

Landscapes in flux: the influence of demographic change and institutional mechanisms on land cover change, climate adaptability and food security in rural India

Aditya Singh, Sarika Mitra, Phil Townsend, Jacob van Etten
Sidhanand Kukrety, Shrawan Acharya



Motivation

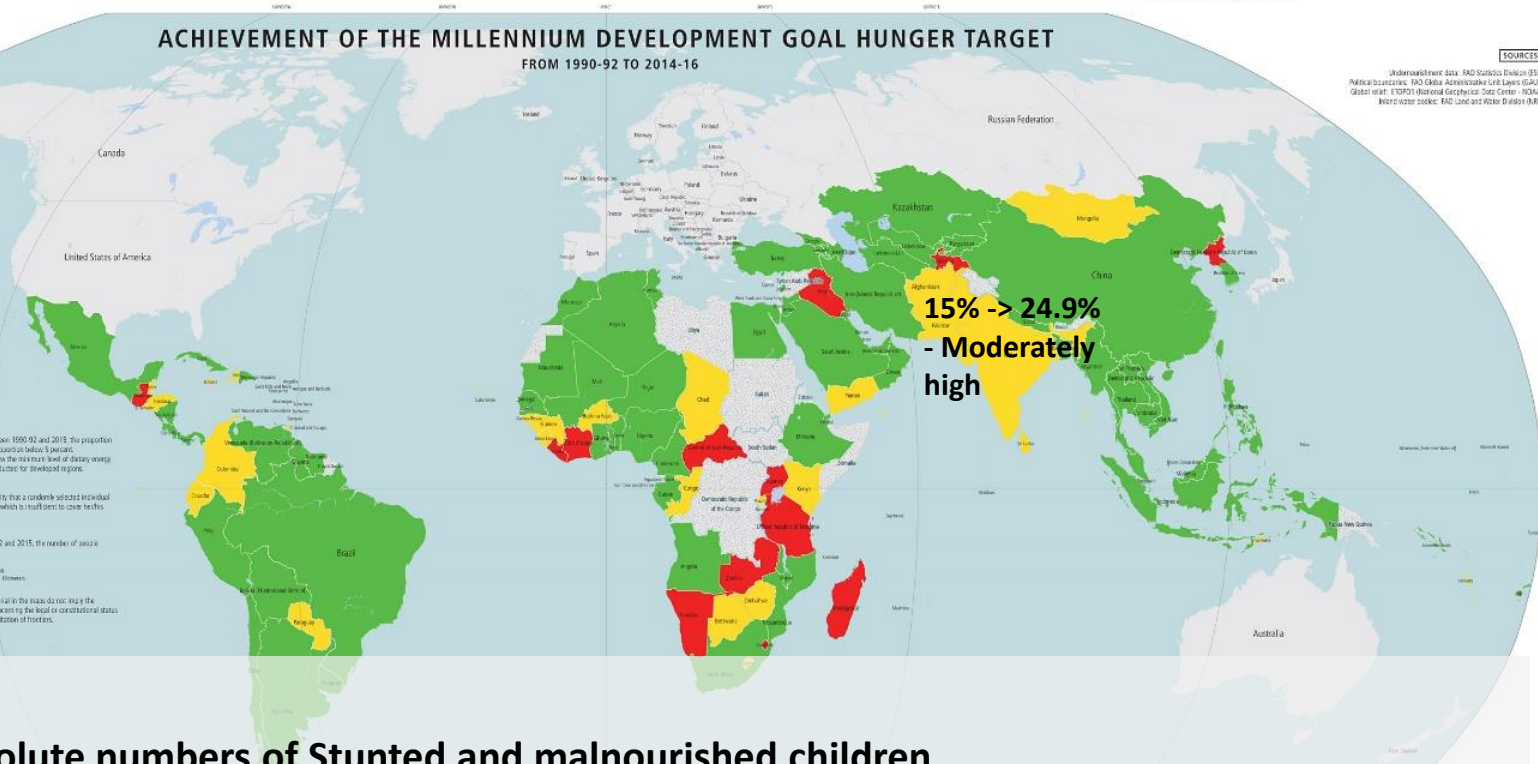
FAO Hunger Map 2015

Millennium Development Goal 1 and World Food Summit Hunger Targets

Produced by the FAO Statistics Division for additional information: <http://www.fao.org/hunger-map>

- 1 About 793 million people in the world still lack sufficient food for conducting an active and healthy life.
- 2 Yet progress has been made, even in the presence of significant population growth. Approximately 218 million fewer people suffer from undernourishment than 25 years ago and 169 million fewer than a decade ago.
- 3 The year 2015 marks the end of the monitoring period for the Millennium Development Goal targets. Seventy three out of 129 developing countries — more than half the countries monitored — have reached the MDG 1C hunger target of halving the proportion of the chronically undernourished.
- 4 In developing regions the target was almost achieved, with the share of undernourished having decreased during the monitoring period from 23.3 to 12.9 percent.
- 5 Some regions, such as Latin America, the most and southeastern regions of Asia, the Caucasus and Central Asia, and the northern and western regions of Africa, have made fast progress. Progress was also recorded in southern Asia, Oceania, the Caribbean and southern and eastern Africa, but at too slow a pace to reach the MDG 1C target.
- 6 In many countries that have failed to reach the international hunger targets, natural and human-induced disasters or political instability have resulted in protracted crises, with increased vulnerability and food insecurity among large segments of the population.

ACHIEVEMENT OF THE MILLENNIUM DEVELOPMENT GOAL HUNGER TARGET FROM 1990-92 TO 2014-16



SOURCES
Undernourishment data: FAO Statistics Division (2015)
Political boundaries: FAO/CEIAS/FAO/UNEP/World Bank/ESA/UNEP
Global relief: IFPRI/International Geographical Data Center - HDX
Water bodies: FAO Land and Water Division (MLL)

LEGEND

Millennium Development Goal 1, Target 1C (hunger), between 1990-92 and 2015: The proportion of people suffering from undernourishment, or below the minimum level of dietary energy consumption (undernourishment). The assessment is not conclusive for developed regions.

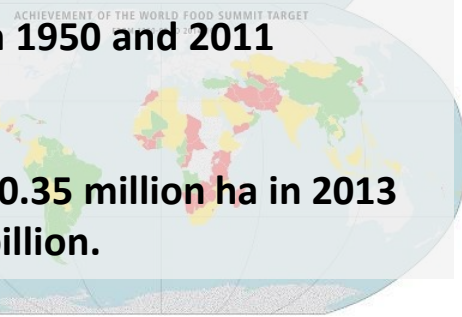
Prevalence of undernourishment measures the probability that a randomly selected individual in the population is consuming an amount of dietary energy, which is insufficient to cover his or her requirements to lead an active and healthy life.

World Food Summit (WFS) goal, between 1992-92 and 2015, is a number of people undernourished.

The boundaries employed and the presentation of the material in the map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

India:

- Largest absolute numbers of Stunted and malnourished children
- Area under non-agricultural use increased from 2.85% to 8.06% between 1950 and 2011 (~increase of 16.85 mha).
- 36.6% of the total geographical area of India is degraded (ICAR, 2010)
- extreme weather events affected 18.33 million ha in 2015 (compared to 0.35 million ha in 2013 and 5.5 million ha in 2014) and contributed to crop losses worth USD 3 billion.



NOTES
1. For more information on agricultural production in Sub-Saharan Africa, see the FAO Agricultural Outlook for Sub-Saharan Africa 2014-2022. For more information on the impact of climate change on food security, see the FAO State of Food Security and Nutrition in the World 2014. For more information on the impact of climate change on food security, see the FAO State of Food Security and Nutrition in the World 2014.
2. Excesses or food losses at the retail level for Cereals were recorded, leading to a minor revision.

Motivation

Investigating regional variations in key indicators of food security as proximal causes of land use/land cover change

Recognizing that:

- Food security is a manifestation of several extant factors rather than a small set of indicators,
- Land use/cover change is a multidimensional concept (...yet a 'zero-sum' game.)



Proposed activities

01

Downscaling socioeconomic data to the unit level using small area estimation methods

02

Combining downscaled socio-economic data to produce localized indicators of food security using a structural equation modeling approach

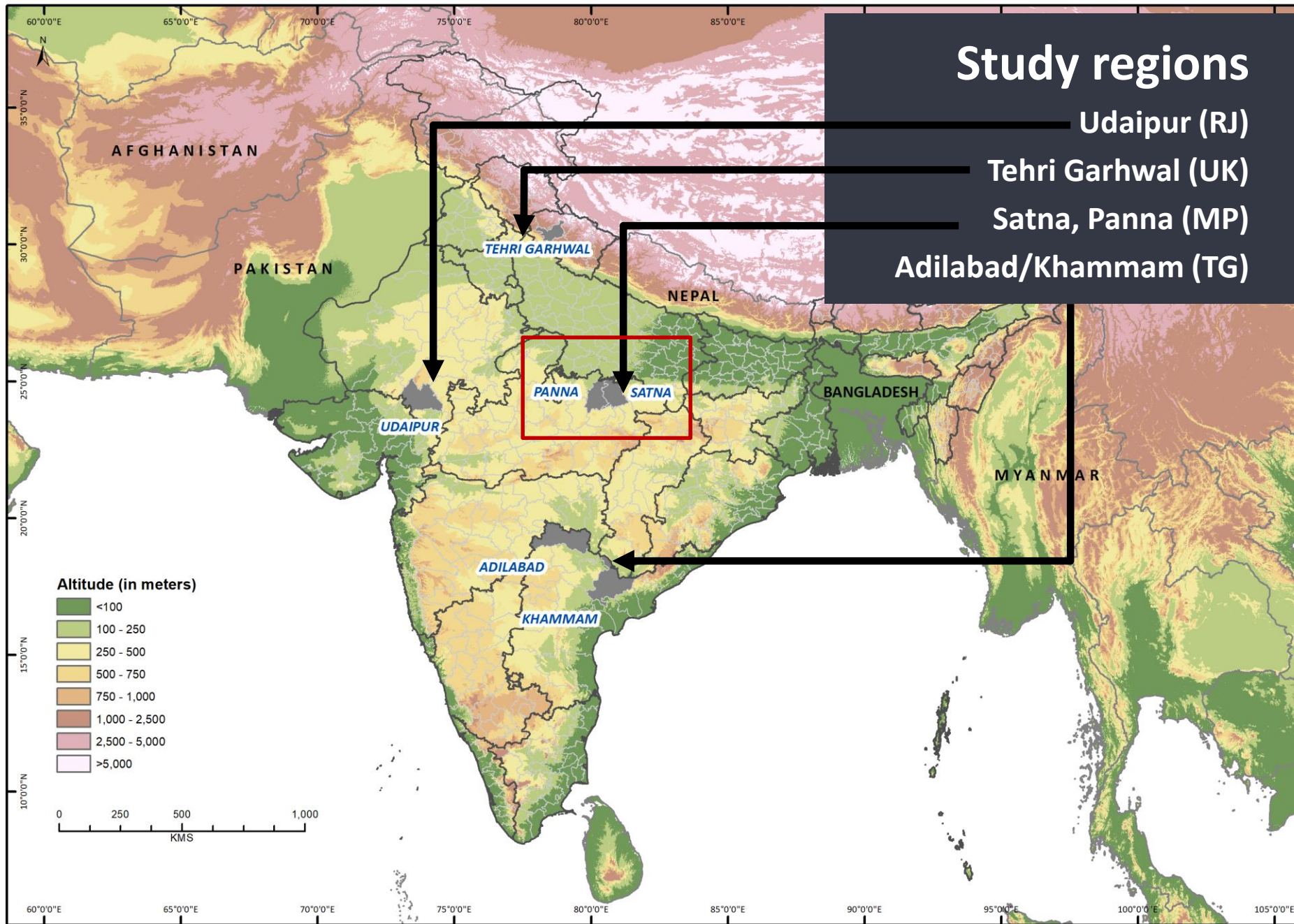
03

Mapping land cover and assessing land cover change at the local (village or taluk) scale across one decade

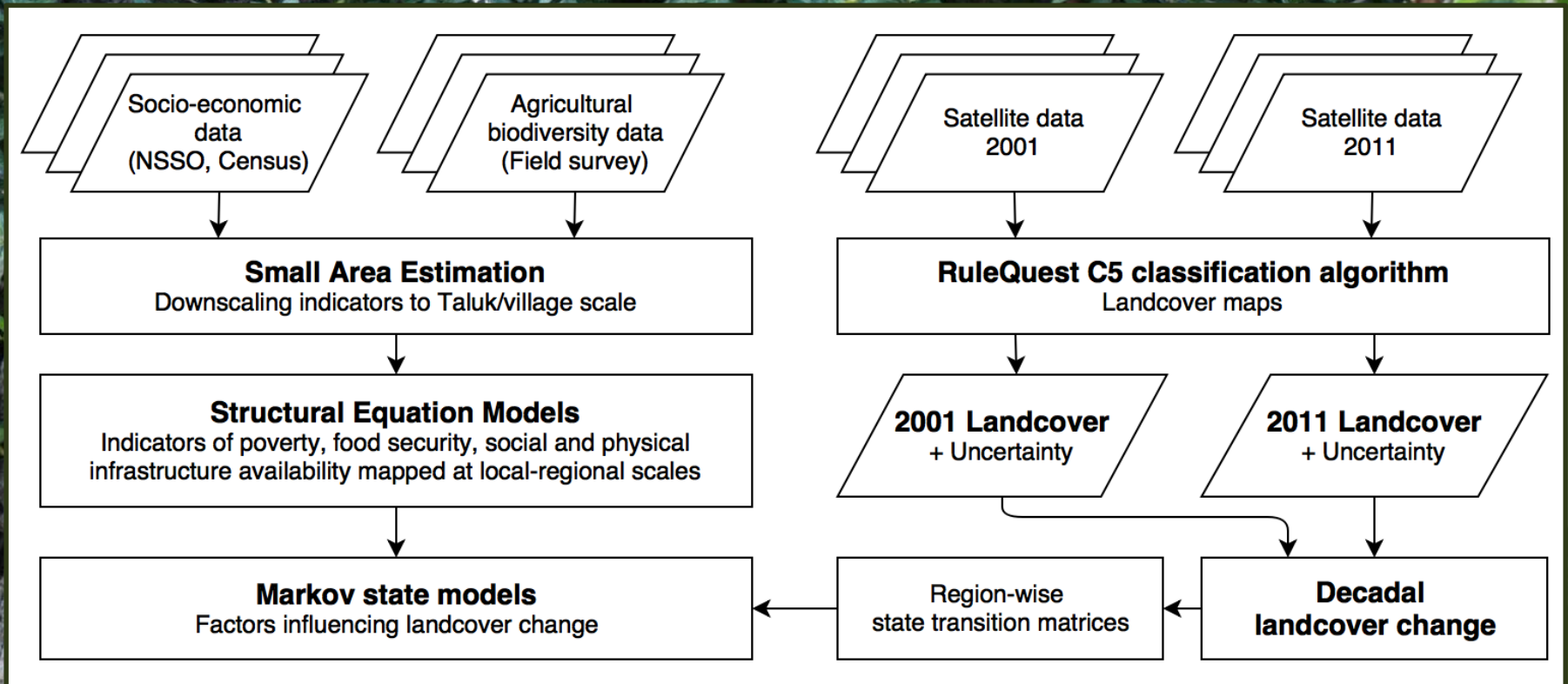
04

Assessing localized drivers of land cover change as functions of food security and extant socio-economic indicators in a probabilistic framework





Proposed activities: Methods



Data sources

Land cover mapping

Landsat TM, ETM+ and OLI data (1991-2001, 2001-2011)

Demographic parameters

Census of India (2001, 2011)

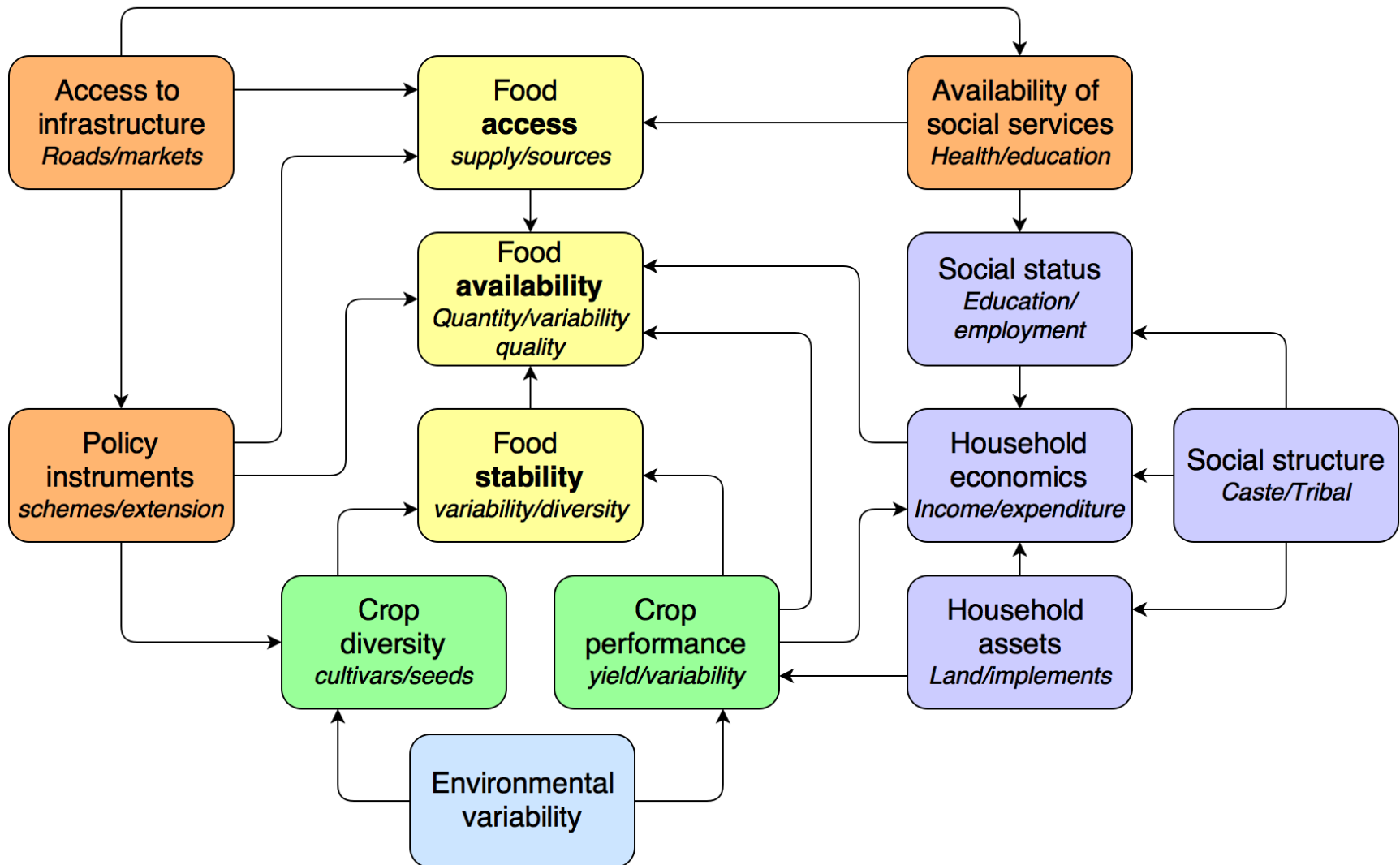
HH data on socioeconomic parameters (village scale)

RHoMIS (Rural Household Multiple Indicator Survey) [rhomis.net]

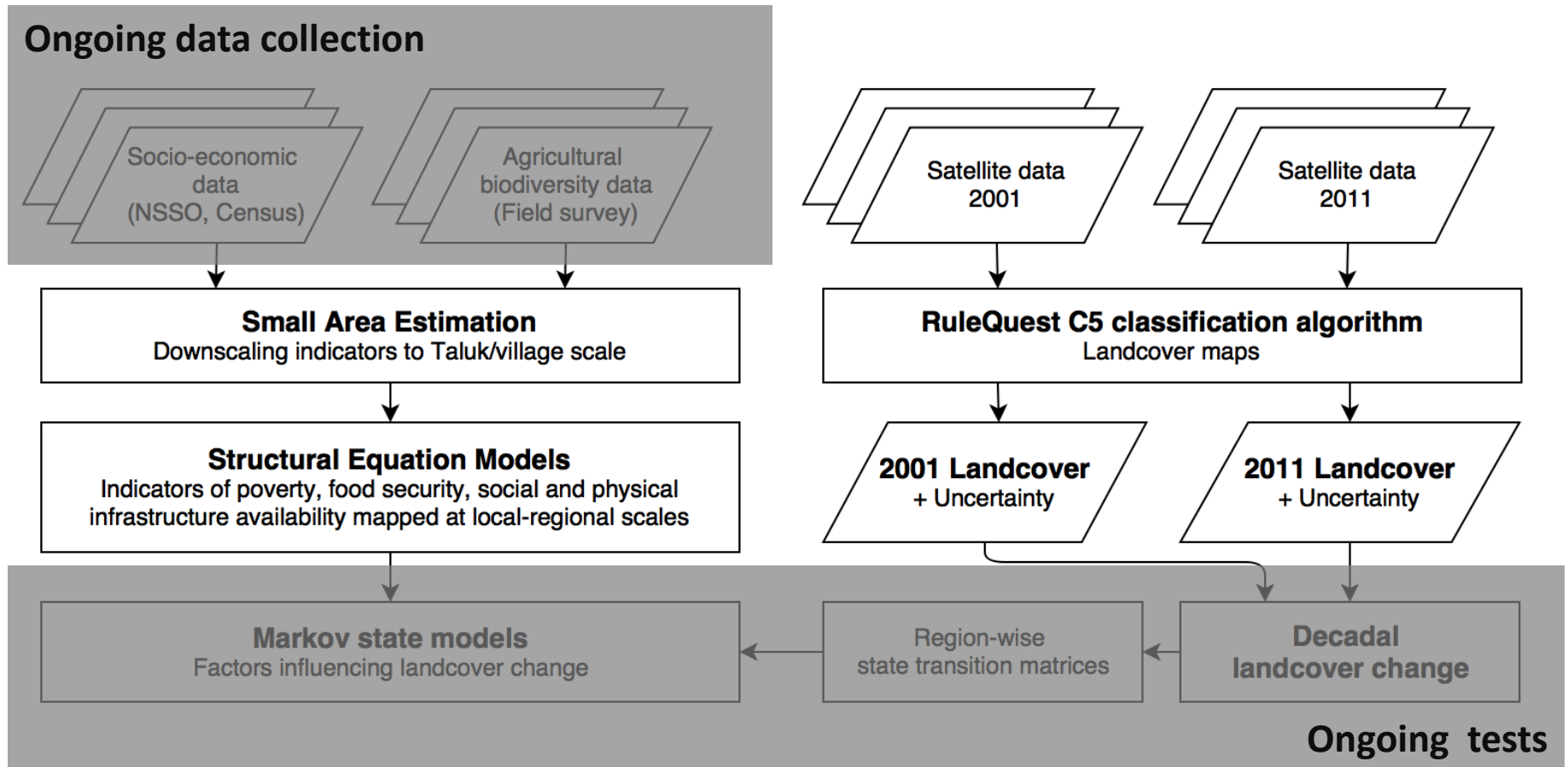
HH data on socioeconomic parameters (district/block scale)

National Sample Survey Organization (NSSO)

Overall idea

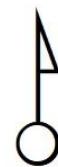


Proposed activities: Methods



Test classification, bootstrapped LDA

Satna, Panna Districts



2011, LT7

Legend

 Panna, Satna Districts

 Cropland

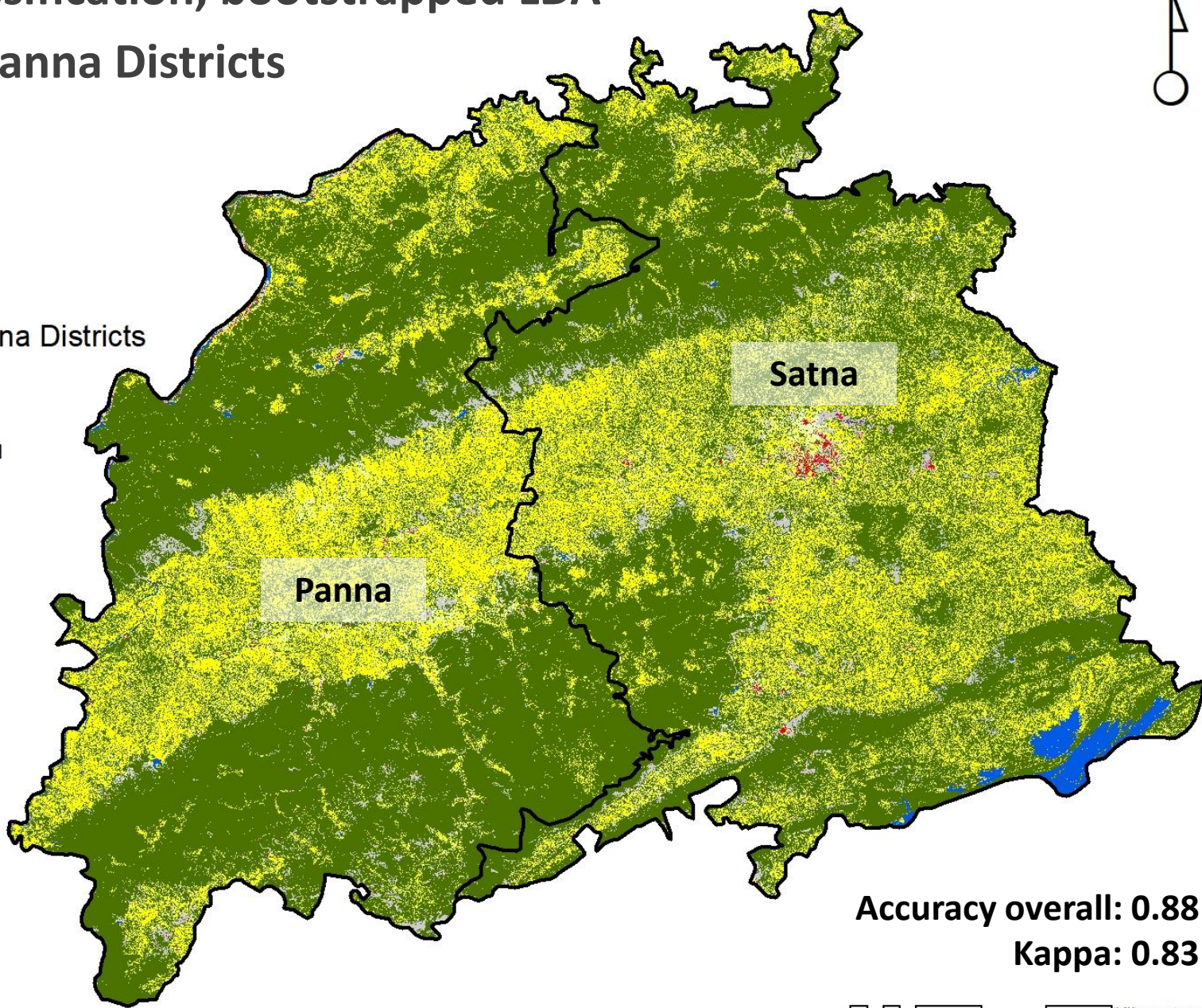
 Barren

 Fallow/grassland

 Forest

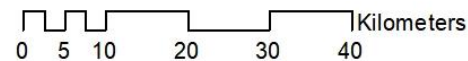
 Settlement

 Water



Accuracy overall: 0.88

Kappa: 0.83




Test classification, uncertainties



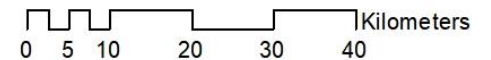
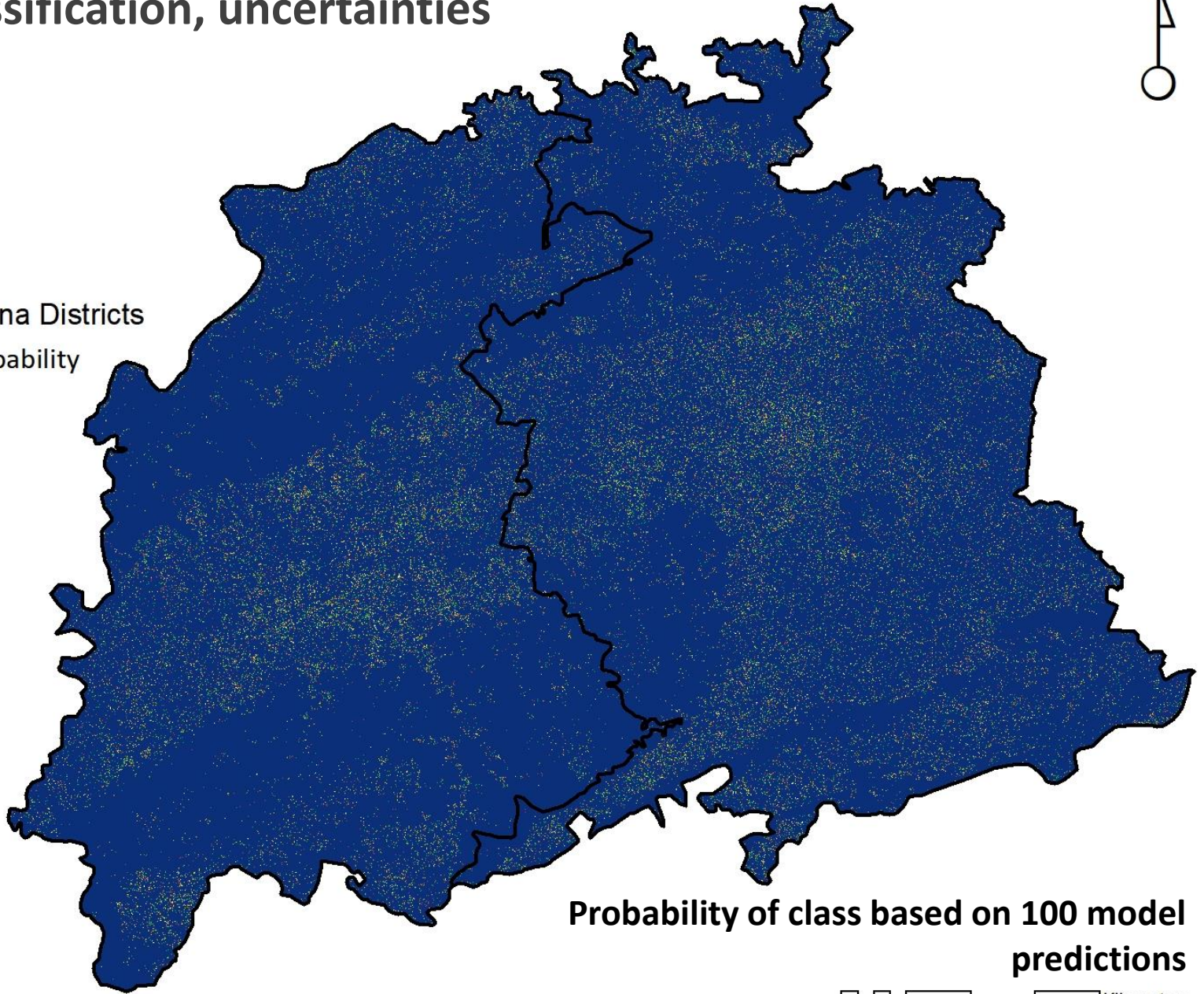
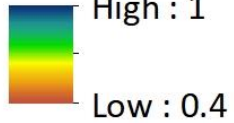
2011

Legend

 Panna, Satna Districts

Classification probability

Value



Modeling land cover transitions

How to:

1. Model attribution of the process of land cover changes, potentially via multiple factors/covariates,
2. Recognize that land cover transitions are essentially bounded (the 'zero-sum' idea),

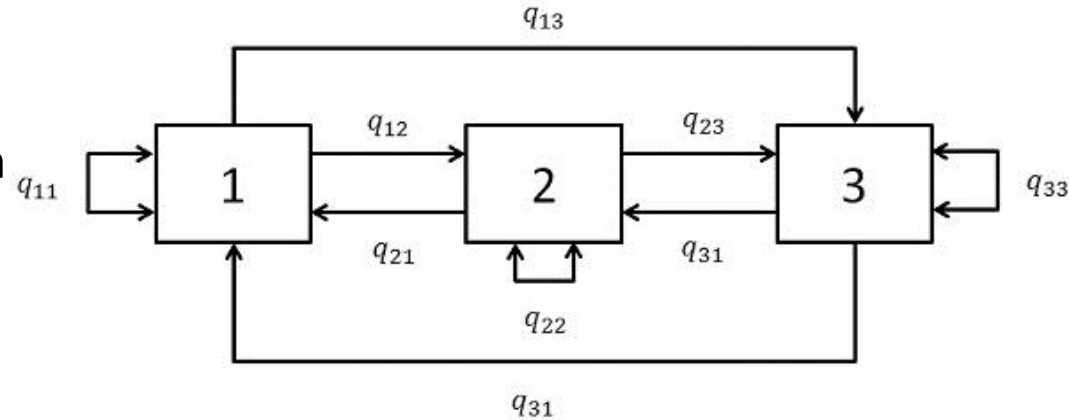
Latent Markov models for longitudinal data

1. Estimate transition probabilities using land cover maps from two time periods,
2. Condition transition probabilities on covariates from existing census data,
3. Eventually, covariates will be latent vectors obtained from SEM.

Modeling land cover transitions

Assumptions

1. All pixels comprise of a population that can be at several different states in a given time period.
2. Pixel ' i ' move from state ' r ' to the state ' s ' at time ' t ' with a probability ' q_{irs} ',
3. The probability of moving from state ' r ' to state ' s ' can be modeled as a function of covariates ' x_i ',
4. ...by maximizing:



$$Q = \begin{pmatrix} q_{11} & q_{12} & q_{13} \\ q_{21} & q_{22} & q_{23} \\ q_{31} & q_{32} & q_{33} \end{pmatrix}$$

$$q_{irs}(t) = \lim_{\Delta t \rightarrow 0} \frac{P(E_i(t + \Delta t) = s | E_i(t) = r)}{\Delta t}$$

$$q_{irs}(x_i(t)) = q_{rs}^{(0)} \exp(\beta_{rs}^T x_i(t))$$


$$L = \prod_{i=1}^n \prod_{k=1}^{\tau-1} P_{E_i(t_k) E_i(t_{k+1})}$$

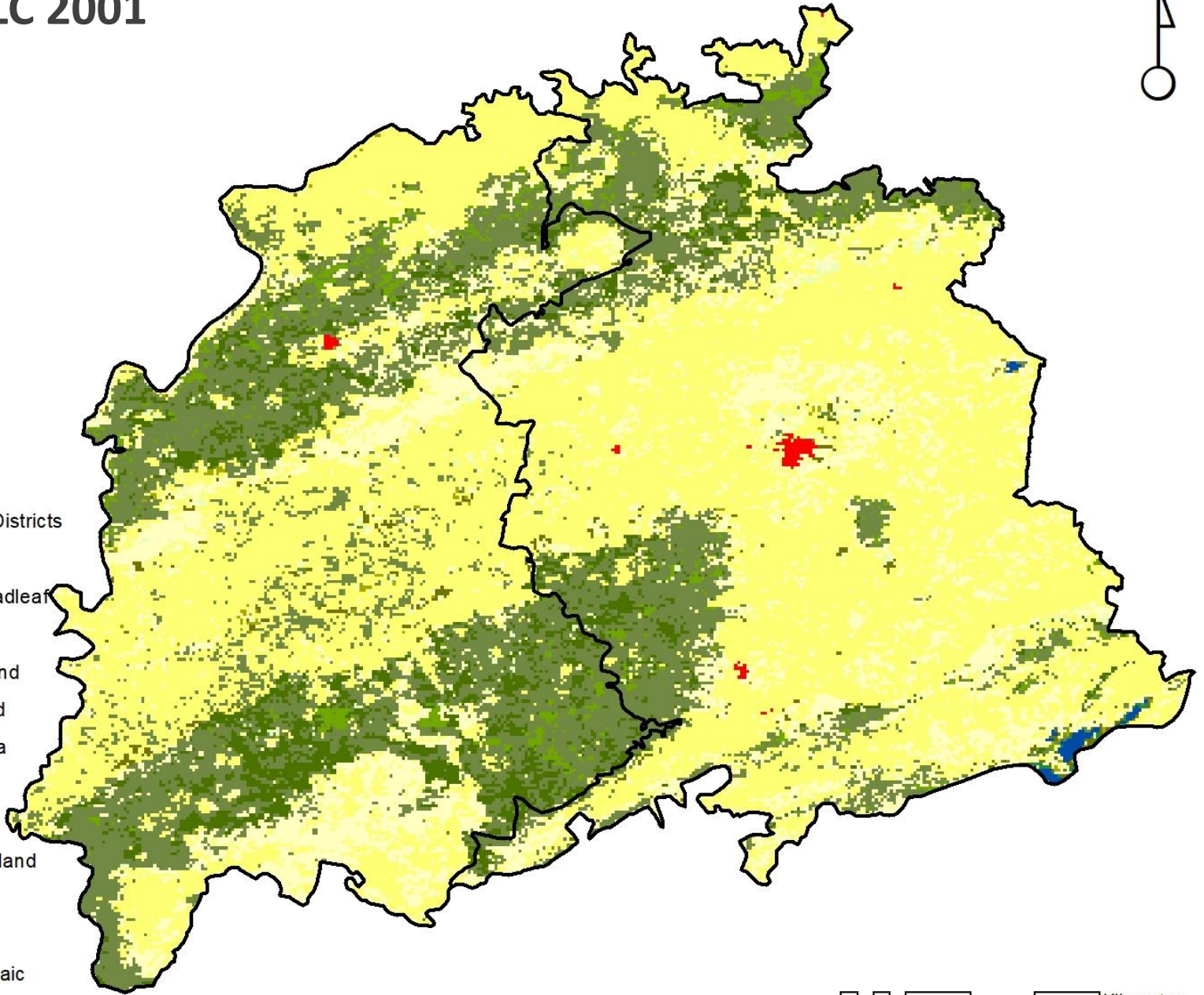
MODIS LC 2001



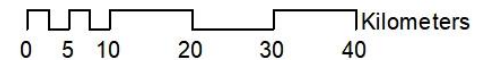
2001

Legend

-  Panna, Satna Districts
-  Water
-  Deciduous broadleaf
-  Mixed forest
-  Closed shrubland
-  Open shrubland
-  Woody savanna
-  Savanna
-  Grassland
-  Permanent wetland
-  Cropland
-  Built up
-  Cropland mosaic
-  Barren



Generalized to Ag, Crop, settlement, forest, scrub

















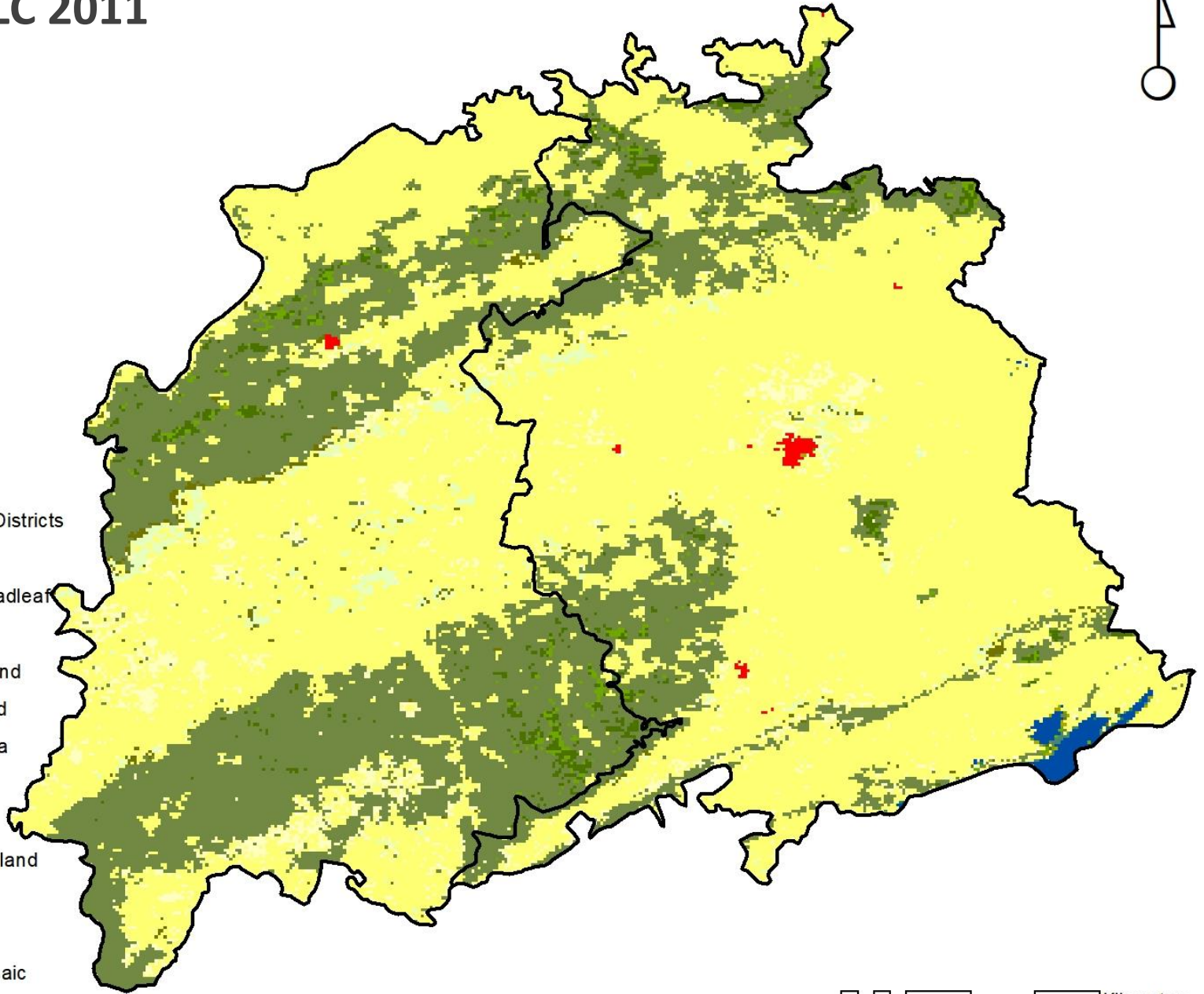
MODIS LC 2011



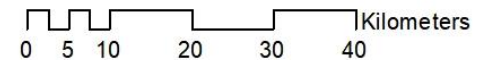
2011

Legend

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Generalized to Ag, Crop, settlement, forest, scrub



MODIS + village amenities

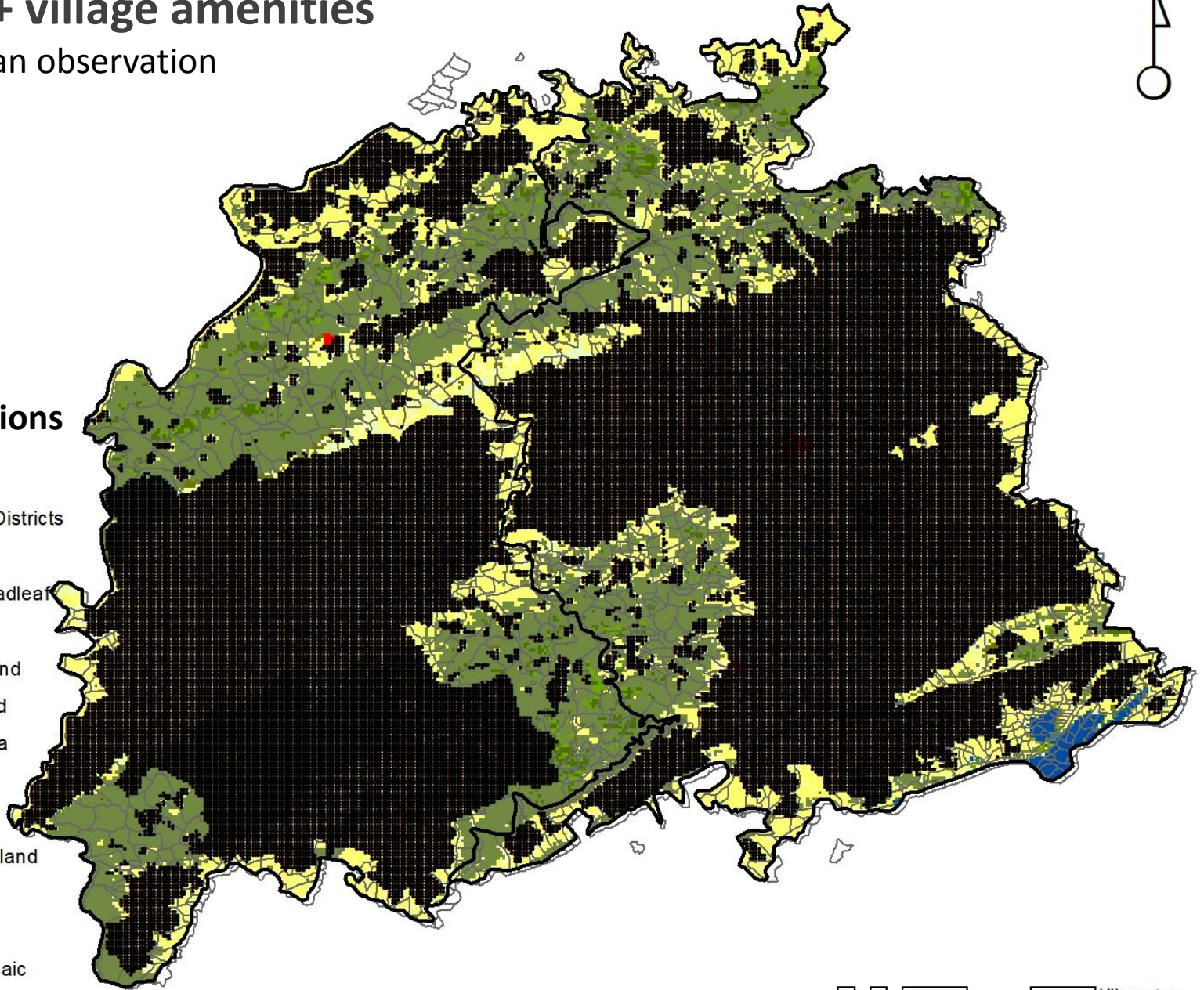
Each pixel an observation



Sample locations

Legend

-  Panna, Satna Districts
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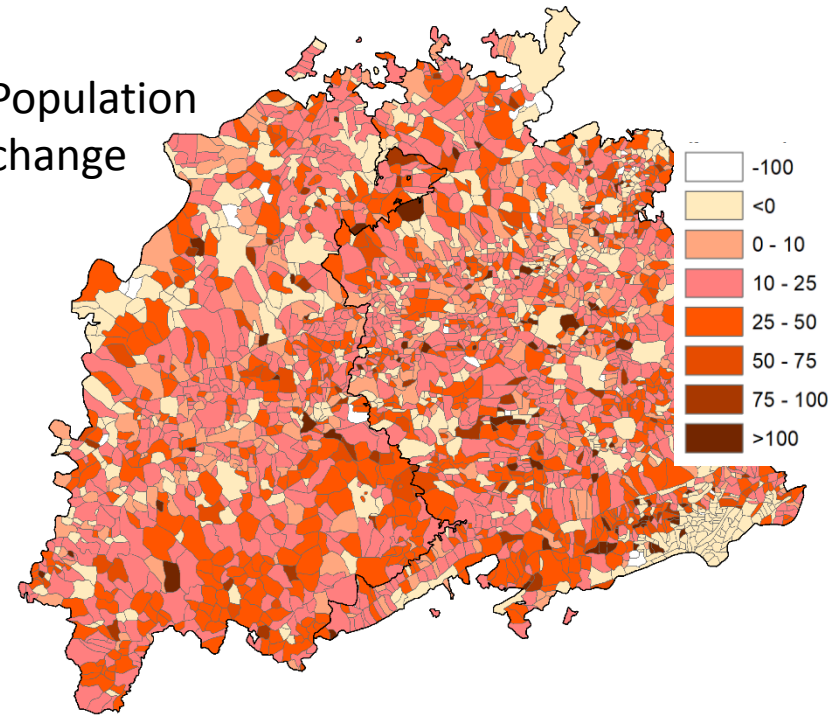


0 5 10 20 30 40 Kilometers

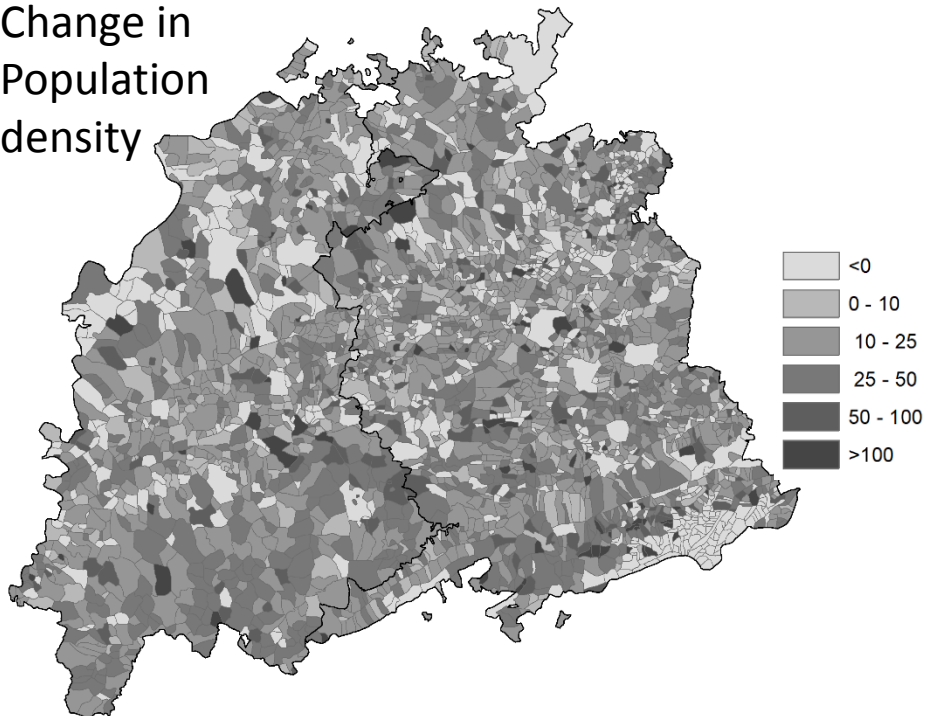
Covariates

- Simple indicators of population growth
- Change in density,
- Change in irrigated land,
- ...

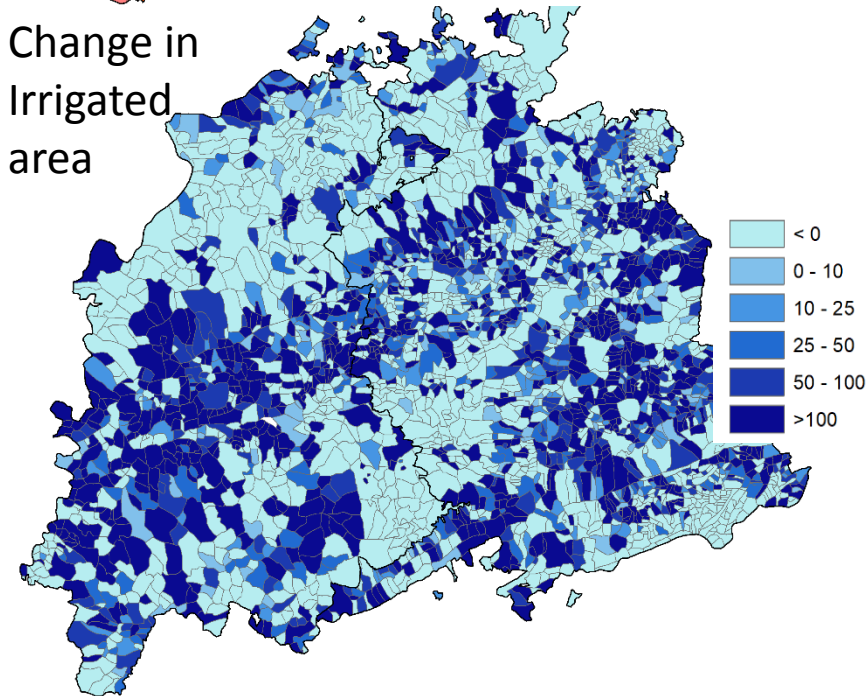
Population change



Change in Population density



Change in Irrigated area



Results

Estimated transition probabilities:

2001/2011	Forest	Shrub	Grassland	Cropland	Settlement
Forest	0.002	0.170	0.315	0.293	0.220
Shrub	0.000	0.392	0.158	0.244	0.207
Grassland	0.002	0.056	0.810	0.074	0.059
Cropland	0.002	0.149	0.108	0.689	0.052
Settlement	0.002	0.193	0.133	0.080	0.592

Log-odds of covariates (trunc.):

Forests->	Shrub	Grassland	Cropland	Settlement
Intercept	0.850	1.547	1.292	0.903
Population	0.011	0.011	0.011	0.010
Irrigation intensity	0.107	0.098	0.090	0.087
Population density	0.474	0.649	0.931	1.041

Estimated transition probabilities:

1. Significant loss of forests inside revenue villages,
2. Likelihood of conversion of shrubland/marginal land to cropland,
3. Cropland does not seem to change much, except likely going fallow,
4. Should settlements be considered an absorbing state?
5. What are the effects of misclassifications?

Effects of covariates:

- Forests seem to be changing as a factor of increasing population density (not size)
- Change in irrigation intensity does not seem to be having a significant effect on land cover transitions.
- Availability of socio-economic indicators will likely boost inferences.

Thank you! Questions?

Team:

Aditya Singh, Sarika Mittra, Phil Townsend, Jacob van Etten, Sidhanand Kukrety, Shrawan Acharya

Local collaborators:

Satna/Panna: RS Negi

Tehri Garhwal: Avtar Negi

Udaipur: Rakesh Kumar

Adilabad/Khammam: Praveen Kumar

Logistics and management:

Anish Sadanandan

