China's urbanization and its sustainability under future climate change

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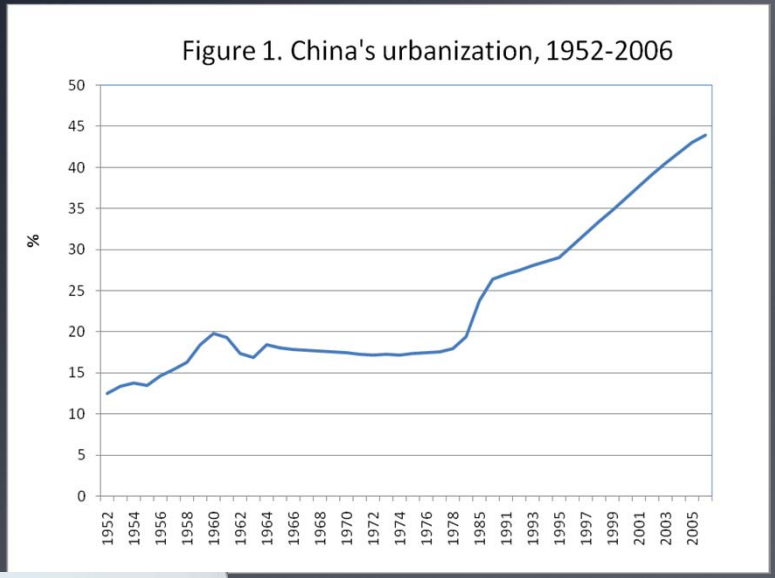
Research Background



- **Rapid urbanization in China after the reform**
  - before: strict control through household registration;
  - after: eco development & rural-urban migration
- => Urban sprawl
- => Degradation of urban environment
- **Current research gaps in Climate change and cities**
  - Climate change at local level remains unclear
  - Lack of evaluation of Impacts of CC on cities
  - Rare quantitative assessment for adaptation and mitigation strategies

Project:

----3 year duration (2009-2012)

----2 case cities: Shanghai and Urumqi

----Team members from various disciplines: urban planning, geography, climatology, etc

----Collaborators in Shanghai and Urumqi

Research Objectives:

(1) to analyze the causal linkages between urbanization, urban sprawl (LCLUC), and climate change

(2) to simulate local scale IPCC climate scenarios for select cities and to evaluate current adaptation strategies and provide adaptation recommendations for various future climate scenarios to urban policy makers.

Our progress so far… (1) finished work

- **Objective 1. Linkage between urbanization, LULC, and climate change**
  - Shanghai:
    - Urbanization , urban sprawl,
    - urban land use changes by different types
    - urban industrial land and its spatial determinants
  - Urumqi:
    - Urbanization, urban sprawl, degraded urban environment
    - Develop LULC maps, focusing on agriculture & urban expansion
    - Uncertainty model for MODIS land cover type product

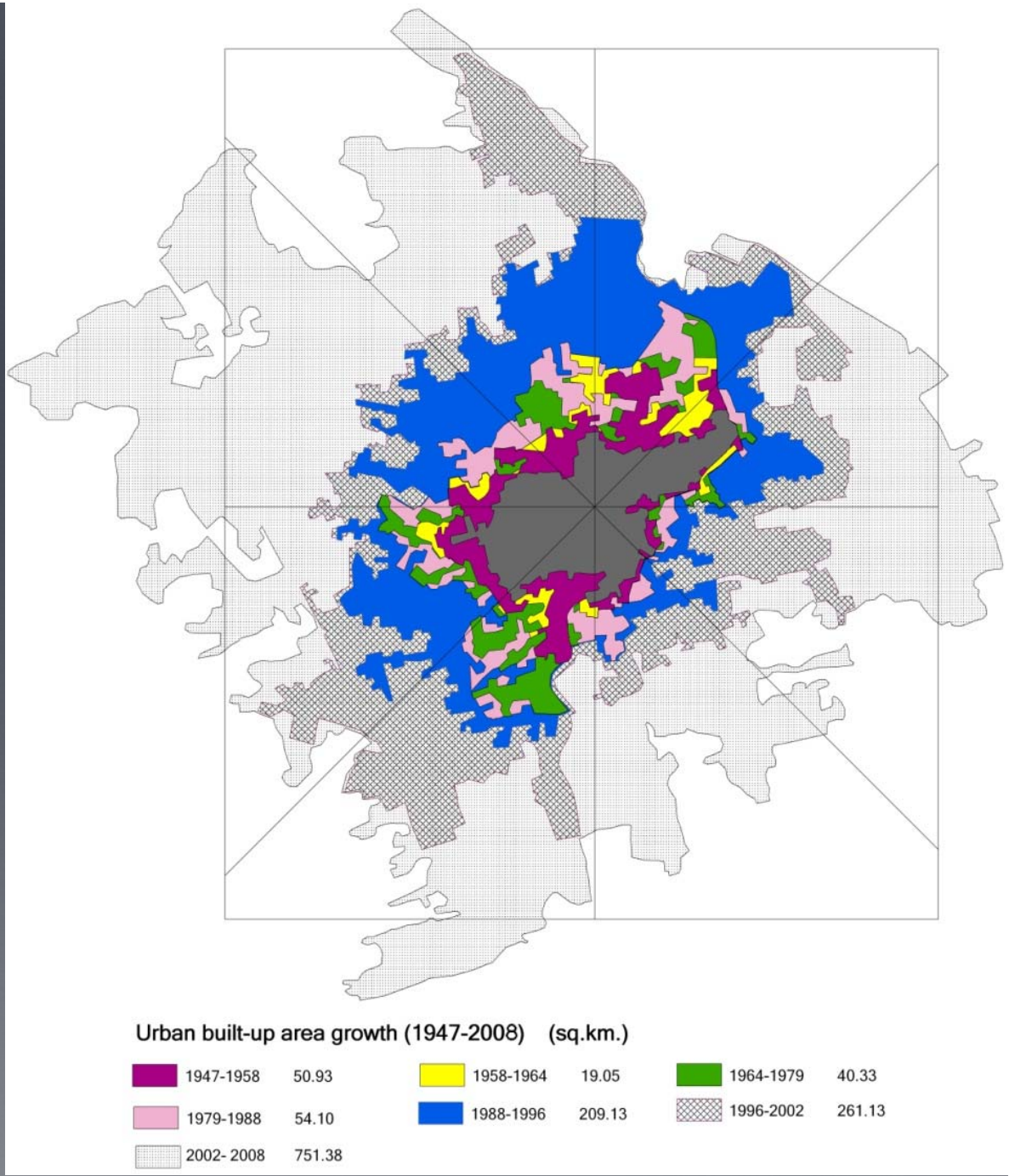
Our progress so far… (2) on-going work

- **Objective 2. Simulation of future LULC and regional climate changes, impact of climate change, and adaption and mitigation strategies**
  - **2a. Simulation of current and future LULC**
  - **2b. Regional climate simulation under IPCC scenarios**
  - **2c. Impact of climate change on cities**
  - **2d Adaptation and mitigation strategies**

Shanghai ,
-urbanization and urban sprawl

- A globalizing city
- largest economic center since 1850
- manufacturing center during Maoist period (1949-78) (>70% of output)
- transition to tertiary sector
- international prominence

- Urbanization:
  - 59% (1978) => 86% (2007)
- **Urban sprawl:**
  - expanded 18 times: 76 (1947) to 1,462 km²(2008)



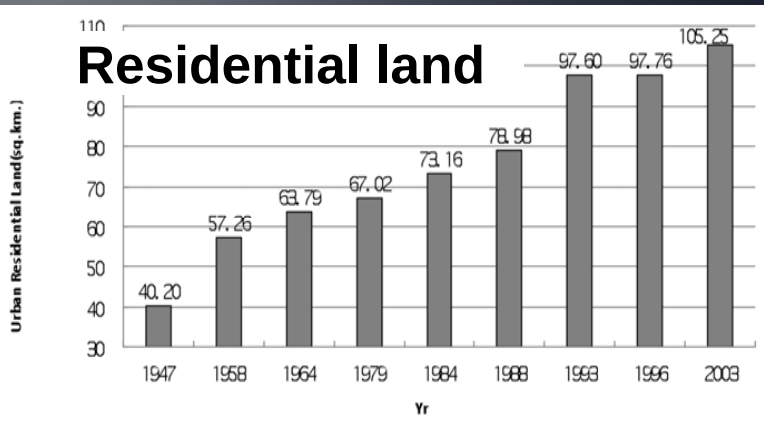
Source: Yue et al, 2010)

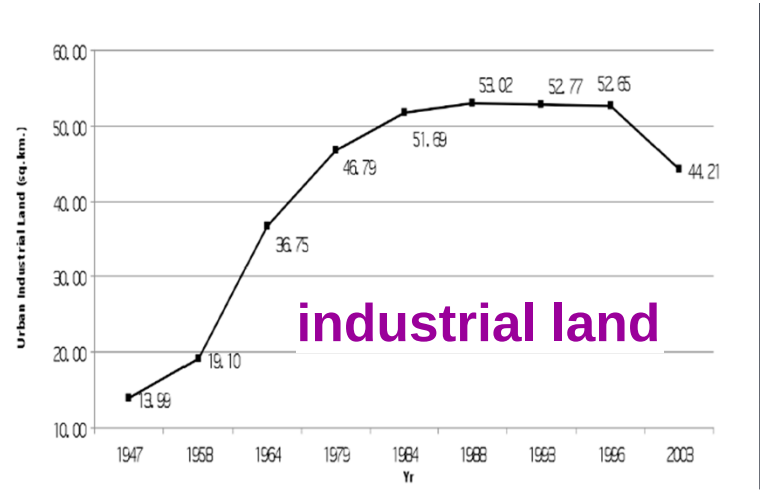
Shanghai – Urban land use by types:

- *residential* - continuous growth
- *industrial* - declined 1993-2003
  relocation of factories
- *commercial* - climbing due to
  increased infrastructure investment,
  urban redevelopment

Key factors?

- Land market reforms
- migration
- preferential policy
  - uneven distribution of
    foreign direct investment (FDI)
  - Economic development zones
- phases of economic transition, restructuring
- role of the multi-scaled state, governance





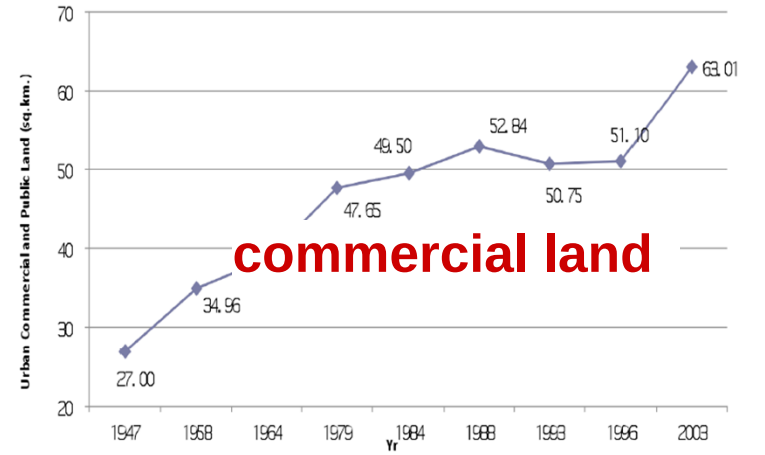
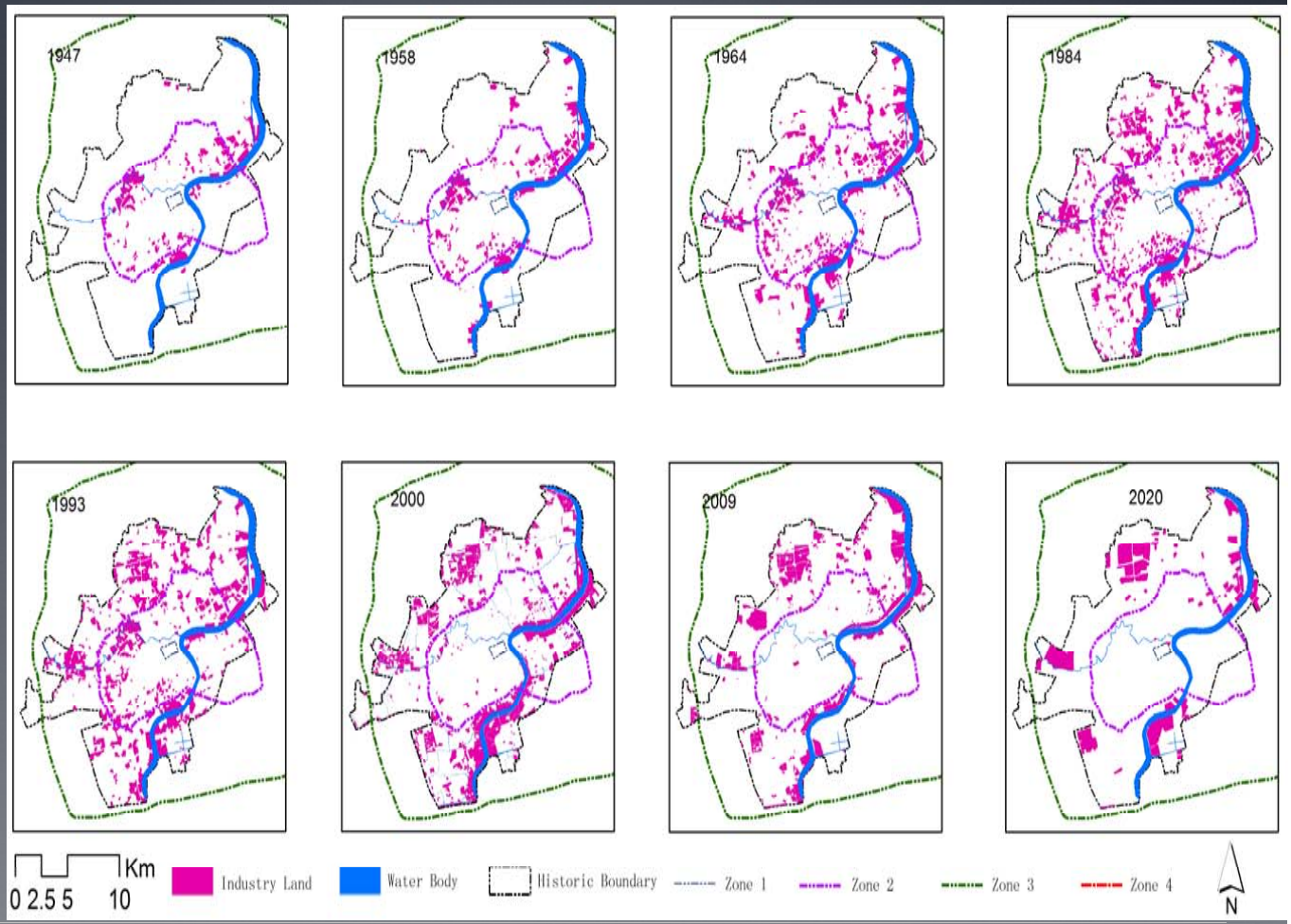


Figure Source: Yue, et al., 2009; Fan & Qi, 2010

Shanghai – Evolution of urban industrial land

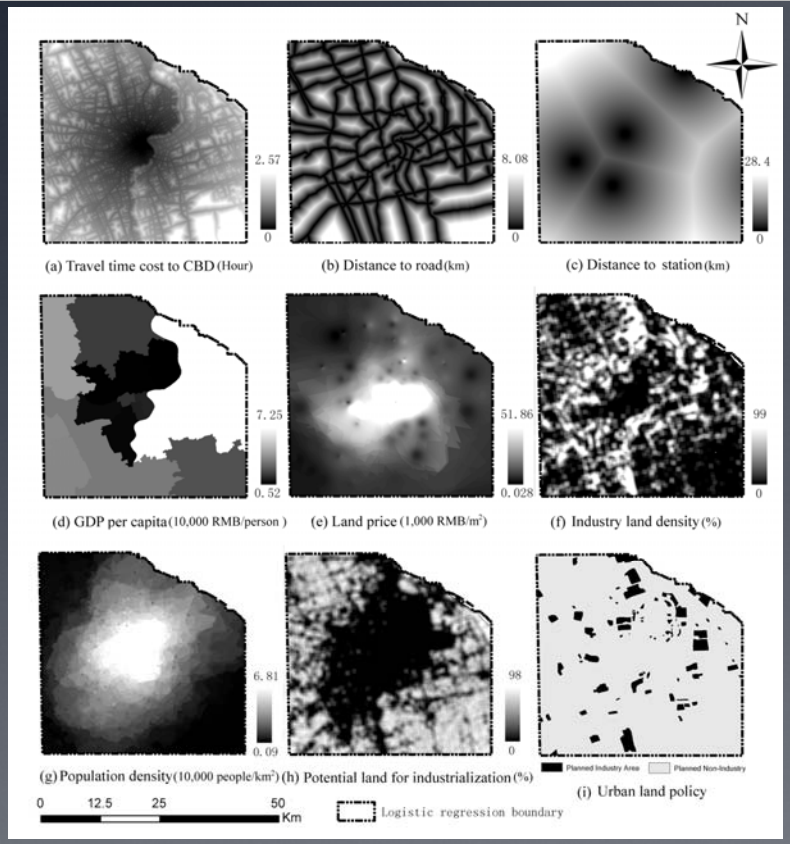
first increased rapidly 1947 - 1984, then started decreasing from 1993

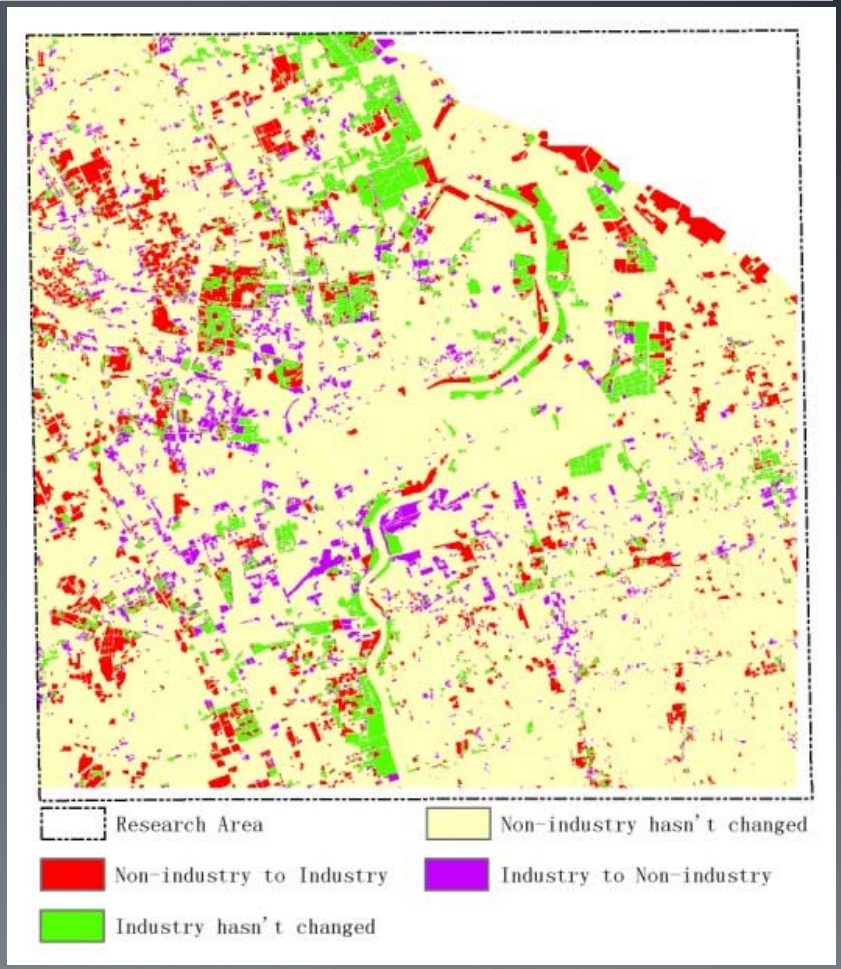
a hybrid monocentric pattern => a specialized polycentric pattern



Source: Fan et al, 2011

Shanghai – spatial determinants of urban industrial land conversion (2002-2009)





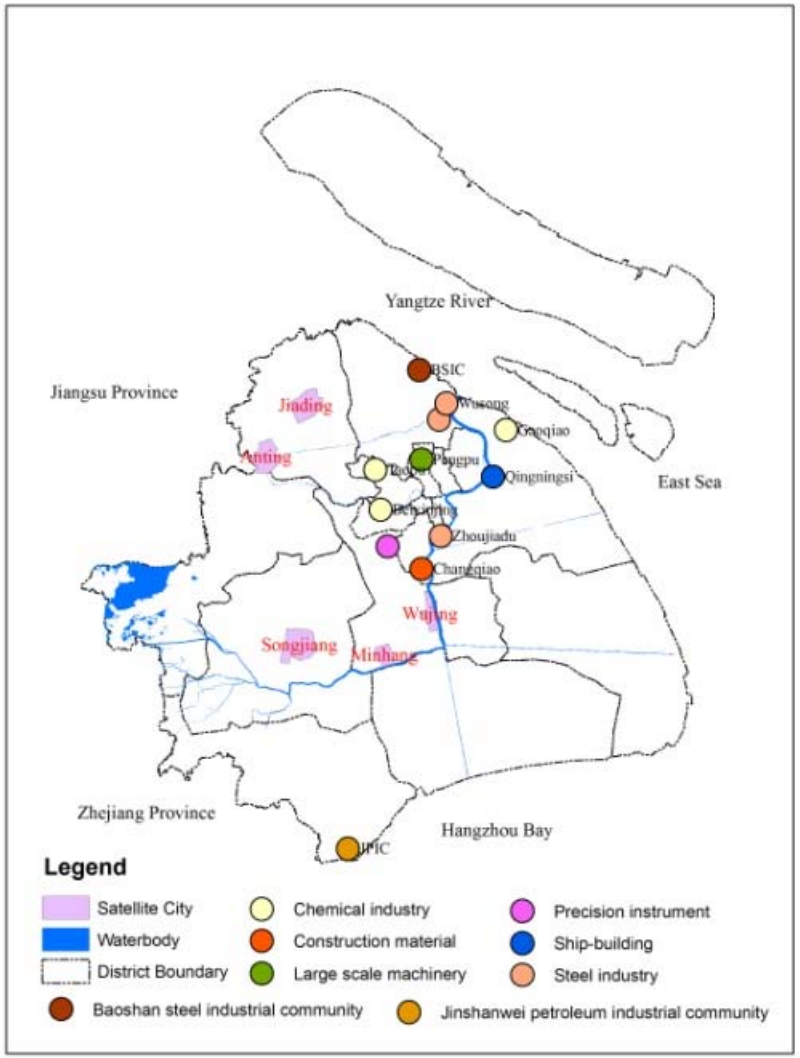
Major spatial determinants:
Travel time to the CBD, land price, existing industrial land, potential land can be converted

Source: Fan et al, 2011

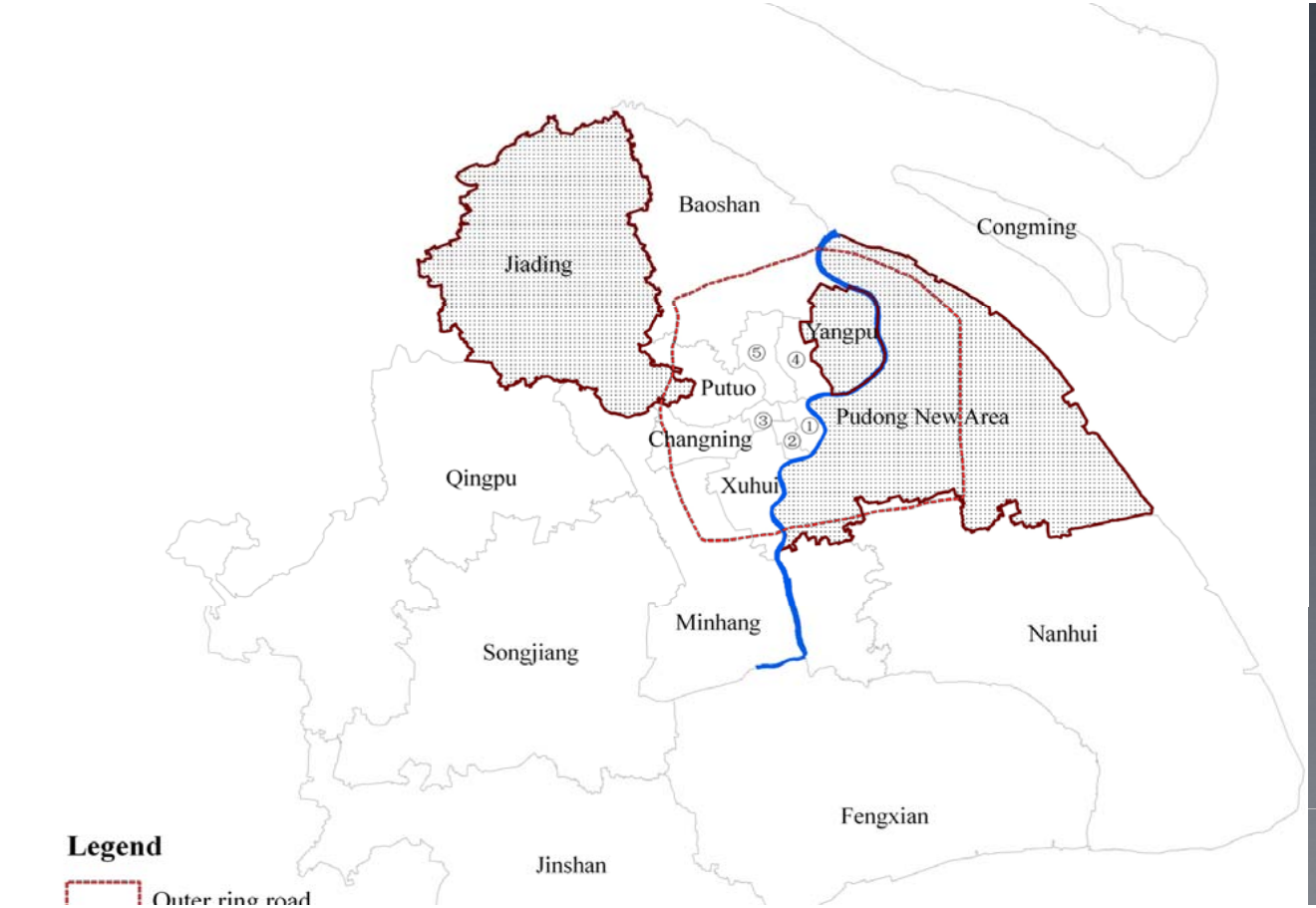
2 industrialization waves

--1958: 5 satellite towns and 10 suburban industrial zones

--1970s: Baoshang Steel IC, Jinshan Petrochemical IC



District	Land Area (sq. km)	Population (million)	Floating pop (million)	Density (persons/sq. km)
Yangpu	60.73	1.19	0.14	19674
Jiading	464.20	1.03	0.46	2228
Pudong	532.76	3.05	0.93	5738



Case: Yangpu

- 60.73 km2, 1.19 m (pop in 2009), 0.13 m floating pop, 19674 persons/km2
- Cradle of China's industrialization,
  - leader of SH's manufacturing
- Decreased industrial land from the 1990s, typical for inner city districts
- From manufacturing YP to Knowledge YP
- Industrial land => recreational land (museum, entertainment), knowledge park for creative industries, green spaces

Areas and percentages of Industry Fall in Different Zones in Yangpu District

Unit:km2

	YEAR							
	1947	1958	1964	1984	1993	2000	2009	2020
ZONE 2	2.26 (22.55%)	1.95 (19.48%)	2.80 (27.96%)	2.84 (28.40%)	2.51 (25.03%)	1.71 (17.05%)	1.32 (13.17%)	0.54 (5.44%)
ZONE 3	2.46 (6.56%)	4.96 (13.21%)	7.66 (20.43%)	9.22 (24.57%)	8.26 (22.02%)	7.48 (19.93%)	8.85 (23.58%)	5.10 (13.59%)
Total	4.72 (9.93%)	6.91 (14.53%)	10.46 (22.02%)	12.06 (25.37%)	10.77 (22.65%)	9.18 (19.32%)	10.16 (21.39%)	5.64 (11.87%)


ART
1001
Chengdu Art Center

Cases: Jiading

- 462 KM2 Pop: 1.03 m (2009), 0.46m floating pop, 2228 persons/KM2
- Part of Jiangsu province, relocated to Shanghia in 1958
- Anting: auto industry
  - Initial growth (58-84)
  - Take off (1984-2000), SH VW
  - Large scale devlopment (2001-present), International auto city

Planning of Shanghai International Auto City

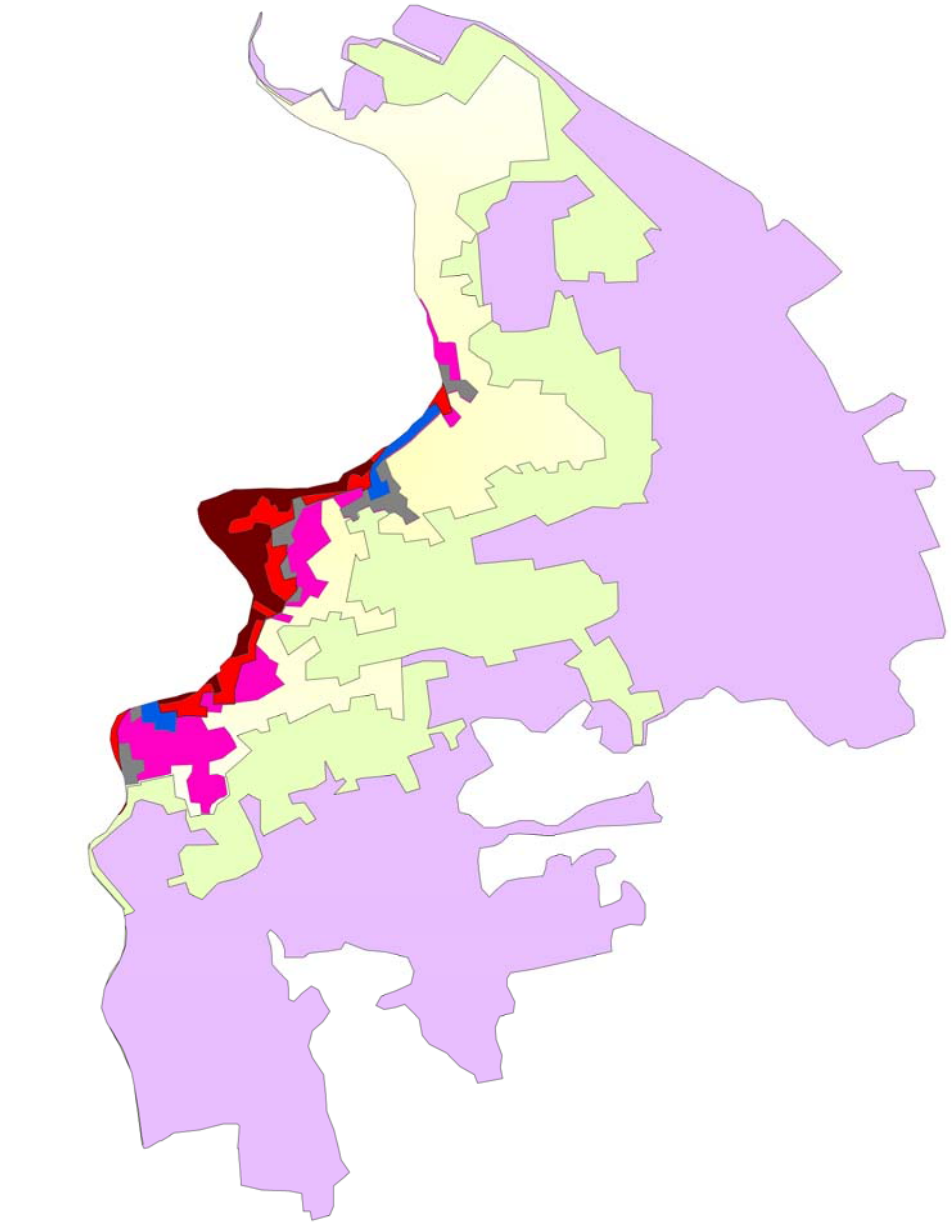
Industrial zones in Jiading District

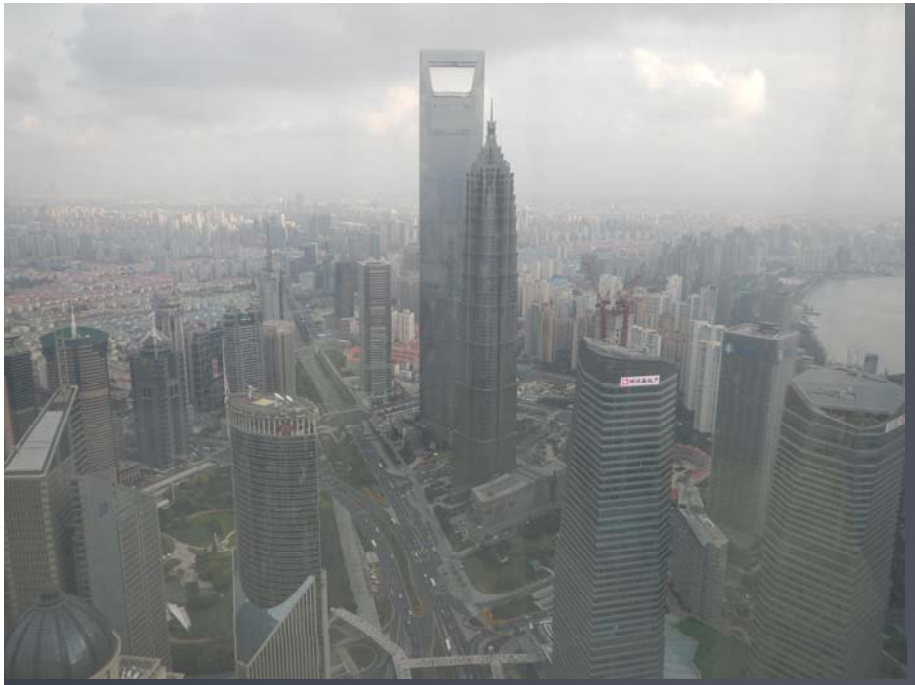
Case: Pudong

- 532.75 km2, Pop: 3.06 m (2009), 0.93 m floating pop, 5738 persons/km2
- 1990: officially announced by the central government to facilitate China's development
  - To deal with decreasing FDI after the Tian'anmen Square event
  - To develop China's YZ hinterland through Shanghai's opening up
- Investors: both domestic and foreign
- Infrastructure: Nanpu and Yangpu, and others
- Financing
- kept growing its industrial land from 1947 to 2003,but the content has been changed
  - Zhangjiang high-tech park (in), Shanghai No. 3 Steel (out)

Pudong's urban built-up area expansion

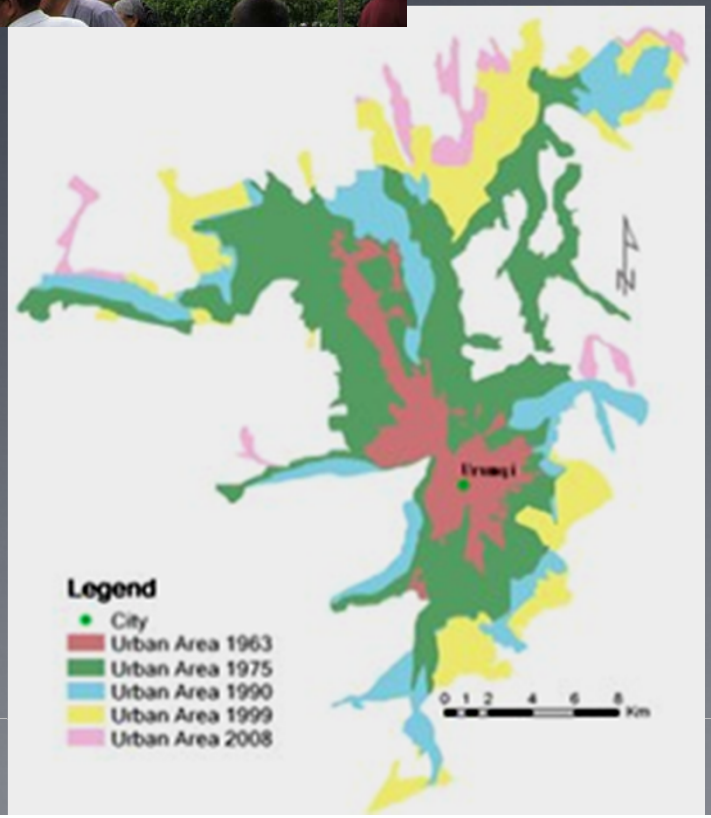
- Before 1988, there is little development of urban built up area in Pudong
- After 1988, urban built-up area expanded rapidly, especially after 2002.





Lujiazui Financial Center,
Pudong, Shanghai

Case 2: Urumqi –urbanization and urban sprawl



Urumqi, Capital of Xinjiang Uyghur Autonomous Region

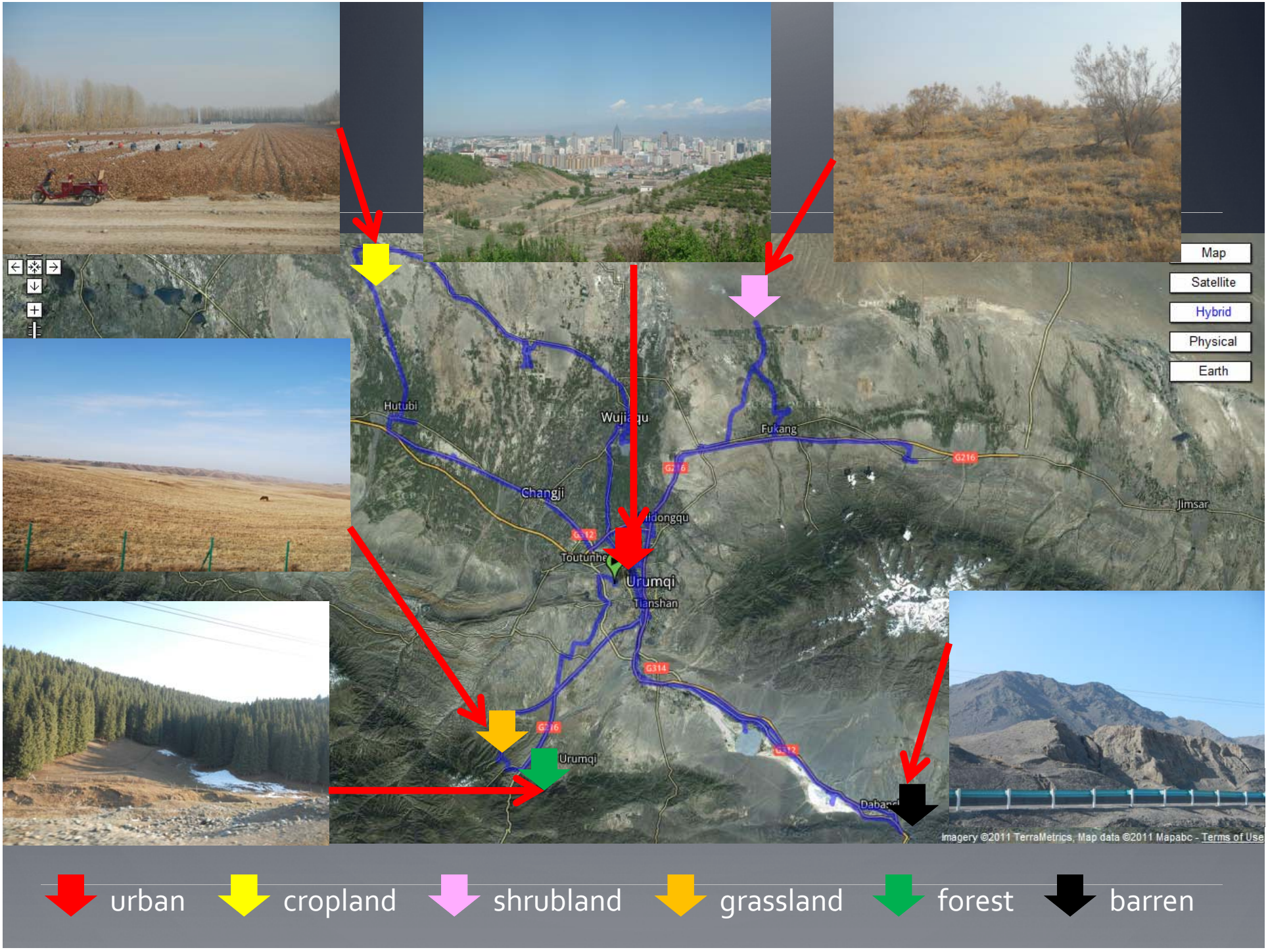
- important trading center for centuries
- military base
- westward migration - factor in industrialization

Urumqi today…

- exponential economic growth 1990s onward
- investment in energy industry
- new growth in tertiary sector
- Int'l trade with Russia, tourism

Urban Land conversion

38 sq km in 1963,
238 sq km in 1990
321 sq km in 2008


Map
Satellite
Hybrid
Physical
Earth
Hutubi
Changji
Fukang
Jimsar
Toutunhe
Urumqi
Tianshan
Urumqi
G216
G314
Imagery ©2011 TerraMetrics, Map data ©2011 Mapabc - Terms of Use
urban
cropland
shrubland
grassland
forest
barren

Urumqi: Develop LULC maps focusing on Agriculture & Urban Expansion

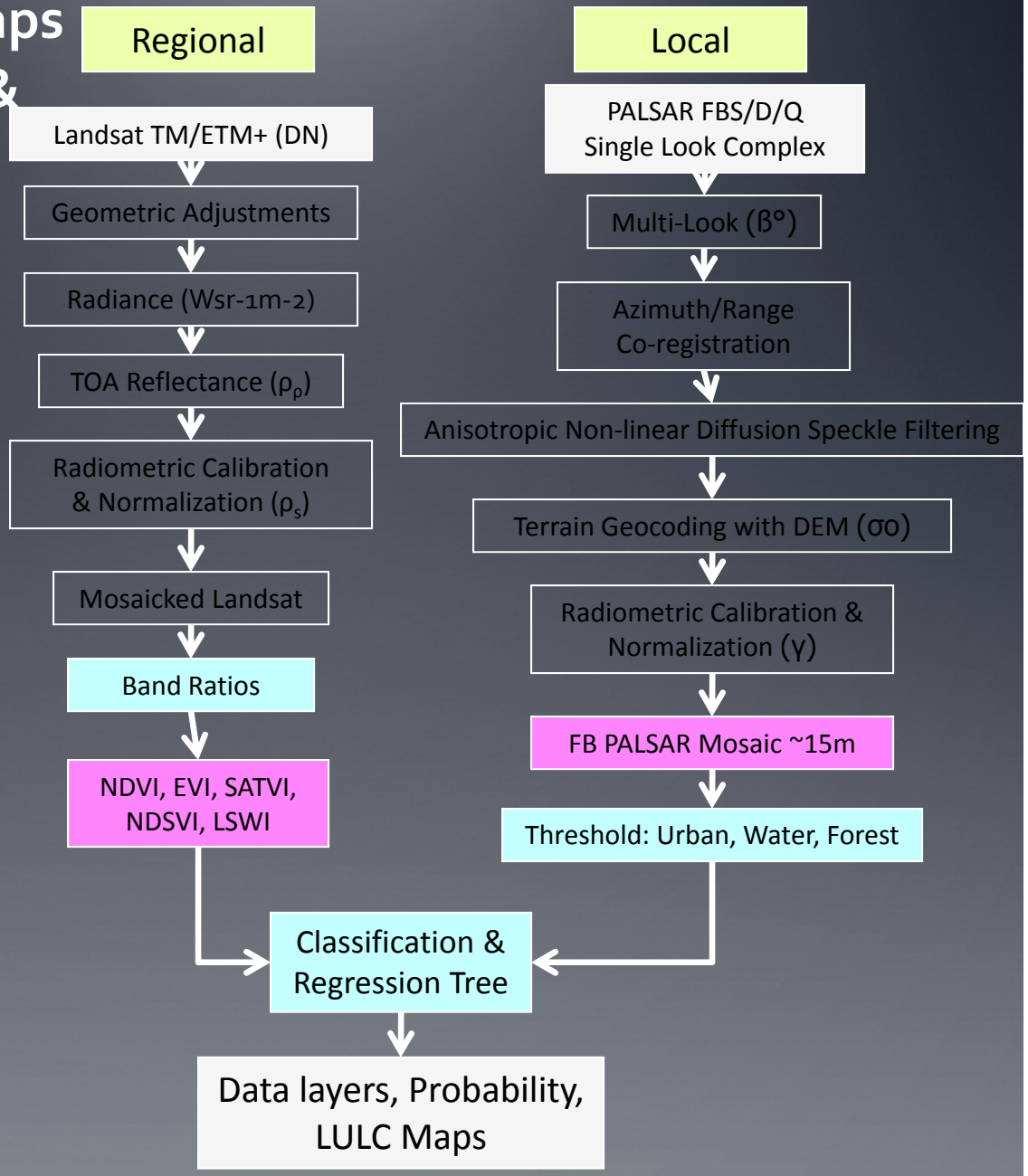
- used GLS / Landsat TM time series to map LULC in 1975, 2000, and 2010

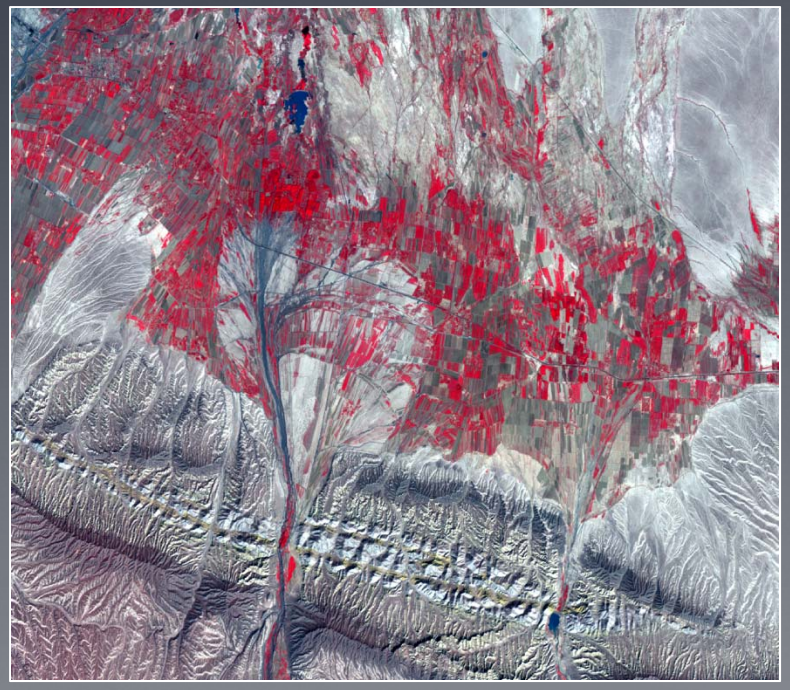
- integrate Landsat TM & ALOS PALSAR to map urban and assess LCLUC to 2010

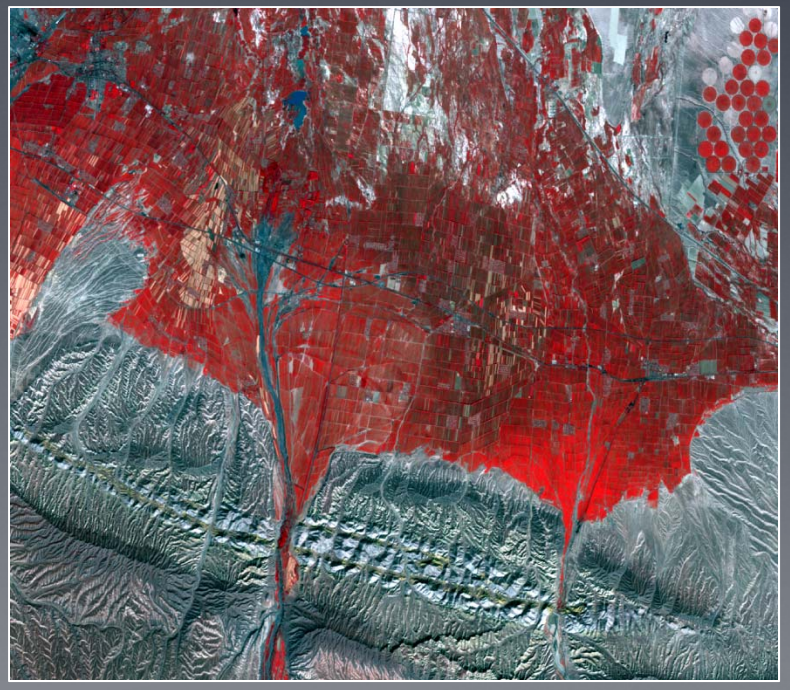
- Preprocessing streams for data =>

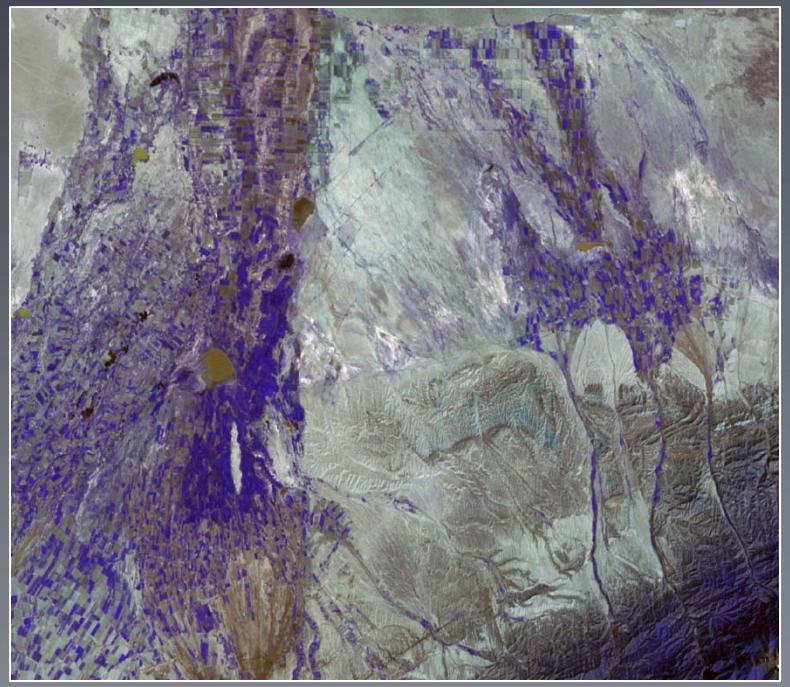
- Approach used a CART

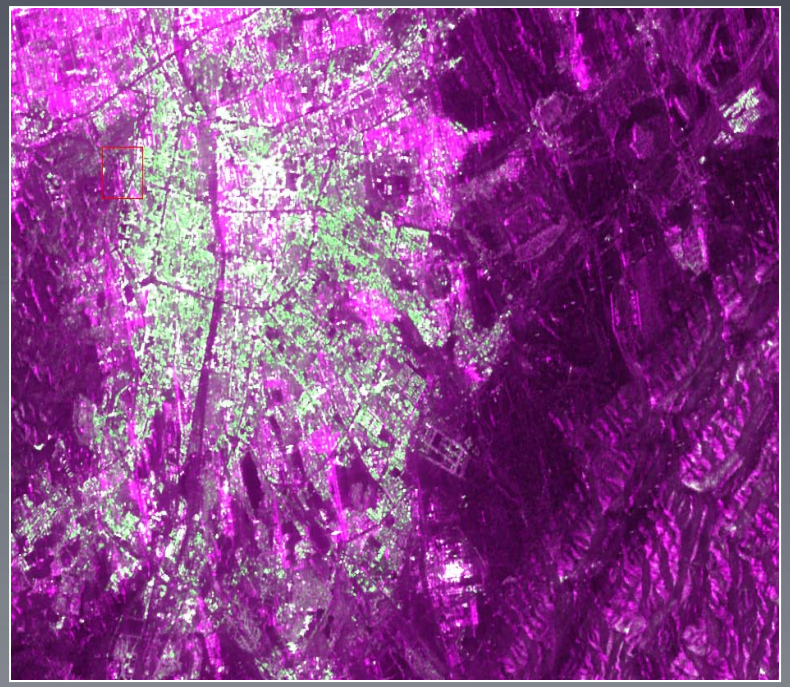
- Post processing applied operational thresholding of Landsat, PALSAR, and Aster DEM indices to adjust products

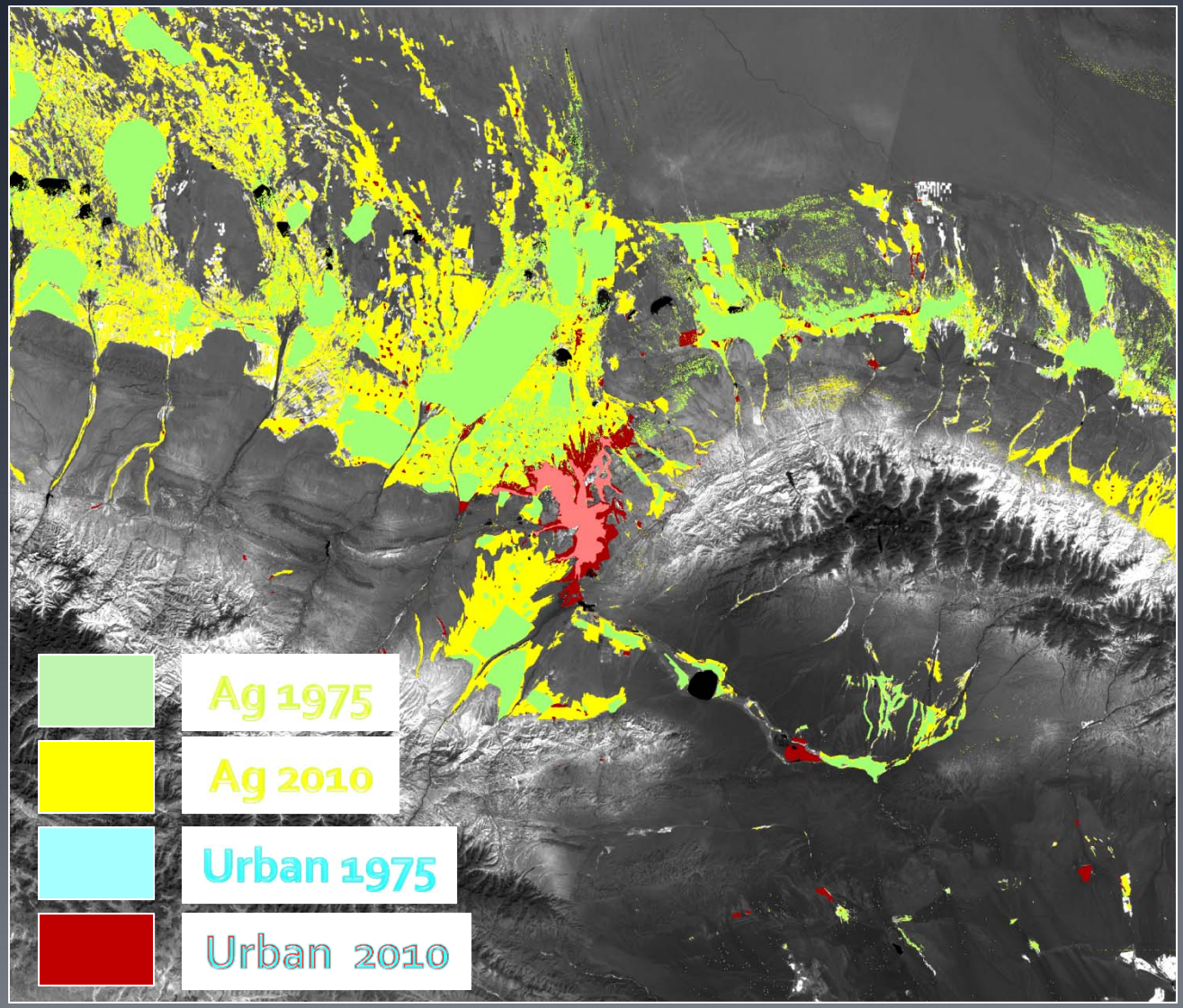






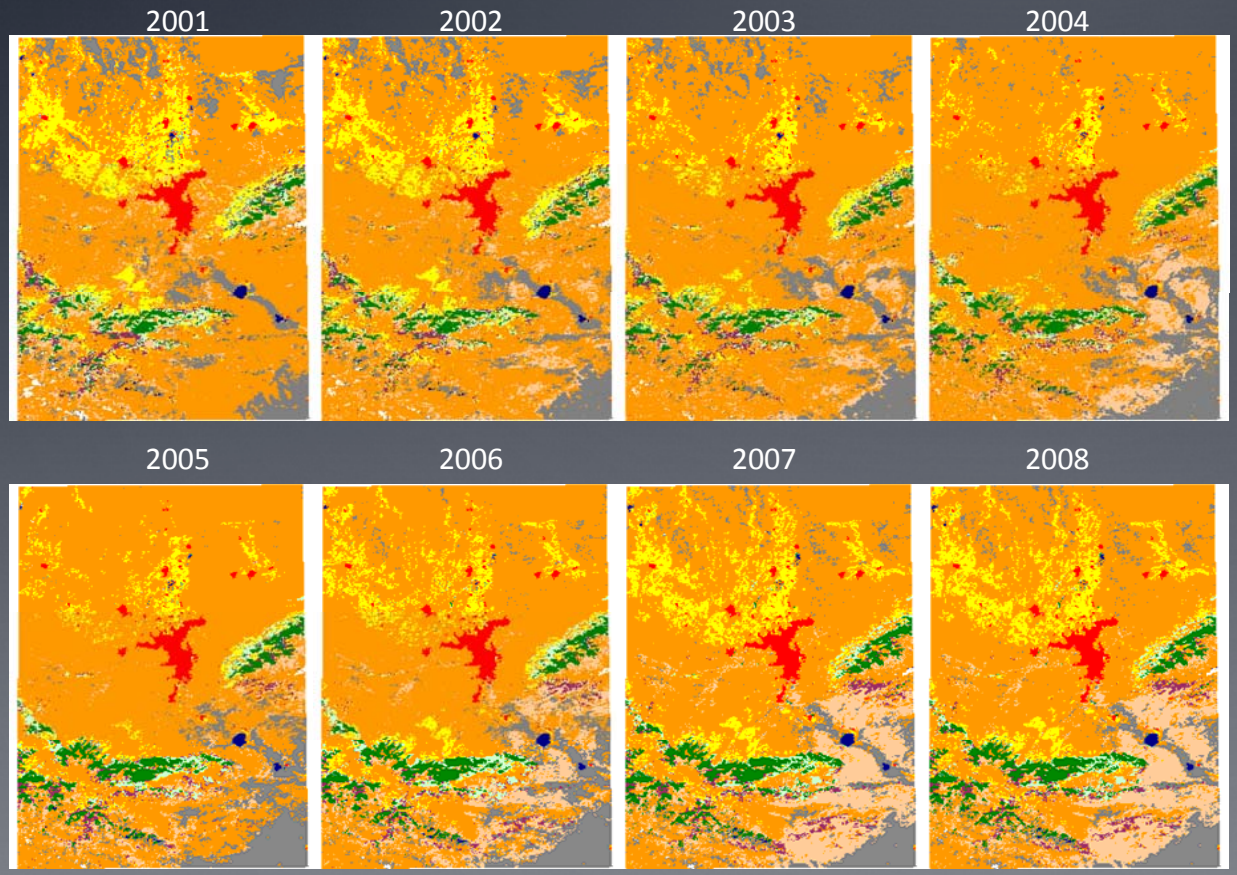


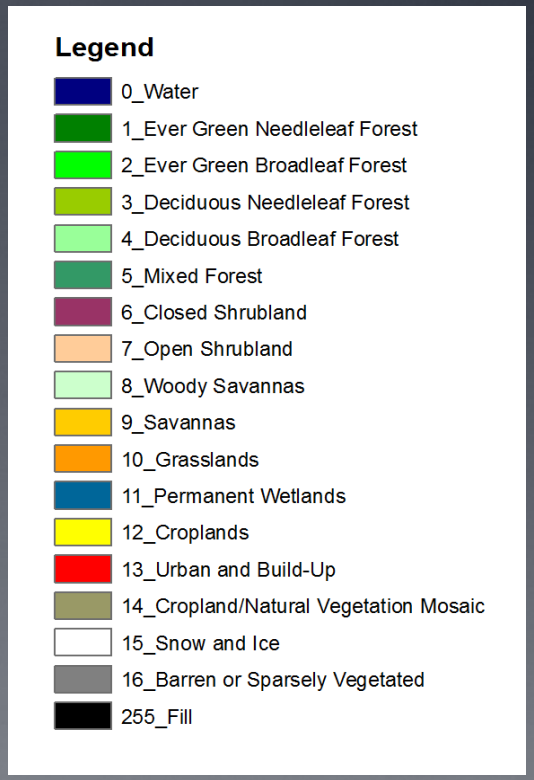


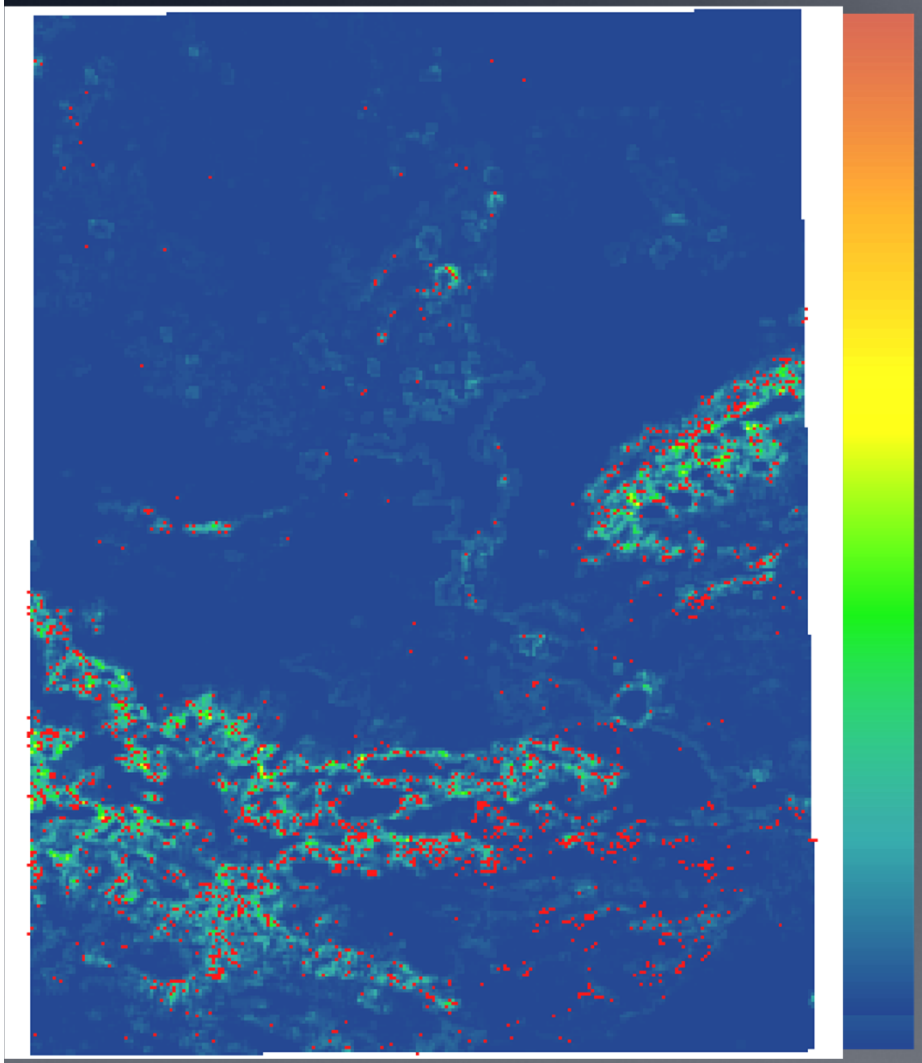

Ag 1975
Ag 2010
Urban 1975
Urban 2010

Urumqi: Uncertainty of MODIS Land Cover Type (MLCT) product

- MLCT 2001-2008







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<= A logit based prediction of uncertainty for the Urumqi region.

0

Areas in red are both predicted to be uncertain and, in our control MODIS data sets, present high levels of land cover confusion.

We have developed an uncertainty model from the time series of MLCT products for the Urumqi study area

Urumqi: degraded urban environment from urbanization/industrialization

Environmental impacts of industrialization

Urban air pollution

- one of top ten most polluted cities in the world (WHO, 1998)
- soot and dust from coal, combined with location in the valley of Tianshan Mountains; it is getting better

Water resources & consumption

- scarce, severely polluted -- available water per capita is ¼ of the national average
- human impacts – overgrazing, industrialization, urbanization

Cautionary tale for urbanization --

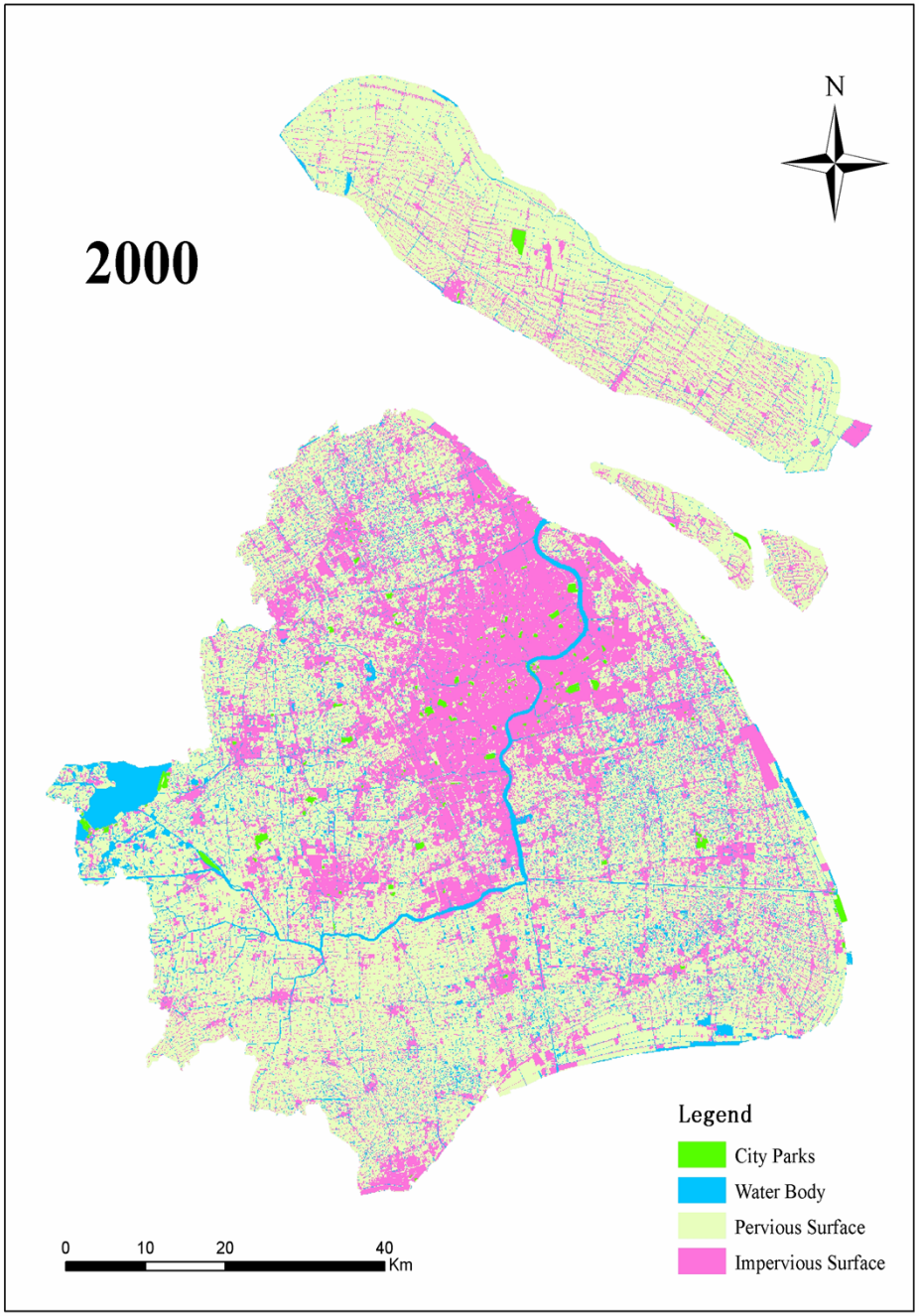
- over-dependence on industries based on fossil fuel resources can lead to rapid economic development, with unintended consequences

High rise condominiums (left), government buildings (up right), and residential houses (lower right) burn coals for heating. Photos were taken by Dr. Qingdong Shi at Xinjiang University, Urumqi, China, on Jan. 30, 2009.

Objective 2a. **Simulation of current and future LULC**

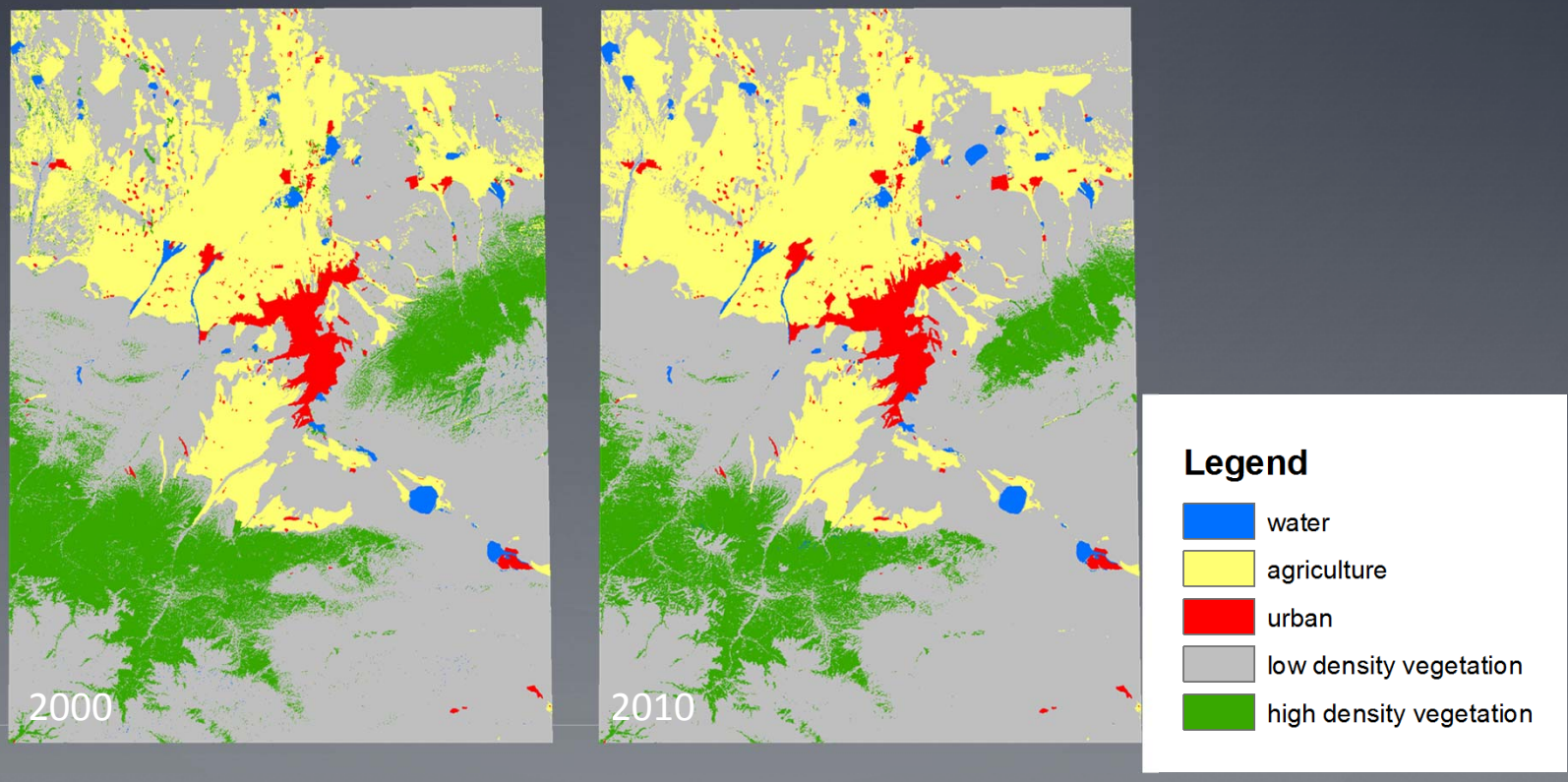
- **Shanghai:** CLUE-S modeling for future land use scenarios
  - Reclassified land use data of 2000 was used as a background start year
  - Above-mentioned driving factors are also inputs here
  - 2020 Year's planning map was used as a target demand of land use

Shanghai Simulation result: impervious surface: 2000 => 2020



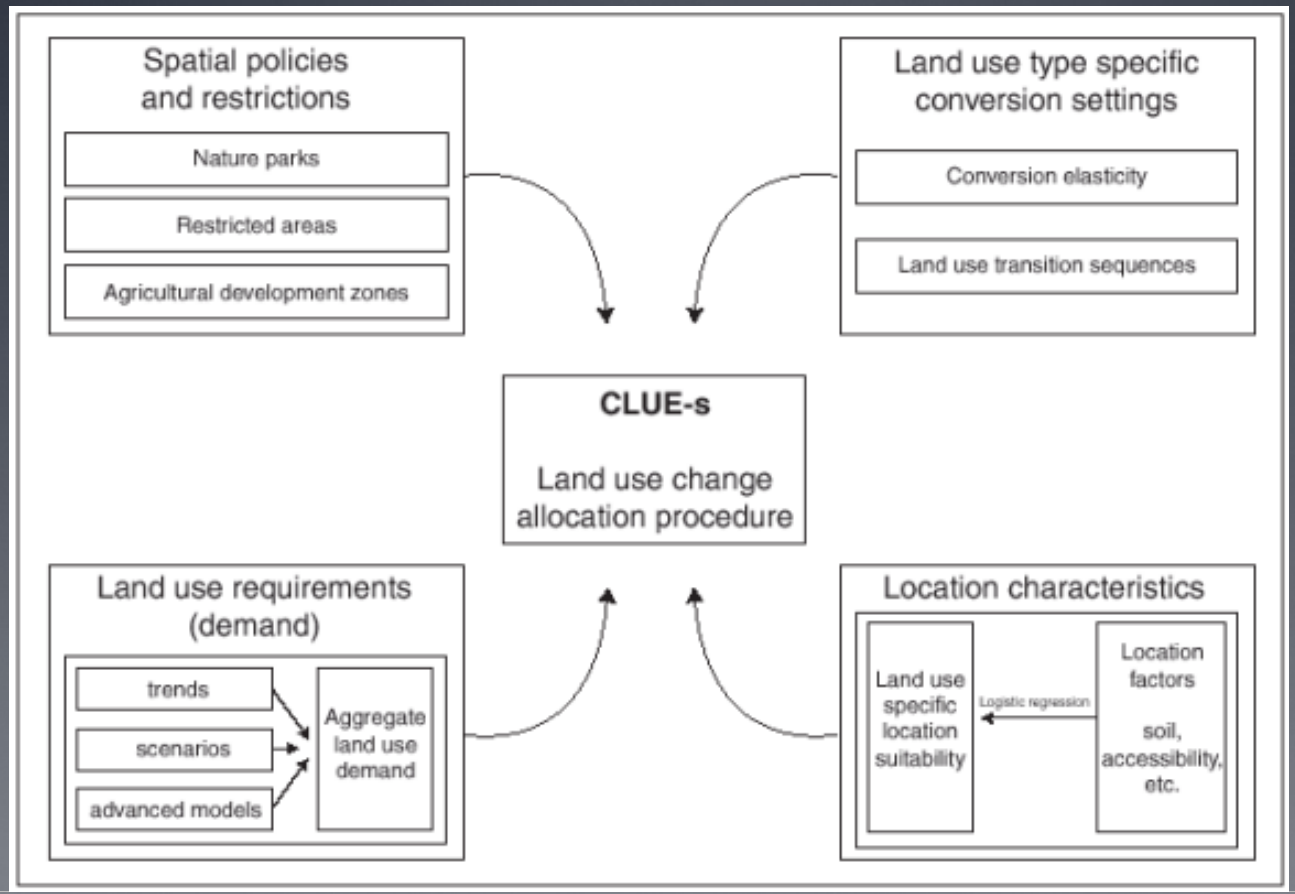
Urumqi Land use change simulation

- Land use data
  - from Landsat TM/ETM+ images
  - resample to 60m resolution



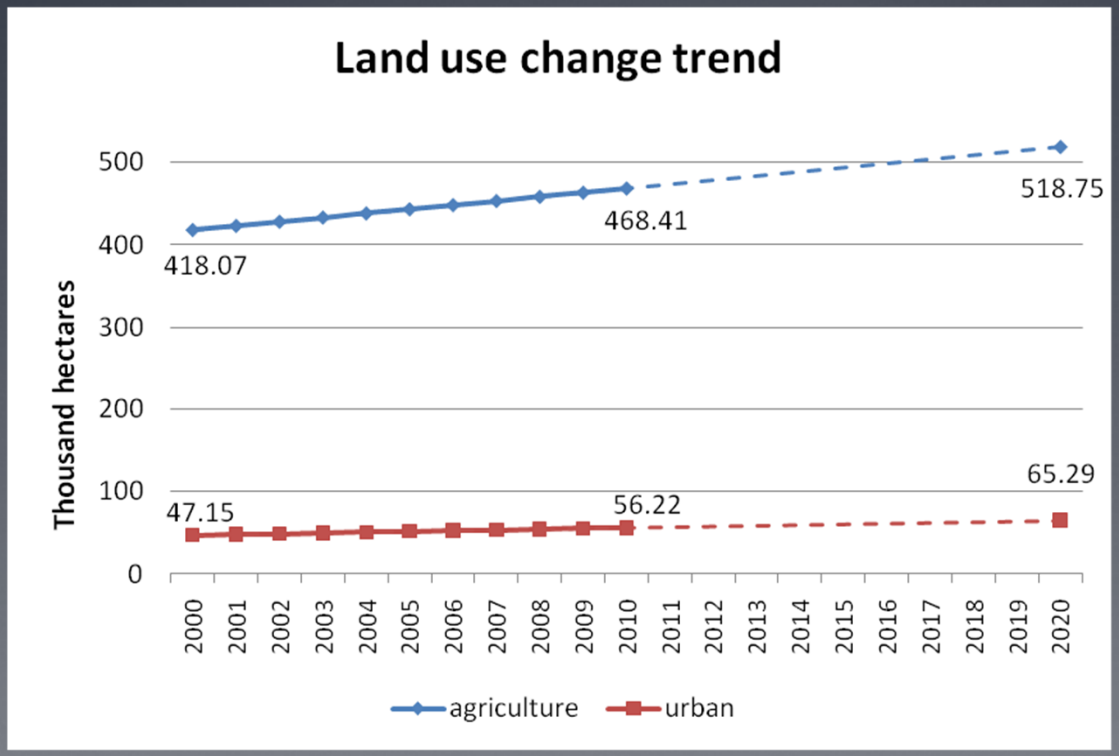
Urumqi Land use change simulation

- dyna-CLUE model



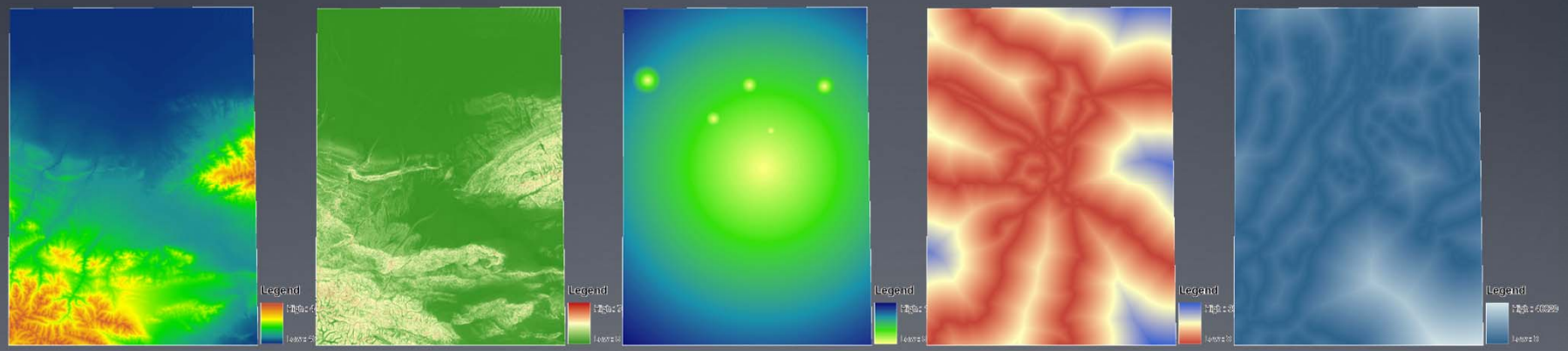
Urumqi Land use change simulation

- Land use demand
  - Basic scenario: historical trend extrapolation



Urumqi LULC change simulation

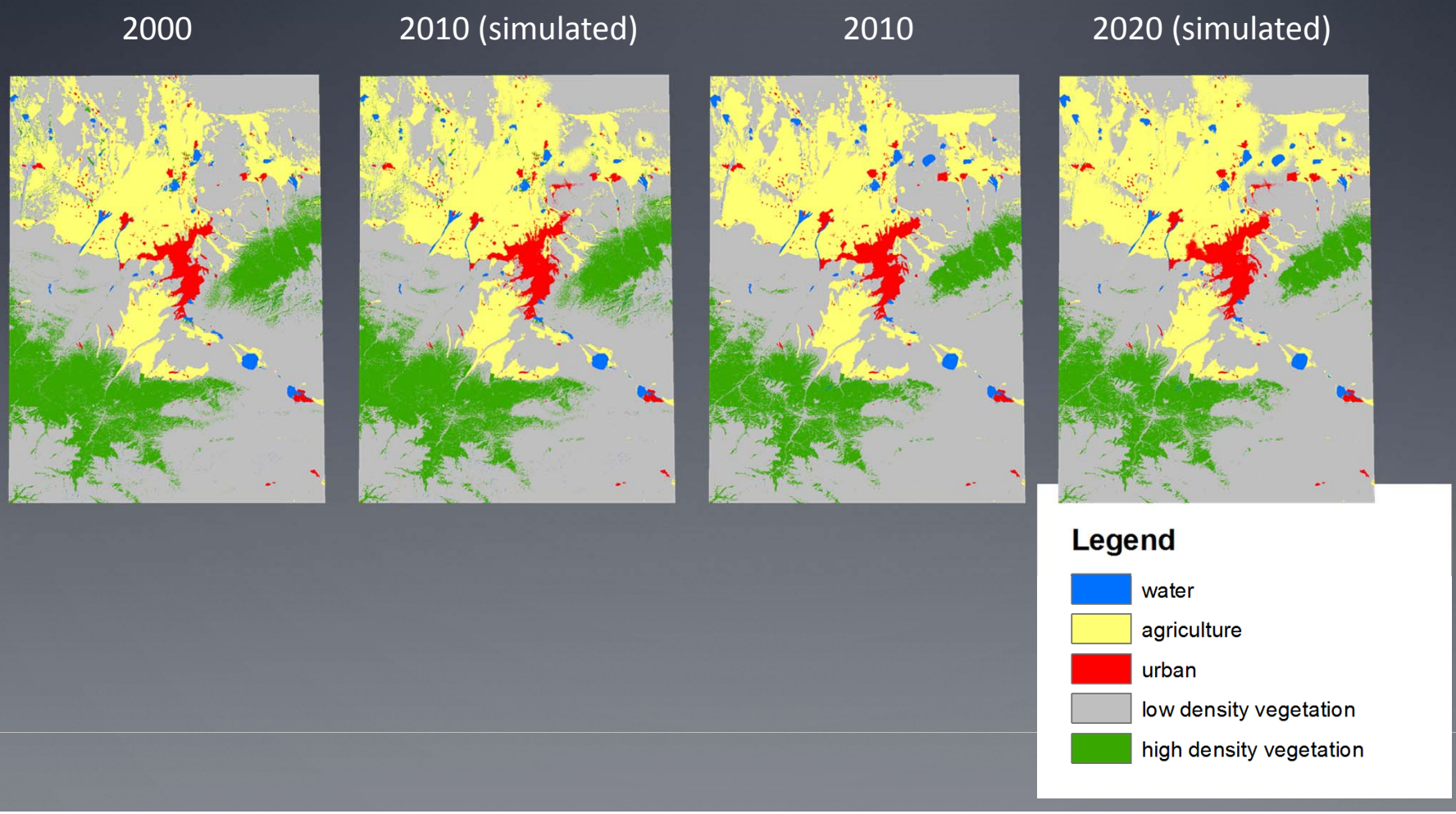
- Location characteristics



DEM Slope Distance to cites Distance to roads Distance to water

Urumqi LULC change simulation

- Simulation result



2b Regional climate simulation under IPCC scenarios

climate analysis due to changing land cover distributions,

Several regional climate model (RCM) simulations are underway.

Will investigate potential changes in land cover (particularly degradation) on overall atmospheric dynamics—convection, wind speed, rainfall, and near-surface humidity

These simulations, at 2 km resolution, are expected to test whether or not recent trends in land cover change will act to suppress growing-season rainfall or not

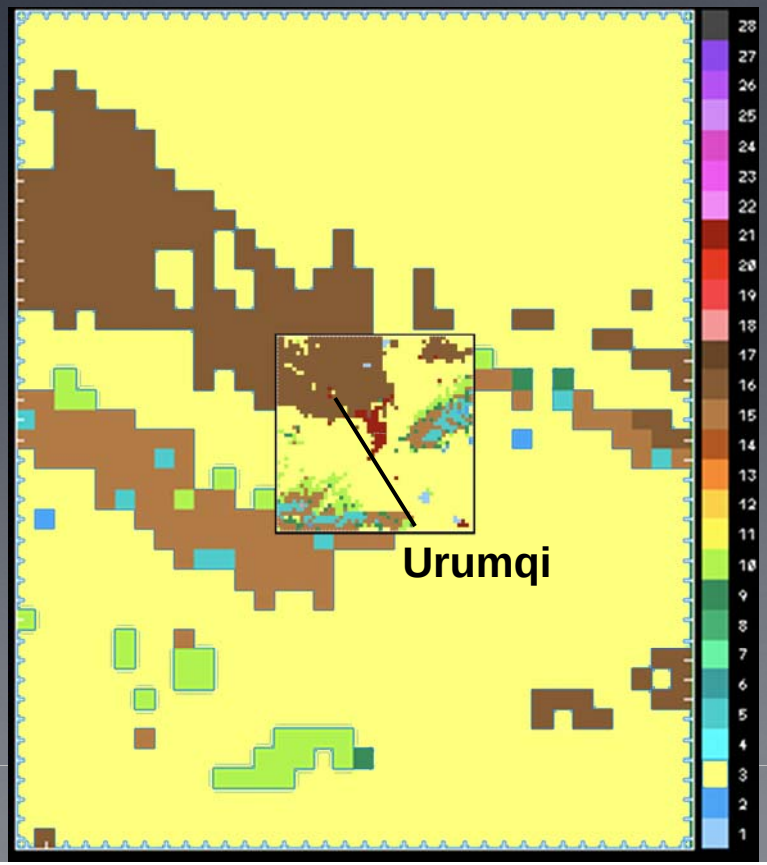
How urban expansion will affect these variables under climate change

We are debugging simulations in order to project these impacts out to 2050

Challenges: numerical stability in the RAMS code; Error propagation from land cover parameterizations

Urumqi - understanding environmental change: Modeling Climate

- incorporate land use in Regional Atmospheric Modeling System (RAMS) 6.0
- MODIS albedo, NDVI variables added directly into land surface model



Preliminary results

- previous work shows region will experience higher temperatures, and thus, increased threat of desertification
- changes in fractional vegetation cover - models show higher wind speeds may better disperse pollutants; may lead to better air quality

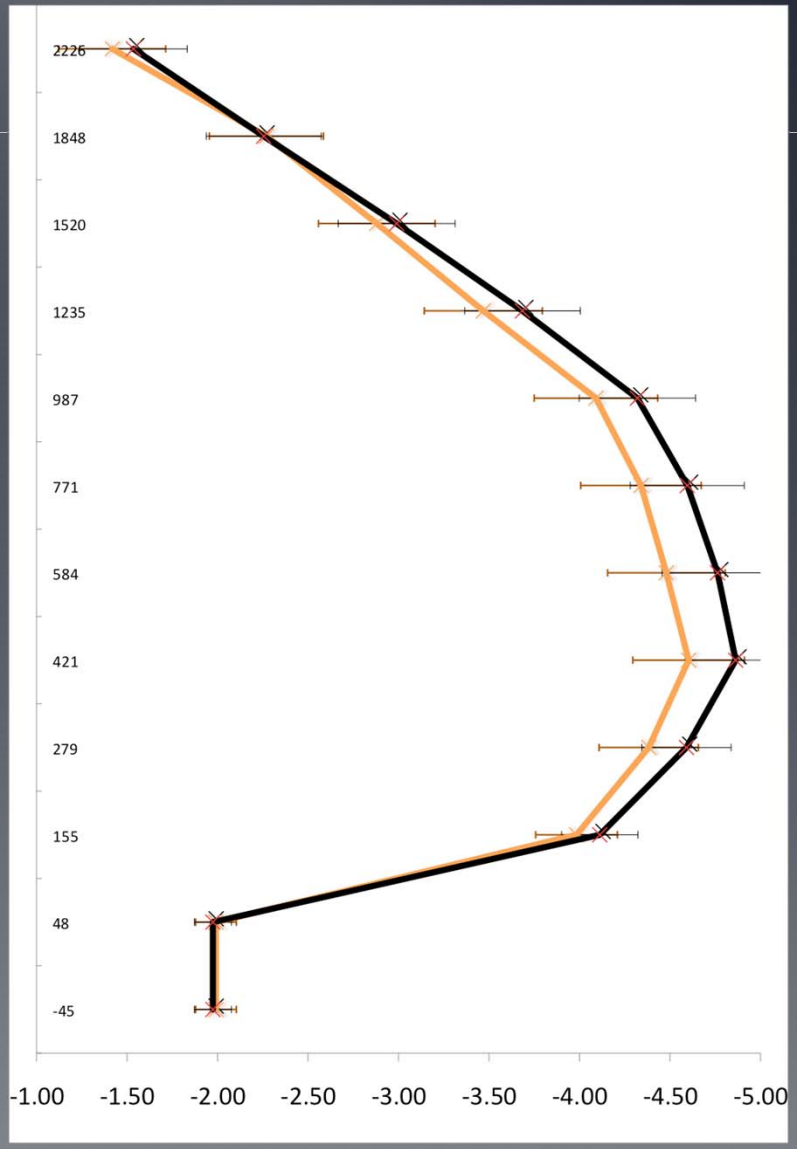
Multiple nested grids (2 and 8 km shown) of the *RAMS model*, and aggregated land cover classes

Moore et al., AGU 2009

Urumqi

- Reduced vegetation
- Higher winds speeds
- Consequences for air quality

- Sensitivities to Land Cover Change— Urban Growth, Expanded Irrigation?



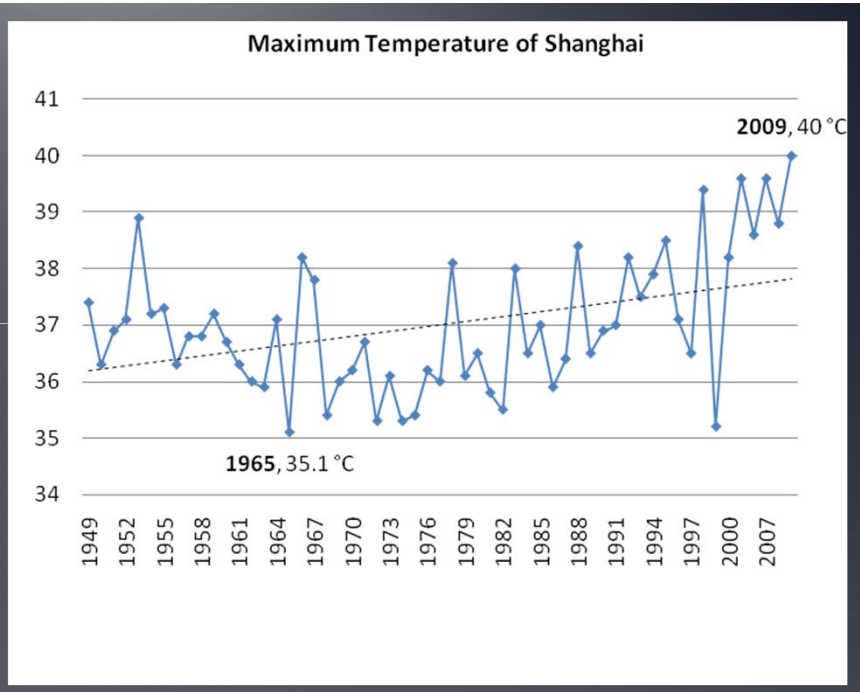
Future Tasks

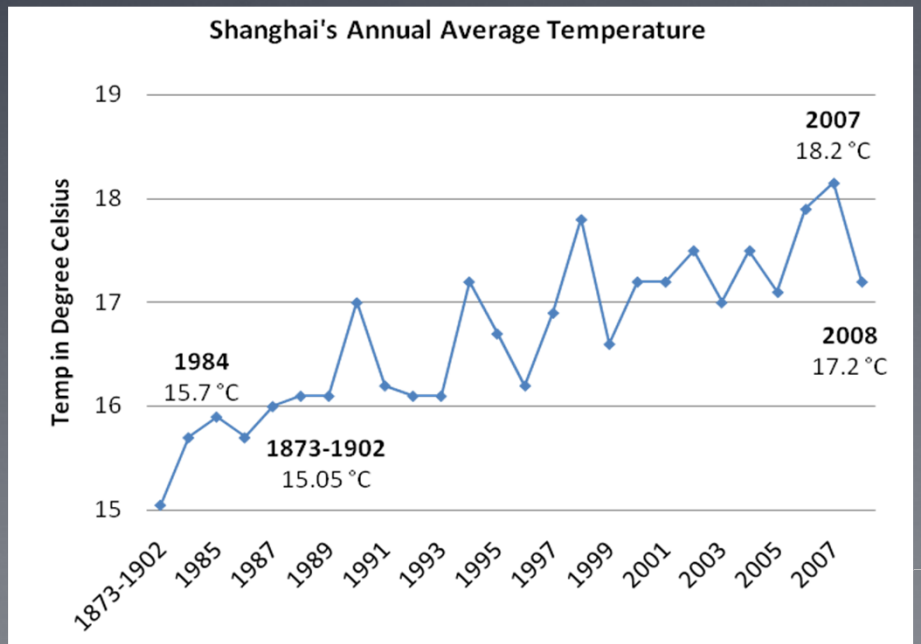
- Monte Carlo trials for simulating potential distributions of heat with urban growth
- Future climate simulations at 1 & 2 km grid spacing (RAMS)
- Standardized Precipitation Index (SPI) drought analysis
- Relay climate results for DPSER analysis

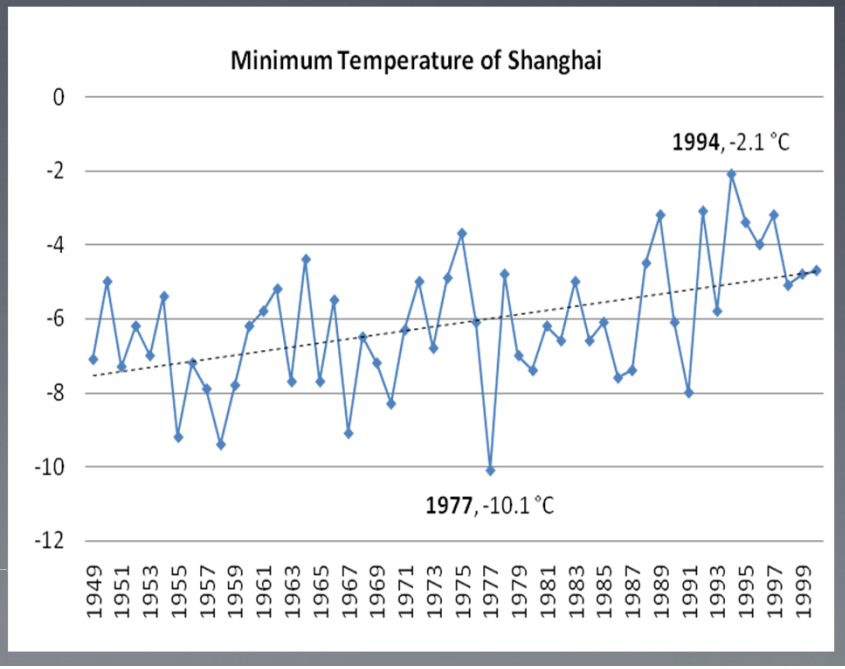
2c Impact of climate change on cities & 2d Adaptation and mitigation strategies

-----Changing climate in Shanghai

- max temp increases 1949-2007, summer gets hotter
- min temp increases 1949-2000, warmer winters
- ongoing work links land use to climate change using regional climate models

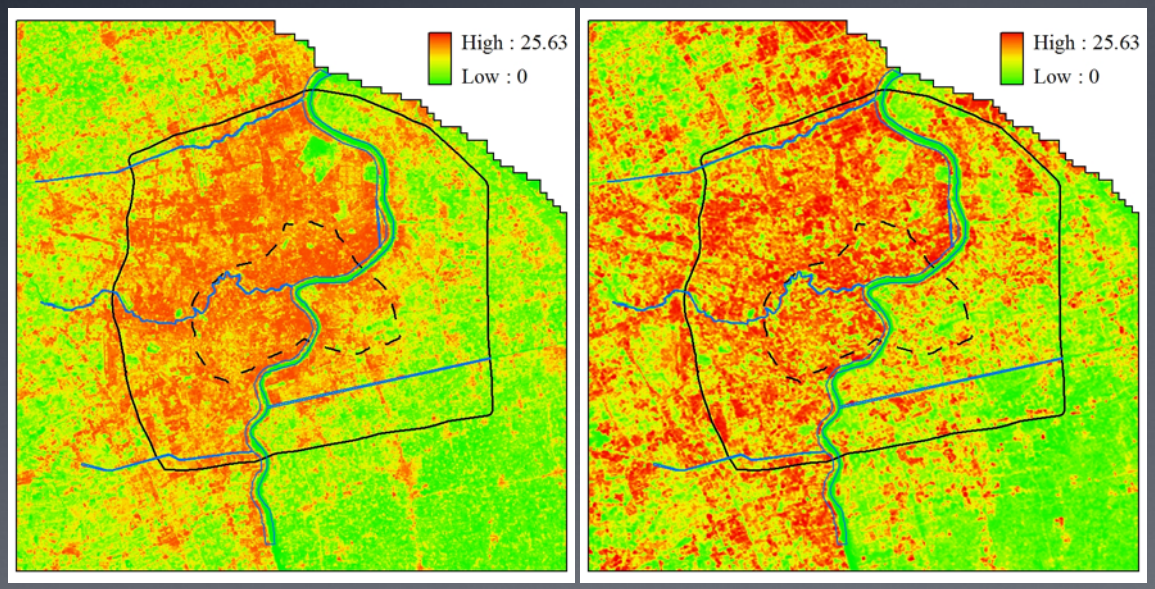






2c Impact of climate change on cities & 2d Adaptation and mitigation strategies

----Urban Heat Island in Shanghai



Shanghai's urban thermal environment (unit: ℃) (L: 2000, R: 2008)

- change in intensity of thermal environment at the urban core
- spread of heat island effects to periphery
- **Findings -** leading factors contributing to the urban thermal environment
  - land surface modification,
  - landscape configuration
  - anthropogenic heat release

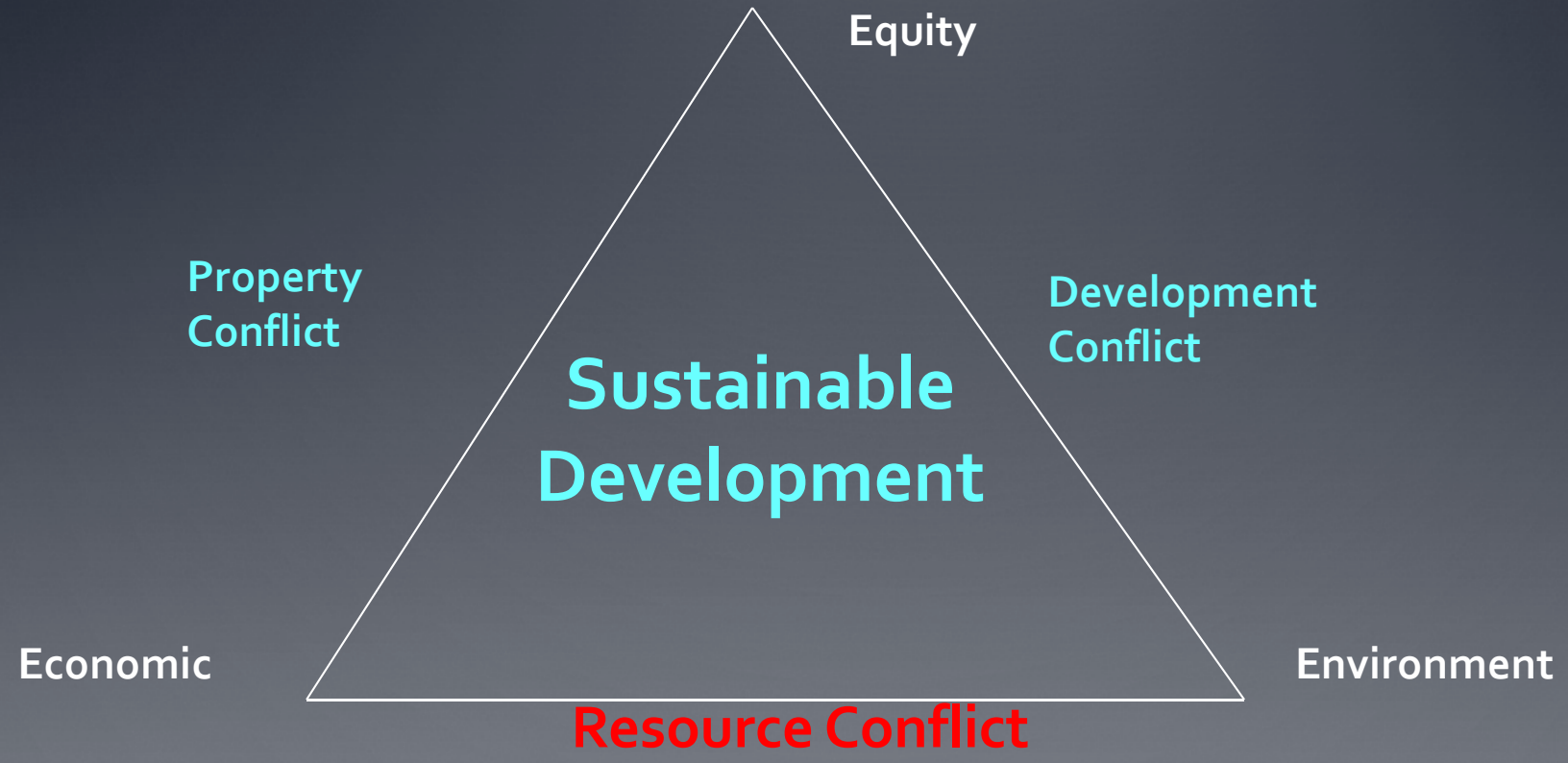
Summary, so far…

- Integrated system
  - urbanization, LCLUC, urban environment change and climate change
- LCLUC:
  - Urban sprawl ++
  - Different dynamics of different types of urban land
  - urban China in a transitional economy: **spatial policy** + **market force**
- Climate Change
  - City level: Contribution of LCLUC to CC?
  - Microclimate: significantly affected by landscape configuration

Spatial policy plays a critical role
----Shanghai Urban Planning Museum, 03/2010

Sustainability as the end goal

Figure Source: Campbell, 1996



Society's needs for economic growth and environmental protection potentially are in conflict with each other.

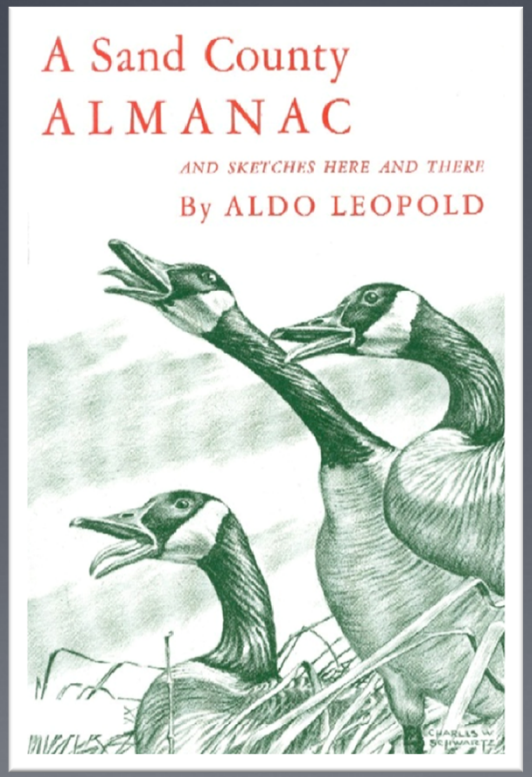
While society has relied on exploitation of natural resources such as water for economic dev. needs, it needs to regulate the exploitation to conserve resources for present and future usage.

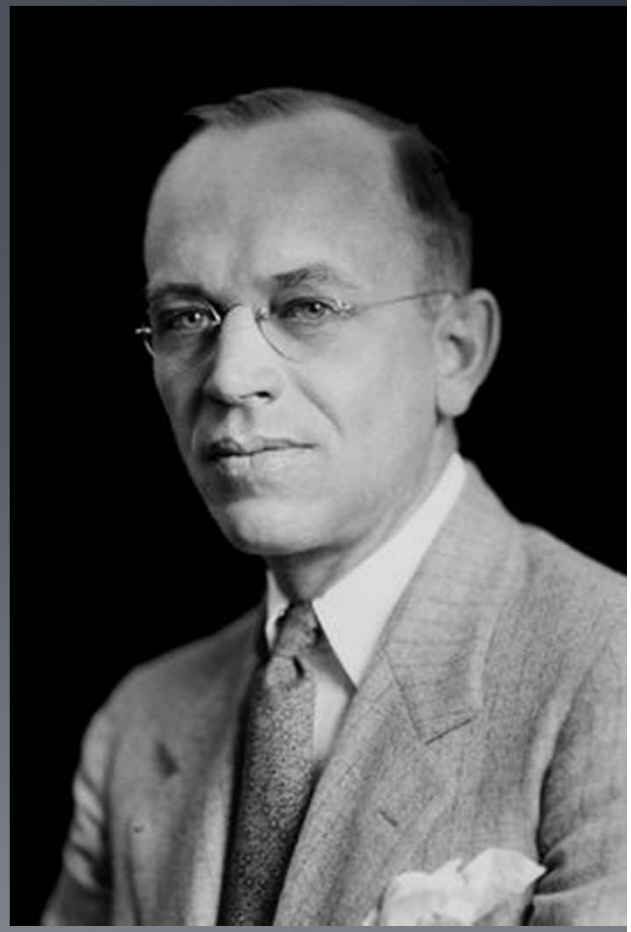
Future research – urbanization and environment consequences

- **three urban regions in different zones**
- Causal linkage: urbanization (socio-economic drivers), LCLUC, and **hydrologic** environment
- Future urbanization and LCLUC scenarios and climate, water quantity

Aldo Leopold

- A Sand County Almanac (1948)
- Conservation Esthetic
- Aldo Leopoldd Ethics





Sources: www.wikipedia and www.aldoleopold.org

Land Ethic:

A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.

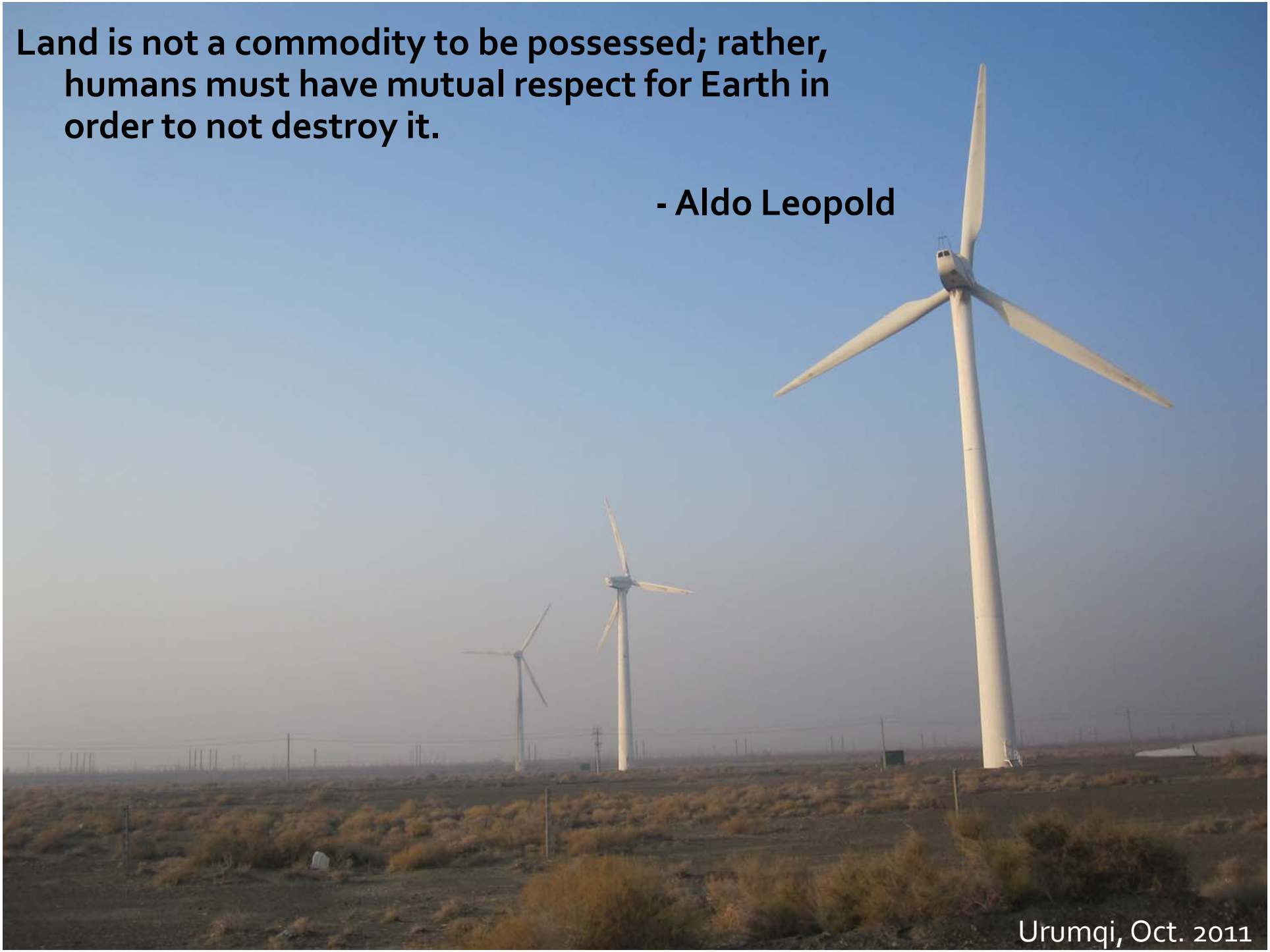
- Aldo Leopold

Tianshan, Urumqi, May 2010

Conservation is a state of harmony between men and land.

- Aldo Leopold

Agricultural land in Shanghai, Nov. 2011


Land is not a commodity to be possessed; rather, humans must have mutual respect for Earth in order to not destroy it.
- Aldo Leopold
Urumqi, Oct. 2011

Thank you!

Urumqi
Fieldtrip in May 2010

Acknowledgement
LCLUC of NASA (Grant No. NNX09AI32G)

- **Xi Chen (Geography and Ecology Institute, CAS, Urumqi)**
- **Guanghui Lv & Qingdong Shi (Xinjiang University, Urumqi)**
- **Bin Zhao (Fudan University, Shanghai)**
- **Anxin Mei (East Normal University, Shanghai)**

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