Land Use Change in Developing Countries

Comparing India and China

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Introduction

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2. Comparing India and China: urbanization and infrastructure
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3. Cellular Automaton/Markov model: Case studies of land use changes
    - India - New Delhi and Chennai
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1. Urbanization in the developing world

- In 1950 only 18% of people in developing countries lived in cities
- In 2000 the proportion was 40%
- In 2030 the developing world will be 56% urban
- In 2000 the developed world is estimated at 76% urban
- Developing countries have much faster urban population growth—an average annual growth rate of 2.3%, compared to the developed world's urban growth rate of 0.4%

Urbanization (cont)

Rapid urban growth in developing countries reflects

- substantial migration to cities from rural areas
- natural population increase among city residents

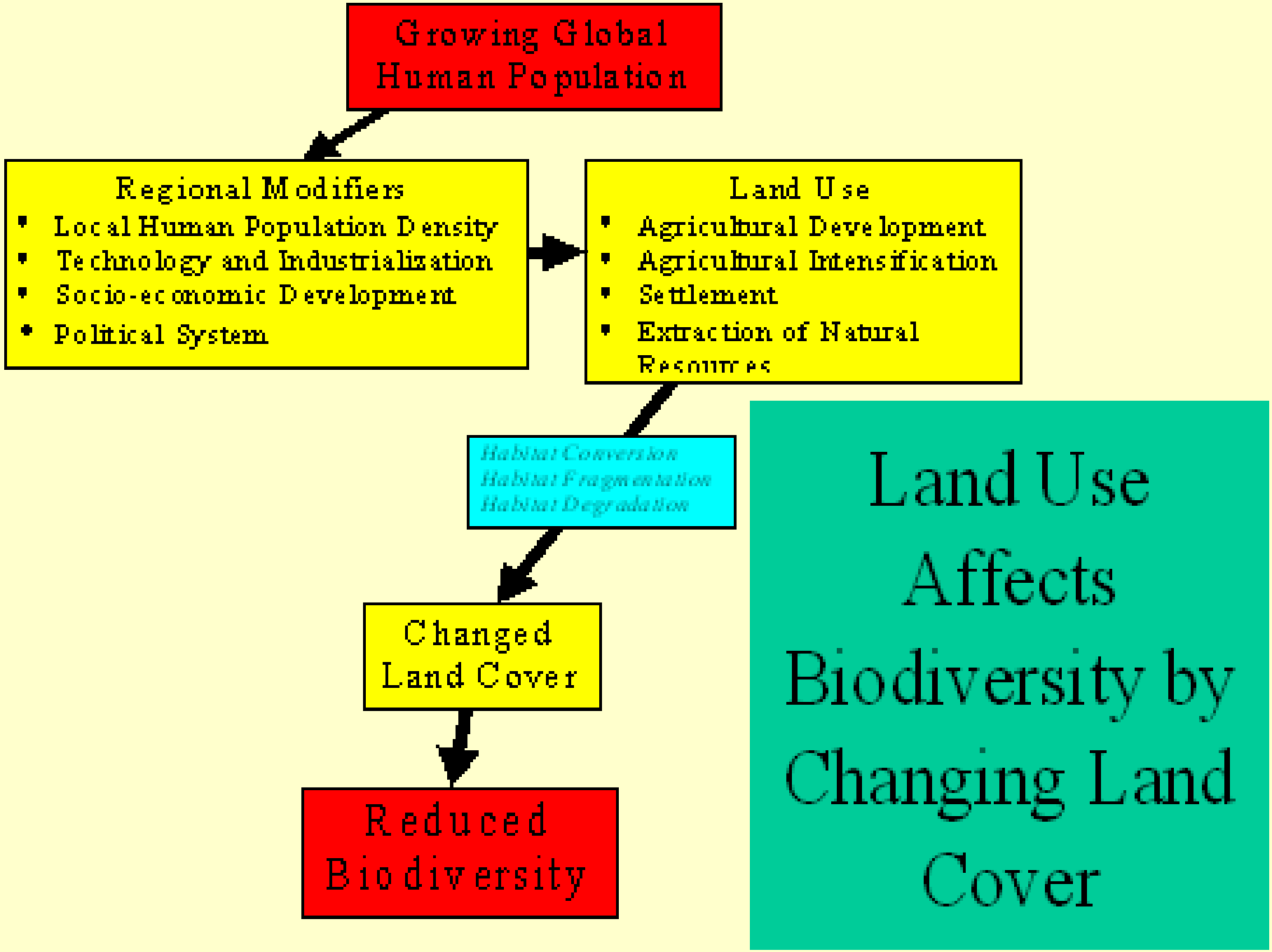
Among developing countries,

- estimated 60% of urban growth in 1960-1990 was from natural increase
- 40% from in-migration from rural areas and the expansion of urban boundaries

Sources:
BROCKHERHOFF, M.P. An urbanizing world. Population Bulletin 55(3): 3-44. 2000.
28.
UNITED NATIONS POPULATION DIVISION. World urbanization prospects: The 1999 revision. New York, United Nations Population Division, 2000. 128 p.

Land use change - Sprawl

A tidal wave of sprawl is likely to come from developing areas


Growing Global Human Population
Regional Modifiers
Local Human Population Density
Technology and Industrialization
Socio-economic Development
Political System
Land Use
Agricultural Development
Agricultural Intensification
Settlement
Extraction of Natural Resources
Habitat Conversion
Habitat Fragmentation
Habitat Degradation
Changed Land Cover
Reduced Biodiversity
Land Use Affects Biodiversity by Changing Land Cover

Land use change

- Land cover is determined by environmental factors
  - soil characteristics, climate, topography, and vegetation
- The major determinants of land use are:
  - demographic factors such as population size and density;
  - technology;
  - level of affluence;
  - political structures;
  - economic factors: systems of ownership;
  - attitudes and values

Land use change

- I = PAT relationship that considers environmental impact (I) to be a function of population (P), affluence (A), and technology (T) (Commoner 1972).
- Population density was found to be related to agricultural expansion and intensification everywhere, but only in some regions to deforestation
- Technological development such as the extension of basic transport infrastructure such as roads, railways, and airports, can open up previously inaccessible resources and lead to their exploitation and degradation

2. Basic facts

	China	India	U.S.A.
Population (2001) (Growth rate)	1,273,111,290 (0.88% est.)	1,029,991,145 (1.55% est.)	278,058,881 (0.9% est.)
Land area (sq km)	9,326,410	2,973,190	9,158,960
Arable land + Forests	10% + 14%	56% + 23%	19% + 30%
GDP	$4.5 trillion	$2.2 trillion	$9.963 trillion
GDP - per capita (purchasing power parity in 2000)	$3,600	$2,200	$36,200
Population below poverty line	10% (1999 est.)	35% (1994 est.)	12.7% (2000 est.)
Life expectancy	71.62 years	62.86 years	77.26
Total telephone lines (2000)	200 million	31 million	270 million

Urbanization in China

- China's urbanization ratio is roughly 40 per cent - significantly lower than that of developed countries and many developing nations.
- There were 666 cities in 1996, which was 3.65 times that in 1982 (182), and 2.05 times in 1985 (324), respectively.
- The urban population grew from 106 in 1957 million to 347.52 million in 1995 (1995's statistics yearbook) dwellers.
- A survey using satellite images shows that urbanized areas in 31 largest cities expanded by 50-200% in 1986-1996.
- The urbanized area in Beijing doubled from 1985-1992.
- Despite a rigid registration system laborers are flocking into the cities (the so called "floating population").

Urbanization in India

- India's mega-cities and and its 4,000 cities and towns account for 60% of the gross domestic product.
- In 2001 the percentage of urban population is 28%; 35 cities have population more than a million; compared to 23 cities in 1991.
- By 2015 more than half of Indians are projected to be urban dwellers; 1/3 will be slum dwellers and squatters.
- In the national capital region 1/2 of households and 1/3 of population were migrants and a little less than 1/2 of migrants were from rural areas.
- The urban to urban stream of migration was found to be more important for larger cities like Delhi. About 1/3 the migrant households were in the category of urban poor households.

China urbanization example

Source: LandSat 5 Thematic Mapper; provided courtesy of Curtis Woodcock, The LandSat Project Team, Boston University

Comparing land policy
land in China

- Since the late 1980s, China has been adopting a land use rights system similar to the land leasehold system in Hong Kong.
- In the past, municipal governments increased their land supply through land acquisition which was easy.
- Since then special economic development zones (SEDZs) were established along east-coast areas in the early 1980s to attract foreign investment.

Comparing land policy
land in China

- The “land administration law” was passed in 1986 (updated 1998) This allows for land rights to be sold
- According to the “provisional act of land use taxation on state owned urban land” of 1989 all work units and individuals are obliged to pay land use taxation or fees
- The state council passed the “basic farmland protection regulation” in 1994 later repealed
- During the last two decades, the central government adopted a national policy that “controls big cities”

Comparing land policy
land in India

- Broadly speaking, three major types of land reform legislation have been enacted since independence in 1947
    - The abolition of intermediary tenures
    - Regulation of the size of holdings (through ceiling-surplus redistribution and/or land consolidation)
    - And the settlement and regulation of tenancy (intentions of these reforms)
- Although there is a trend away from a regulatory approach towards a more market orientated approach progress to date has not been promising
- Poor land records is recognized to be one of the major obstacles to progress

Comparing land policy
land in India

- Improving land registration: both rural and urban development is believed to be constrained by insecurity or uncertainty of land title
- Land “grabbing” in urban areas continues to be an issue
- The planning commission has constituted a national task force on urban perspective and policy in 1995
- The draft national slum policy (January 1999) establishes the principle “that households in all urban informal settlements should have access to certain basic minimum services”

Comparing infrastructure

roadways

	India	China	U.S.
Total Length (million km)	2.47	1.53 (1.35)	6.35
Paved (million km)	1.4	0.3 (1.27)	5.73
Unpaved (million km)	1.1	1.23 (0.08)	0.64
km per 100 sq. km	69	11 (14.1)	69

Comparing infrastructure
railways

	India	China	U.S.
Total Length	63,693	67,524	225,750
Electrified	13,771	13,362	-
Double Line	12,617	20,250	-
km per 1000 sq. km	19	7	25

Comparing infrastructure

	India	**China**	**U.S.**
Railways	(per $ million of PPP GDP)		
Pass km	195,355	82,693	1020
Ton km	136,165	260,427	352,942
Road			
Pass km (billion)	400	705	2500
Ton km (million)	958	572,430	1,534,430

Transportation Infrastructure policies

- Infrastructure investment is a key element of China's economic growth potential, with major infusions scheduled for the road, railway, port, telecommunications, oil and gas, and coal sectors. In 1998, infrastructure investment grew by more than 20 percent in nominal terms, and the funds earmarked for investment rose by 21 percent to RMB 1.1 trillion.
- In India, with recent attempts at decentralization and increased participation by all levels of government in the reform process, the focus of reform efforts has been shifting increasingly to state governments, particularly for infrastructure development.

3. Cellular Automaton/Markov model

Definitions

- A Markovian process is one in which the state of a system at time 2 can be predicted by the state of the system at time 1
- One of the basic spatial elements that underlies the dynamics of many change events is proximity
- A cellular automaton (CA) is a cellular entity that independently varies its state based on its previous state and that of its immediate neighbors according to a specific rule

Cellular Automaton/ Markov model

- Modeled three kinds of land use based on density:
  - » Rural (< 1000 persons per sq km)
  - » Suburban (1000-5000 persons per sq km)
  - » Urban (> 5000 persons per sq km)
- Modeled rural suitability based on :
  - » Availability of moisture, average annual rainfall, access to streams , soil type/agricultural productive potential, slope and land cover suitability to agricultural use
- Modeled urban and suburban suitability based on
  - » Identification of macro-economic zones in close proximity to existing cities
  - » Based on proximity to urban centers, water availability, slope, roadways and railways

Model Data

Data for both India and China from:

- UNEP/GRID (Global Resource Information Database) 1987, United Nations Department of Economic and Social Affairs Population Division national estimates and the Oak Ridge National Labs (ORNL) Landscan Population Density product (1998),
- Major roadways DCW 1991
- Existing urban land cover DCW 1991
- Railways DCW 1991
- Water sources DCW 1991
- Slope DCW 1991
- Land cover (Earth Satellite Corp) 1991
- Agricultural suitability (Earth Satellite Corp) 1991

Cellular Automaton and Markov model

- Suitability maps for each land use type are considered as an objective.
- For each host class, the suitability maps of all others are masked
- Then, for each mask image a contiguity filter is used to weight contiguous areas.
- The area requirements for each land use category are taken from the transitions areas file developed using a Markov model.
- Finally, an overlay is applied to all the results onto the base land cover map.

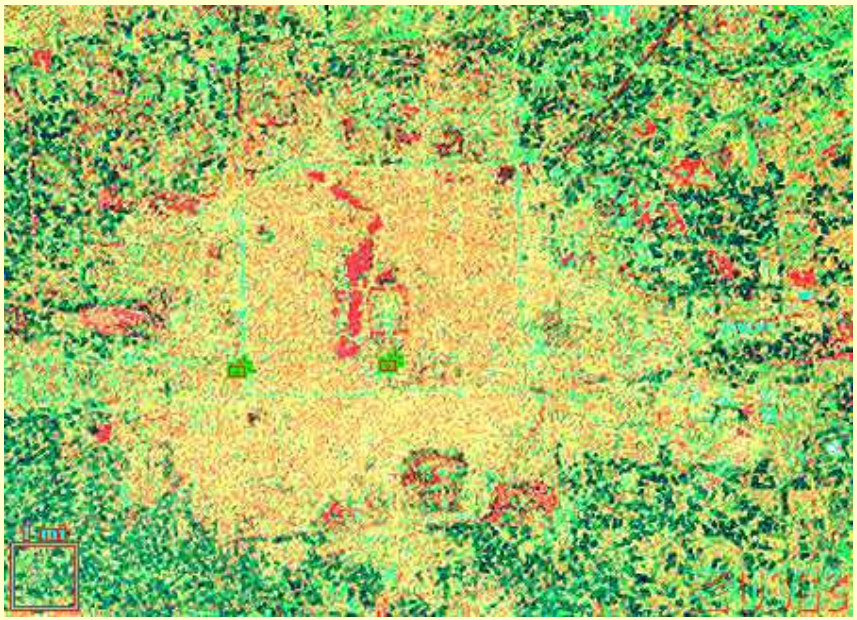
4. Comparing the case study cities

	Delhi	Beijing	Chennai	Jinan
Total population millions (urban)	16 (10)	13 (8.5)	7.5 (4.9)	5.6 (2.6)
Slum population	30%	18% (est)	40%	4% (est)
Growth rate (1990-2000)	46%	37%	27%	7.5%
Total area (city area) (sq km)	1483 (357)	1282 (170)	1171 (172)	391 (116)
Roads (km)	26379	13311	2200	1829
Main mode transport	Bus(60%)	Bus (40%) NMV(50%)	Bus (38%) NMV(45%)	Bus (60%) NMV (30%)

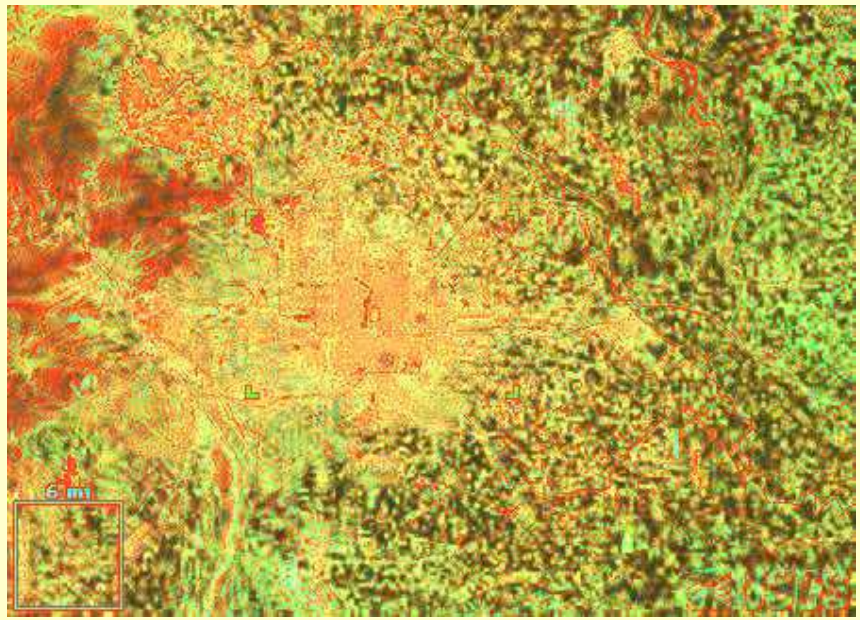
Beijing 1976 - 1991

Source: USGS **Landsat 2 MSS, 26 October 1976,**
Landsat 5 TM, 16 May 1991

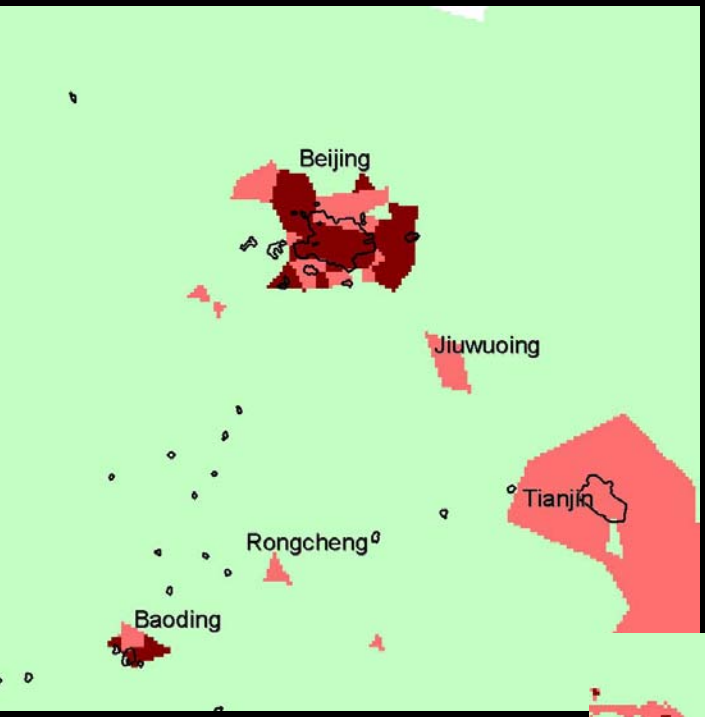
Red represent urban areas, other tones represent natural and agricultural vegetation



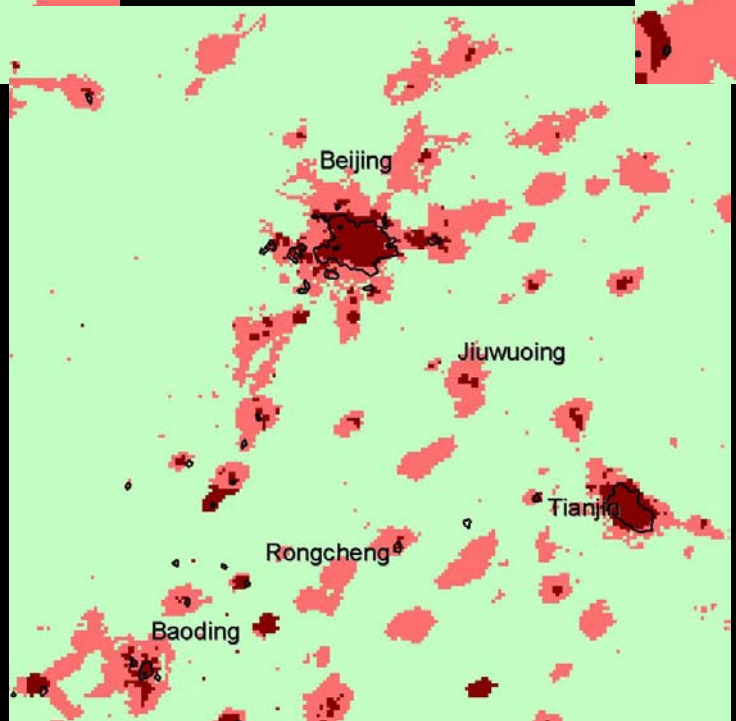
1976



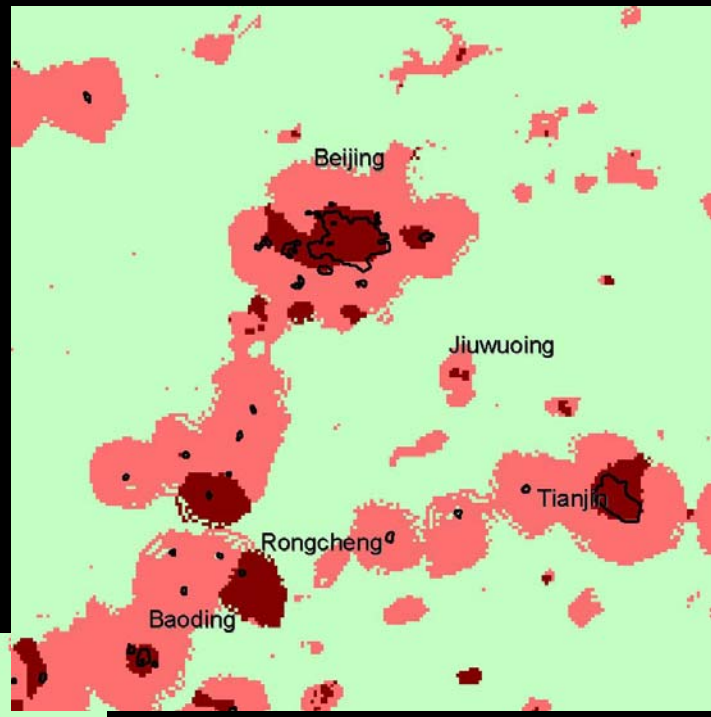
1991



1987



1998

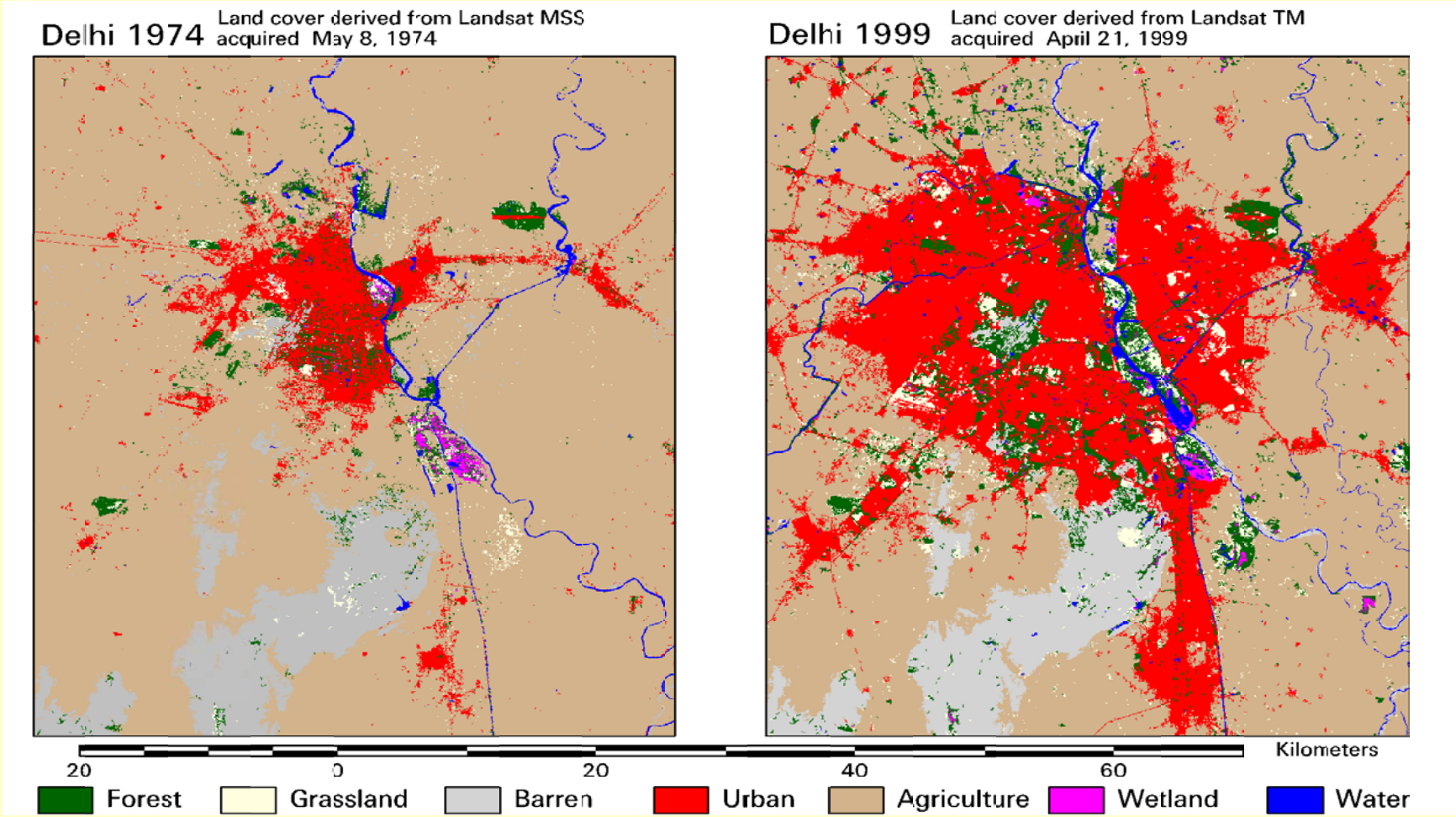


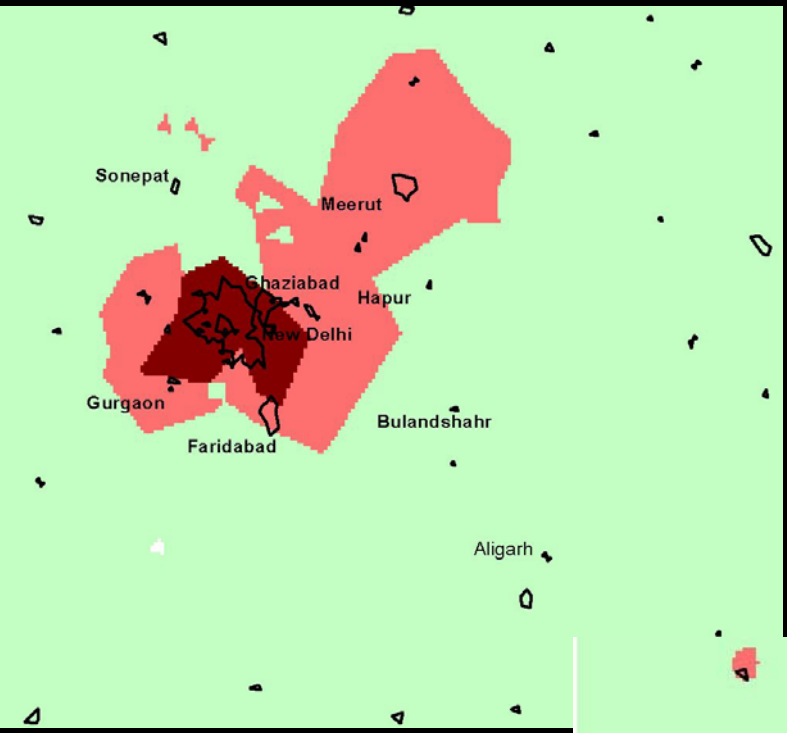
2009

Beijing Model Results

New Delhi 1974 - 1999

Increase in population of 4.2 million
60,000 hectares of agricultural land lost





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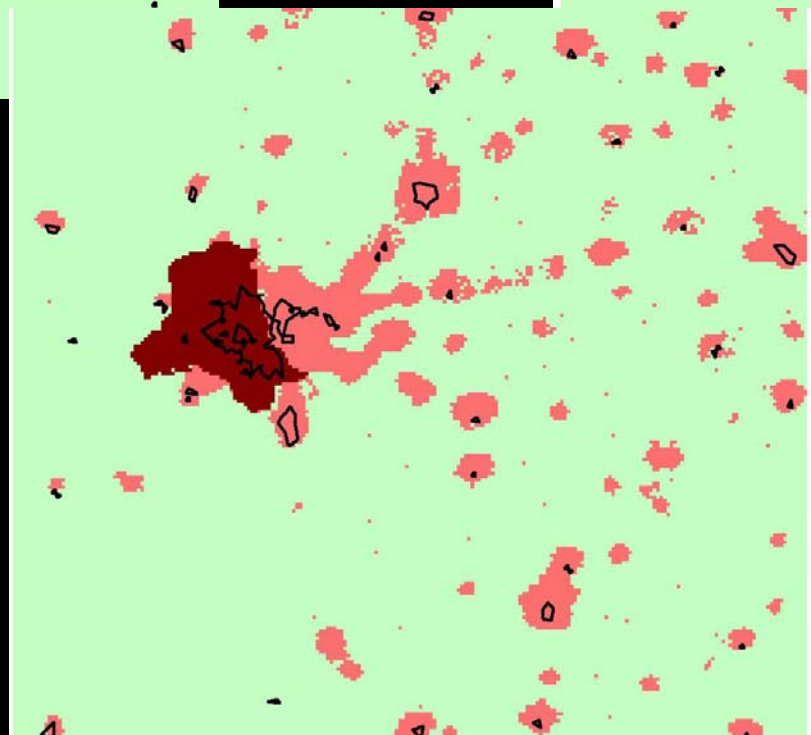

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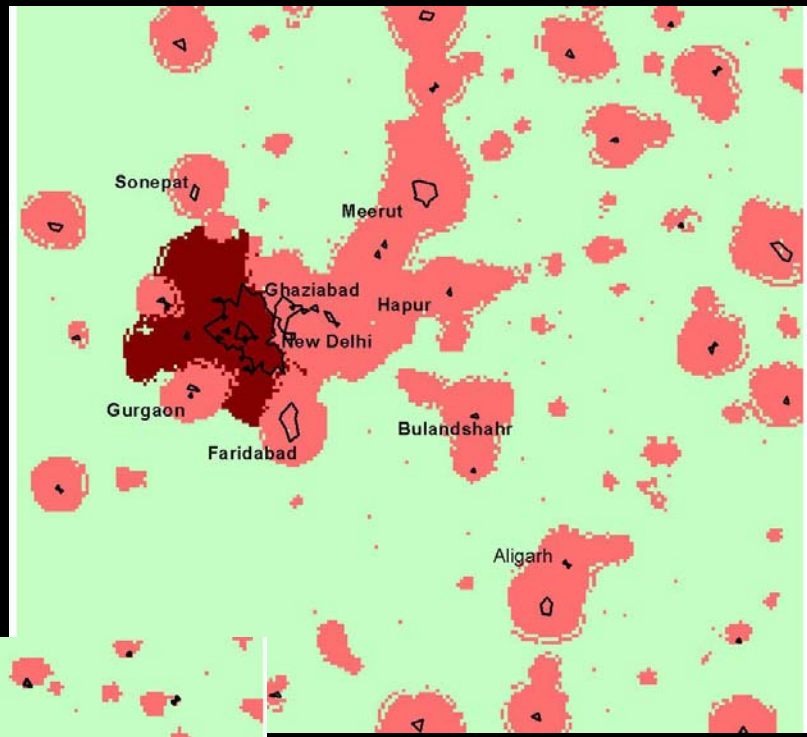


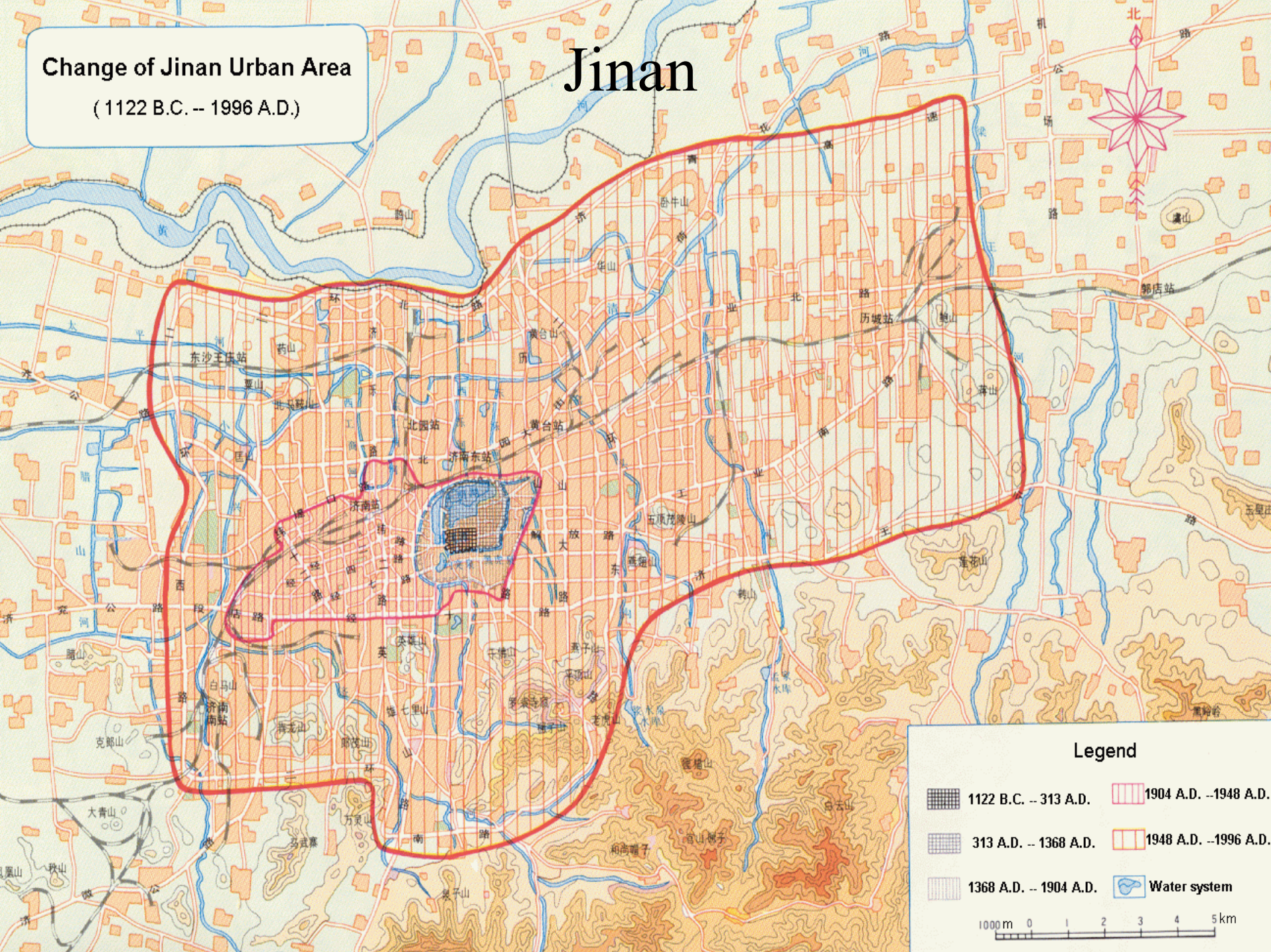
2009

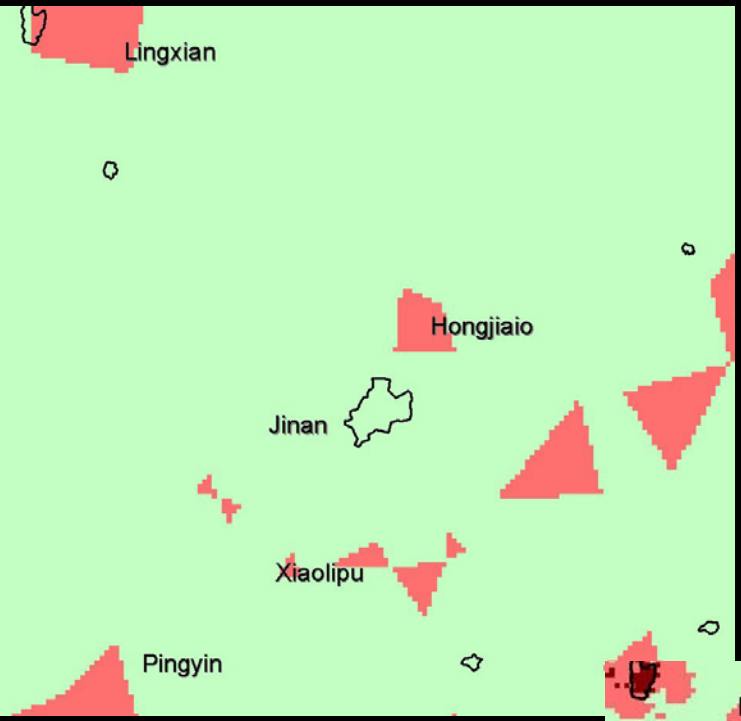
New Delhi Model Results

Jinan

Change of Jinan Urban Area

(1122 B.C. -- 1996 A.D.)





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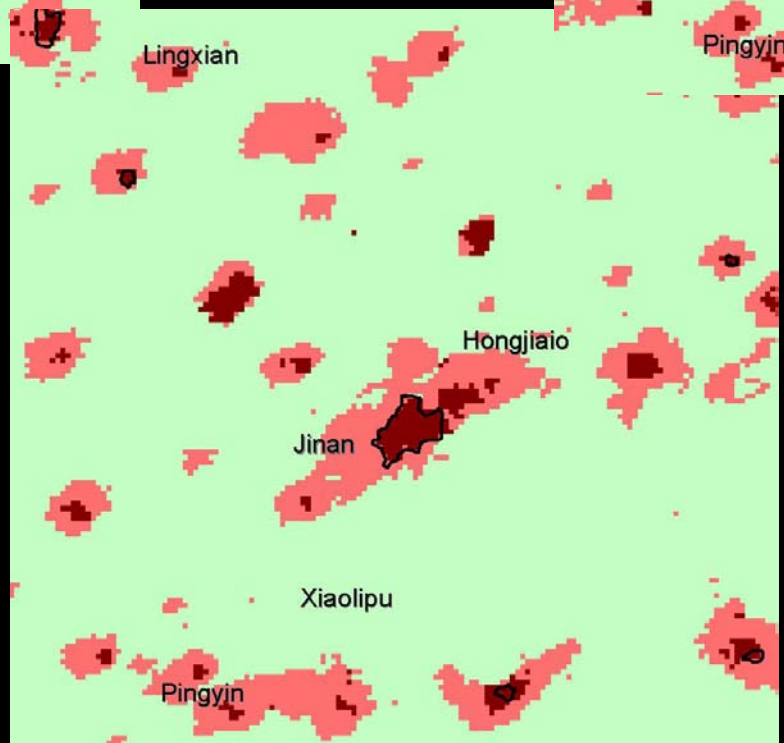
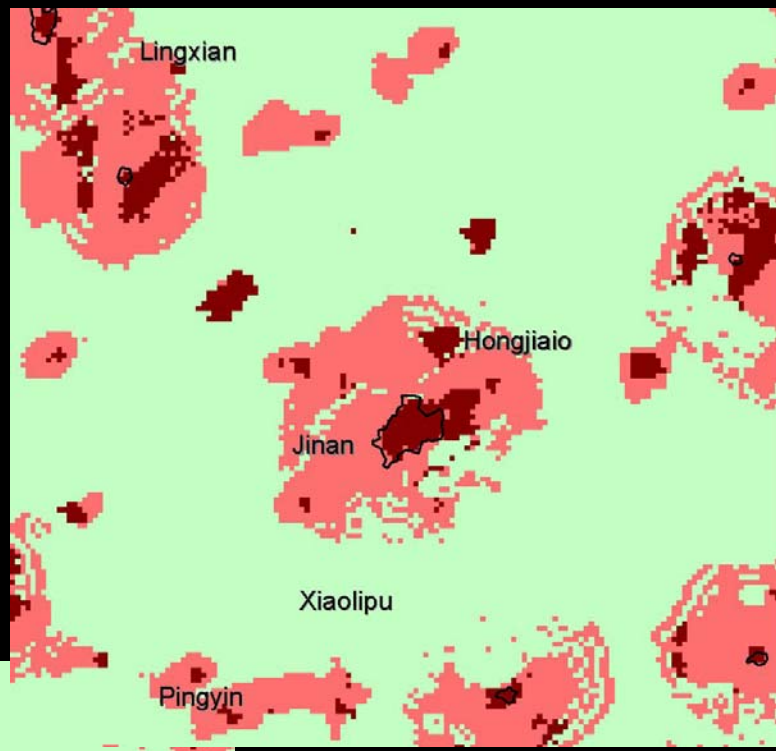


1998

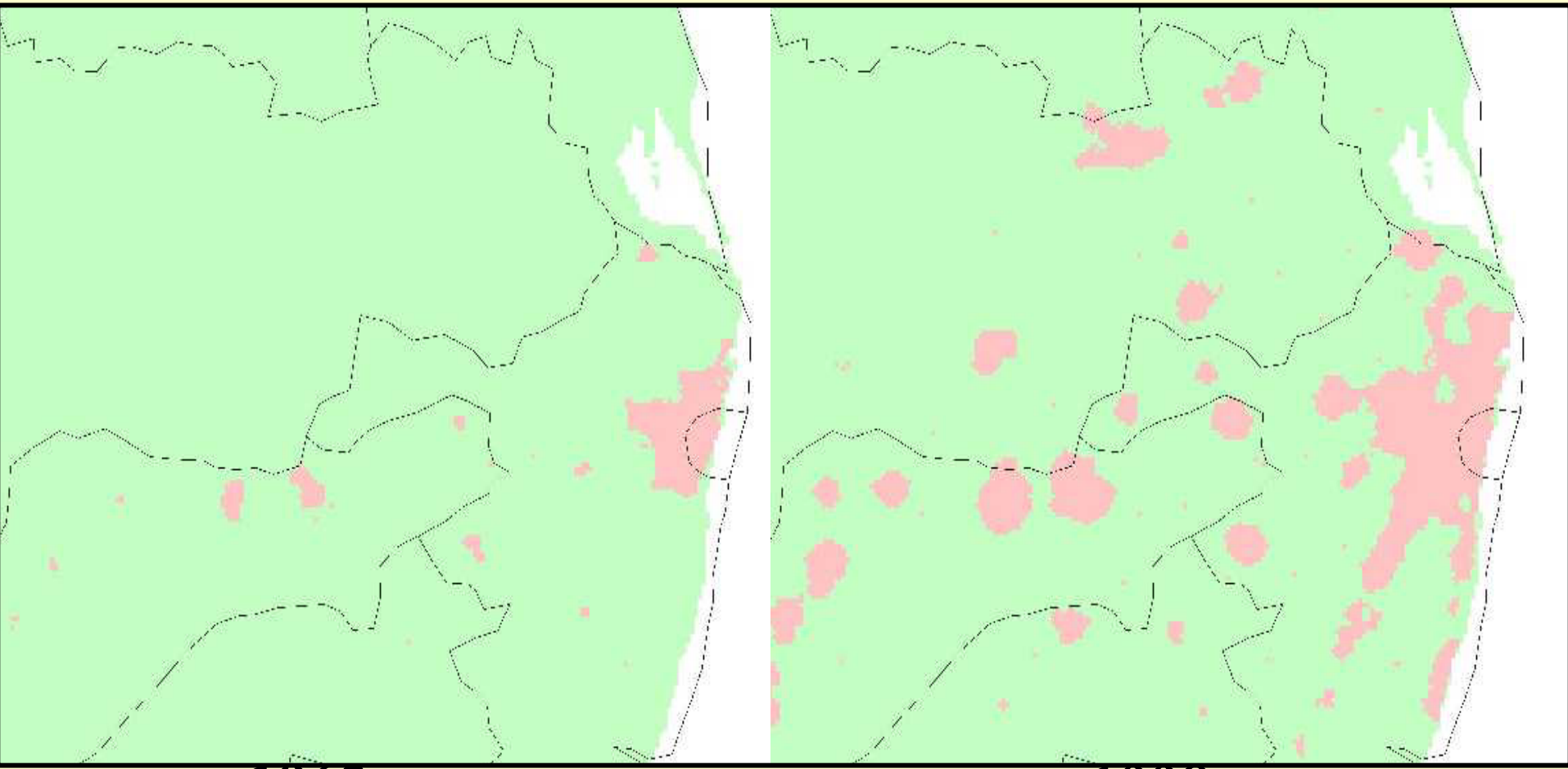


2009

Jinan Model Results

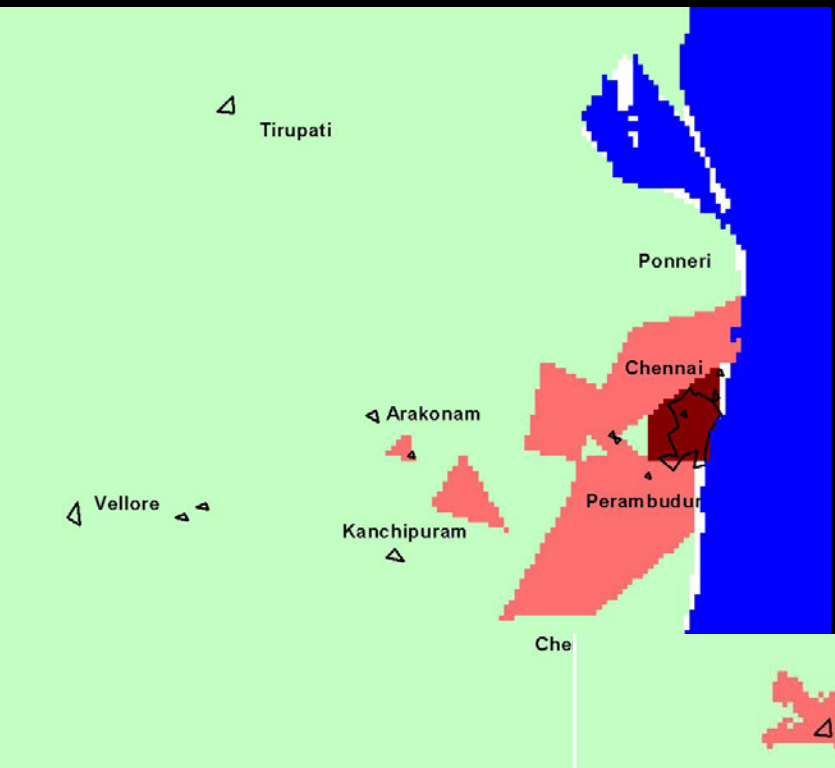
Chennai 1963-1998

red represents urbanized areas



1963

1998



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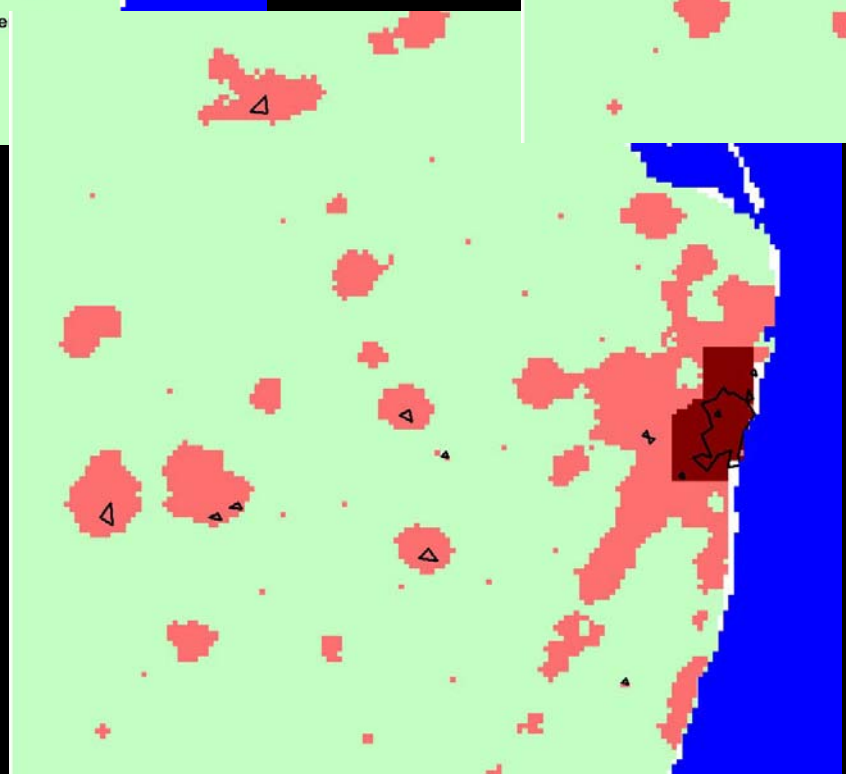

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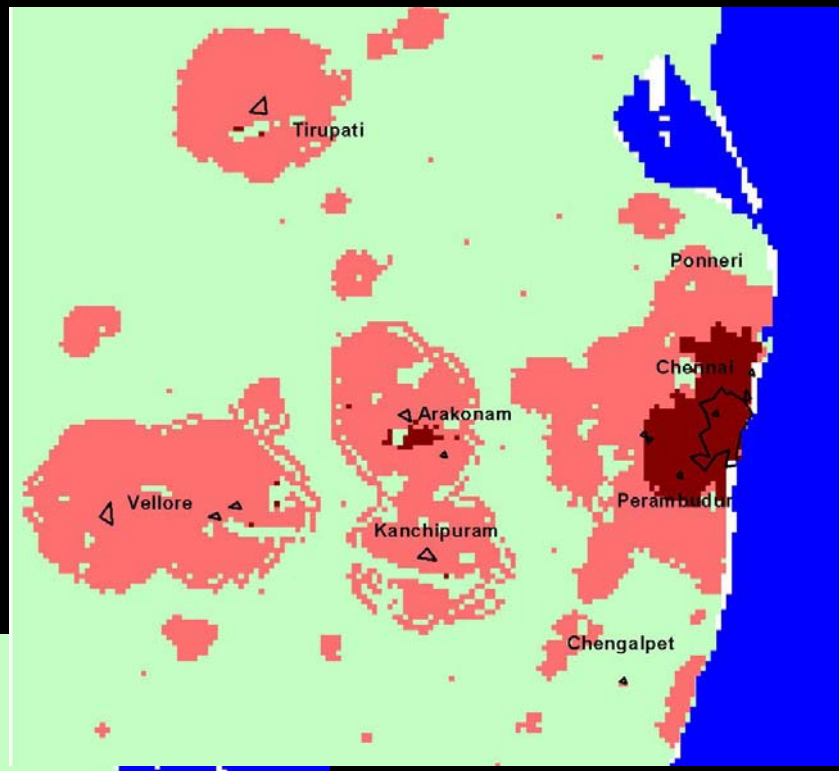

2009

Chennai Model Results

Results summary

- Clearly, much of the model results is dependent on the quality of the data. However, results with different data for the Indian cities indicates similar results in terms of growth.
- Also, we lack of data to validate the results or calibrate the models.
- Sprawl is an issue in all the cities though exact numbers cannot be assessed without calibrating the model.
- Need more detailed intra-city level information for assessing growth management issues.

4. Implications for planning

- Clearly growth in terms of population as well as area is an ongoing phenomenon
- Recent population statistics indicate that this growth in Chennai and Jinan may not be as rapid as in the capital cities of both countries.
- However, both are part of larger regions that may experience rapid growth (Chennai's proximity to Bangalore for example and Jinan's location in Shandong, a relatively wealthy province)
- Also, all cities experienced enormous growth in personal vehicles as planners struggled to provide transit. Congestion is a visible problem in all the cities.

Beijing Plans

- 1991 city planning of the 20-year development (i.e., by year 2010) is to be realized in 2005, 5 years earlier than originally planned

- The relationship between the development of satellite cities and small townships surrounding Beijing (www.beijing.gov.cn, March 20, 2001)

- Accelerate development of small township and push forward urbanization process (www.beijing.gov.cn, August 14, 2001)

- Beijing city planning: 14 satellite cities and 169 small townships: “Very general, vague policy statements”

New Delhi Plans

- The Delhi 21 plan notes that the solution to Delhi's transport problems depends on the linkages to the National Capital Region (NCR) and mentions that none of the NCRPB proposed expressways have been developed. The Plan suggests park and ride facilities and more parking supply in "critical areas"
- They continue to suggest that industrialization be allowed only in NCR towns rather than within Delhi and that only "high tech industries" be allowed within Delhi
- The plan mentions organizational issues but has no solution other than a common information system (or database) to be shared by all agencies. It mentions strengthening of "horizontal and vertical linkages"

Jinan Plans

- Jinan city economic and social development: the 10th five-year plan adopted by the Jinan people's congress on Feb 27, 2001, chapter 4 – "accelerating urbanization process and building effective urban form"
- City development principles – "primary city center-secondary city centers-satellite city – central township-small township":

  (A) developing along the river (east-west direction) and towards the north side of the river

  (B) forming a y-shape "one primary city center-three secondary city center" urban form

  (C) building 4 satellite cities (Zangqiu, Pingyin, Jiyang, and Shanghe) and 13 central towns
- Regular residents in downtown will be well controlled at about 2.2 million

Chennai Plans

- Chennai Metropolitan Development Authority formulated the 1st Master Plan in 1976. The 1st Master Plan advocated development along the radial corridors linked to Satellite towns and to develop Urban Nodes.
- In 1980, the Structure Plan for Chennai Metropolitan Area was prepared. During this period work on formulation of Detailed Development Plans of 1976 were either slowed down or given up.
- The Second Master Plan for the Chennai Metropolitan Area was for the period 1991-2011. The CMDA suggested a minimally directed organic strategy (MIDOS) of “managing market led development”

Implications for future research

1. Researchers continue to debate if sprawl is a problem in the US. However, the lack of basic services in suburbs in India and the lack of transportation facilities (in both countries) is a problem unique to these countries.
2. Furthermore sprawl is usually accompanied by loss of heterogeneity of land uses which affects travel behavior.
3. Further research to determine how location of transportation and other infrastructure influences the process of intensification and loss of mix within the cities
4. Further incorporation of data into the current models to validate these models
5. Use of SLEUTH (and other land use change models), which need more data, to validate the current model