE & RS*, 2018.

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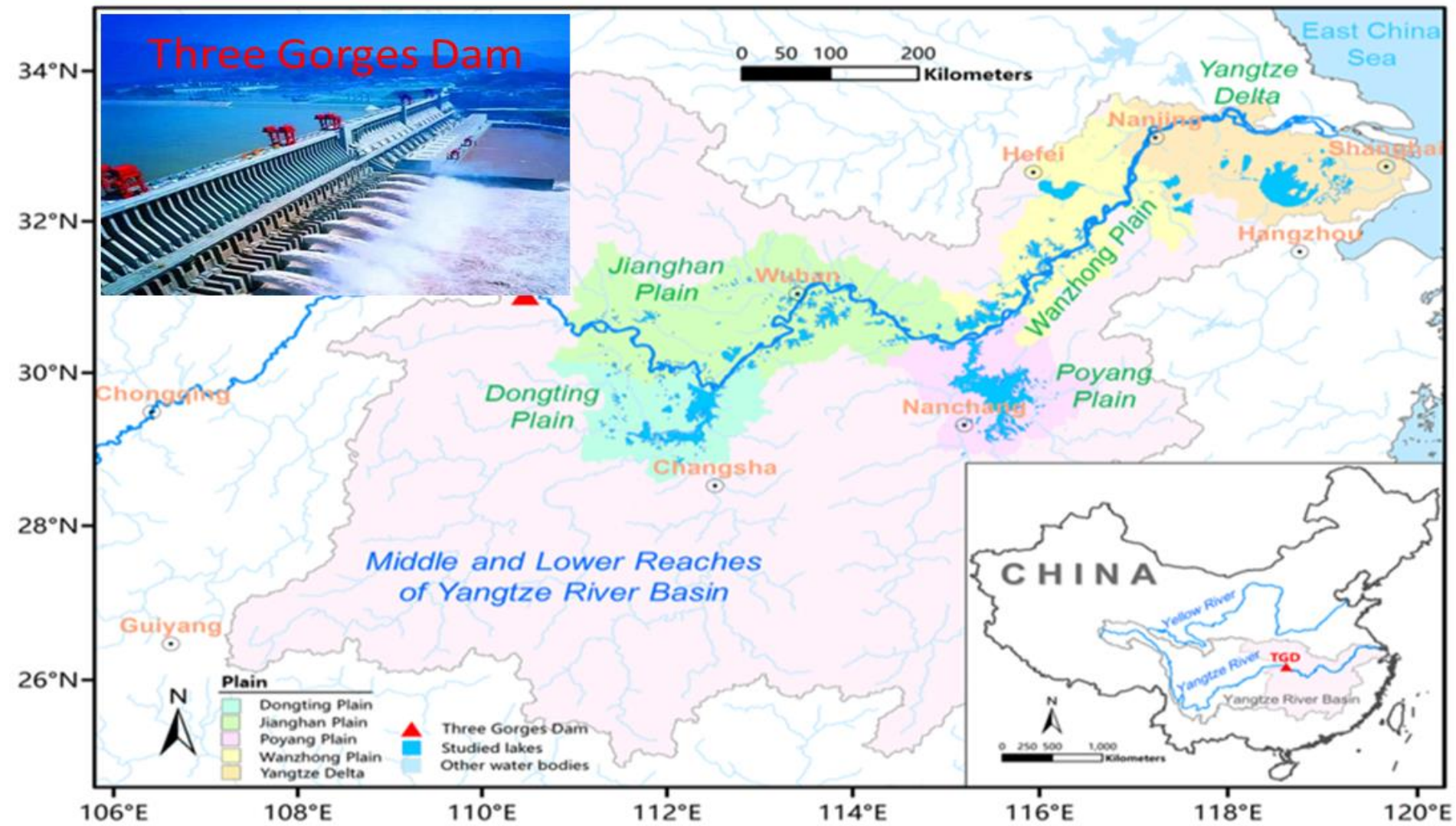
02 Lakes in the Yangtze Floodplain



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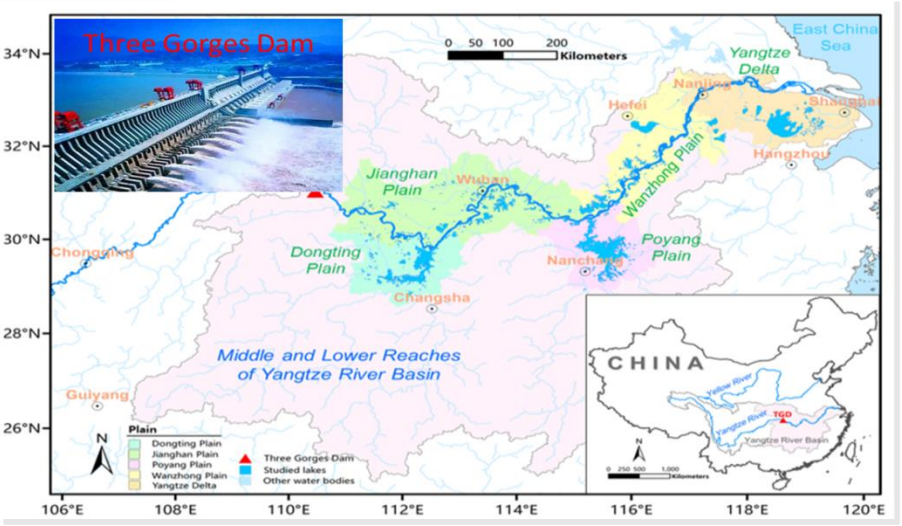
02 Lakes in the Yangtze Floodplain



The lake clusters suffered from long-term lake reclamation due to intensive cultivation, fish rearing, and urban expansion. However, quantitative knowledge about such drivers of lake degradation is unclear.

Extensive land-use changes on lakes

Urban expansion

Land reclamation

Fish pond

Wetland vegetation

Huang *et al*., Impacts of Land-Use Changes on the Lakes across the Yangtze Floodplain in China, *Environmental Science & Technology*, 2017.

02 Lakes in the Yangtze Floodplain

Remote sensing data

- Landsat MSS/TM/ETM+/OLI images
  --United States Geological Survey (USGS, http://www.usgs.gov/)
- Time span: 1975-2015
- Cloud-free images (50)
- Wet season (almost June-October)

Path/row	Acquisition date Around 1975 (MSS)	Path/row	Acquisition date			
			Around 1990 (TM)	Around 2000 (TM)	Around 2010 (TM/ETM+)	Around 2015 (OLI)
128/038	17/10/1977	119/038	07/06/1992	13/06/2000	24/05/2010	22/07/2014
129/038	25/08/1977	120/038	11/07/1990	10/10/2000	03/10/2009	11/08/2013
130/038	26/08/1977	121/038	11/08/1987	15/09/2000	03/05/2009	01/05/2014
130/039	26/08/1977	121/039	15/07/1989	07/10/2002	04/06/2009	09/09/2015
130/040	03/07/1977	121/040	15/07/1989	15/09/2000	20/08/2008	05/08/2014
131/039	31/10/1975	122/039	18/10/1992	18/06/2000	17/10/2009	02/10/2015
132/039	30/06/1978	123/039	02/09/1990	13/09/2000	06/09/2009	06/10/2014
133/039	09/10/1976	124/039	28/07/1992	02/05/2001	18/08/2011	06/05/2014
133/040	06/07/1977	123/040	19/07/1991	25/06/2000	06/09/2009	29/07/2015
133/040	06/07/1977	124/040	28/07/1992	13/09/2000	30/07/2010	28/07/2015

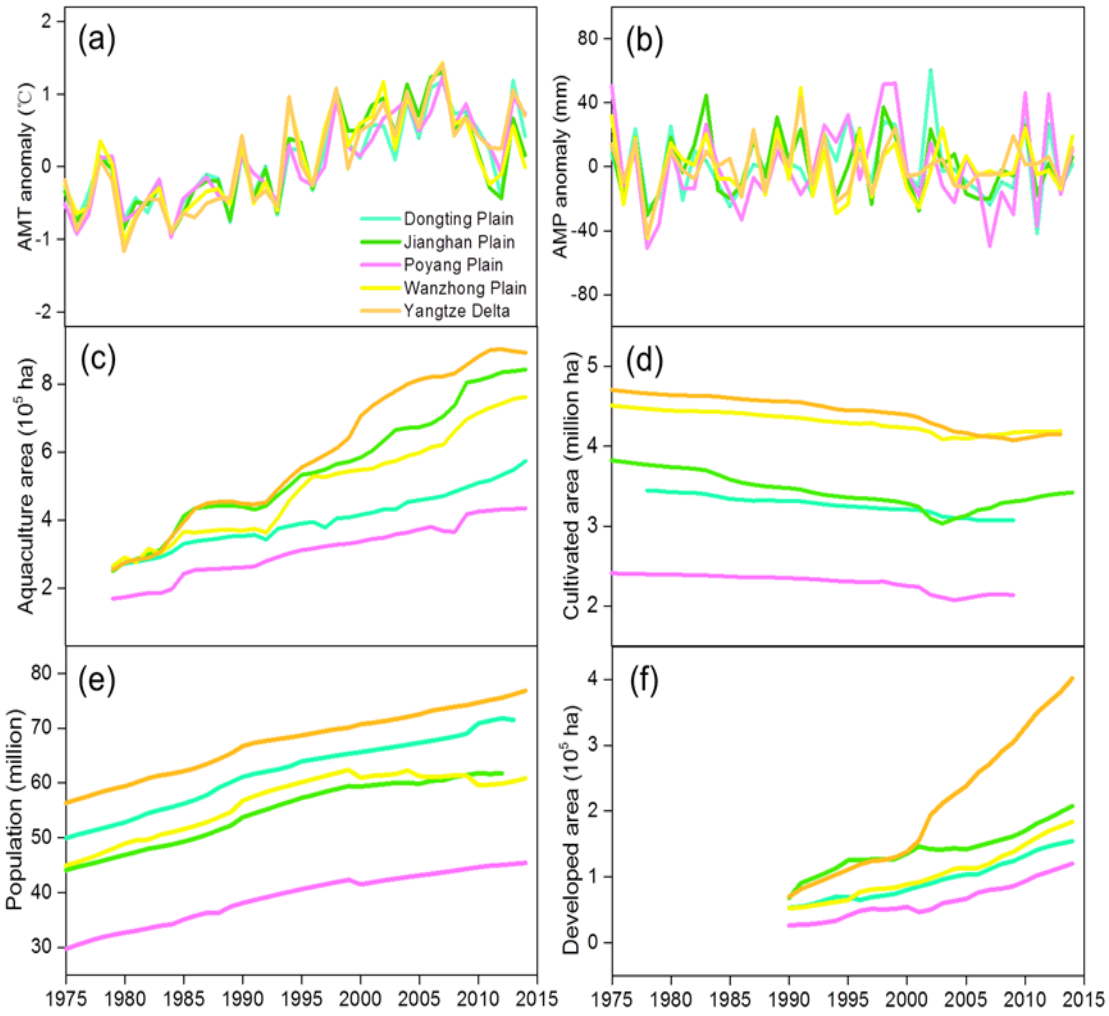
02 Lakes in the Yangtze Floodplain

Climatic data

- Monthly temperature data
- Monthly precipitation data
- Time span: 1975-2015

Socioeconomic data

- Aquaculture area
- Cultivated area
- Human population
- Developed area
- Time span: 1975-2015



02 Lakes in the Yangtze Floodplain

Lake dataset production

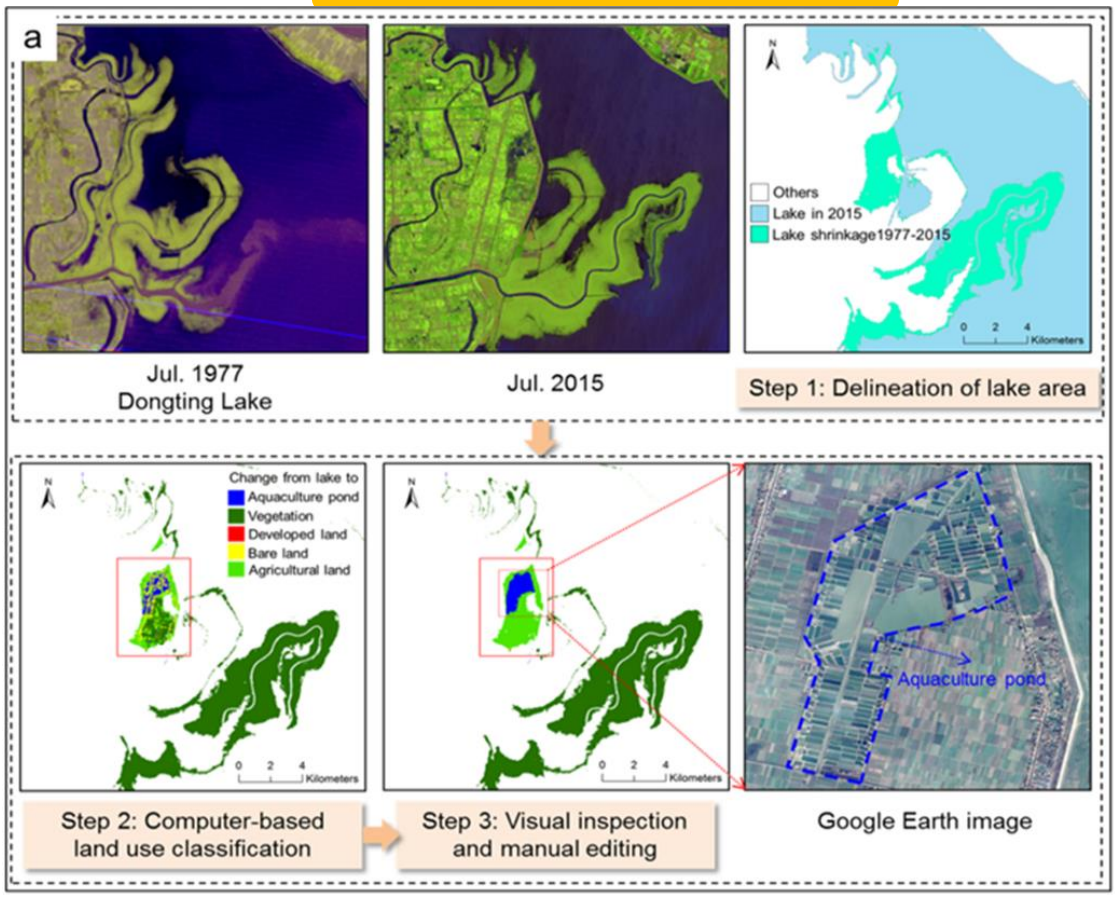
Lake area extraction

- Data: Landsat images (1975-2015)
- Initial extraction: feature index (NDWI/MNDWI)
- Fine extraction: manual editing of lake boundaries

Lake conversion identification

- Change detection: lake boundary overlay
- Initial detection: multi-index land-use classification
- Fine processing: manual correction

① Lake area extraction



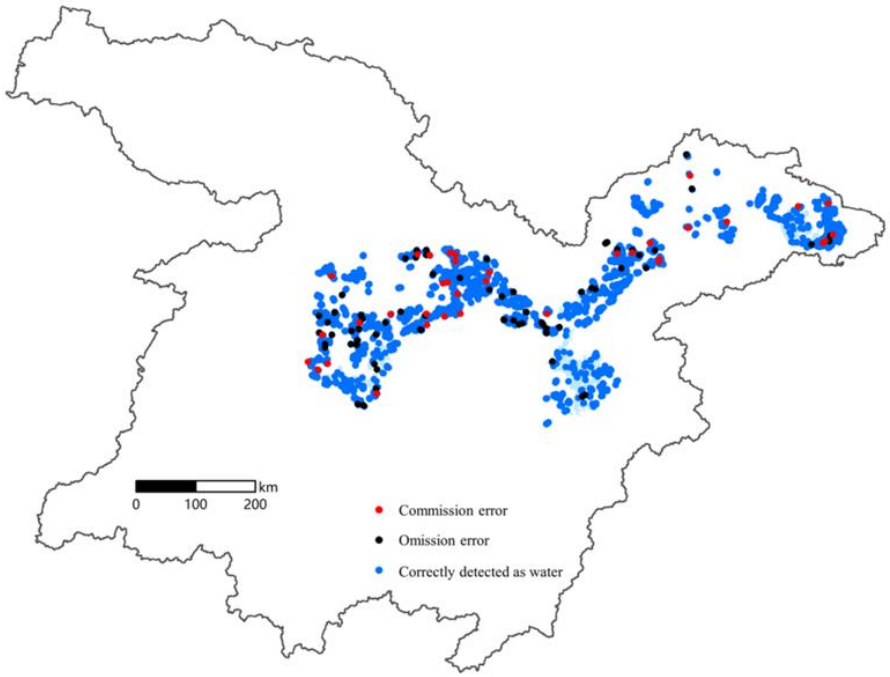
② Lake conversion identification

We established a database of lake changes in the Yangtze Basin by using Landsat images from 1975 to 2015 (spatial resolution: 30 meters).

Lakes in the Yangtze Floodplain

Accuracy validation

- Accuracy of lake mapping
  - A total of 4525 control points
  - Validated by Landsat images and Google Earth images
- Omission error: 2.93%
- Commission error: 1.71%



Accuracy evaluation

		MSS	TM/ETM+	OLI	Overall
Omission	Misclassified as land #	27	23	21	71
	Correctly classified as water #	815	790	749	2354
	Omission accuracy	96.79%	97.17%	97.27%	97.07%
Commission	Misclassified as water #	16	12	8	36
	Correctly classified as water #	711	699	654	2064
	Commission accuracy	97.80%	98.31%	98.79%	98.29%

Lakes in the Yangtze Floodplain

Accuracy validation

- Accuracy of land-use classification
- A total of 1000 validation samples
- Validated by Landsat images and Google Earth images

- Overall accuracy: 92.2% Kappa coefficient: 0.9
- UA and PA of individual classes: ranging from 88.3% to 96.3%

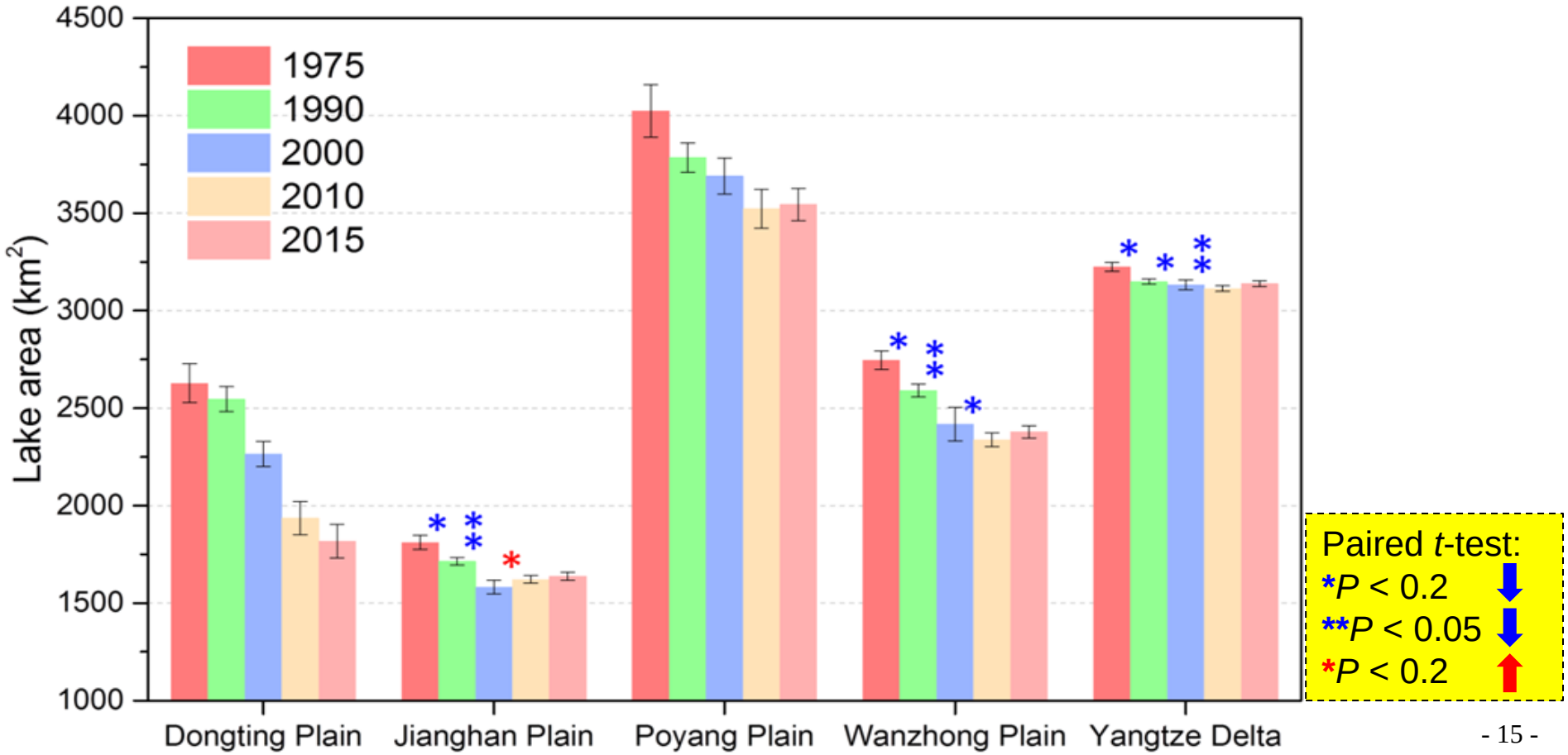
Accuracy evaluation

	Reference class						
Classified class	**Aquaculture pond**	**Vegetation**	**Developed land**	**Bare land**	**Agricultural land**	**Total**	**User's accuracy**
Aquaculture pond	188	4	0	3	5	200	94.0%
Vegetation	7	190	1	1	1	200	95.0%
Developed land	3	3	181	6	7	200	90.5%
Bare land	5	4	2	184	5	200	92.0%
Agricultural land	10	6	4	1	179	200	89.5%
Total	213	207	188	195	197	1000	
Producer's accuracy	88.3%	91.8%	96.3%	94.4%	90.9%		
Overall accuracy	92.2%						
Kappa coefficient	0.9						

02 Lakes in the Yangtze Floodplain

Temporal changes of lake area during 1975-2015

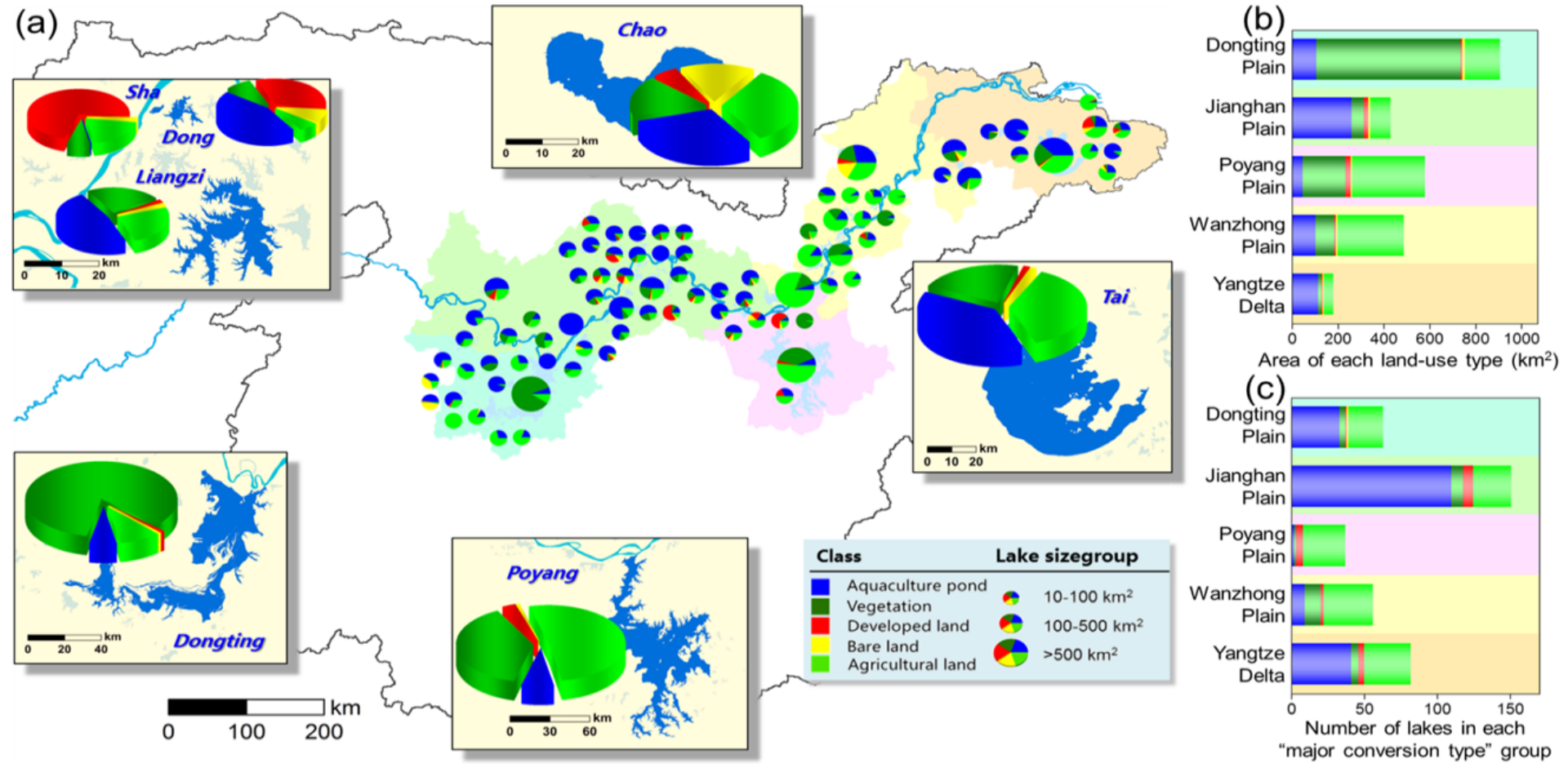
- Rapid loss in total lake area: -2132.3 km^2 (13.8±1.4%); number of lakes: -26 (from 389 to 363)
- Changing trend: rapid reduction during 1975–2000, a slight increase after 2000
- A largest reduction of lake area occurred in Dongting Plain



02 Lakes in the Yangtze Floodplain

Spatial pattern of lake conversion

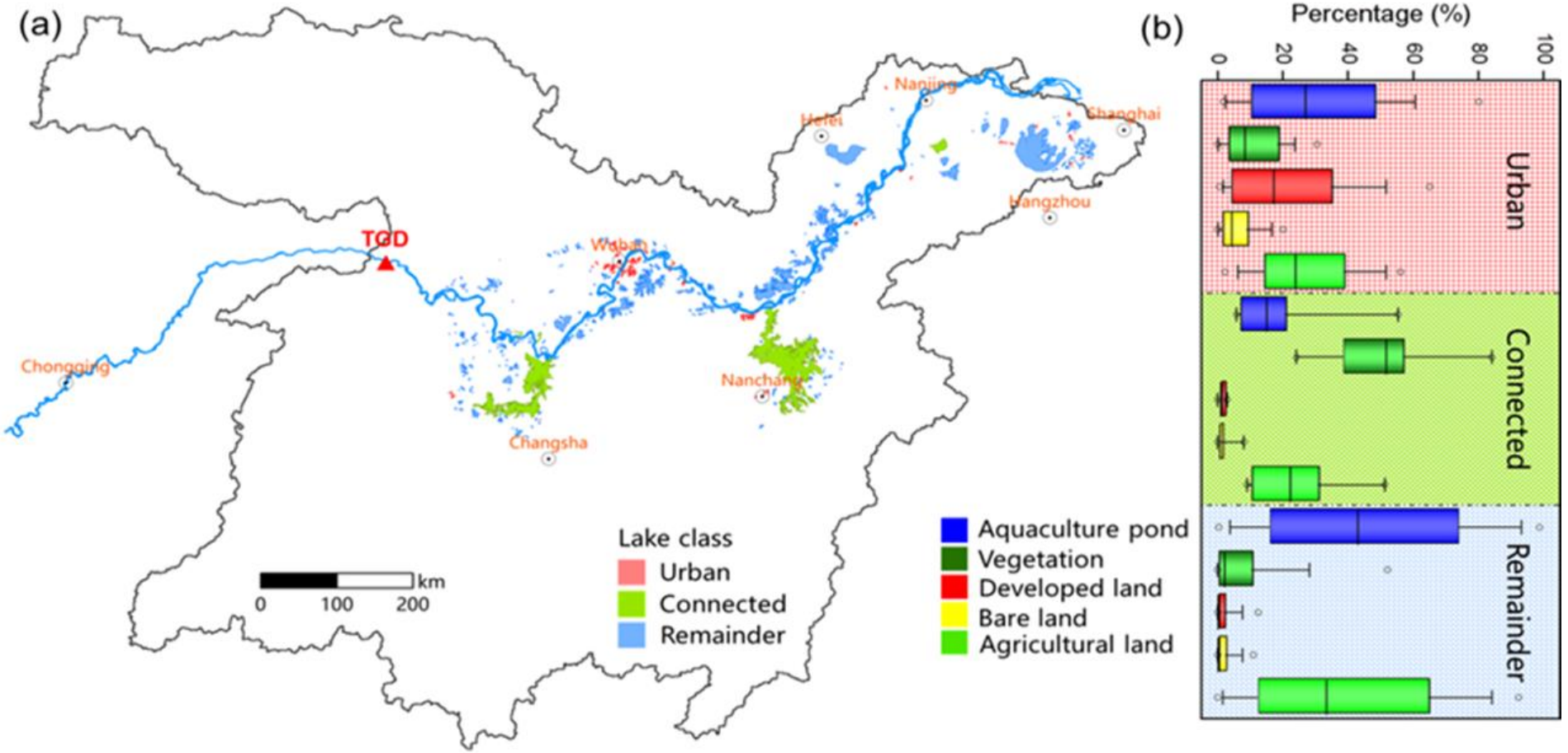
- Lakes were directly converted into cropland (34.6%), aquaculture ponds (24.2%), and built-up areas (2.5%) predominantly due to human-induced land-use changes
- Conversion of lakes into vegetation (37.3%) and bare land (1.4%) can explain remaining lake loss



02 Lakes in the Yangtze Floodplain

Conversion pattern of three lake classes

- Class I (Urban lakes, 63): human settlements (22.2 km^2) under rapid urbanization
- Class II (Connected-Yangtze lakes, 5): wetland vegetation (816.0 km^2) induced by the Yangtze flows
- Class III (Remainder, 321): cropland (45.7%) and fish ponds (39.0%) due to human activities



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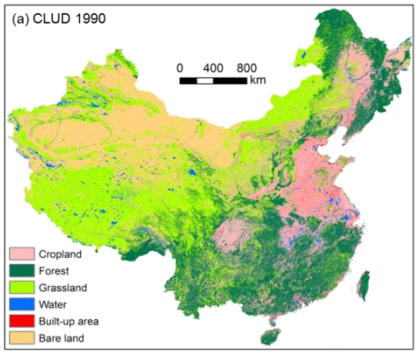
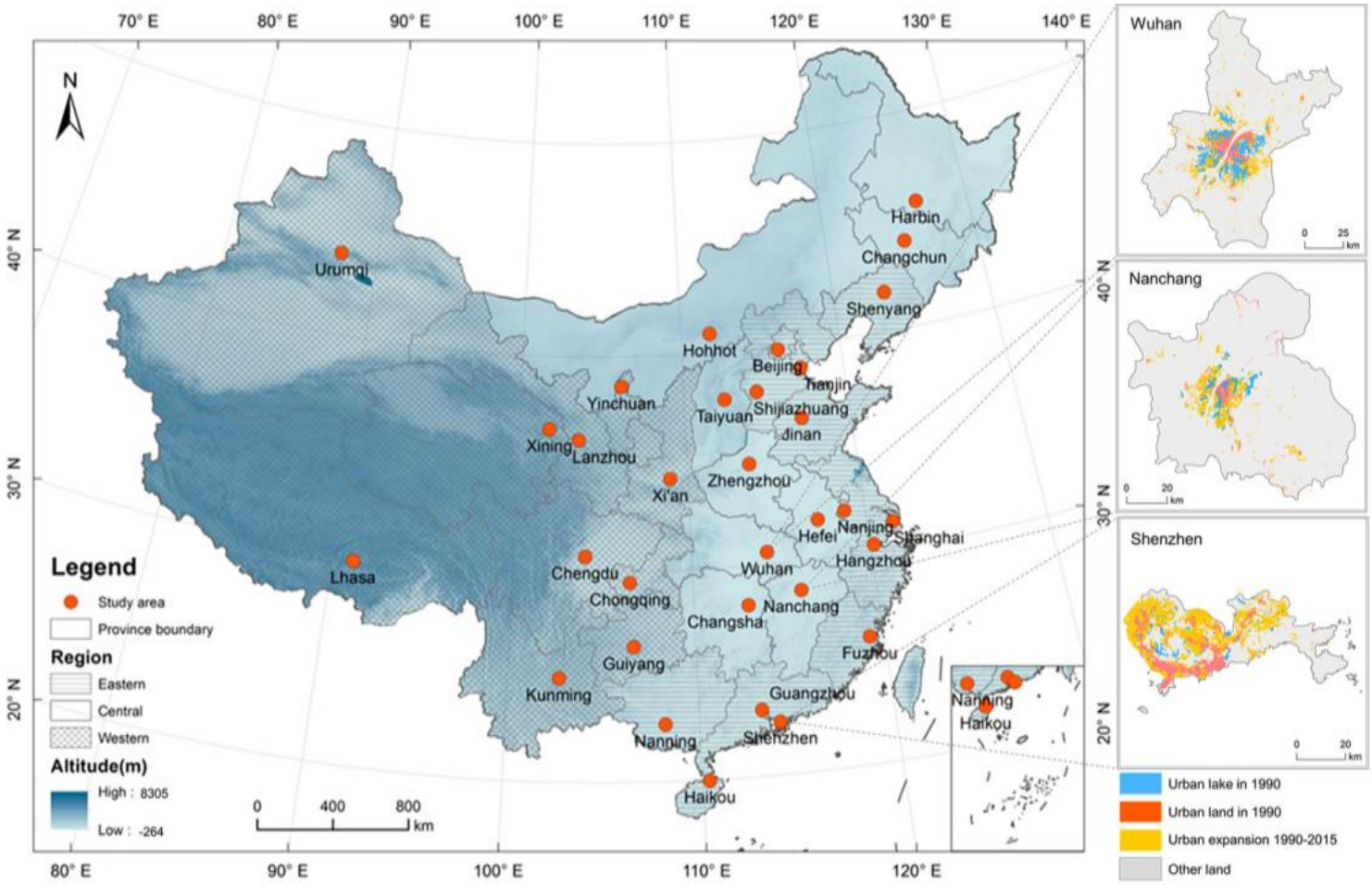
Lakes in urban area

Lakes in 32 major cities of China

China Land Use/cover Data





Huang *et al*., Spatiotemporal change patterns of urban lakes in China's major cities between 1990 and 2015, *International Journal of Digital Earth*, 2017.

Lakes in urban area

Landscape metrics

To quantify the landscape change patterns of urban lakes, we selected six most commonly used landscape metrics.

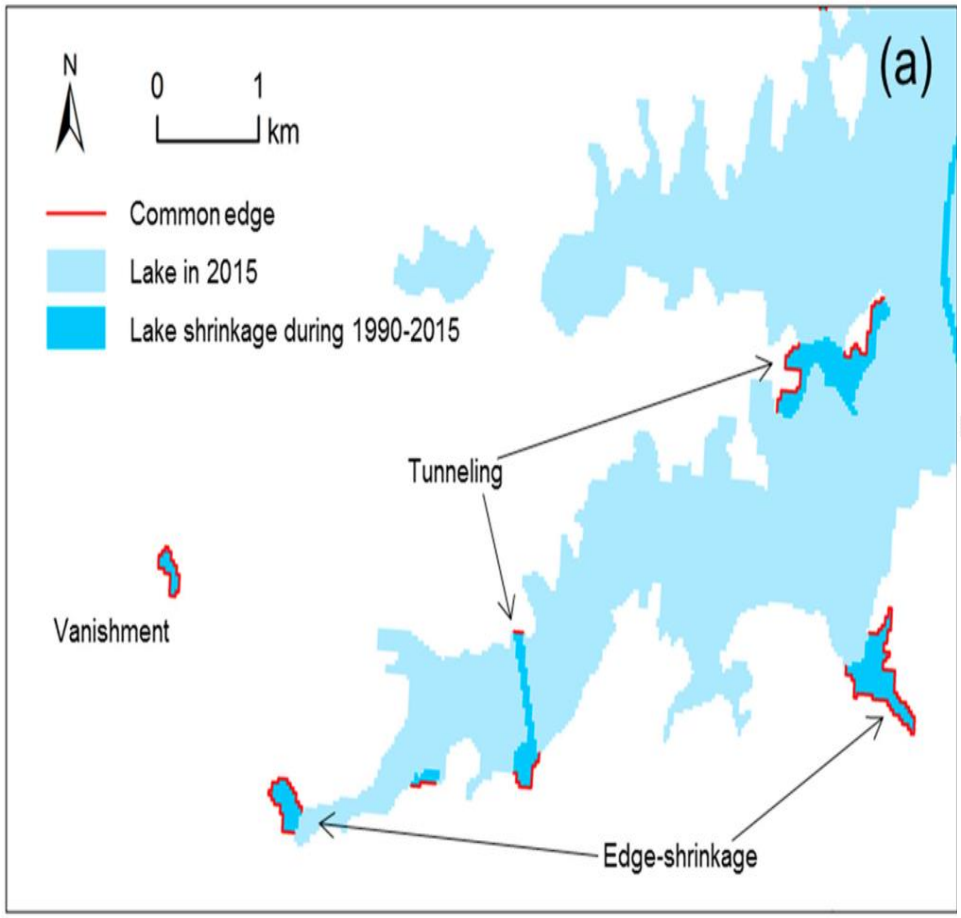
Landscape metrics	Abbreviation	Formula	Description	
Total lake area (ha)	CA	$CA = \sum_{j=1}^{n} a_j (1/10000)$	Absolute size	Size
Number of patches (#)	NP	$NP = n$	Absolute size	Size
Mean patch size (ha)	MPS	$MPS = \frac{\sum_{j=1}^{n} a_j}{n} (1/10000)$	Relative size	Size
Edge density (m/ha)	ED	$ED = \frac{\sum_{j=1}^{n} e_j}{A} (10000)$	Edge metric	Edge
Area weighted mean shape index (unitless)	AWMSI	$AWMSI = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{0.25P_{ij}}{\sqrt{a_{ij}}}\right)\left(\frac{a_{ij}}{A}\right)\right]$	Shape complexity	Shape
Area weighted mean patch fractal dimension (unitless)	AWMPFD	$AWMPFD = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{2\ln(0.25P_{ij})}{\ln(a_{ij})}\right)\left(\frac{a_{ij}}{A}\right)\right]$	Shape complexity	Shape

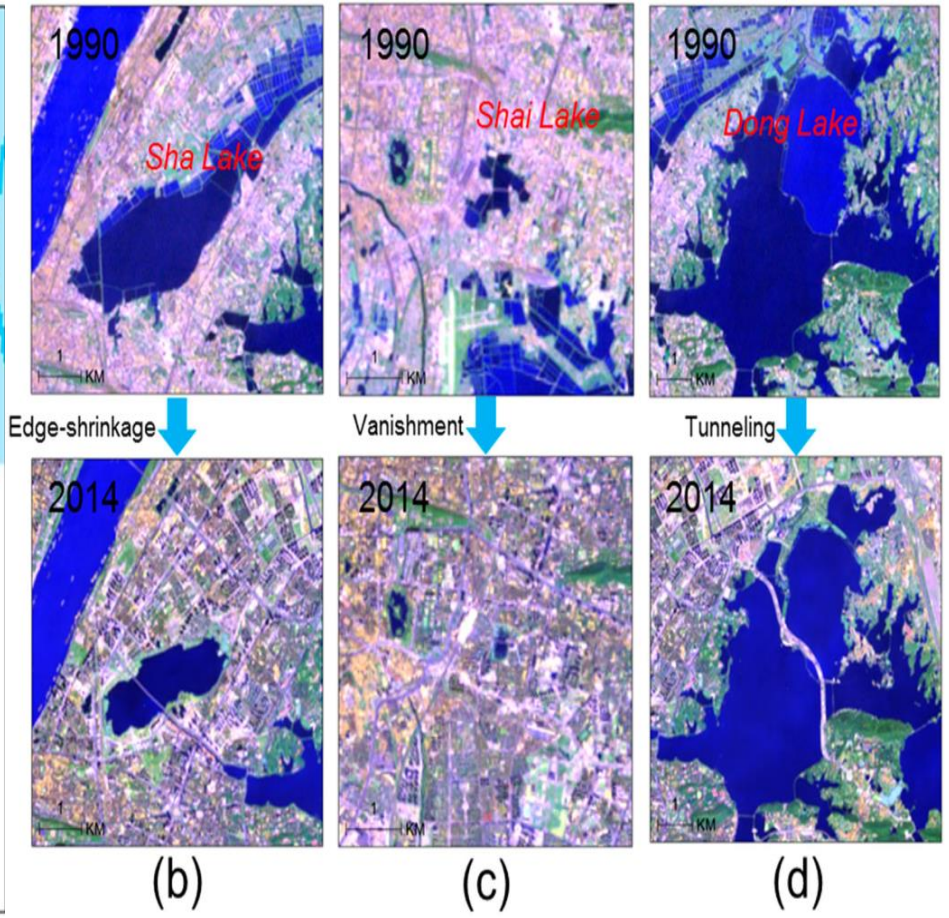
03

Lakes in urban area

Three lake shrinkage types

- Vanishment denotes that an existing lake patch has disappeared
- Edge-shrinkage refers to the fringe of an existing lake being converted to non-lake area
- Tunneling indicates that an urban lake may be segmented by artificial features

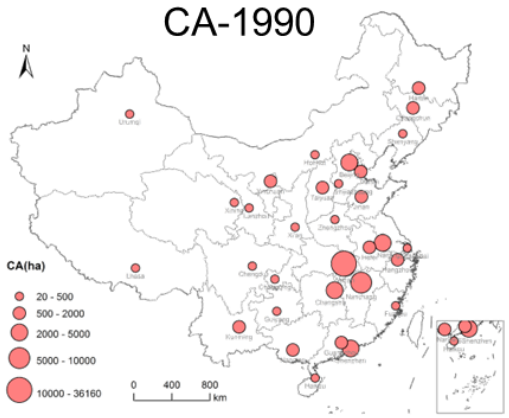


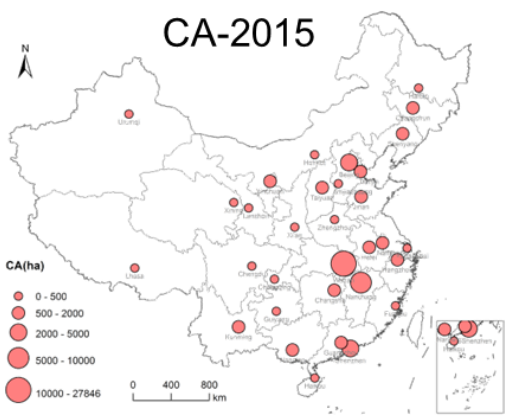


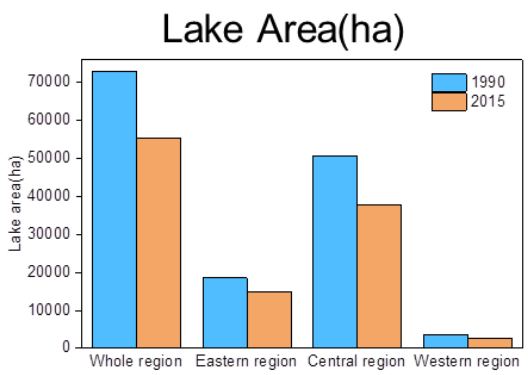
Lakes in urban area

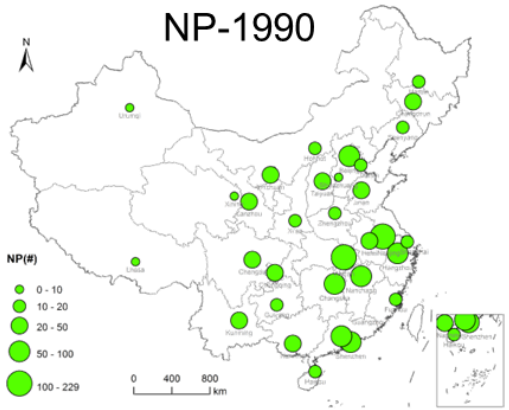
Landscape change pattern of urban lakes

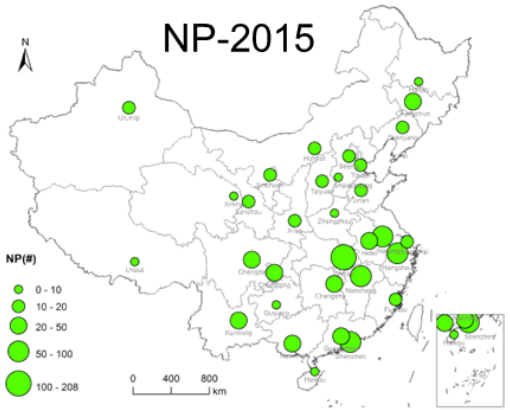
- The total surface area of the associated urban lakes showed a significant decrease of 17,620.02 ha or 24.22% over the 25 years.
- A rapid reduction (30.5%) of the number of lake patches (NP) was also observed.

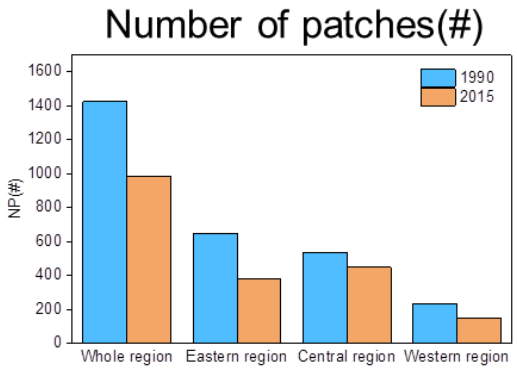








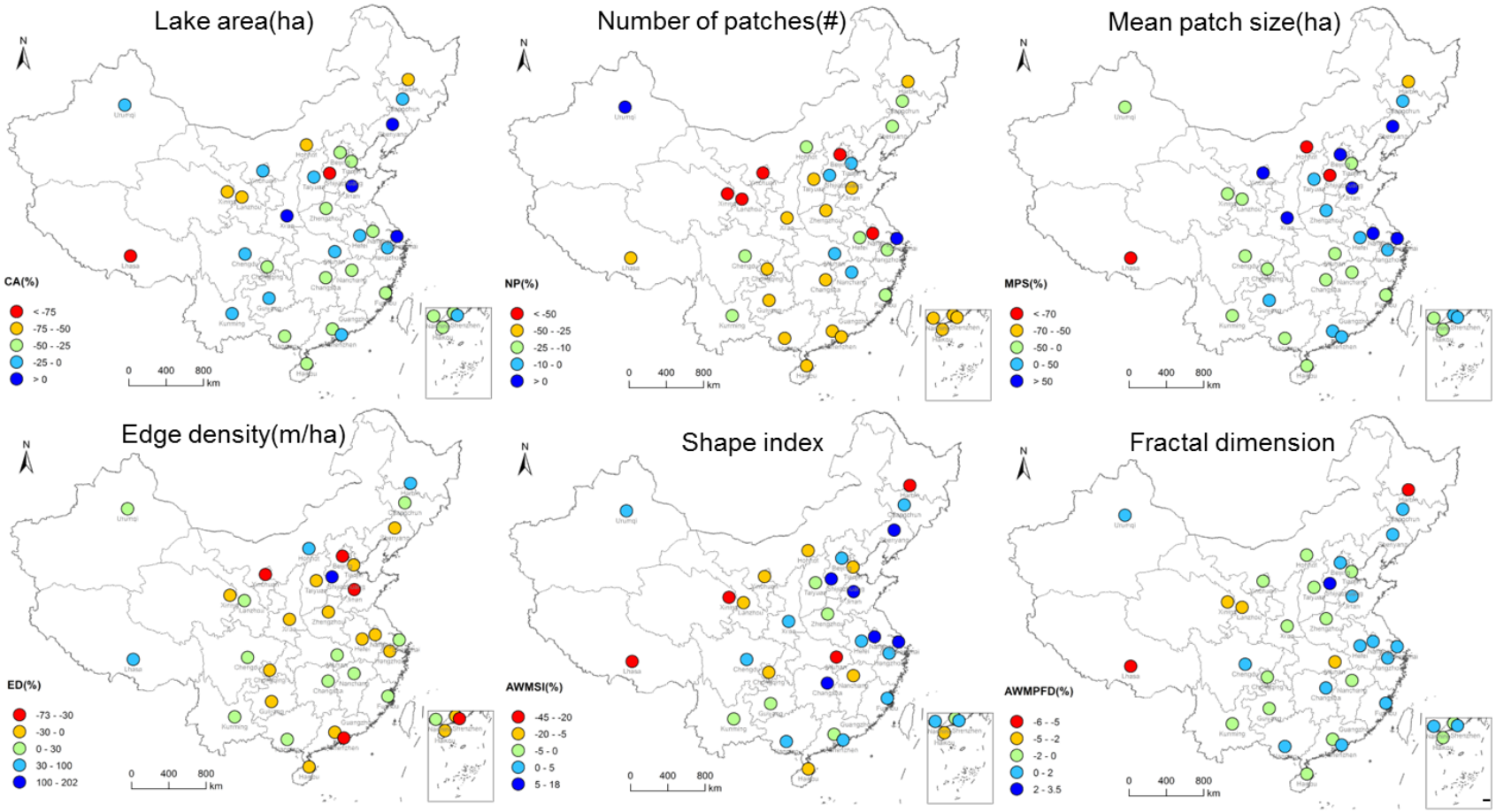




Lakes in urban area

Spatiotemporal dynamics of landscape metrics of urban lakes

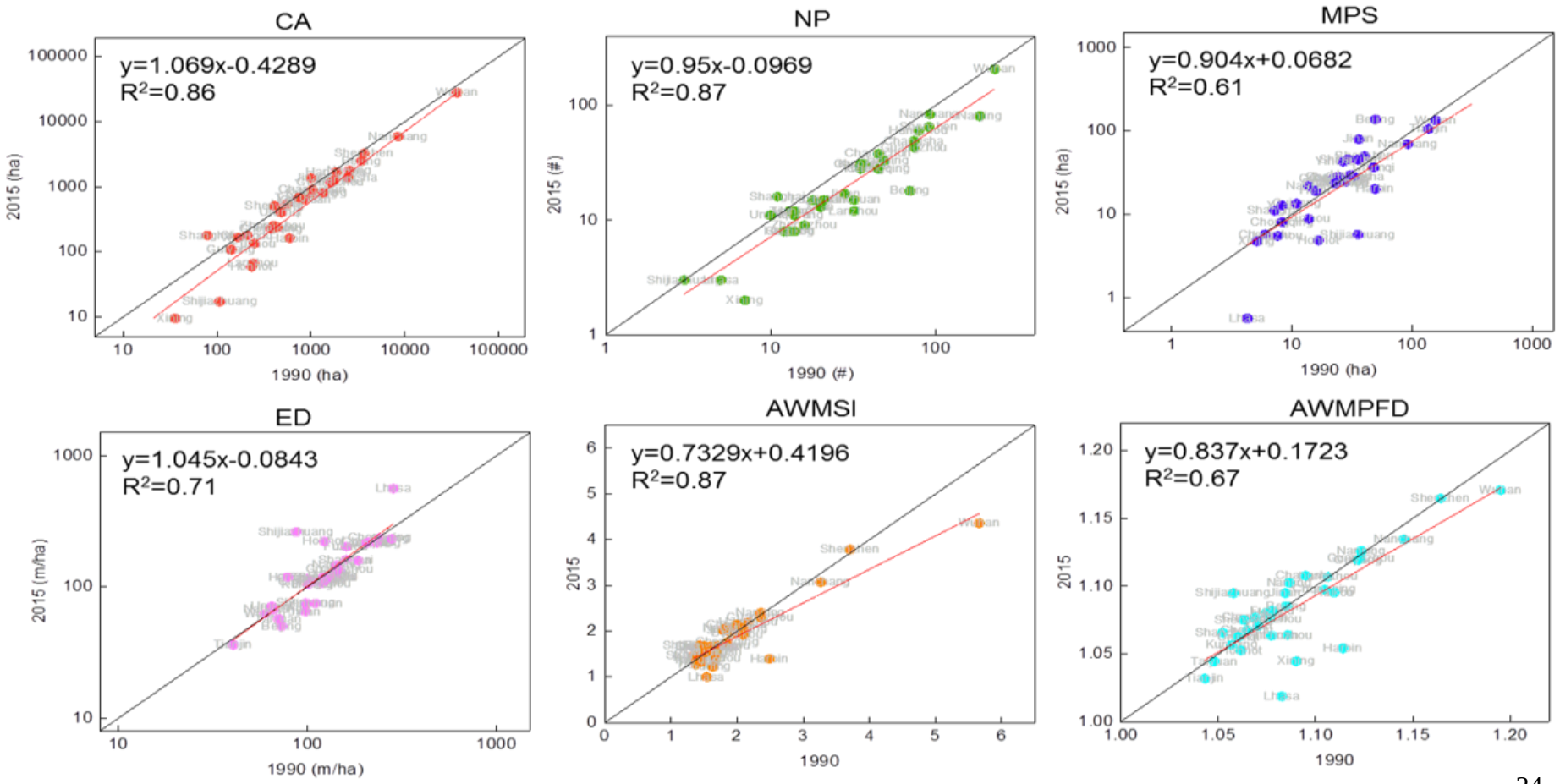
- The largest decline in the number of lake patches was observed in the eastern region (41.14%).
- MPS of lakes in central region has a decrease of 16.65%, suggesting a more fragmented landscape.
- The whole region witnessed a decline in the value of AWMSI, suggesting more regular shape.



Lakes in urban area

Comparison of landscape metrics between 1990 and 2015

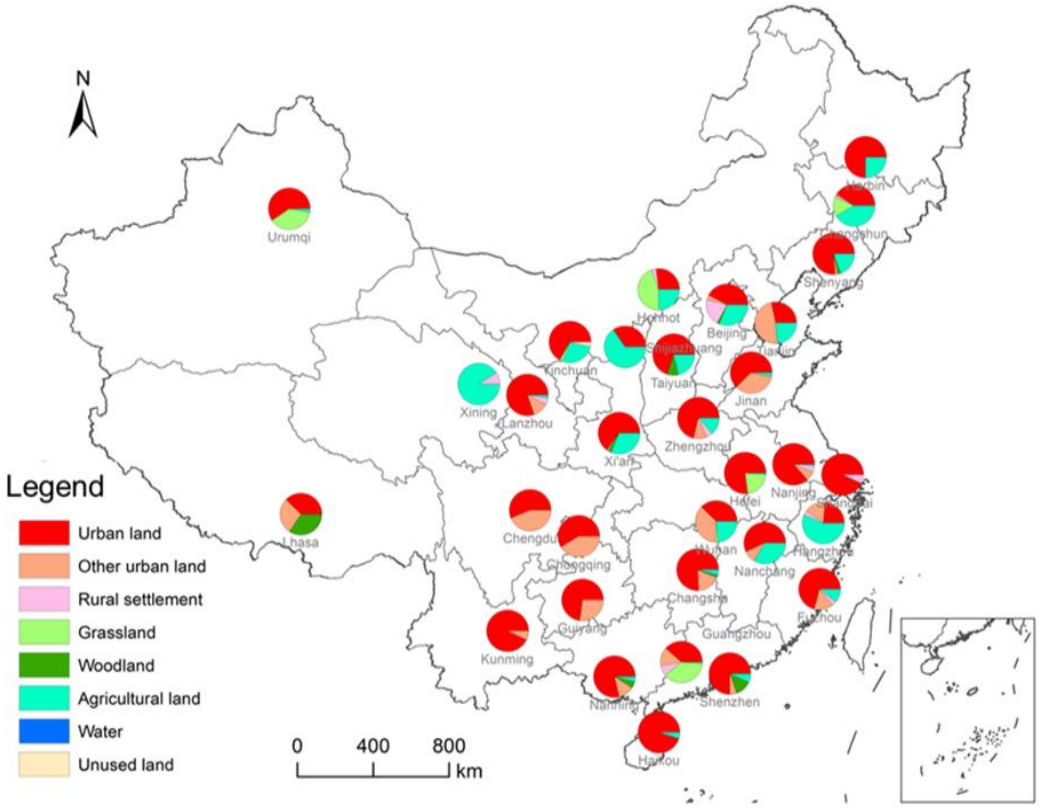
- There is relative consistency for different landscape metrics between 1990 and 2015 ($0.61 \le R^2 \le 0.87$, $p < .05$).



Lakes in urban area

Impacts of land-use change on urban lake

- Lakes were directly converted into urban and industrial land, accounting for 47.05% and 20.84% of the total area loss, respectively.
- The transition from lakes into agricultural land can also explain a large proportion of decline in surface area (i.e. 4967.18 ha, 19.86%), as a result of extensive lake reclamation for cultivated areas.



Urban lake degradation

Contents

Conclusions and prospect

Conclusions

- Impacts of land-use changes on the lakes across the Yangtze Floodplain in China
- Landscape change patterns of urban lakes in China's major cities

Prospect

- High resolution mapping of the nationwide lakes
- Quantitative analysis of driving force of lake changes

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Thanks for your attention!

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