Understanding changes in agricultural land use and land cover in the breadbasket area of the Ganges Basin 2000-2015: A socioeconomic-ecological analysis

Liping Di, Junmei Tang, Eugene Yu
Center for Spatial Information Science and Systems (CSISS)
George Mason University (GMU)
ldi@gmu.edu
http://csiss.gmu.edu

Man Li, Wei Zhang, Zhe Guo
International Food Policy Research Institute (IFPRI)

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Introduction

- This presentation is for the NASA LCLUC Project:

"*Understanding changes in agricultural land use and land cover in the breadbasket area of the Ganges Basin 2000-2015: A socioeconomic-ecological analysis*" *(PI: Liping Di)*

- Quick overview of the project:

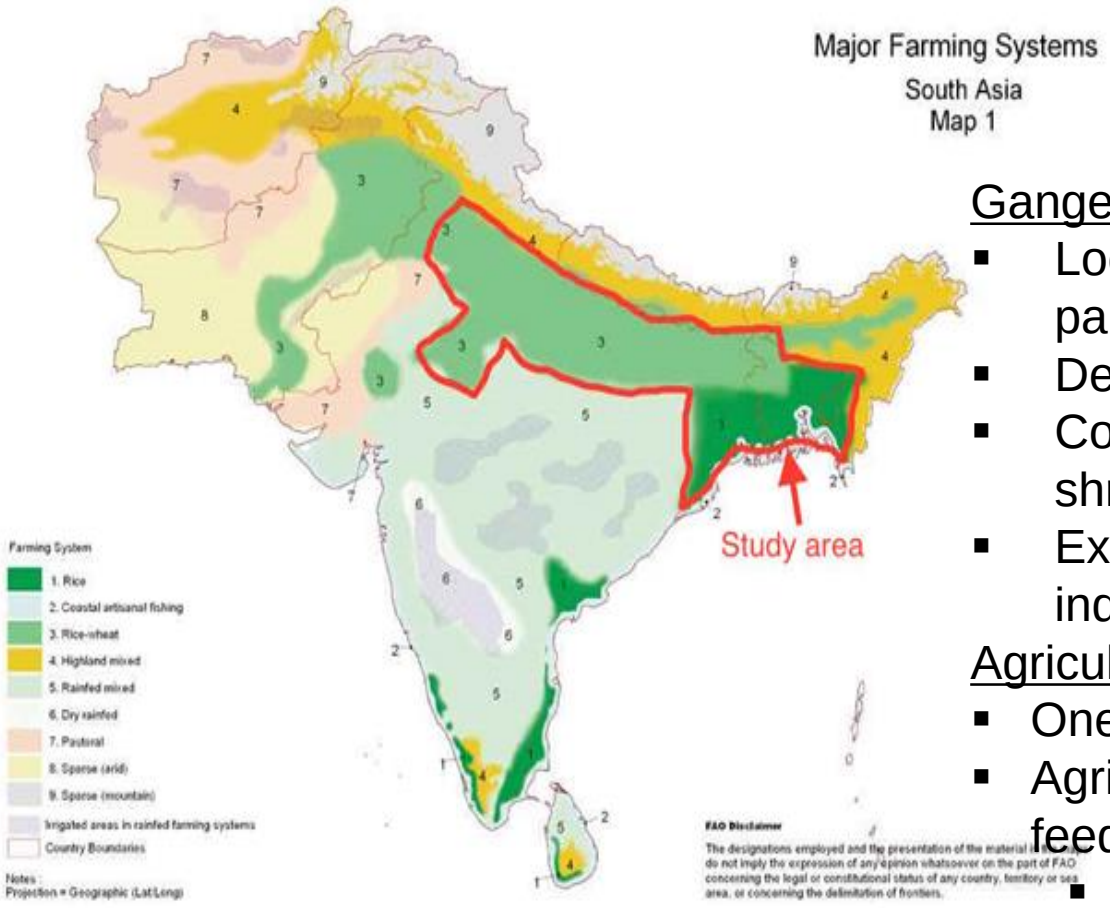
Performance period: March 2017 – March 2020

Study area: The major agricultural production area of Ganges Basin, the "breadbasket" of South Asia

Research goal: Understanding LCLUC in the past 15 years, its drivers, feedbacks, policy-relevant implications.

Current status: Progress well according to schedule.

Study Area



Ganges river: 2,500 km in length

- Located in northern India and major part of Bangladesh;
- Densely populated;
- Commercial centers and religion shrine;
- Experienced rapid urbanization and industrialization in the past 15 years

Agriculture activities:

- One of the most fertility area;
- Agricultural output in the study area feeds
  - 2/3 population of Bangladesh;
  - 80% population of India.

Landsat Images

Figure 2. Landsat Scenes covering the study area

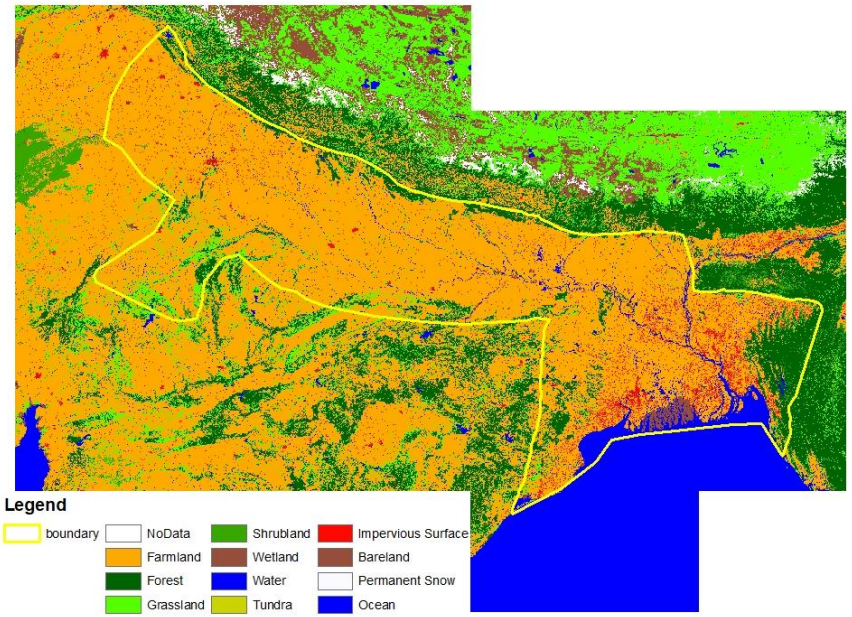
- For mapping the LCLUC, Landsat images are the key data source;
- 58 Landsat scenes to cover entire study area;
- 2000: Landsat 5/7; 2005 & 2010: Landsat 5; 2015: Landsat 8.

Three Levels of LCLUC

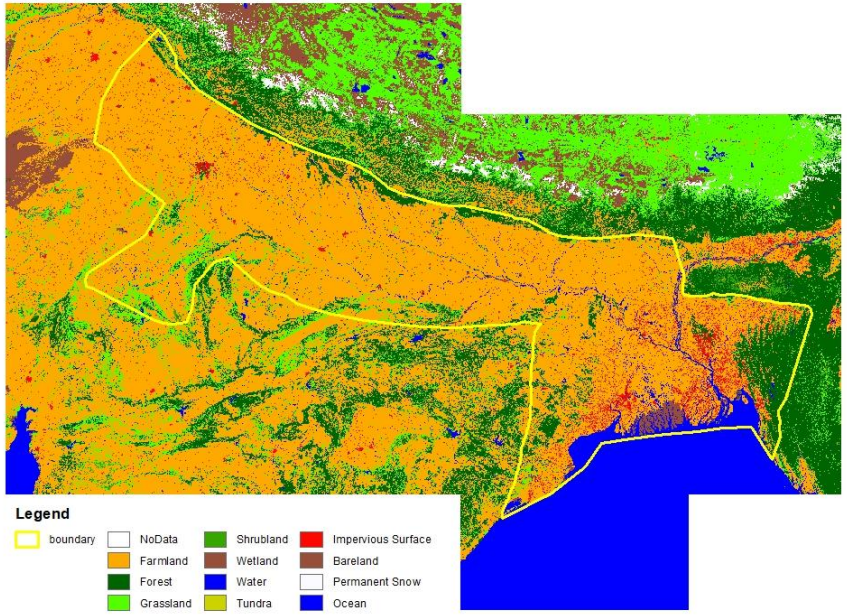
- 1) change of land use from agricultural to non-agricultural use, or vice versa;
  - For entire study area
- 2) change in cropping systems, such as from rice to maize;
  - For key agricultural regions
- 3) change in agricultural intensity, such as non-irrigation to irrigation, fallow, and two crops to three crops
  - For detailed study area
- It is important to note that changes in agricultural practices or farming systems are thus part of the LCLUC defined in this project.

Initial study on LCLUC

GLC30 - Ganges Area in 2000

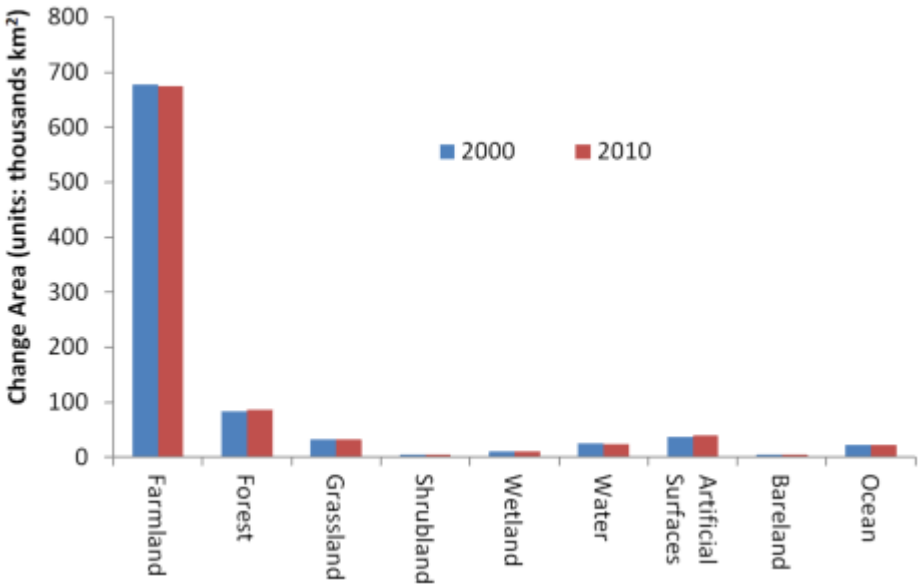


GLC30 - Ganges Area in 2010



Data source: Globe Land 30 (GLC30)

Change Area from 2000-2010



LULC	2000	2010	Changed area
Farmland	677290	674880	-2410
Forest	83858	85865	2007
Grassland	32385	32908	523
Shrubland	5444	4979	-465
Wetland	10190	10620	430
Water	25450	23373	-2077
Artificial Surfaces	37166	40102	2936
Bareland	4950	4468	-482
Ocean	22297	21834	-462

(Unites: km^2)

Top five change LCLU types

Change Matrix from 2000- 2010:

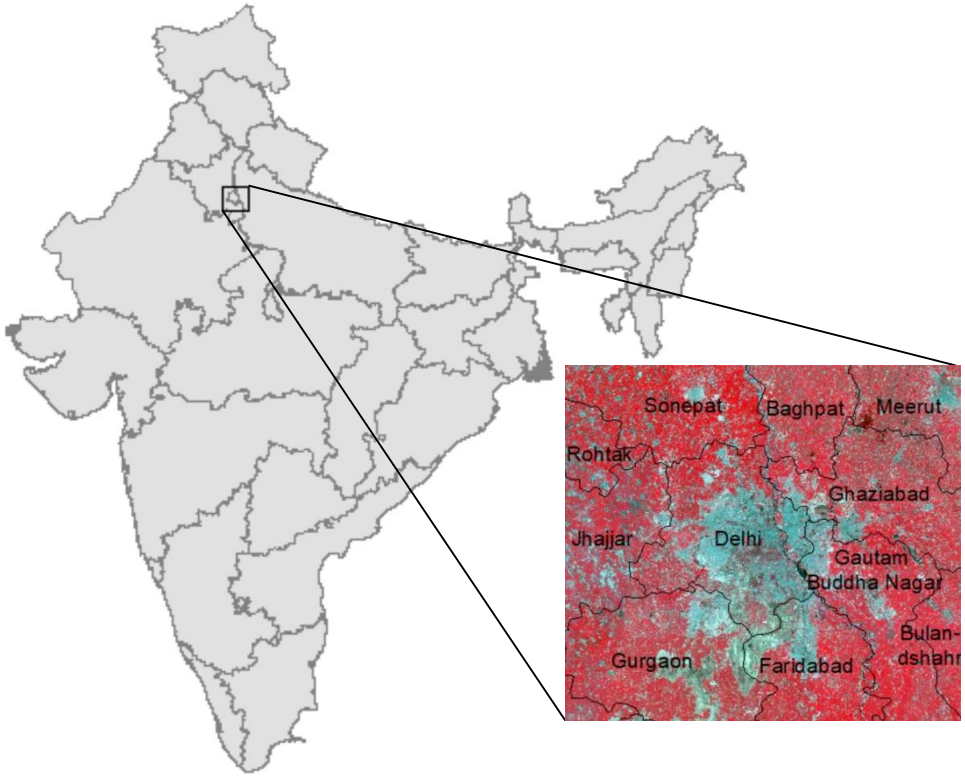
2000 \ 2010	Farmland	Forest	Grassland	Shrubland	Wetland	Water	Artificial Surfaces	Bareland	Ocean
Farmland	668617	2829	303	78	314	615	4477	53	5
Forest	730	79496	2606	633	19	43	307	9	15
Grassland	379	2126	29424	206	56	75	105	12	1
Shrubland	95	850	212	4003	3	7	111	162	0
Wetland	609	40	10	1	9229	200	17	1	84
Water	2235	267	91	11	548	22099	90	83	26
Artificial Surfaces	1771	229	19	30	56	70	34986	4	0
Bareland	410	17	243	17	37	73	9	4144	0
Ocean	35	11	1	0	356	190	0	0	21703

Top five change types: Farmland → Artificial Surfaces (4477 km^2);
Farmland → Forest (2829 km^2);
Forest → Grassland (2606 km^2);
Water → Farmland (2235 km^2);
Grassland → Forest (2126 km^2).

Level-1 classification

- Level 1 classification will cover the entire study area
- Progress has been made to produce LCLU map once every 5 years from 2000 to 2015
- The algorithm for land cover/land use classification
  - primarily an ensemble decision tree classifier
    - Decision tree, See5, is the base decision tree algorithm
    - The boosting algorithm is AdaBoost.M1
  - Object-base classifier has also been tried

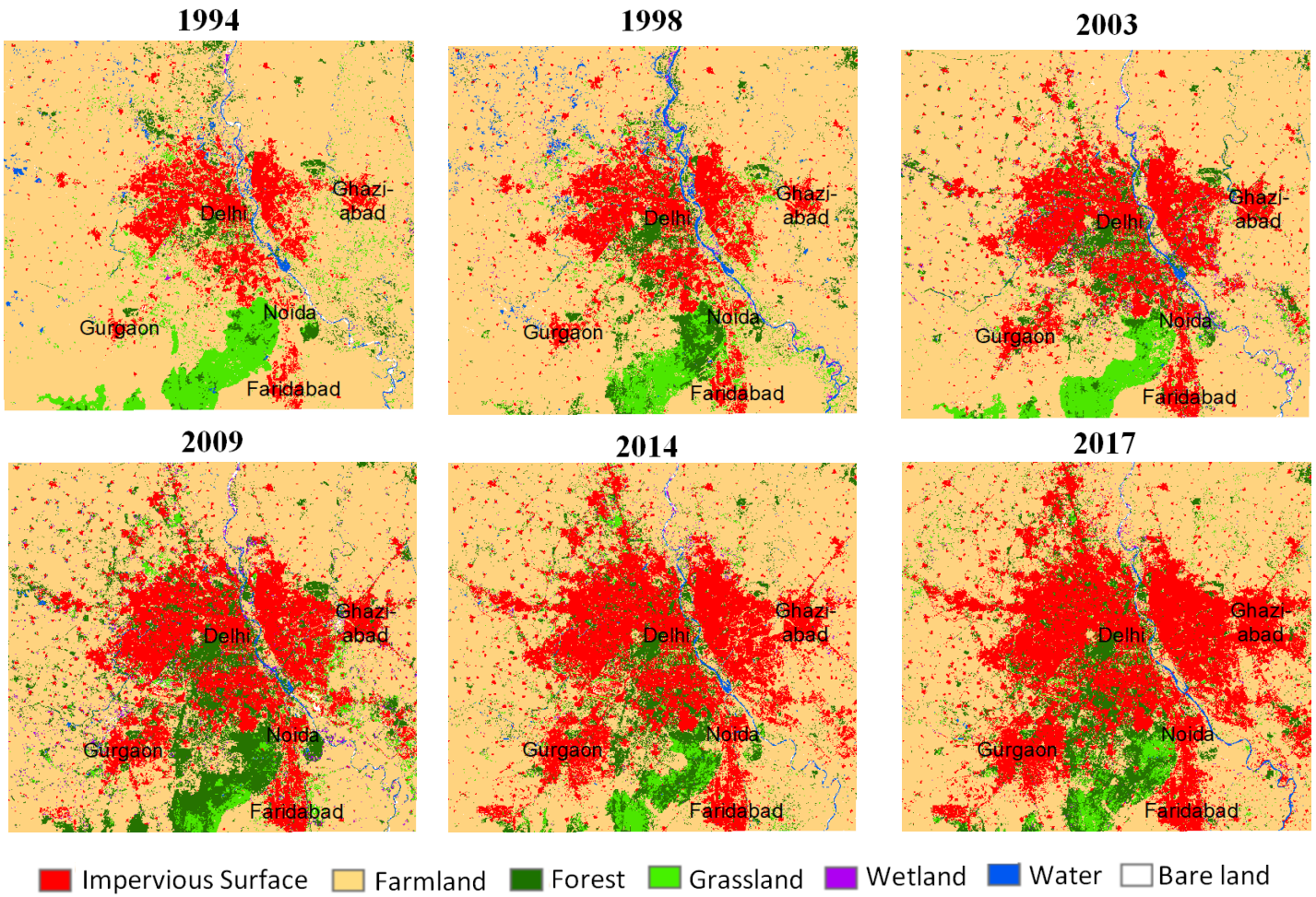
Key study area



Delhi Metropolitan Area:

- ✓ Around 4,500 km^2;
- ✓ Second largest city in India;
- ✓ Most populated in India (19 million), second in the world;
- ✓ Includes ten nearby cities.

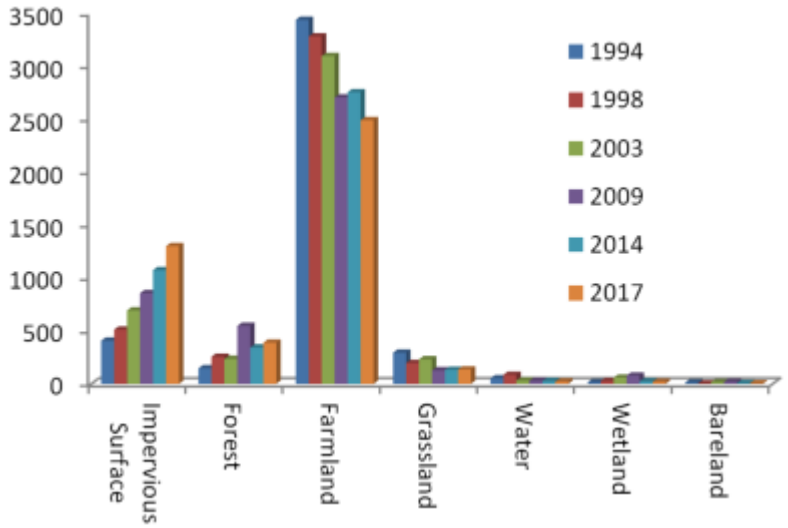
Classification results



Basic change analysis

Total Change area from 1994 to 2017

Area (km^2)	Impervious Surface	Forest	Farmland	Grassland	Water	Wetland	Bareland
1994	406.98	146.96	3435.03	293.87	51.47	14.79	11.78
1998	511.96	255.27	3278.93	196.86	85.21	26.78	3.72
2003	692.34	235.31	3093.75	231.21	32.00	58.84	15.27
2009	855.78	546.61	2702.85	127.22	29.09	77.91	19.28
2014	1072.98	342.51	2752.01	132.56	27.24	24.19	7.23
2017	1299.63	388.11	2488.79	136.03	22.04	19.12	5.02



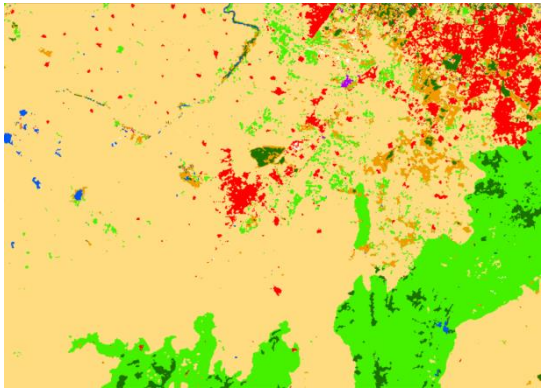
Total change area: 1961km^2 (45% of total area)

Agriculture to Urban: 813km^2 (19%), 62% of total increased urban area.

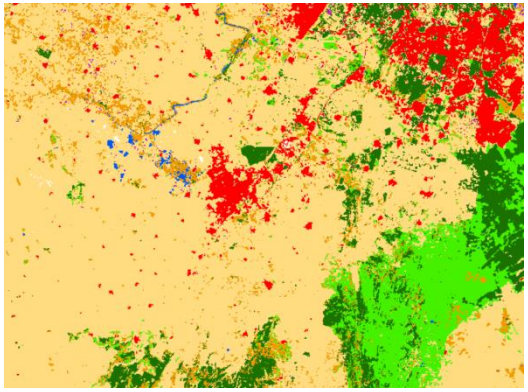
- ✓ 1994-1998: (104km^2, 3%);
- ✓ 1998-2003: (166km^2, 5%);
- ✓ 2003-2009: (135km^2, 4%);
- ✓ 2009-2014: (152km^2, 6%);
- ✓ 2014-2017: (201km^2, 7%).

Rapid suburban expansion: Gurgaon

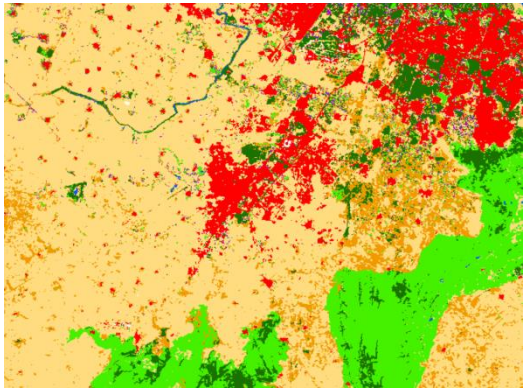
1994



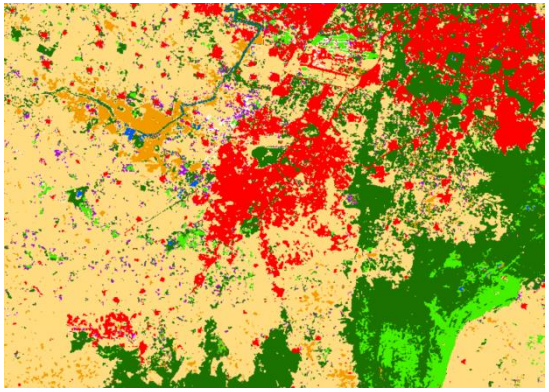
1998



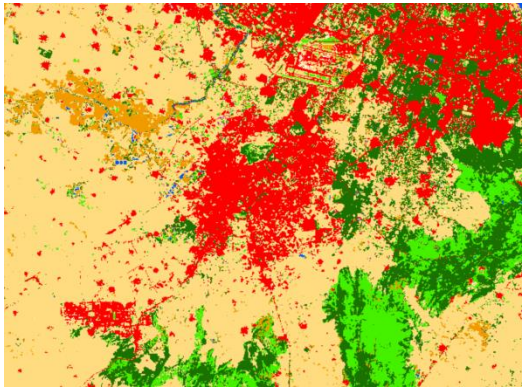
2003



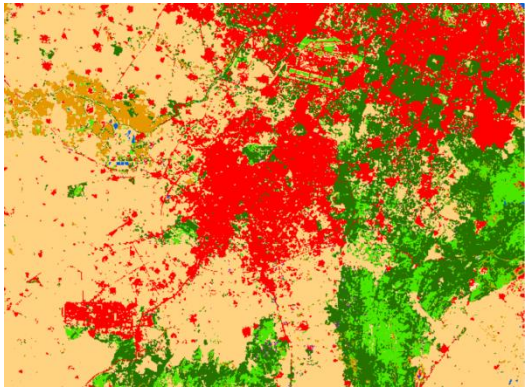
2009



2014



2017



Study on drivers, impacts, and implications

1. Scoping visit to India and Bangladesh in November 2017
2. Two research abstracts accepted for presentations at the 2018 Agricultural & Applied Economics Association (AAEA) annual conference, Washington, D.C. August 5-7, 2018
3. Participation in the 2018 Natural Capital Symposium, March 19-22, 2018, Stanford University, and discussion of ecosystem service modeling with the Natural Capital Project's InVEST modeling team

Scoping visit to India and Bangladesh in November 2017

- Held discussions about the NASA project with a number of research and government partners:
  - Deputy Executive Chairman of Bangladesh Agricultural Research Council (BARC), Government of Bangladesh, Director of Research and Evaluation Division at BRAC in Bangladesh, Executive Director of Bangladesh Centre for Advance Studies (BCAS), and the Director of National Institute of Agricultural Policy (NIAP) in India.
  - Colleagues from several CGIAR centers: IWMI, CYMMT, and IRRI
  - Researchers and program leaders from Central Agricultural University in India, Bangladesh Agricultural University, and World Vision area office in Bangladesh
  - Akhter Ahmed, IFPRI-Dhaka office head, Bangladesh; Pramod Joshi, Director of South Asia Office, IFPRI-Delhi
- Held two research seminars, one at the Agricultural Policy Support Unit (APSU), Ministry of Agriculture, Bangladesh, and the other at the National Agriculture Science Complex (NASC) on the Indian Council of Agricultural Research (ICAR) campus.
  - Natural Resource Management Games for Research and Impact
  - Deforestation and Smallholder Income: Evidence from Remittances to Nepal
- Conducted field visits and held a total of eight focus group discussions with farmers in Bangladesh and India

Published paper and conference presentation

- Tang, J., Di, L., Md. Rahman, S., Yu, Z., Spatial-temporal Landscape Pattern Change under Rapid Urbanization. Landscape and Urban Planning, Submitted.
- Zhang, W. and M. Li. 2018. Do disabilities promote migration in Bangladesh? Evidence from panel household survey. Selected Paper for presentation at a Lightning Session.
- Li, M. and W. Zhang. 2018. Farm Size, Risk Aversion, and Labor Migration under Natural Disaster Risks. Selected Paper for presentation at a Selected Paper Session
- Participation in the 2018 Natural Capital Symposium, March 19-22, 2018, Stanford University, and discussion of ecosystem service modeling with the Natural Capital Project's InVEST modeling team

Plan for the next year

- Conduct level-2 LCLUC for key agriculture region subject to large LCLUC
- Drivers of LCLUC
  - Socio-economic data and LCLUC derived from classification
- *Scenarios of LCLUC*
  - Using the IMPACT model to examine alternative futures for global food supply, demand, trade, prices, and food security
- The Impact of LCLUC
  - Food security and welfare
  - Ecosystem services and land degradation
    - The InVEST model: to evaluate the impact of LCLUC on key ecosystem services and land degradation