Great divergence in climate change adaptation during 1500-1900AD:

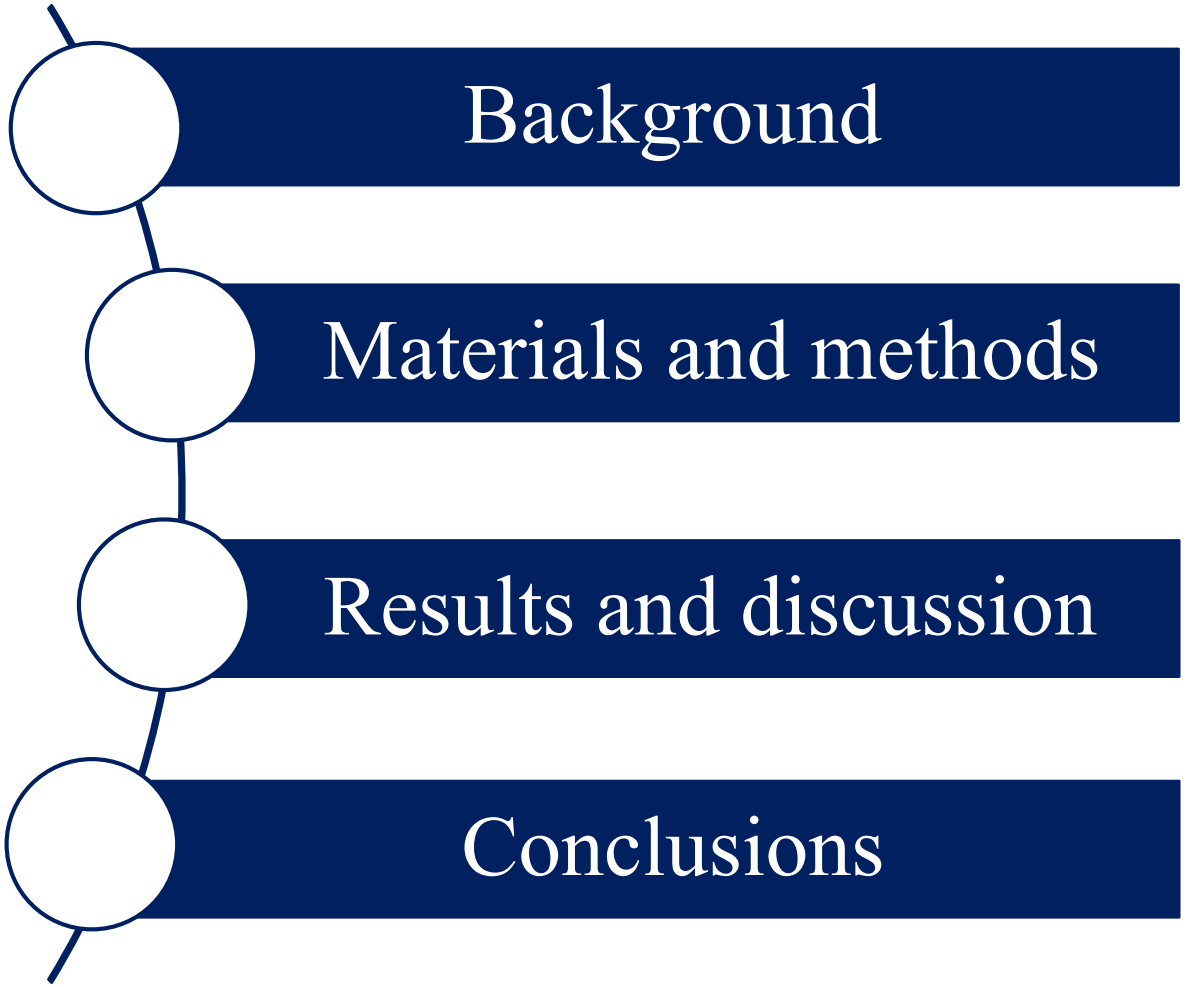
A comparative study on social resilience of Germany and China from a food security perspective

Diyang Zhang[1], Xiuqi Fang[1], Yanjun Wen[1,2]

1. Beijing Normal University, Faculty of Geographical Science, Beijing, China

2. School of Geography and Environment, Baoji University of Arts and Sciences, Baoji, China

E-mail: zdy2014@mail.bnu.edu.cn


Background
Materials and methods
Results and discussion
Conclusions

Background

Climate change adaptation

- **An important component of climate change risk management** (Salehi et al., 2019)
- **Its effectiveness depends on the social resilience**

Historical case studies

- **Better understand the diverse impacts of climate change in different communities, as well as their preferred adaptations and the possible reasons behind**
- **Provide analogies for coping with the risk of the ongoing global climate changes**

Germany & China

- **Under the similar background of climate change — the Little Ice Age**
- **Great divergence in social-economic development since 19th century** (Pomeranz et al., 2000)
- **The role of climate change adaptations in such great divergence**

Materials and methods

☐ Climate change, social resilience and effective adaptations in Germany (1500-1900AD)

Social resilience (SR)

$$SR = \frac{F_p - F_0}{F_0} = \frac{Y \times A_p + T_p - F_0}{F_0}$$

F_p: food availability per capita

F_0: critical share of food security *(based on minimum dietary energy requirement 1990-1992AD)*

Y : grain yield per unit area

A_p: cropland area per capita

T_p: external grain trade per capita

Effectiveness of climate change adaptations

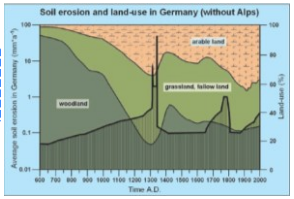
Climate change

- Temperature
- Precipitation

NOAA (https://www.ncdc.noaa.gov/paleo-search/)

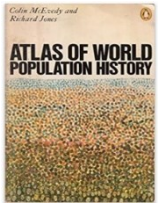
Food security

- Total area of cropland



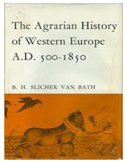
Soil erosion and land-use in Germany (Bork et al., 1998)

- Population



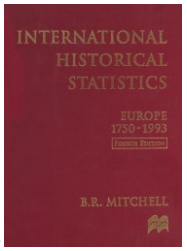
Atlas of world population history (McEvedy and Jones, 1978)

- Yield
  - 1530-1850AD



The agrarian history of western Europe A.D. 500-1850 (Slicher Van Bath, 1963)

  - After 1850AD

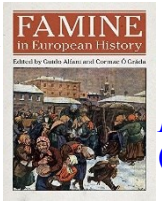


- External trade
- Emigration

International historical statistics: Europe 1750-1993 (Mitchell, 1998)

Direct reflection of insecurity

- Famine
  - Frequency
  - Severity



Famine in European history (Alfani and Gráda, 2017)

A comparison between Germany and the North China Plain

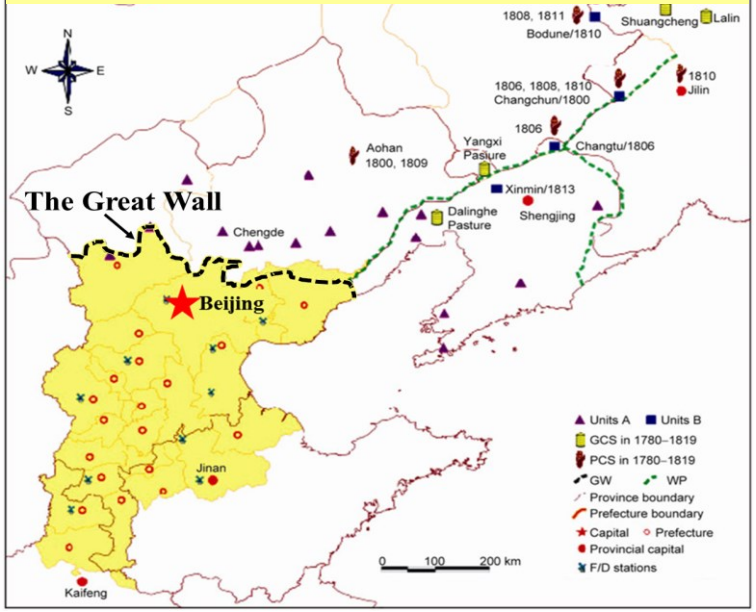
The North China Plain (NCP)

- ✓ **Densely populated agricultural area**
  - developed agrarian society
  - similar socioeconomic conditions
  - wheat as a main crop planted
- ✓ **Moderately sensitive to climate change**
  - certain adaptability
- ✓ **The seat of the political centre in Qing Dynasty**
  - representative and responsive

Comparison

- ✓ **mid-17th to early 19th centuries**
  - climatic shift around late 18th century
  - rapid population growth
- ✓ **Social resilience**
  - changing trends and turning point
- ✓ **adaptation measures**
  - effectiveness
  - choice preference and the possible causes

Location of the North China Plain



(Fang et al., 2013)

Previous researches on NCP in light of the food security

SCIENCE CHINA
Earth Sciences

• RESEARCH PAPER •

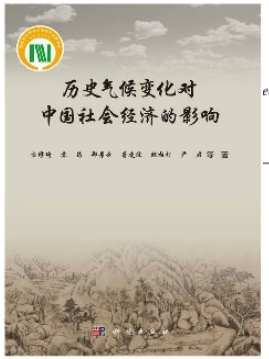
June 2013 Vol. 56 No. 6: 1044–1058
doi: 10.1007/s11430-012-4487-z

Social impacts of the climatic shift around the turn of the 19th century on the North China Plain

FANG XiuQi[1], XIAO LingBo[1,2*] & WEI ZhuDeng[1]

[1] School of Geography, Beijing Normal University, Beijing 100875, China;
eographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

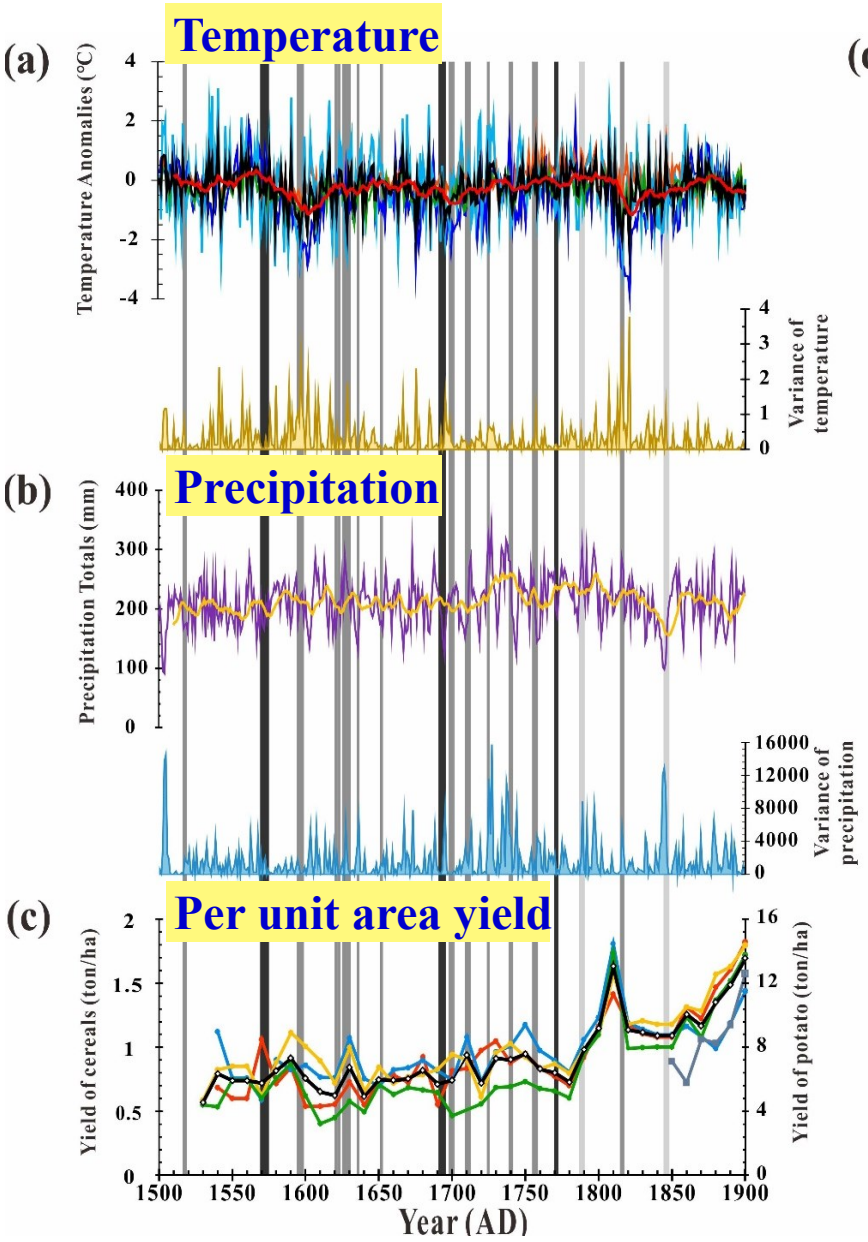
Received February 16, 2012; accepted July 20, 2012; published online November 19, 2012

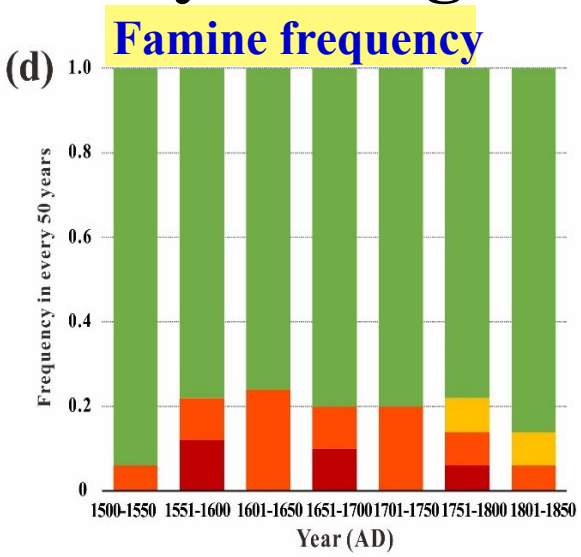


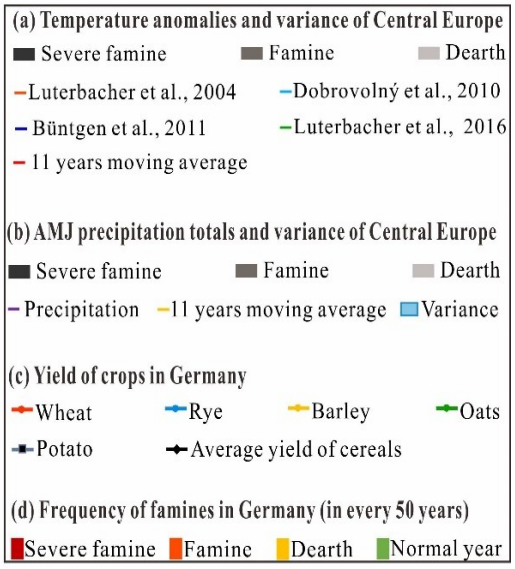
Social and economic impacts of climate change in the historical China
(Fang et al., 2019)

Results

Climate change, harvest and famines in Germany during 1500-1900AD







☐ 1500-1700AD

- **Agricultural system**
  - ✓ Sensitive *(Cold / Fluctuant)*
  - ✓ Poor harvest *(except the Thirty Years' War)*
- **Famines**
  - ✓ ≥30% were severe
  - ✓ No dearth

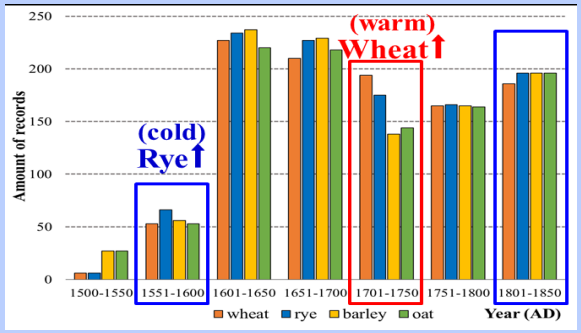
☐ From 1700AD

- **Agricultural system**
  - ✓ Correlation with T ⬇
  - ✓ Rainfall extremes impact still existed
- **Famines**
  - ✓ Severity declined
  - ✓ 29% were dearth
  - ✓ One severe famine *(1770-72AD, after back-to-back harvest failure)*

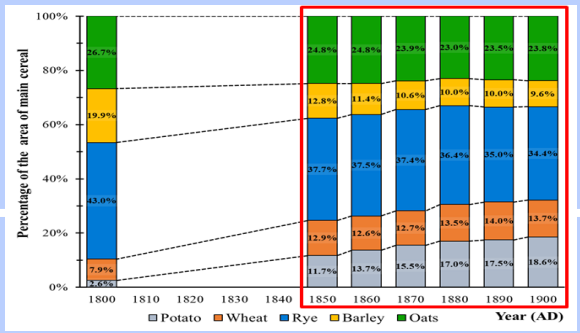
Results

Four effective climate change adaptation measures in Germany

Planting structure adjustment



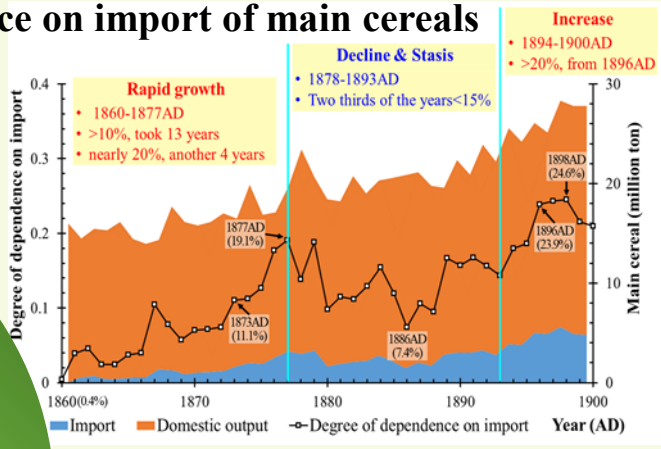
Amount of seed/yield ratio records



Proportion of the main grains

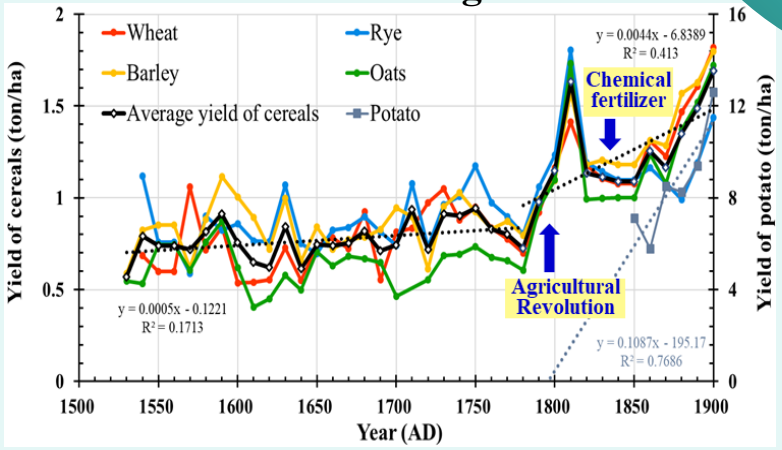
Grain import

Import, domestic output, and the degree of dependence on import of main cereals



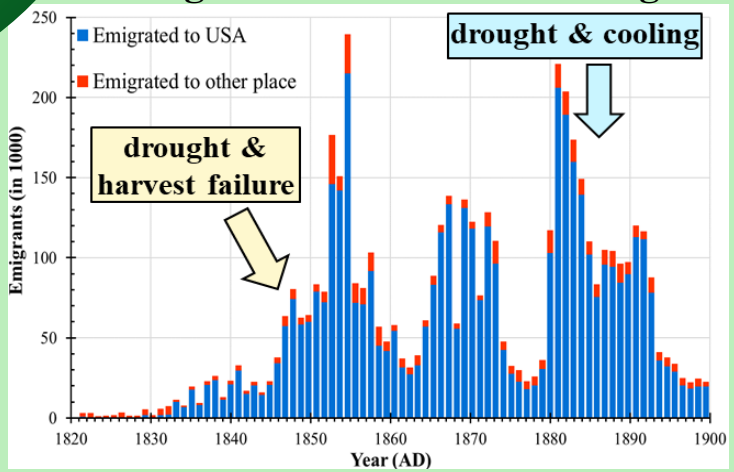
Grain yield increase (agro-technology progress)

Yield of main grains



Emigration

Emigration and climate change



Climate change impact-adaptation in Germany

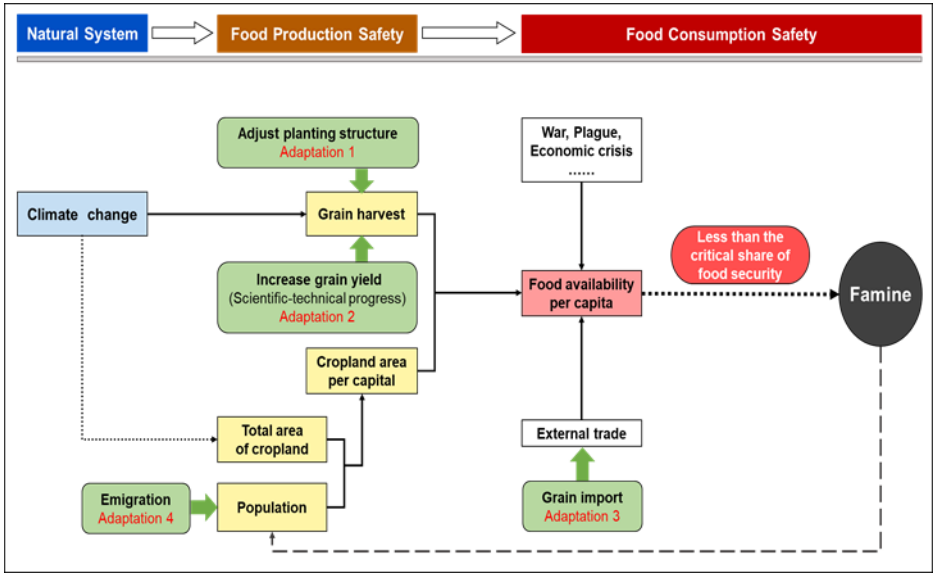
Adjust planting structure: limited effectiveness until the widely acceptance of potato

Grain yield increase: reversed the trend of social resilience decreasing with population growth, but was not enough to fully offset the impact of climatic deterioration

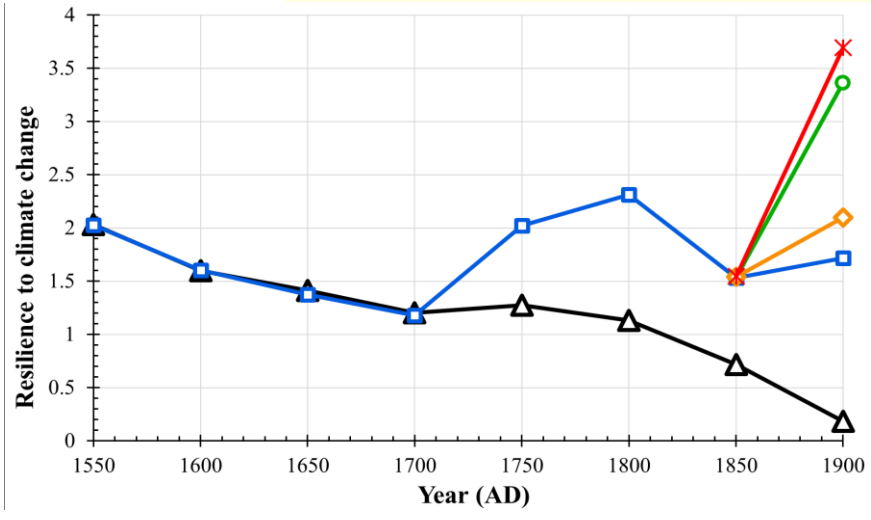
External trade: oversea food supply, further reduced the famine risk in German mainland

Emigration: not obvious on the national-scale, but might alleviate food shortage on a local-scale, and then preventing it from developing into famines, which needs a further quantitative analysis

Food-security-based framework of historical climate change impact-adaptation in Germany



German social resilience with different adaptation measures



Scenario 1: Considering population growth only

Scenario 2: Coupled with cereal yield increase

Scenario 3: Coupled with cereal yield increase and potato planting

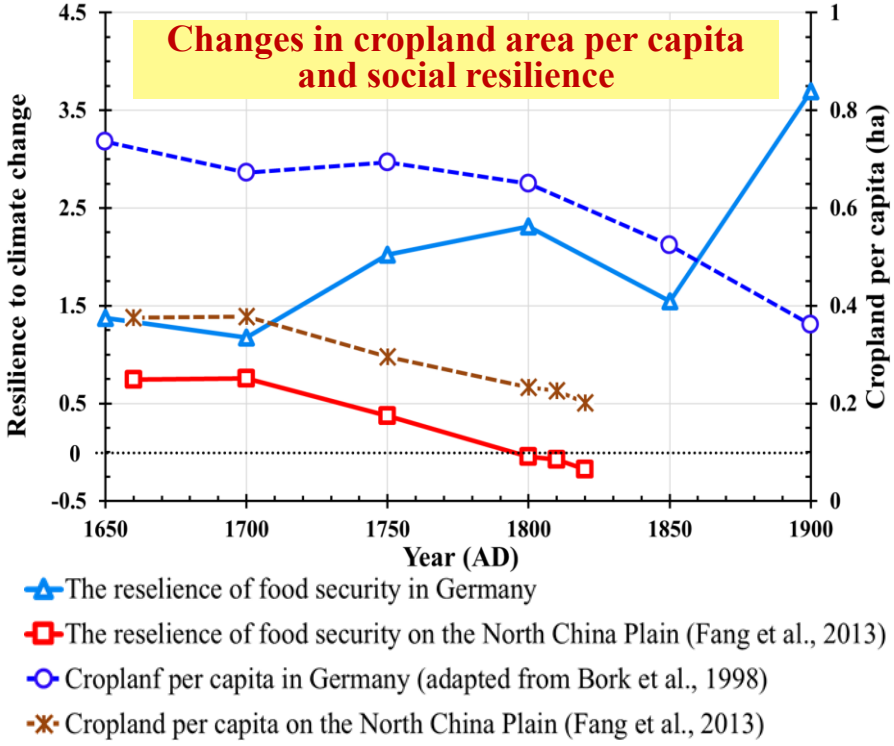
Scenario 4: Coupled with cereal yield increase and external trade in crops

Scenario 5: Coupled with cereal yield increase, potato planting and external trade in crops

Discussion

A comparison between Germany and the North China Plain

☐ Social resilience



- **Common background**
  cropland expansion failed to relieve the pressure of population growth
- **Turning point: 1700AD**

Germany

✓ **Cropland area per capita**
- sustained downward trend
- much higher than NCP

✓ **Social resilience**
- turn into increasing trend from 1700AD
- always > 0 (less sensitive)
- completely escaped from famine since 1850AD

North China Plain (NCP)

✓ **Cropland area per capita**
- rapid decline since 1700AD
- higher population pressure

✓ **Social resilience**
- keep decreasing since 1700AD
- < 0 since late 18th century (extremely sensitive)
- climate change accelerated the occurrence of food insecurity

Discussion

A comparison between Germany and the North China Plain

☐ Adaptations

Germany

✓ **Location**
- a divided continent without superpower
- close to the origin of the first industrial revolution

✓ **Social cultural background**
- foreign trade tradition
- great attraction of the America
- feudal separation before 1871AD

✓ **Preference**
- benefited from international exchange
- new technology/external food supply/risk transfer

China (NCP)

✓ **Location**
- unified and powerful empire in east Asia
- far from the origin of the first industrial revolution

✓ **Social cultural background**
- self-sufficient agricultural society
- large internal market
- centralization of authority (absolute monarchy)

✓ **Preference**
- more prone to domestic adjustment
- the government (emperor) played a crucial role

Table 1 Adaptation measures between Germany and China (NCP)

	Production	Consumption	Effective period	Food security
Germany	Adjust planting structure		from 1850AD	Escaped from famine after mid-19th century
	Increase grain yield		late 18th century	
		Import grain	from 19th60s	
		Emigration	??	
China (NCP)	Cropland expansion		17th40s to 18th20s	Climate change intensified food insecurity and social unrest since early 19th century
		Governmental disaster relief	before the flood of 1801AD	
		Migration	1730-1780AD, 1792-1803AD	

Conclusions

- **Four effective adaptations significantly increased German social resilience, and helped Germany escaped from famine after 1850AD**

- **The opposite trend of social resilience between Germany and China, which was caused by the great divergence in climate change adaptations, first appeared in 1700AD**

- **Effective period of adaptations**
  - effective period ≠ existing period
  - adaptive capacity ＞ climate change intensity
  - limited by the acceptation in a certain community before exceeding the threshold

- **The choice preference of adaptations**
  - deeply influenced by location, social-economic basis and cultural background
  - suitable is the premise of effective

Thanks