



The biodiversity footprint of urban consumption in China declined by one quarter between 2012 and 2017

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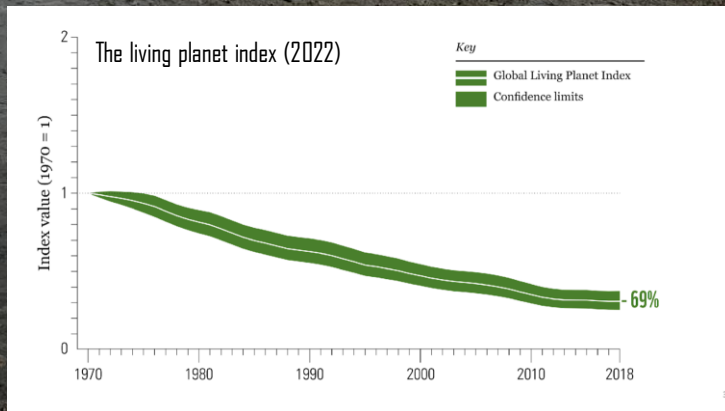
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EAST CHINA NORMAL UNIVERSITY

Background

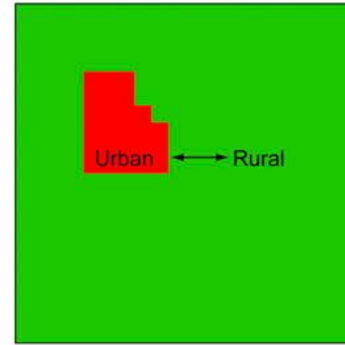
- **Biodiversity is lost and its trend never stops:** The 2022 global LPI shows an average 69% decline in monitored populations between 1970 and 2018.
- The biodiversity crisis is a business crisis: Biodiversity loss ranks as the 3rd global risk by severity over the next 5-10 years to World Economic Forum in Davos 2022.
- Over the last 30 years, global urban land increased from 0.2% to 2.4% of the terrestrial land, and more than half of the world's population now live in urban areas, which has increased people's consumption in urban areas and threatened habitats of species.



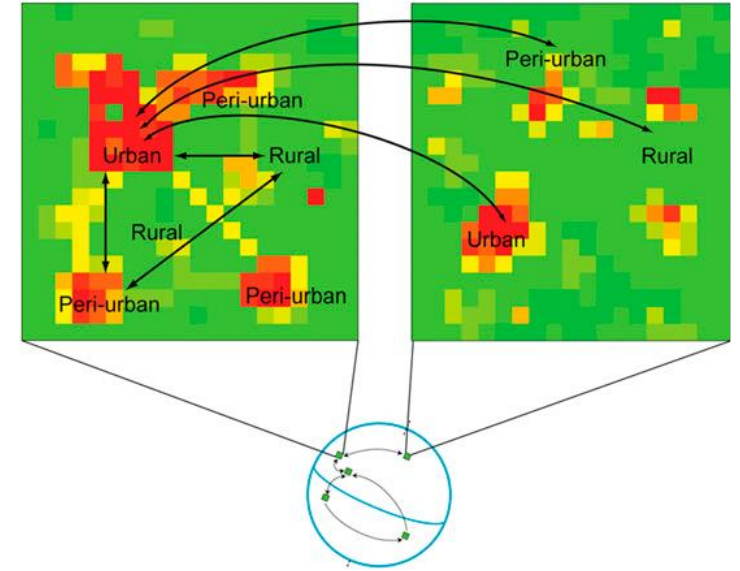
(Living Planet Report, 2022; The Global Risks Report, 2022)



The development of urban systems



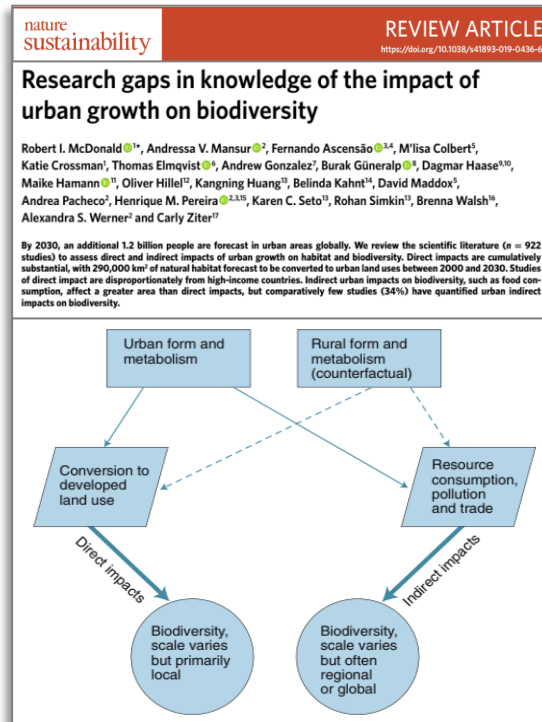
(a) Spatial expansion between urban and rural areas



(b) Teleconnections with land, food, water and other resources

Research Gaps:

- Tele-connected effect of urban consumption on biodiversity at the city level
- Driving forces of this biodiversity impact for different cities



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COMMENT OPEN

Cities should respond to the biodiversity extinction crisis

Cathy Oke^{1,2,3*}, Sarah A. Bekessy⁴, Niki Frantzeskaki⁵, Judy Bush⁶, James A. Fitzsimons^{7,8}, Georgia E. Garrard⁹, Maree Grenfell⁹, Lee Harrison¹⁰, Martin Hartigan¹⁰, David Callow¹¹, Bernie Cotter¹² and Steve Gawler¹³

Cities globally are greening their urban fabric, but to contribute positively to the biodiversity extinction crisis, local governments must explicitly target actions for biodiversity. We apply the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) framework — nature for nature, society and culture — to elevate local governments' efforts in the lead up to the 2021 UN Biodiversity Conference. The UN's Vision of Living in Harmony with Nature can only be realised if cities are recognised and resourced for their roles in biodiversity protection — for nature, for society and for culture.

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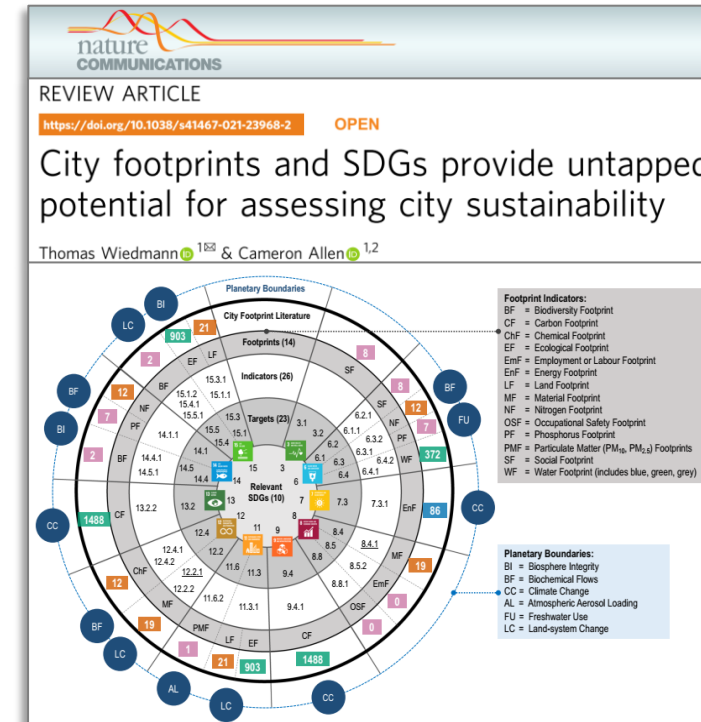
INTRODUCTION

Following the release of the *Global Assessment Report on Biodiversity and Ecosystem Services* (IPBES), awareness of the biodiversity extinction crisis has heightened, catalysing calls for cities and nations to respond. Mass global protests, including youth climate strikes and Extinction Rebellion, and crises such as the Australian bushfires are increasingly engaging local and sub-national governments with these issues. In responses to date, more than 1700 jurisdictions from around the world have declared a climate emergency, many linking their actions on climate change to biodiversity.

The 15th meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP 15), with a theme of *Ecological Civilization: Building a Shared Future for All Life on Earth*, will be held in Kunming, China in 2021. At this gathering, the Post-2020 Global Biodiversity Framework to safeguard nature and its contributions to human well-being will be determined by national governments. This is a vital opportunity to address the extinction crisis alongside the climate emergency, as well as embedding cities' previous and ongoing roles in these global efforts for nature restoration. 'Nature' is understood here as biodiversity (species, habitats and ecosystems) that is native to the region, consistent with the CBD and IPBES. Although non-native species, which are common in cities, can provide important ecosystem services and other benefits, native species (including threatened species) are typically more diverse and abundant in native habitats.

contributing to **biodiversity and civic amenity**⁴. The *CitiesWithNature* platform (<https://citieswithnature.org/>) hosts cities with dedicated strategies on biodiversity and nature-based solutions to share knowledge and create a global community of pioneering local and subnational governments. For example, the cities of Montreal and Melbourne have incorporated biodiversity actions into strategic plans. The city of Edmonton has an extensive network of biodiversity corridors across the city and its periphery. Yet, while these mounting actions show a shift towards biodiversity action at the local scale, for cities to effectively respond to the extinction crisis, nature-based solutions need to explicitly address and deliver on biodiversity conservation.

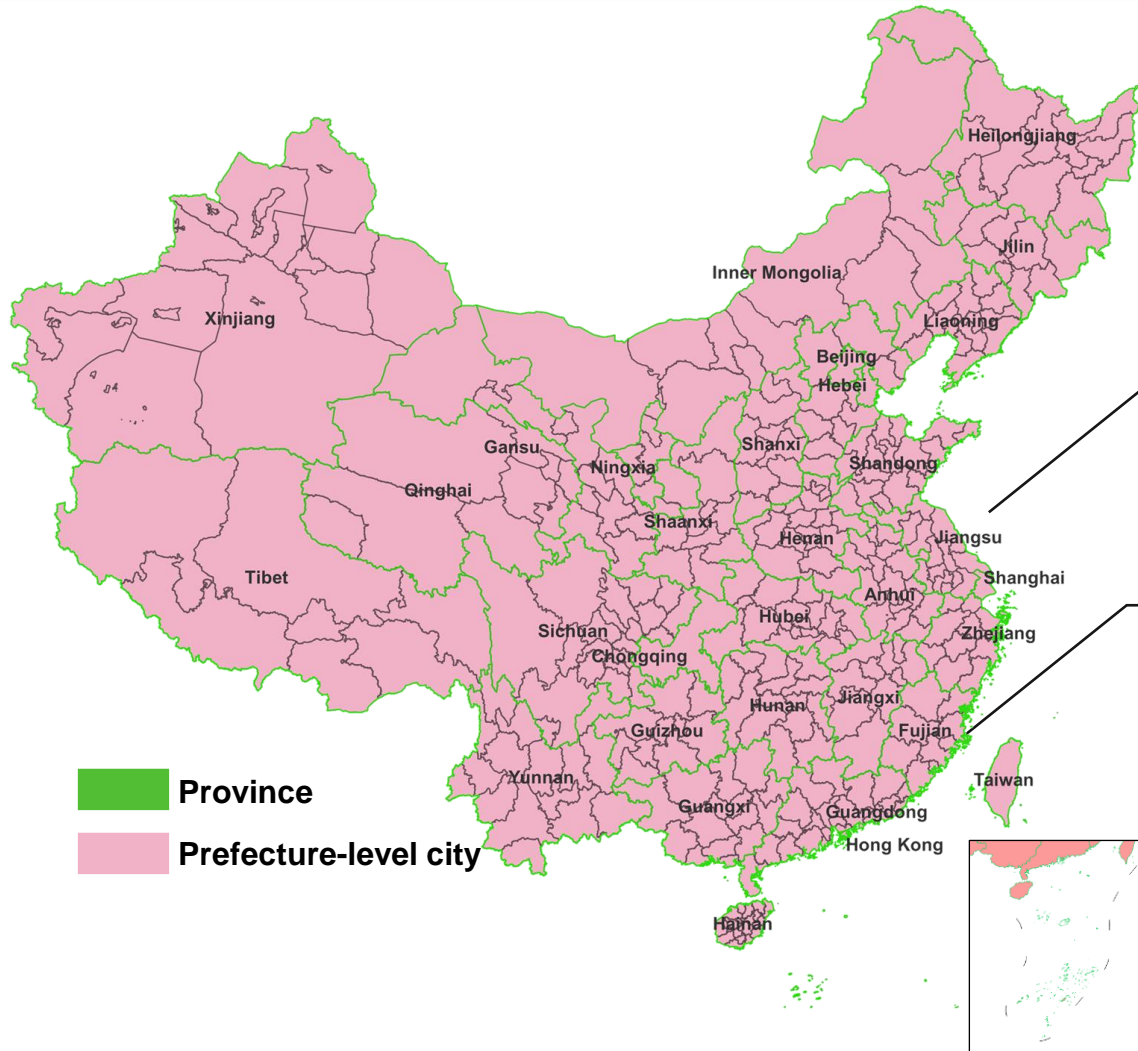
Our **perspective paper** aims to provide strategic direction for addressing the extinction crisis in cities to urban planners, designers, policy makers and researchers. We utilise the IPBES conceptual framework⁵ that positions three dimensions of nature — 'nature for nature', 'nature for society' and 'nature for culture' — to propose a suite of opportunities for effective nature-based solutions to benefit biodiversity. In the following sections, we discuss how urban nature addresses these dimensions and identify priorities for action. We argue that cities' roles in responding to the extinction crisis should be explicitly acknowledged and coordinated, and targeted actions identified to amplify their effectiveness locally and globally. We propose solutions that could form the foundations for a bolder progressive agenda for discussion at the CBD COP 15.



(McDonald et al., 2019, NS; Oke et al., 2021, npj urban sustainability; Wiedmann & Allen, 2021, NC)

Methods

1. Linking the IUCN Red List records with the MRIO table



(a) Downscaled the provincial species records to the prefectural-city level

(i) Species with range maps:
Range map & Administrative map

(ii) Species without range maps:
IUCN records & Administrative map

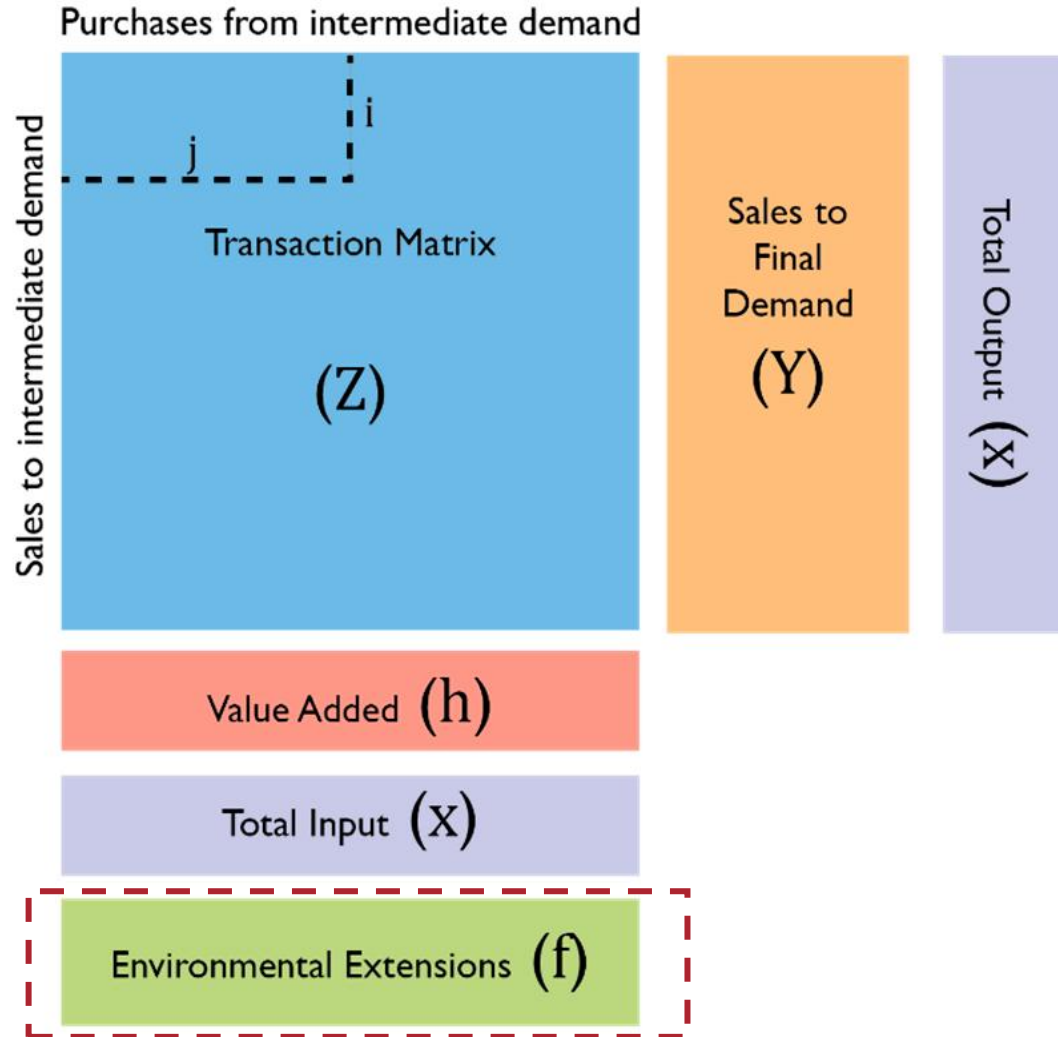
(b) Linking the IUCN Red List records with the MRIO table

Multi-regional IO table structure

Multi-regional IO table for 31 provinces										Multi-regional IO table structure																
Muti-regional Input-Output table			Intermediate Use							Final Demand										Export	Total Output					
			Province 1			...	Province 31			Province 1					...	Province 31										
			Sector 1	...	Sector 42	...	Sector 1	...	Sector 42	F1	F2	F3	F4	F5	...	F1	F2	F3	F4			F5				
Intermediate input	Province 1	Sector 1	Z _{1,1}			...			Z _{1,31}			F _{1,1}					...		F _{1,31}					EX	TO	
		...																								
		Sector 42																								
										
	Province 31	Sector 1	Z _{31,1}			...			Z _{31,31}			F _{31,1}					...		F _{31,31}							
		...																								
		Sector 42																								
Import			IM _{inter use}							IM _{final demand}																
Value added	Compensation of employees		V _{1,1}			...			V _{1,31}																	
	Net taxes on production		V _{2,1}			...			V _{2,31}																	
	Depreciation on the fixed capital		V _{3,1}			...			V _{3,31}																	
	Operations surplus		V _{4,1}			...			V _{4,31}																	
Total input			TI																							

Environmental extension/Satellite account Q

2. Environmentally-extended MRIO model

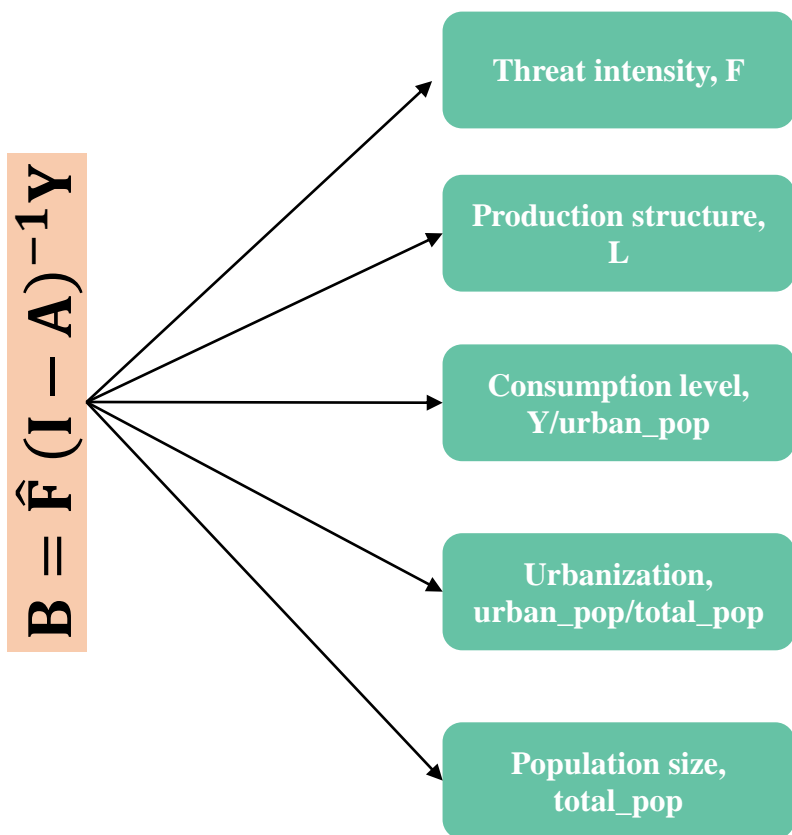


$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{Y}$$

$$\mathbf{F} = \mathbf{f} / \mathbf{X}$$

$$\mathbf{B} = \hat{\mathbf{F}} (\mathbf{I} - \mathbf{A})^{-1} \mathbf{Y}$$

3. structural decomposition analysis (SDA)



Threat intensity:

$$f(\Delta \hat{F}) = \frac{1}{2} \Delta \hat{F} (I - A_{t0})^{-1} V_{t0} U_{t0} P_{t0} + \frac{1}{2} \Delta \hat{F} (I - A_{t1})^{-1} V_{t1} U_{t1} P_{t1}$$

Production structure:

$$f(\Delta (I - A)^{-1}) = \frac{1}{2} \hat{F}_{t1} \Delta (I - A)^{-1} V_{t0} U_{t0} P_{t0} + \frac{1}{2} \hat{F}_{t0} \Delta (I - A)^{-1} V_{t1} U_{t1} P_{t1}$$

Consumption level:

$$f(\Delta V) = \frac{1}{2} \hat{F}_{t1} (I - A_{t1})^{-1} \Delta V U_{t0} P_{t0} + \frac{1}{2} \hat{F}_{t0} (I - A_{t0})^{-1} \Delta V U_{t1} P_{t1}$$

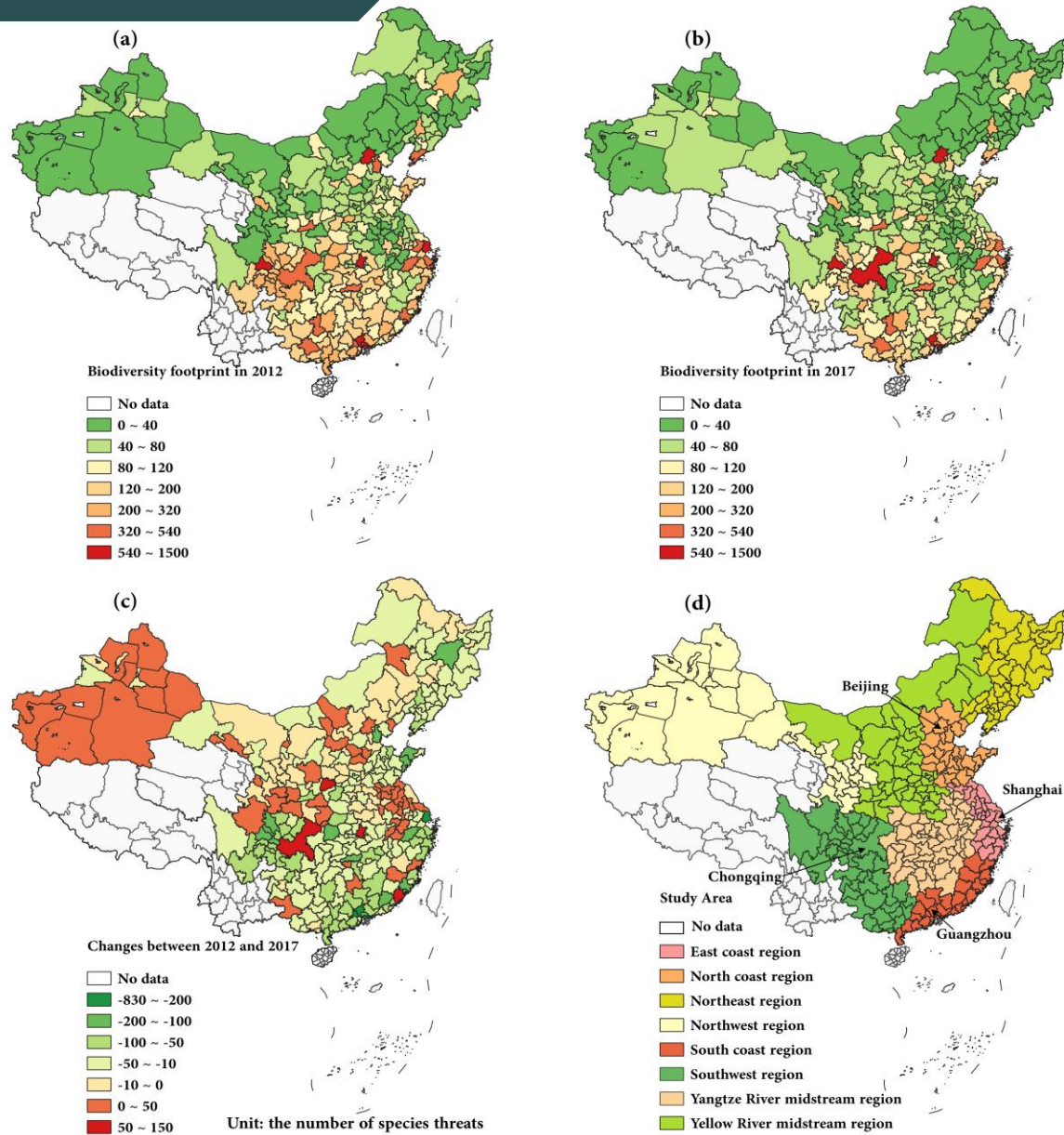
Urbanization:

$$f(\Delta U) = \frac{1}{2} \hat{F}_{t1} (I - A_{t1})^{-1} V_{t1} \Delta U P_{t0} + \frac{1}{2} \hat{F}_{t0} (I - A_{t0})^{-1} V_{t0} \Delta U P_{t1}$$

Population size:

$$f(\Delta P) = \frac{1}{2} \hat{F}_{t1} (I - A_{t1})^{-1} V_{t1} U_{t1} \Delta P + \frac{1}{2} \hat{F}_{t0} (I - A_{t0})^{-1} V_{t0} U_{t0} \Delta P$$

Results

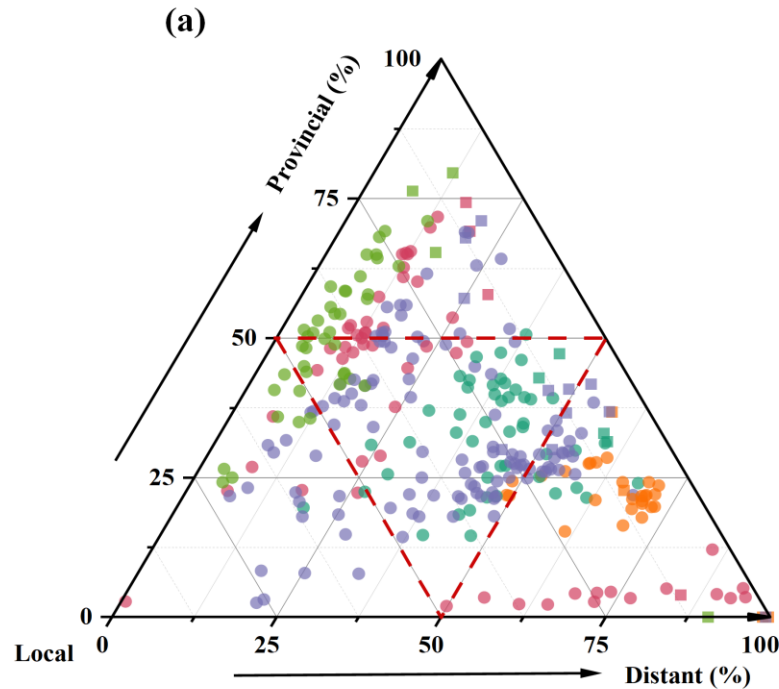


1. Urban consumption-embodied biodiversity footprint in China

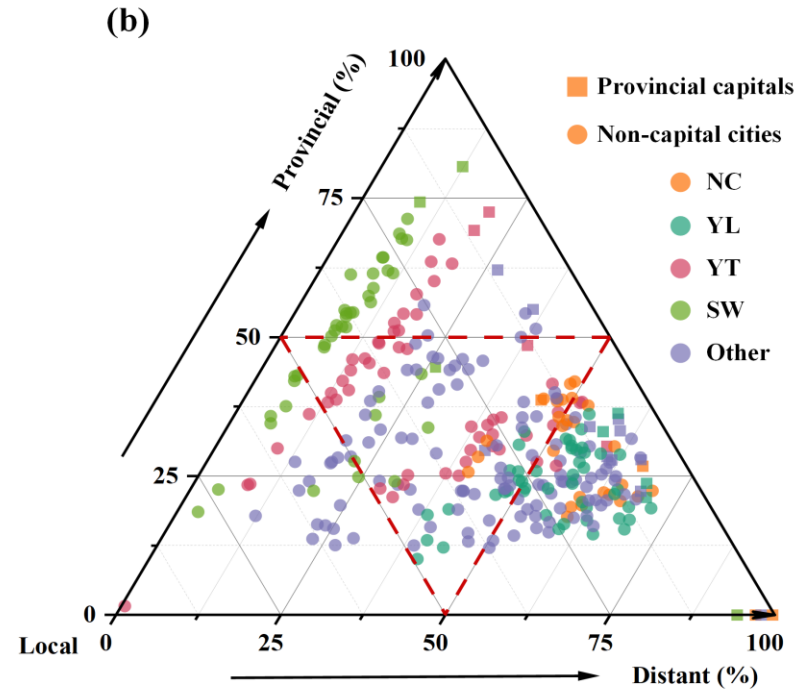
- evenly distributed at the city level;
- Approximately 24% of urban consumption-embodied biodiversity footprint reduced

Figure 2. Urban consumption-embodied biodiversity footprint at the city level across China (a) in 2012, (b) in 2017, (c) changes in biodiversity footprint between 2012 and 2017, and (d) the study area.

2. Change in the composition of biodiversity footprint



Composition of biodiversity footprint in 2012

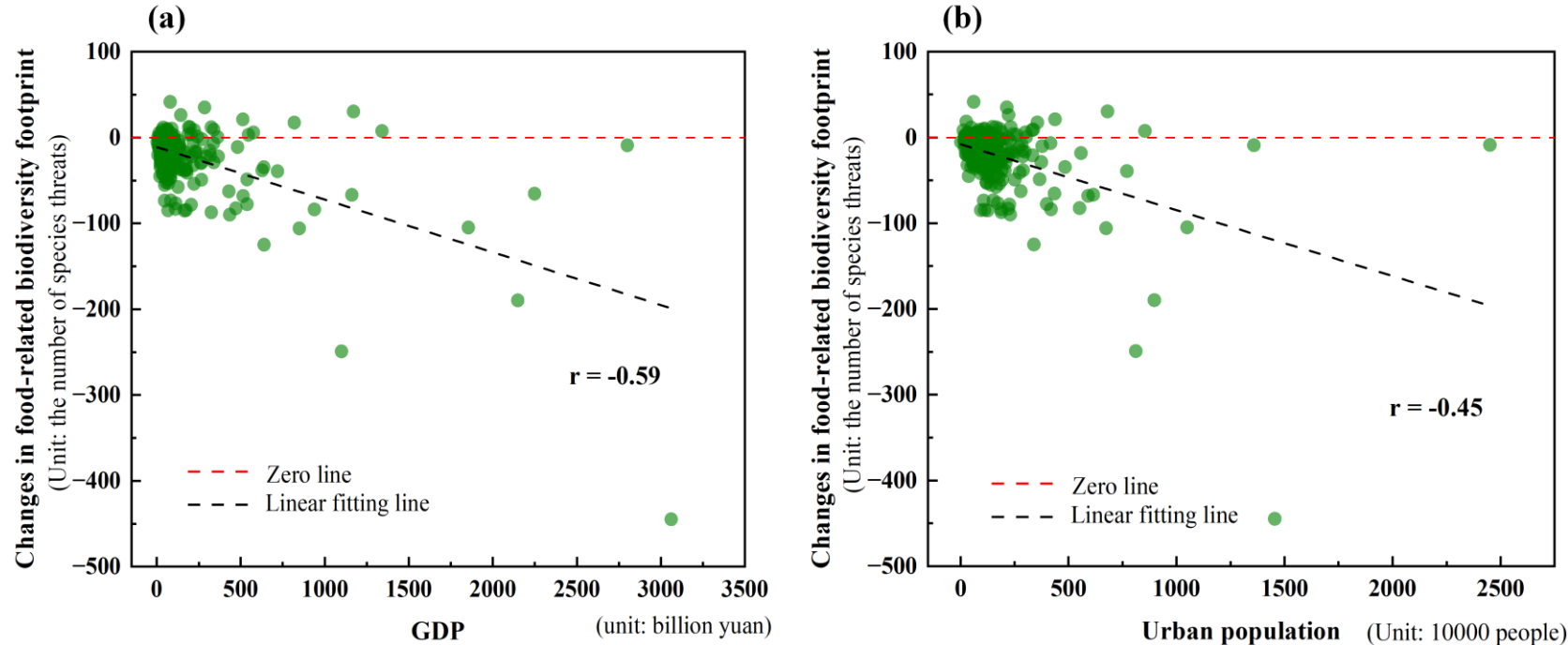


Composition of biodiversity footprint in 2017

➤ A greater share of biodiversity footprint was shifted beyond cities' borders

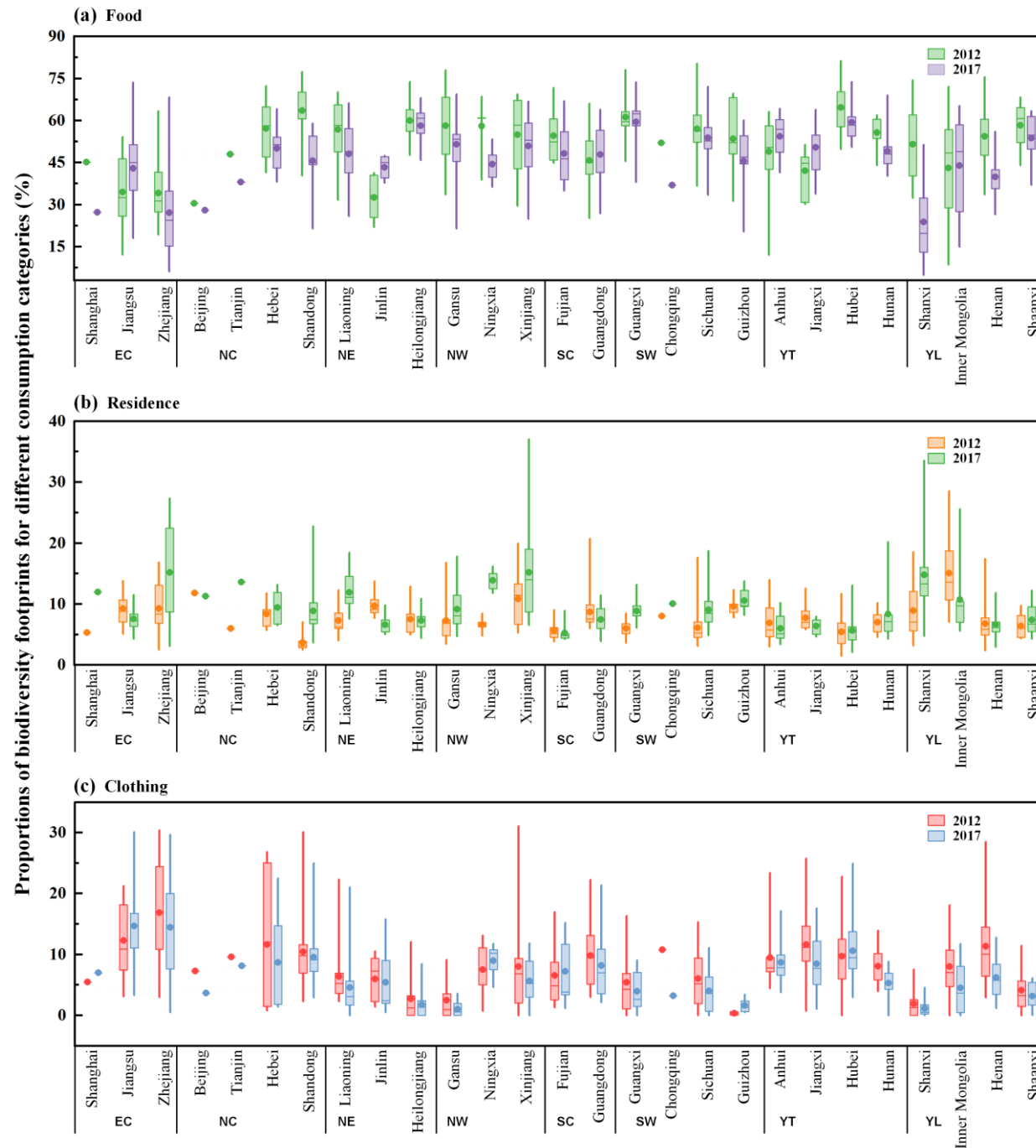
Figure 3. The composition of urban consumption-embodied biodiversity footprint in (a) 2012 and (b) 2017. Squares and dots in ternary diagrams represent the provincial capitals and non-capitals, respectively. NC: north coast region, YL: the Yellow River midstream region, YT: the Yangtze River midstream region, SW: southwest region, Other: east coast, northeast, northwest, and south coast regions.

3. Biodiversity footprint variation across consumption categories



➤ the reduction in food-related footprint was the dominant part of the large-scale shrinkage in biodiversity footprint.

Figure 4. Changes in food-related biodiversity footprint against gross domestic production (GDP) and urban population for 309 cities. r is the Pearson's correlation ($p < 0.001$).



➤ a combination of an absolute reduction in food consumption, and an increasing proportion of non-food categories

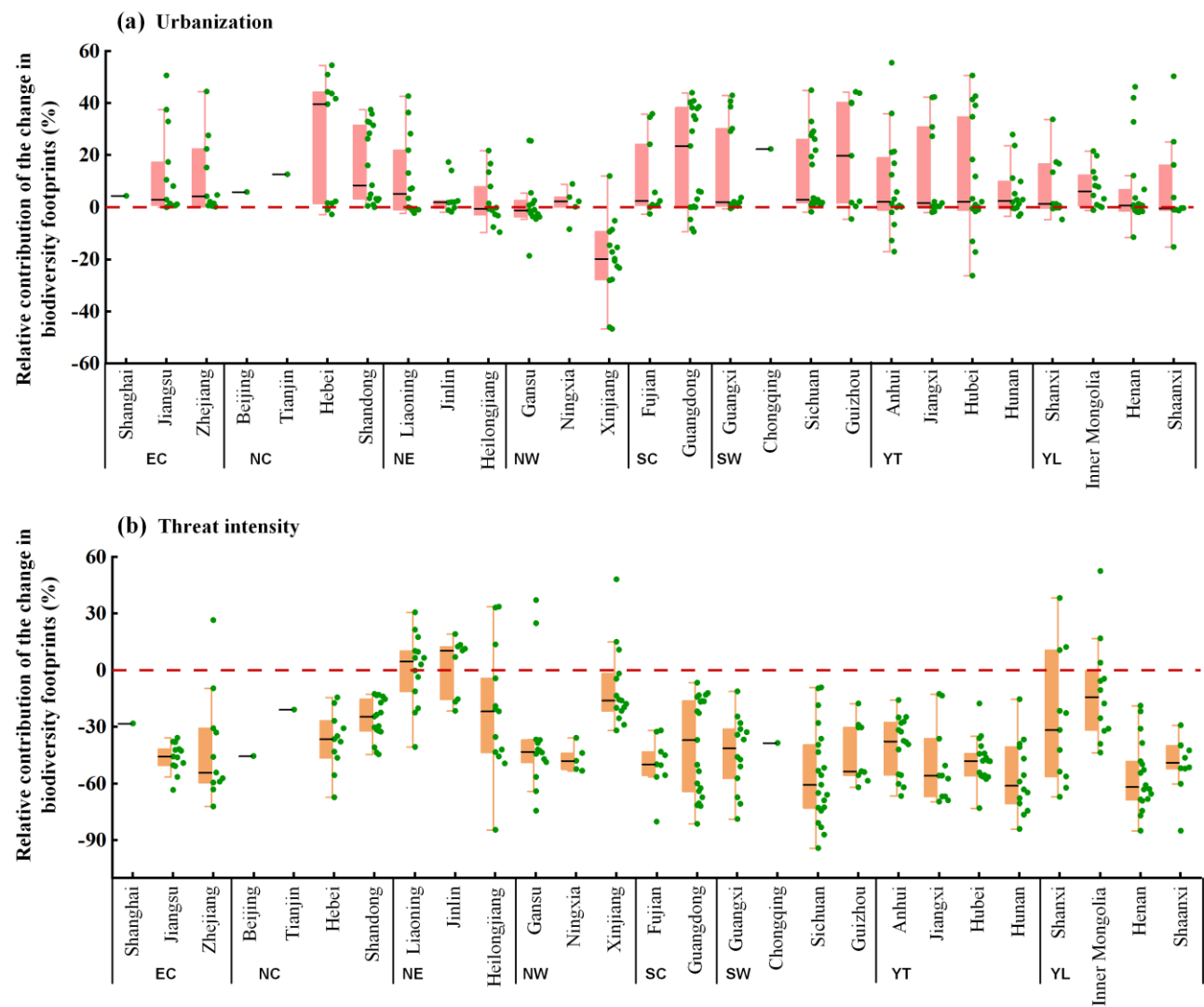
Food: from 52.64% to 47.97%

Residence: from 7.69% to 9.03%

Clothing: from 7.91% to 6.46%

Figure 5. Proportions of biodiversity footprint from different categories of consumption in 2012 and 2017. (a) food; (b) residence; (c) clothing.

4. Driving forces of biodiversity footprint change



- urbanization was one of the main contributors to change in biodiversity footprint
- the decline in threat intensity, approximately in 90% of Chinese cities, became a factor that effectively reduced the biodiversity footprint

Figure 6. The relative contributions of driving forces to the city-level biodiversity footprint for 309 cities. The contributions of (a) urbanization, (b) threat intensity, and (c) consumption level.

Discussion

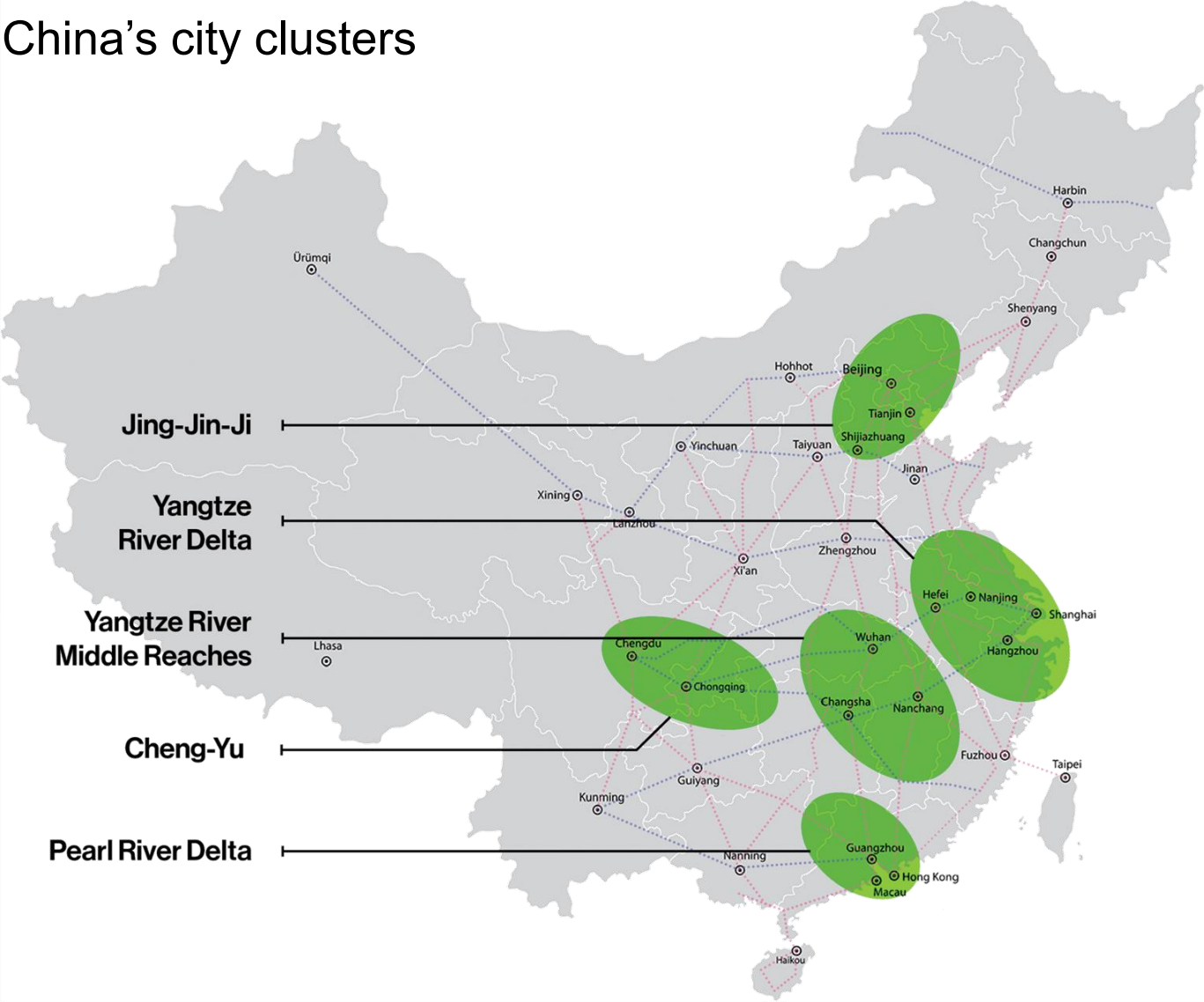
1. The large-scale shrinkage in biodiversity footprint

Similar to the study of CO2 emissions;

Caused by multiple reasons: technological innovation, consumption pattern, national governance and so on.

2. The more tele-connected biodiversity impact across China

a. China's city clusters



Five major city clusters generate over half of the nation's GDP and house over half its urban population

b. China's poverty alleviation program

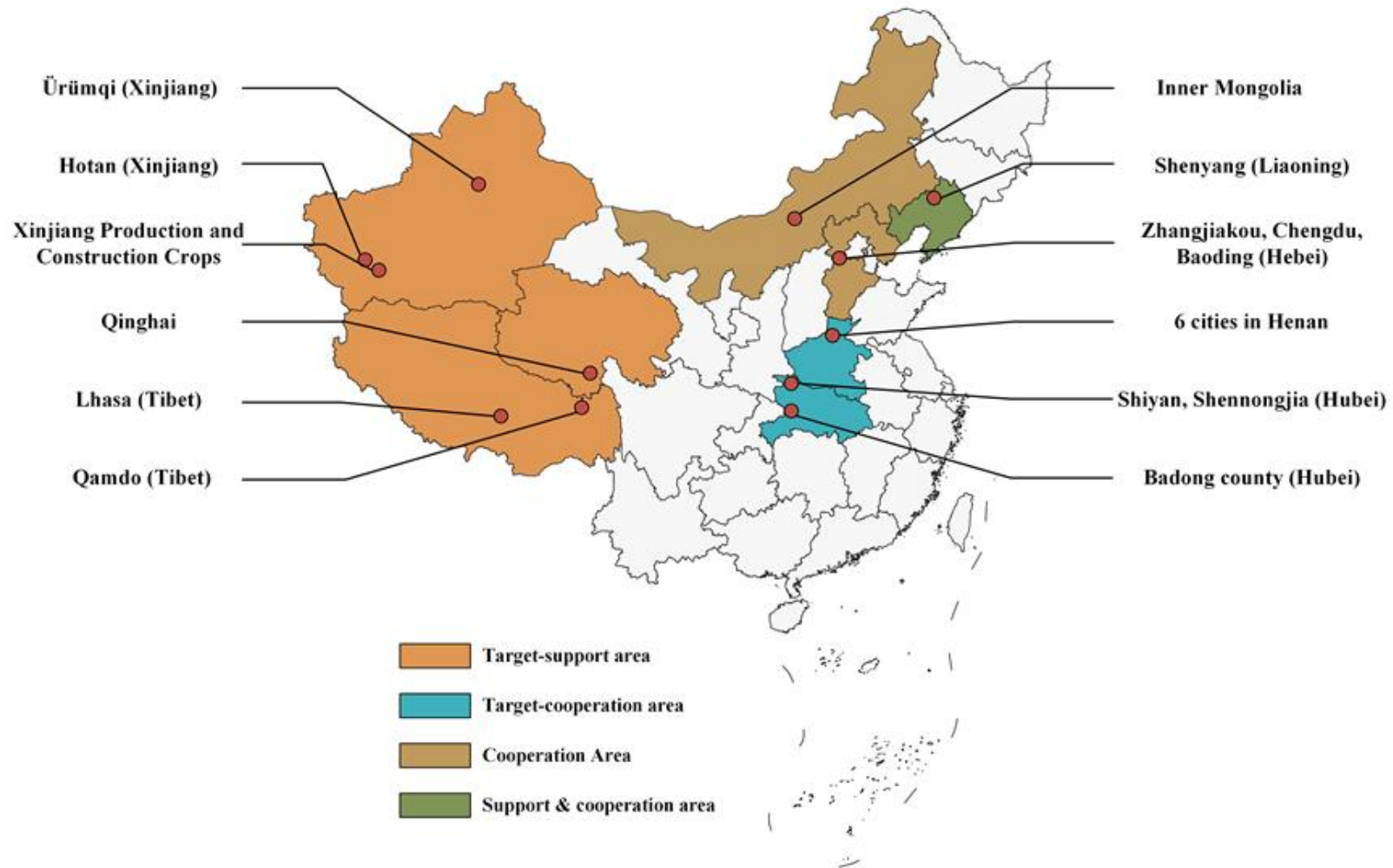
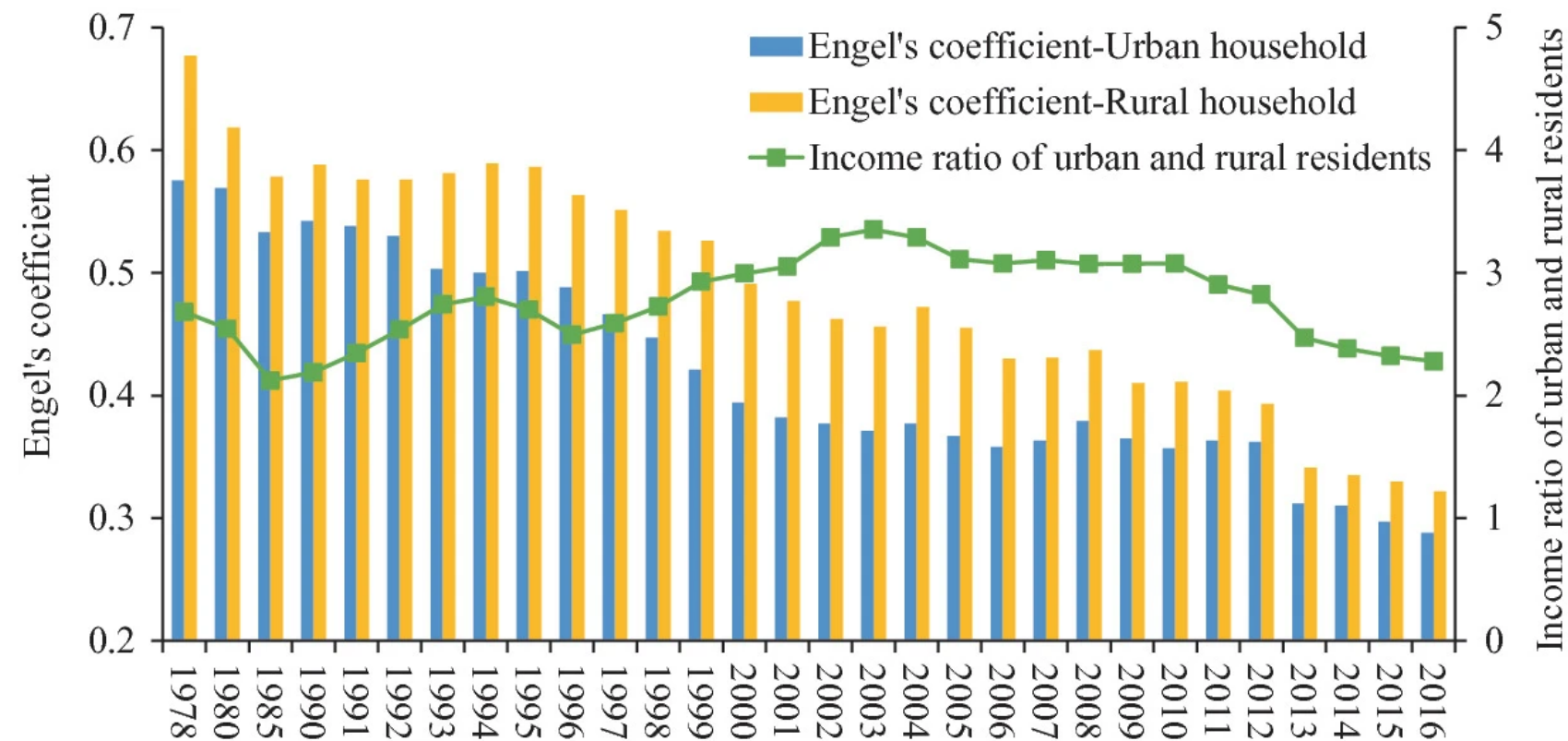


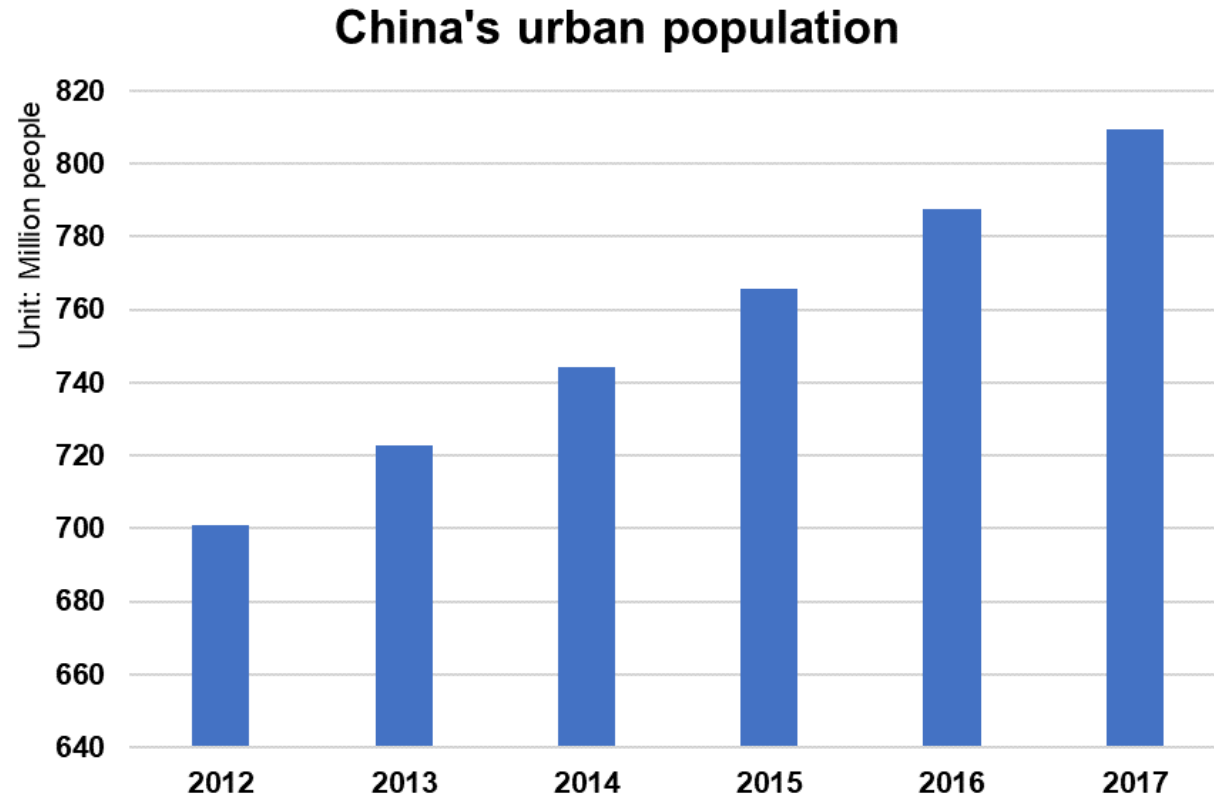
Figure S5. Target-support and cooperation areas from Beijing in China's poverty alleviation (Source: <http://fpzg.cpad.gov.cn/>)

3. Reduction in food-related biodiversity impact



(Yansui Liu., 2021, Urban-rural transformation geograhpy)

4. Urbanization and sustainable supply chains as drivers



Sustainable supply chains:
Technology advancement

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