Disentangling facets of food insecurity in economically depressed regions of India

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AGRICULTURAL & BIOLOGICAL ENGINEERING

Motivation

Food and Agriculture Organization of the United Nations

FAO Hunger Map 2015

Millennium Development Goal 1 an[illegible] Hu[illegible]

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 east 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 (ESS)
Political boundaries: FAO Global Administrative Unit Layers (GAUL)
Global relief: ETOPO1 (National Geophysical Data Center - NOAA)
Inland water bodies: FAO Land and Water Division (NRL)

15% -> 24.9% - Moderately high

1 ERADICATE EXTREME POVERTY AND HUNGER
2 ACHIEVE UNIVERSAL PRIMARY EDUCATION
3 PROMOTE GENDER EQUALITY AND EMPOWER WOMEN
4 REDUCE CHILD MORTALITY
5 IMPROVE MATERNAL HEALTH
6 COMBAT HIV/AIDS, MALARIA AND OTHER DISEASES
7 ENSURE ENVIRONMENTAL SUSTAINABILITY
8 GLOBAL PARTNERSHIP FOR DEVELOPMENT

Indicators

1. Reduce by half the proportion of people living on less than a dollar a day.
2. Achieve full and productive employment and decent work for all, including women and young people.
3. Reduce by half the proportion of people who suffer from hunger

1 ERADICATE EXTREME POVERTY AND HUNGER

http://www.fao.org/fileadmin/templates/hunger-map/images/FAO_HUNGER_MAP_2015_sm.jpg

Food security, the Indian context

Food security in India (FAO):

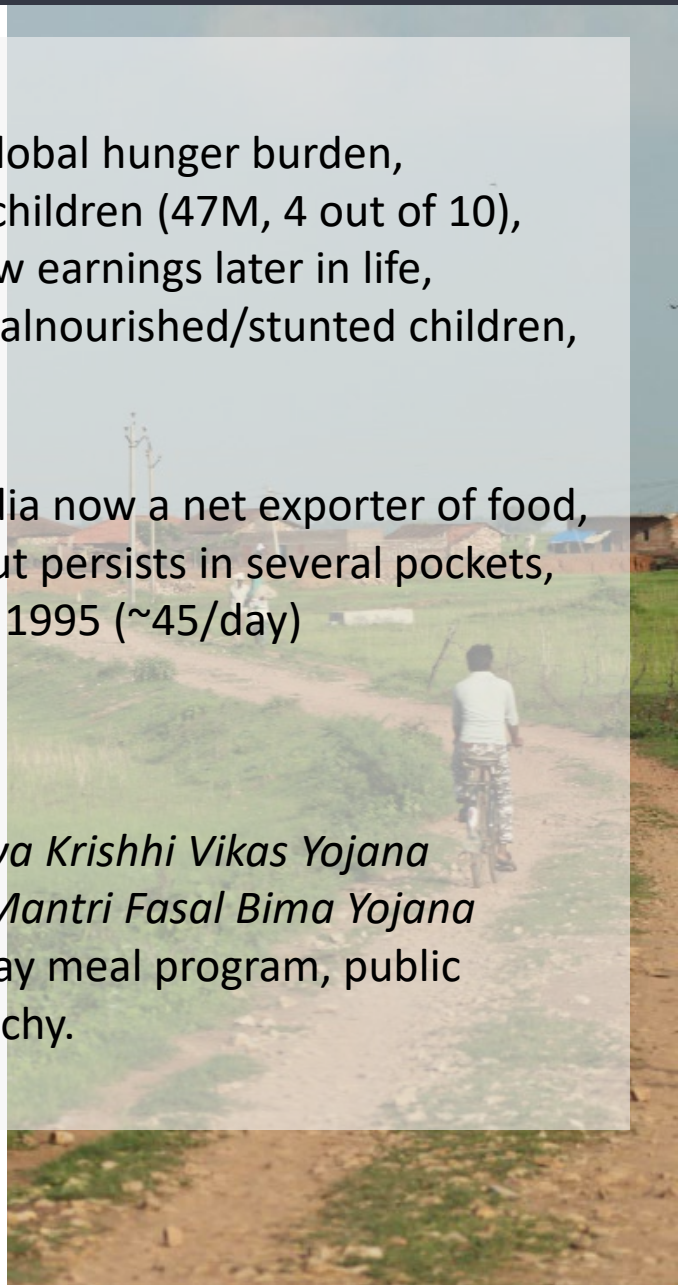
- 195 million undernourished people, almost 25% of the global hunger burden,
- Largest absolute numbers of stunted and malnourished children (47M, 4 out of 10),
- Impacts learning capacity – low school performance – low earnings later in life,
- Multi-generational impacts – malnourished mothers – malnourished/stunted children,

The food production paradox:

- 500% increase in food grain production from the 50s: India now a net exporter of food,
- Rural poverty has been falling (55% - 25% 1973-2012), but persists in several pockets,
- Almost 300,000 farmers have taken their own lives since 1995 (~45/day)
- Droughts, financial issues, social problems,

Multiple programs to tackle these issues:

Multiple programs: National Food Security Program, *Rashtriya Krishhi Vikas Yojana* (National Agricultural Improvement Program), *Pradhan Mantri Fasal Bima Yojana* (Prime Minister's Crop Insurance Scheme), School mid-day meal program, public distribution network etc. Implementation is however patchy.

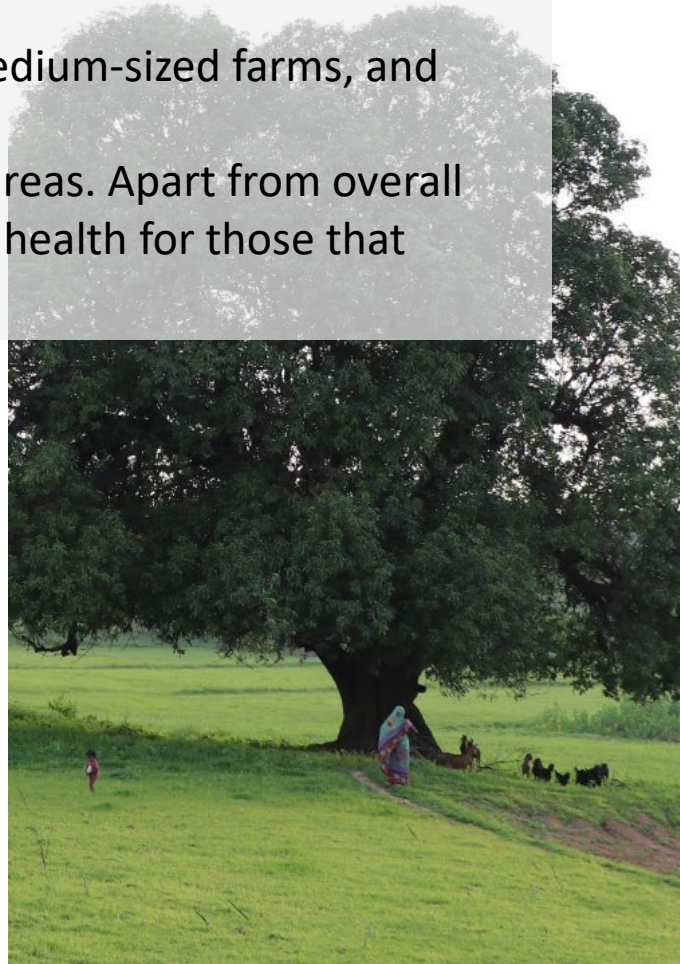


Correlates with land use/land cover

Major trends

- Area under non-agricultural use increased (2.85% - 8.06% 1950 and 2011).
- Operational landholding sizes decreased (1.15- 1.08 ha 2015-16). Mostly in marginal (<1ha) or small-holder farmers (1-2ha 86.7%),

- Intensively subsistence, higher cropping diversity than medium-sized farms, and some livestock.
- Food gathered from wild sources important in the tribal areas. Apart from overall caloric needs, also contributes to nutrition – essential for health for those that cannot afford medical services (access and cost)



Big questions:

- What are the patterns of landcover/land use change across socio-economically distressed regions of India (urbanization, degradation, deforestation, abandonment)?
- Are patterns of land cover change related to issues of food insecurity?
- What are the similarities/differences in these relationships across regions?

Project objectives

01
Downscaling socioeconomic data to the unit level using small area estimation techniques,

02
Combine 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 socio-economic indicators in a probabilistic framework,

Project activities

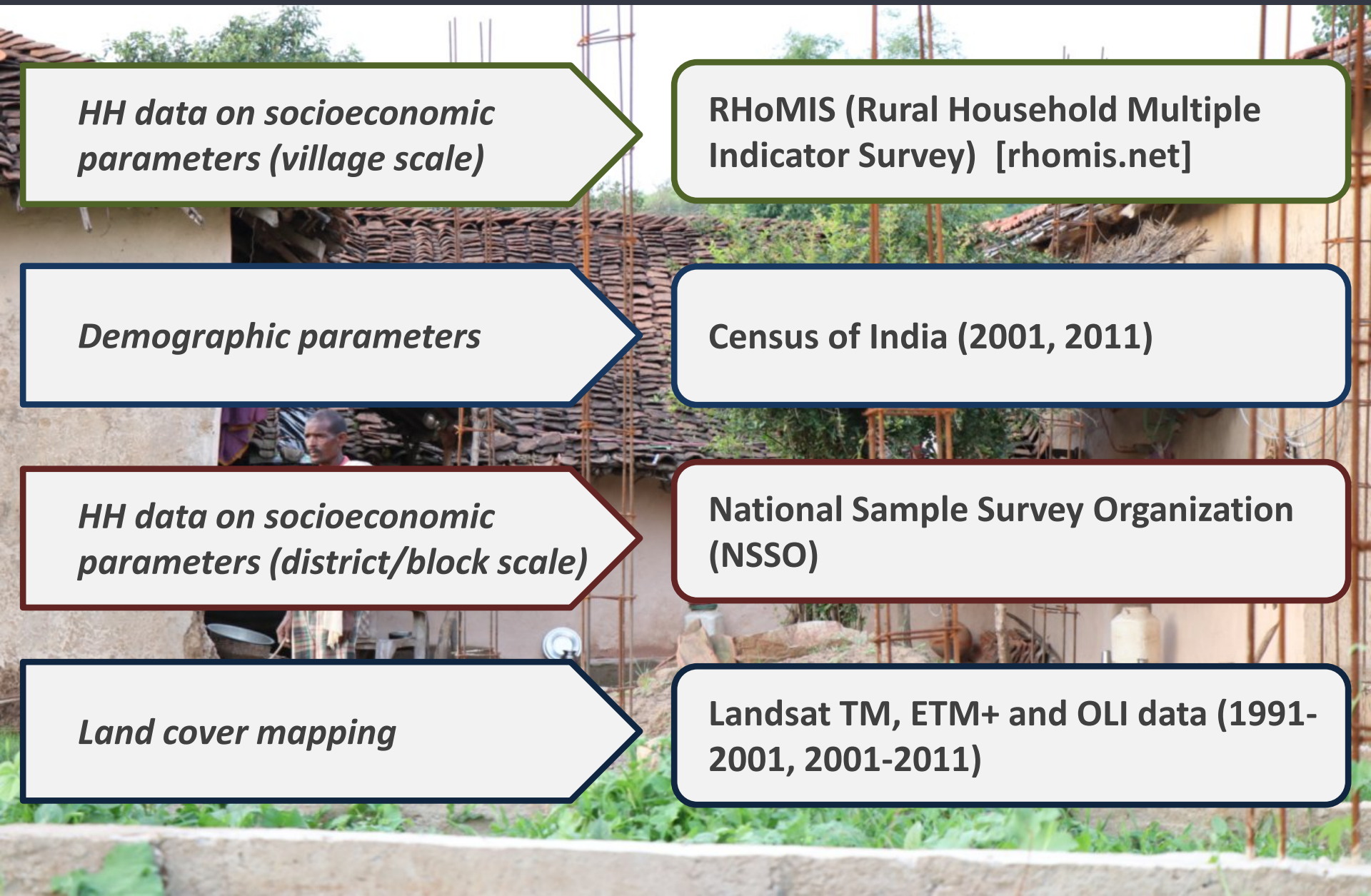
01
Understanding the facets of food security in India (household surveys),

02
Generating spatial estimates of indicators of food insecurity (government data),

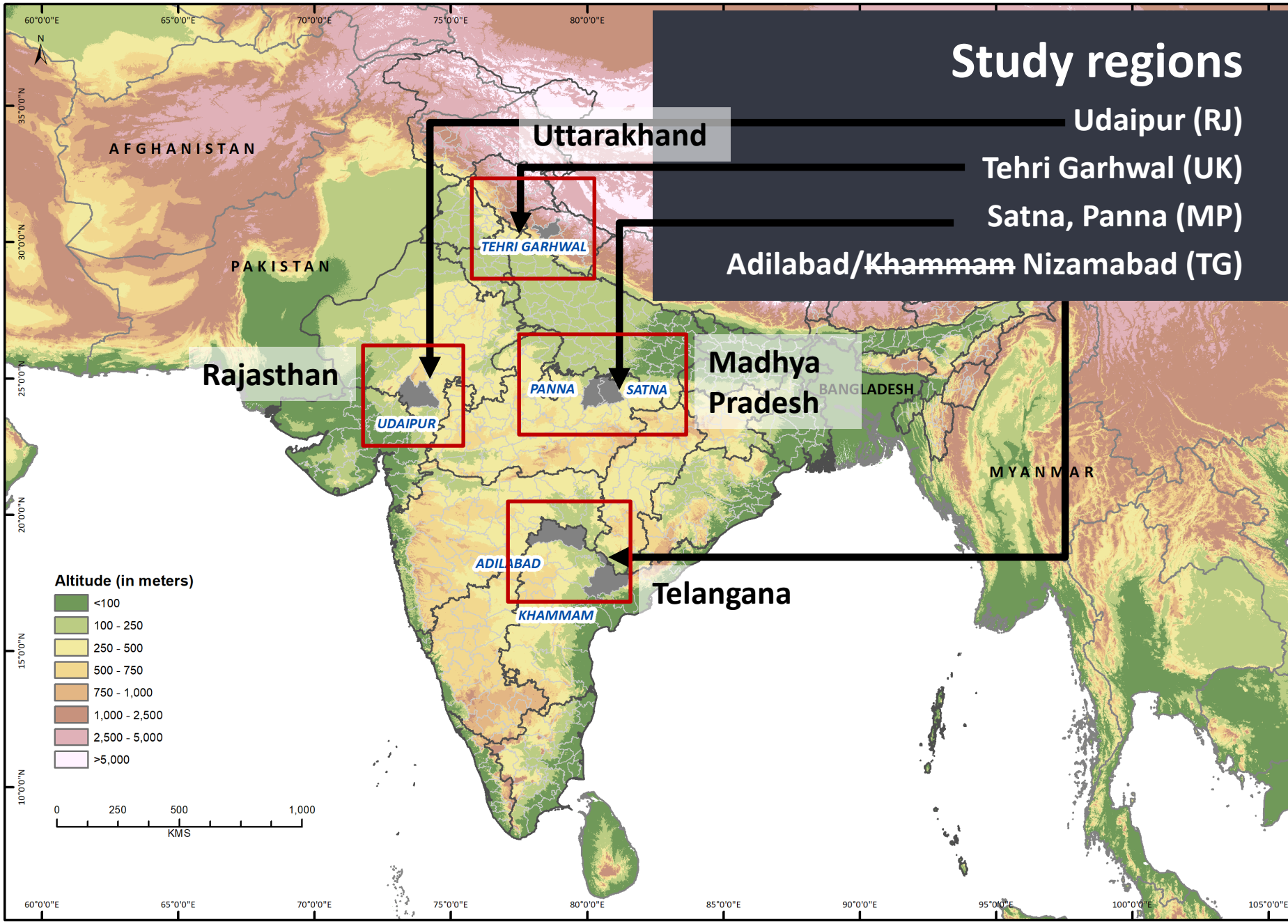
03
Developing a generalized method of land cover mapping (remote sensing),

04
Assessing where/how indicators of food insecurity correlate with land cover change (combination).

Data sources



HH data on socioeconomic parameters (village scale)	RHoMIS (Rural Household Multiple Indicator Survey) [rhomis.net]
Demographic parameters	Census of India (2001, 2011)
HH data on socioeconomic parameters (district/block scale)	National Sample Survey Organization (NSSO)
Land cover mapping	Landsat TM, ETM+ and OLI data (1991-2001, 2001-2011)


Study regions
Udaipur (RJ)
Tehri Garhwal (UK)
Satna, Panna (MP)
Adilabad/~~Khammam~~ Nizamabad (TG)
Uttarakhand
Rajasthan
Madhya Pradesh
Telangana
TEHRI GARHWAL
UDAIPUR
PANNA
SATNA
ADILABAD
KHAMMAM
AFGHANISTAN
PAKISTAN
BANGLADESH
MYANMAR
Altitude (in meters)
<100
100 - 250
250 - 500
500 - 750
750 - 1,000
1,000 - 2,500
2,500 - 5,000
>5,000
0 250 500 1,000
KMS
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65°0'0"E
70°0'0"E
75°0'0"E
80°0'0"E
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35°0'0"N
30°0'0"N
25°0'0"N
20°0'0"N
15°0'0"N
10°0'0"N
N

Study areas

Six districts across 4 states

- Government of India designated “backward districts”
  - poverty, education, health, nutrition, rural road connectivity, rural household electrification, access to potable water and individual toilets etc.

A wide diversity of issues:

- Uttarakhand: Tehri Garhwal: Land abandonment, rural-urban migration, forest fires, low land productivity, feminization of poverty,

- Madhya Pradesh: Satna, Panna: poverty, landlessness, insufficient food delivery through the public distribution system, low irrigation development (~25%),

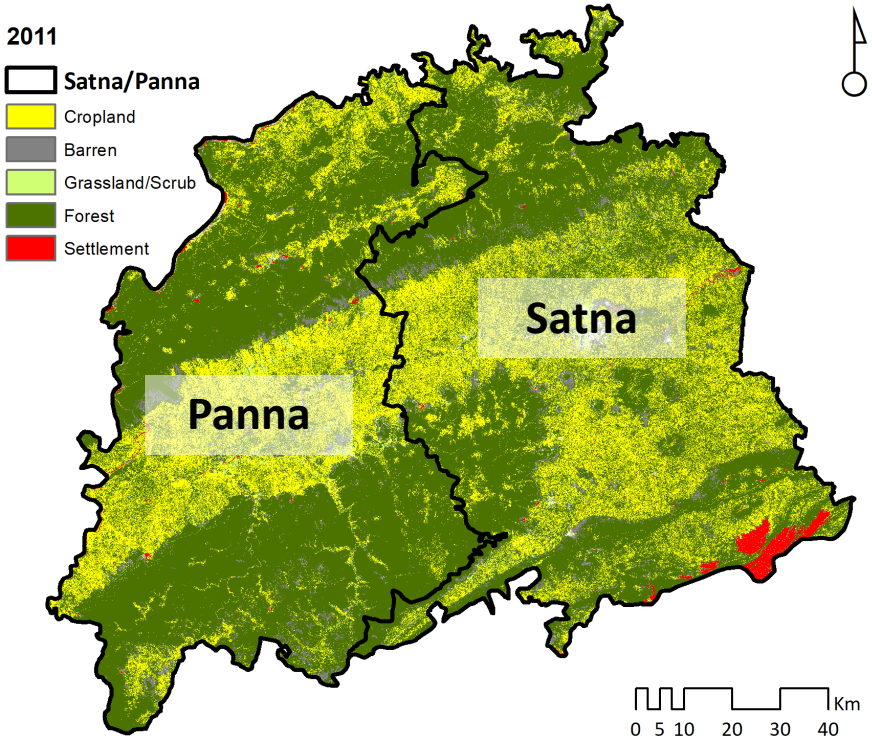
- Telangana: Adilabad, Nizamabad: high forest cover (~45%), low irrigation development (~15%), low nutritional indicators, high incidence of anemic children,

- Rajasthan: Udaipur: drought-prone (40/50 years), low irrigation development, falling groundwater levels, high groundwater pollution (F, NO_3),

Estimating land cover change

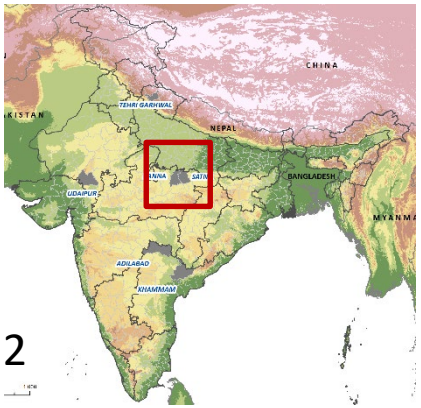
Madhya Pradesh, Satna/Panna districts

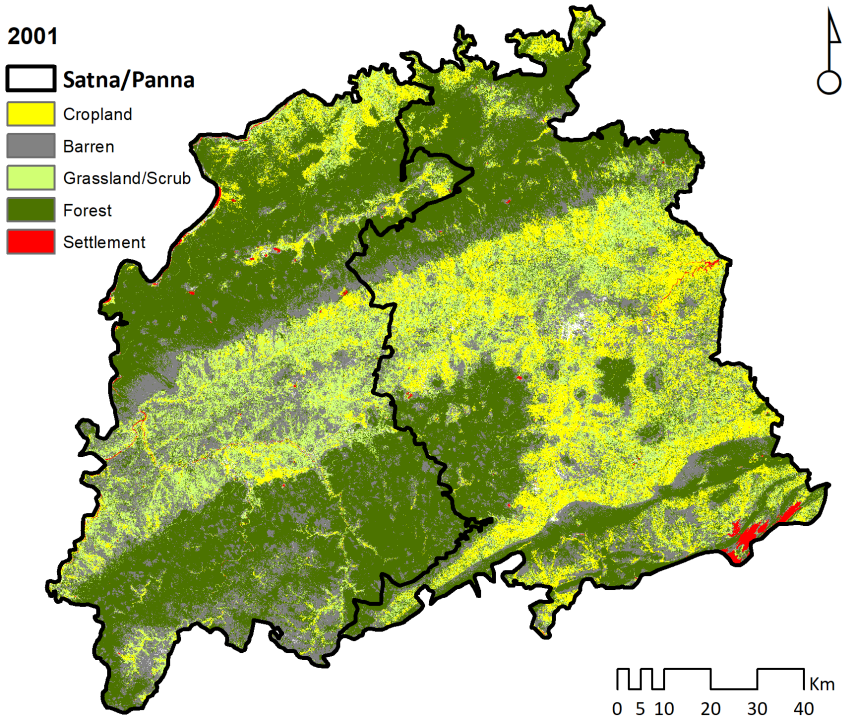
Test classification, 100x bootstrapped LDA



Approach

1. Obtain imagery
2. Generate indices
3. Classify and validate
4. Quant Uncertainties
5. Apply model to date 2
6. Assess change.

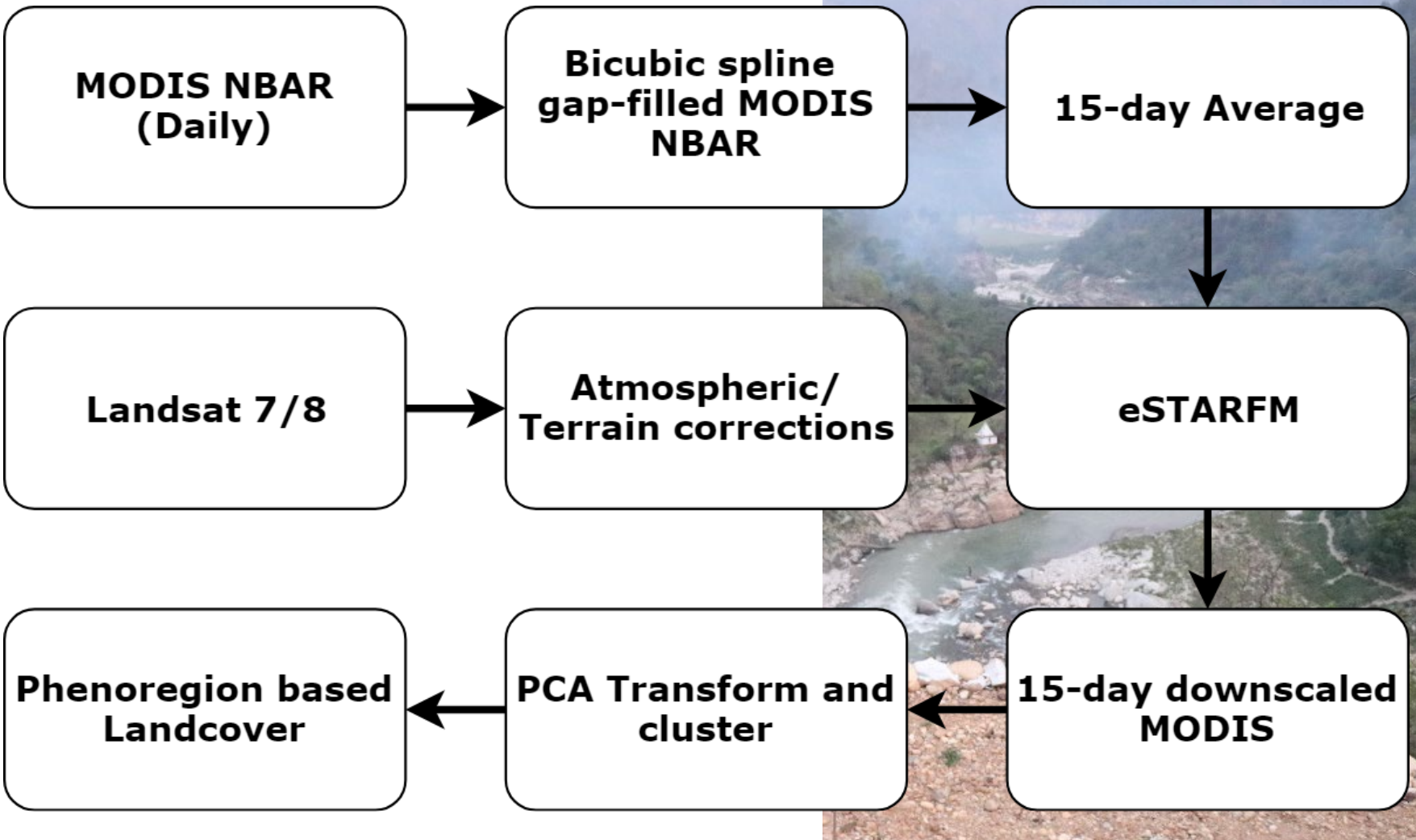




Good overall accuracy, (overall: 0.88, Kappa: 0.83), but are these patterns real?

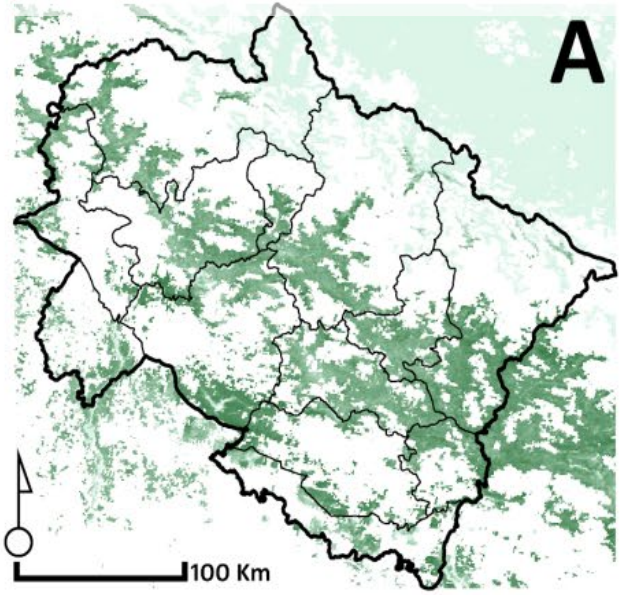
Estimating land cover change

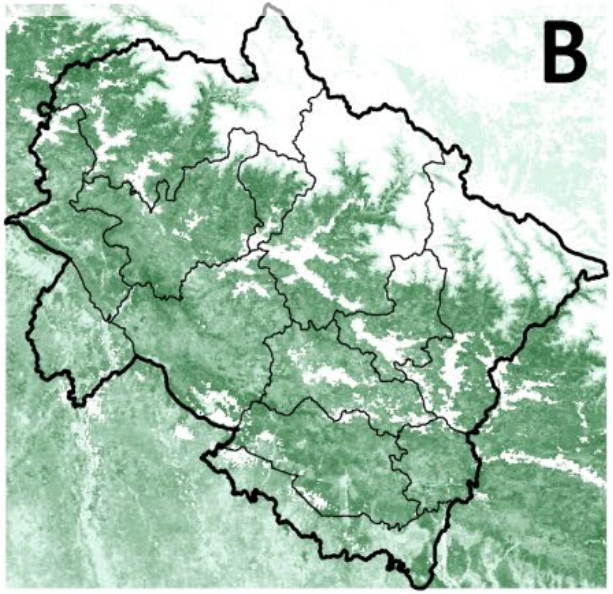
New approach:

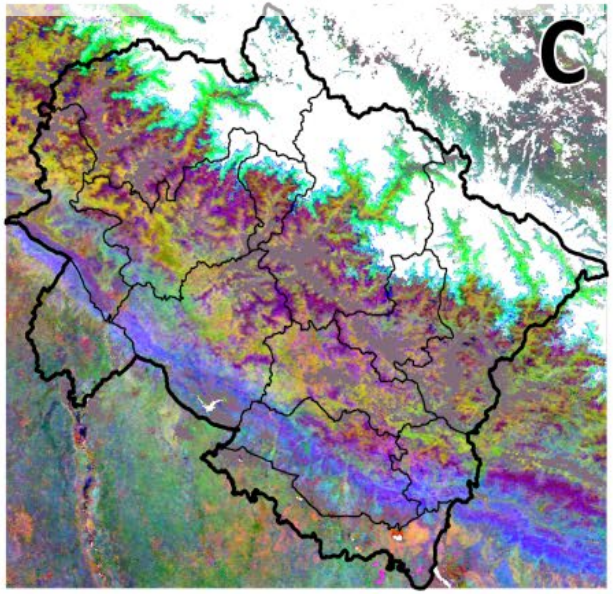


Estimating land cover change

Preliminary results Uttarakhand:



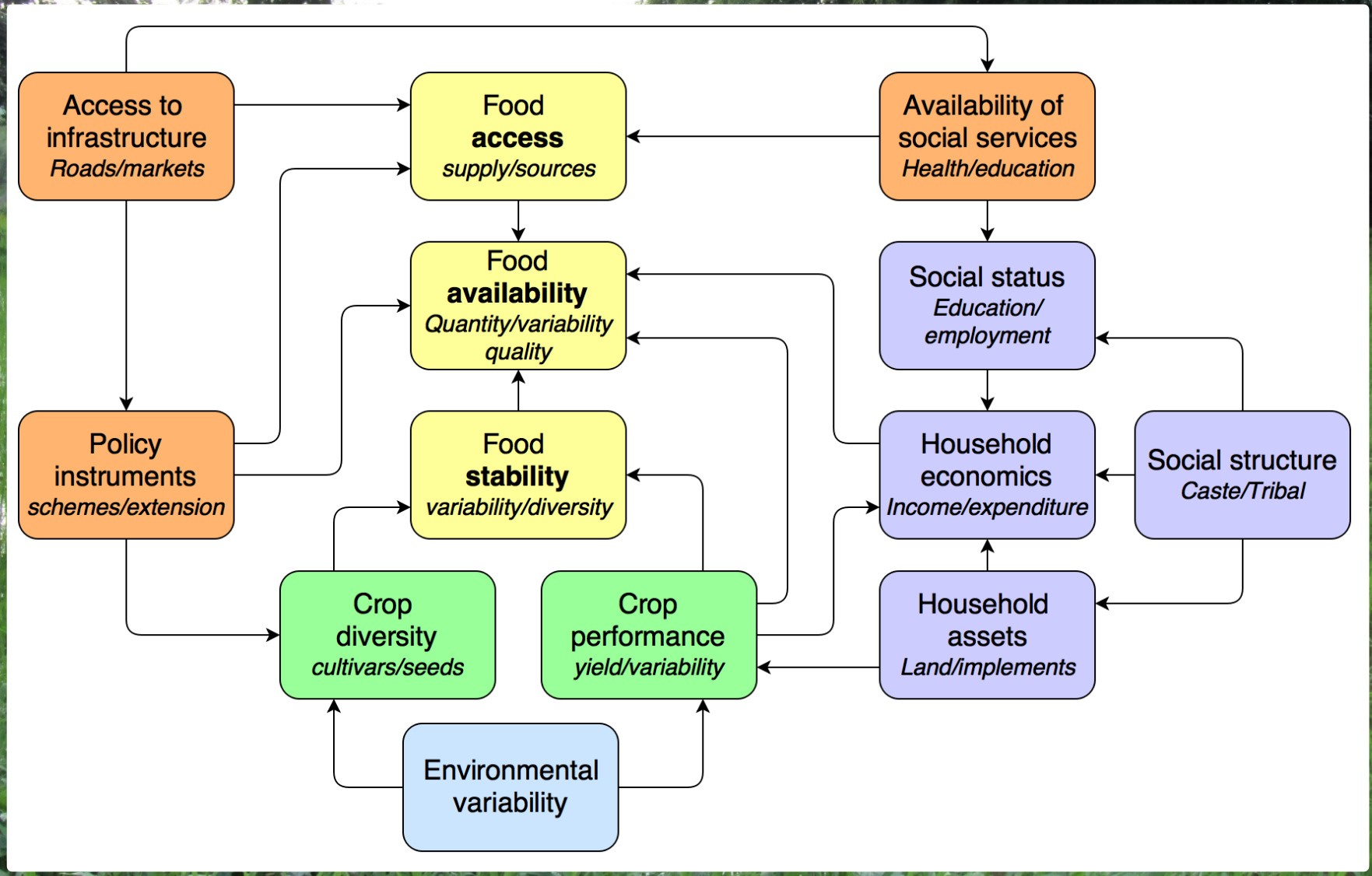




Observations:

- **The phenoregion-based classification is much better at capturing landscape dynamics across the entire year,**
- **Classification will be representative of inter-annual land cover changes not just anniversary dates.**

Food insecurity and LCC: Overall idea

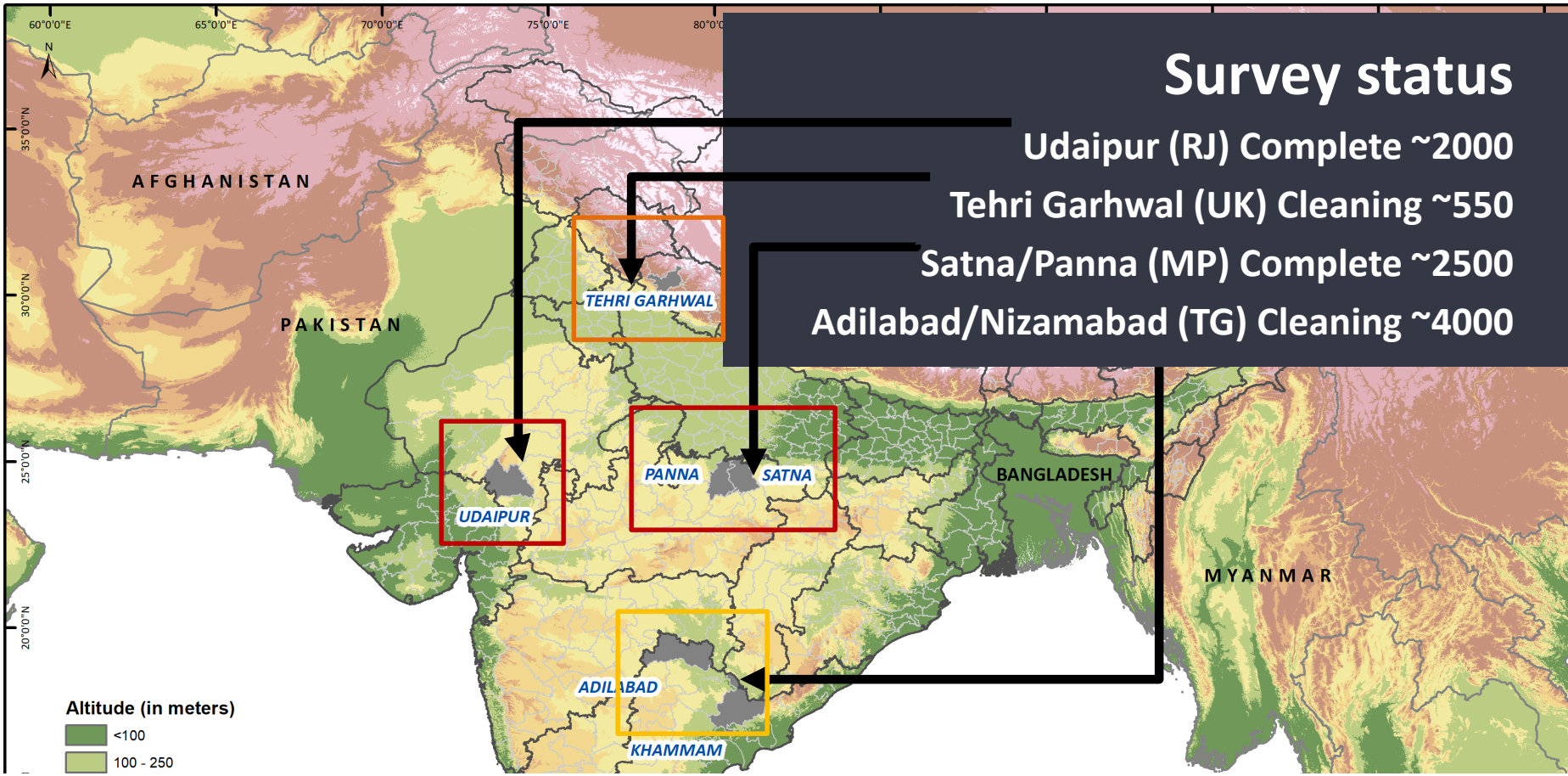


Understanding food insecurity

RHoMIS: Rapid Household Multiple Indicator Survey (https://www.rhomis.org/)

- Designed to improve gathering of information from farming households in the developing world,
- For wider intercomparison of findings among projects across the world
- Built using open-source software (ODK)
- Surveys are conducted using smartphones (or tablets)
- 23016 interviews conducted in 31 countries
- **Supplemented by questions pertaining to land use.**

Household-level questionnaire, ~150 questions, 5% of villages, 1% of population = ~10,000 HHs

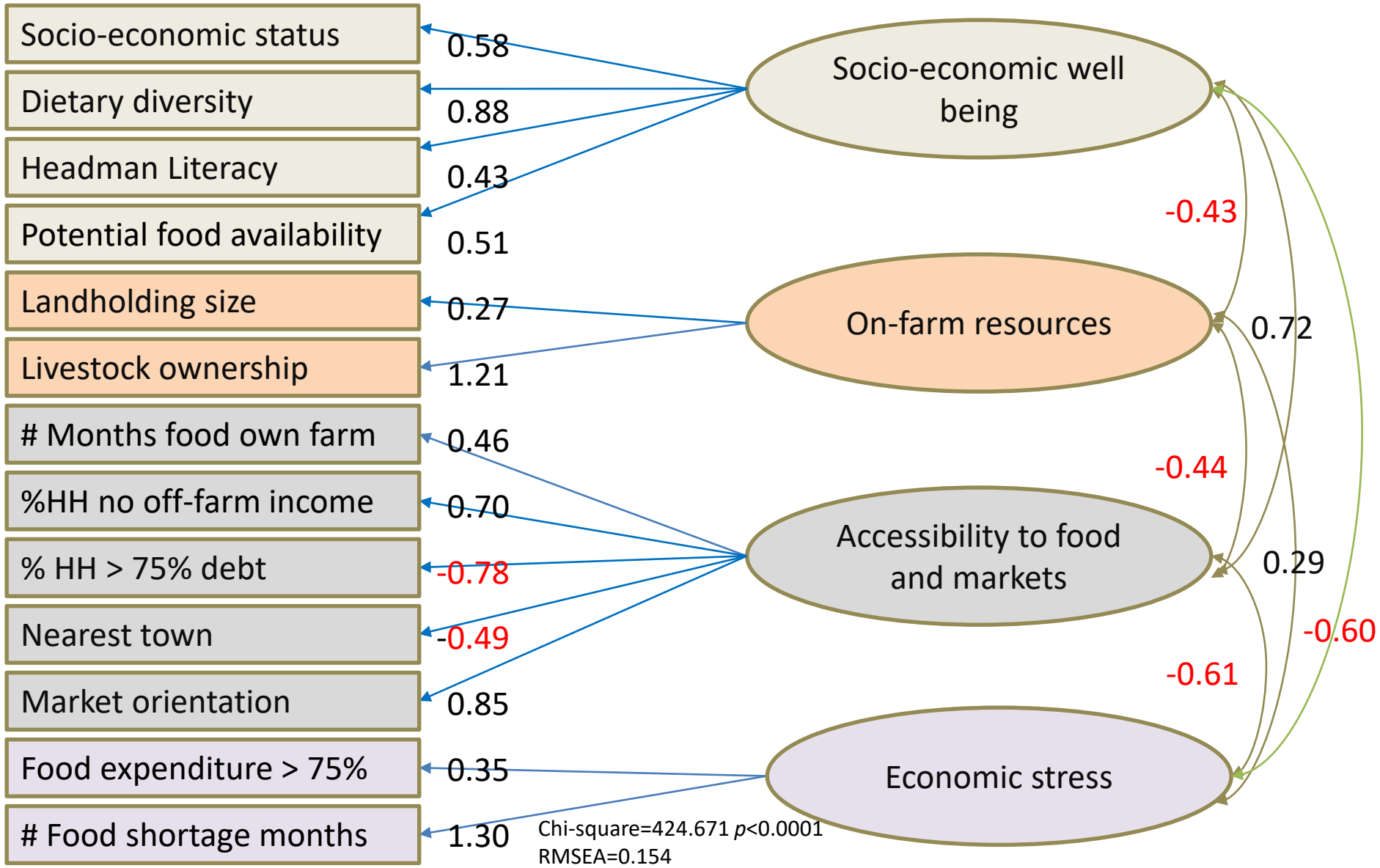


Structural Equation Modeling (SEM) process:

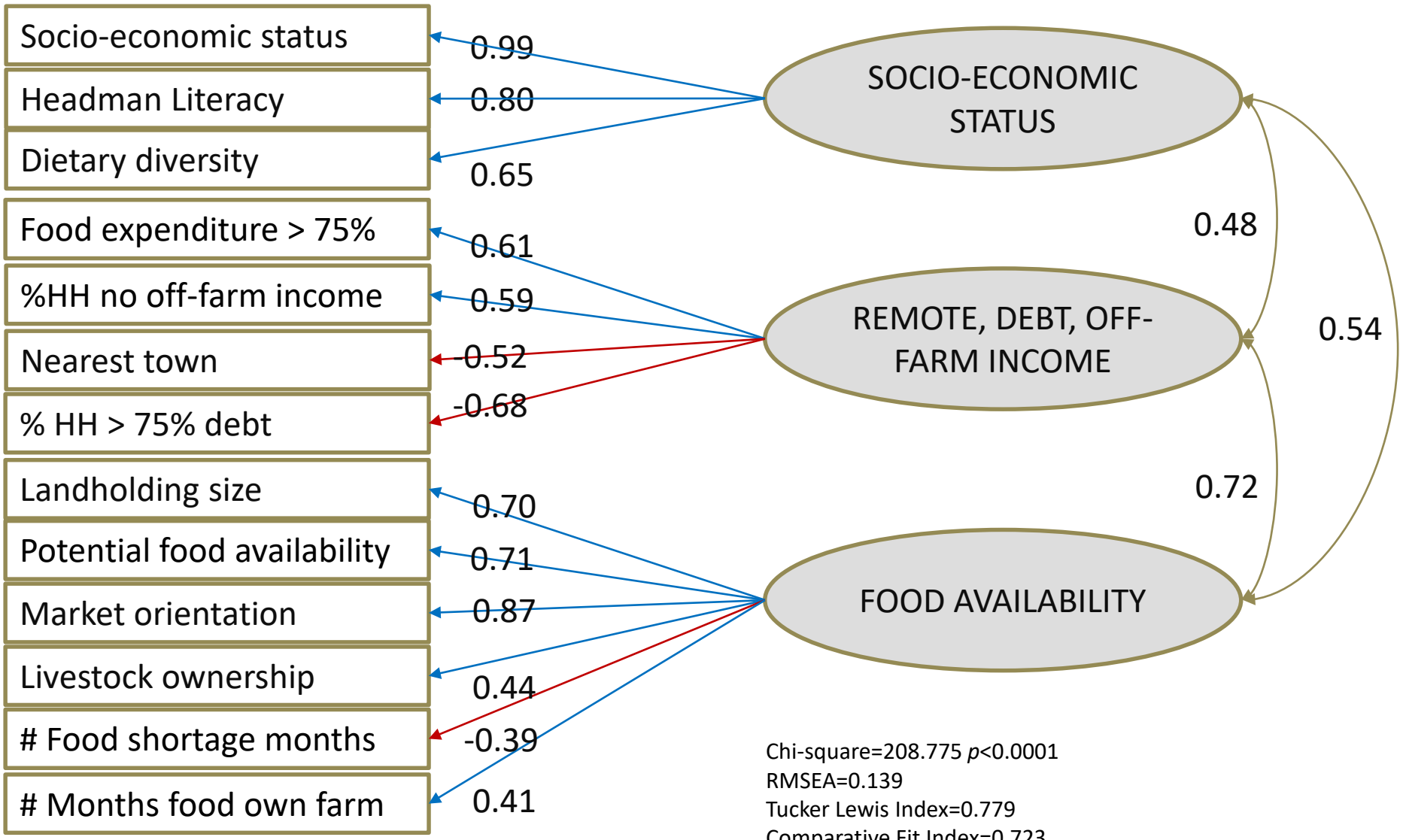
1. *Clean responses for errors,*
2. Combine responses into indicators,
3. Convert hypotheses to relationships,
4. Analyze interrelationships to establish putative correlations,
5. Confront hypothesized indicators with data,
6. Analyze, reorganize, repeat…

Variable names	Variable definitions (unit) [possible range]	Mean	SD
Socio-economic status	Socio-economic status index. Predicted 1st factor from a factor analysis performed on the HH's assets.	0.66	1.29
Family head literacy	Head man literacy level [1-5]	1.77	0.53
Dietary diversity	HH dietary diversity score. Number of food groups consumed annually [0-10]	4.29	0.57
Food expenditure > 75%	HHs with food expenditure greater than 75% of total off-farm income (percent)	9.49	14.36
%HH no off-farm income	HHs with no off-farm income (percent)	3.99	6.70
Nearest town	Nearest town (kms)	39.40	26.85
%HH > 75% debt	HHs with more than 75% unpaid debt in last 1 year	20.63	11.43
Land holding	Land holding (ha)	1.23	0.45
Potential food availability	Potential Food Availability (kcal per male per day). Estimated from the potential amount of food generated through each HH's supply from on and off-farm activities.	3827.60	2358.93
Market Orientation	Market Orientation. Ratio of agricultural products sold by the total agricultural production for each HH (both expressed in kcal) (0-1)	0.15	0.15
Livestock ownership	Livestock ownership (tlu)	1.60	0.70
# Food shortage months	Number of months experiencing food shortage	3.07	0.80
# Months food own farm	Number of months food sourced from own farm	4.75	1.43

SEM Preliminary findings: All districts



SEM Preliminary findings: Udaipur, Rajasthan



Chi-square=208.775 $p<0.0001$
RMSEA=0.139
Tucker Lewis Index=0.779
Comparative Fit Index=0.723

Preliminary findings: Udaipur, Rajasthan

Take-home points
In Rajasthan:

1. High levels of educational attainment are correlated with higher ownership of assets (motorbikes, vehicles, TV units, refrigerators) and therefore higher socio-economic status. Socio-economically well-off households are associated with high dietary diversity,

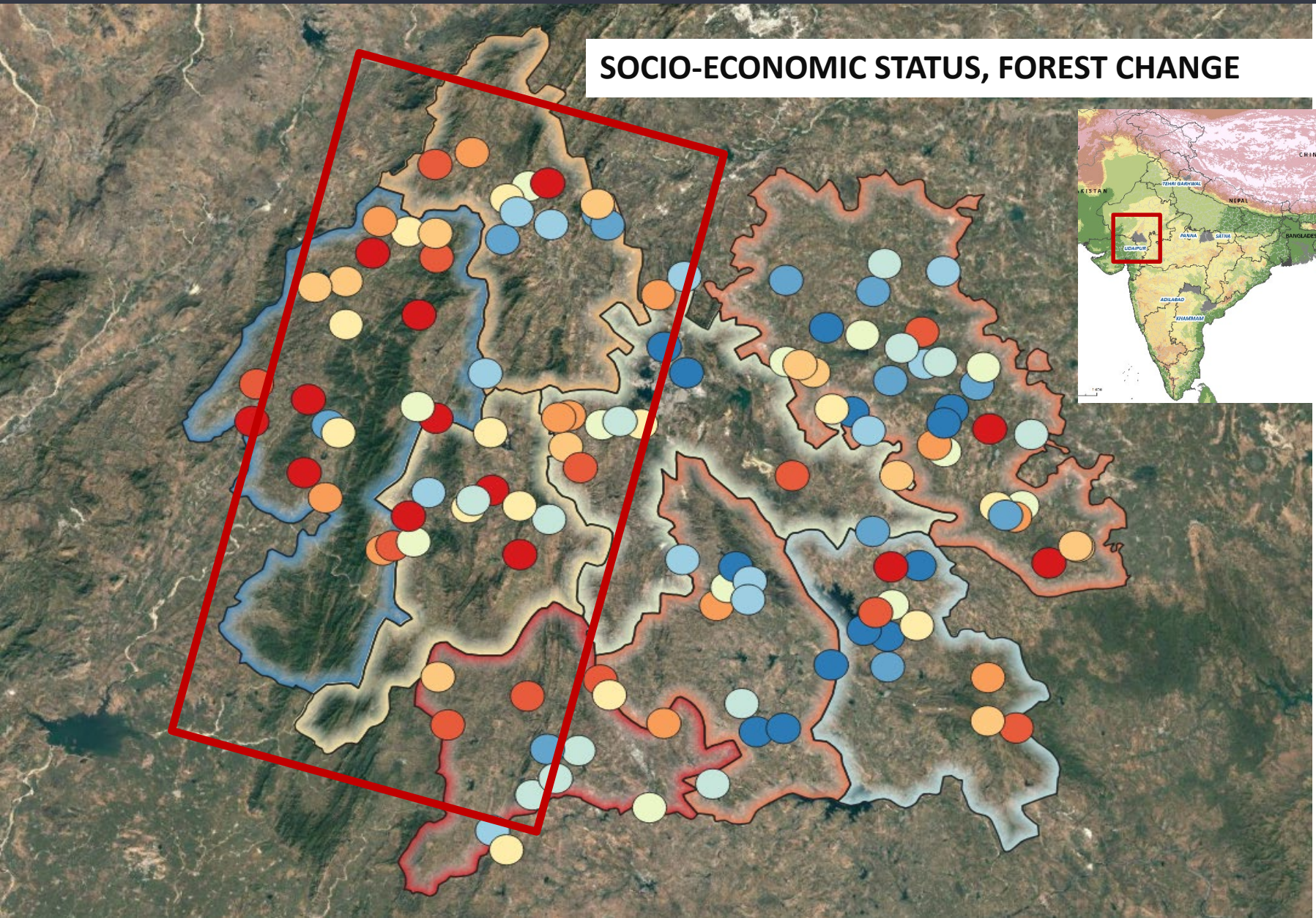
2. There is a pattern of indebtedness in remote villages correlated with limited off-farm income, and a large fraction of direct expenditure towards food,

3. Large landholders generally obtain most of their food from their own lands, generally own livestock, and do not suffer from food shortages.

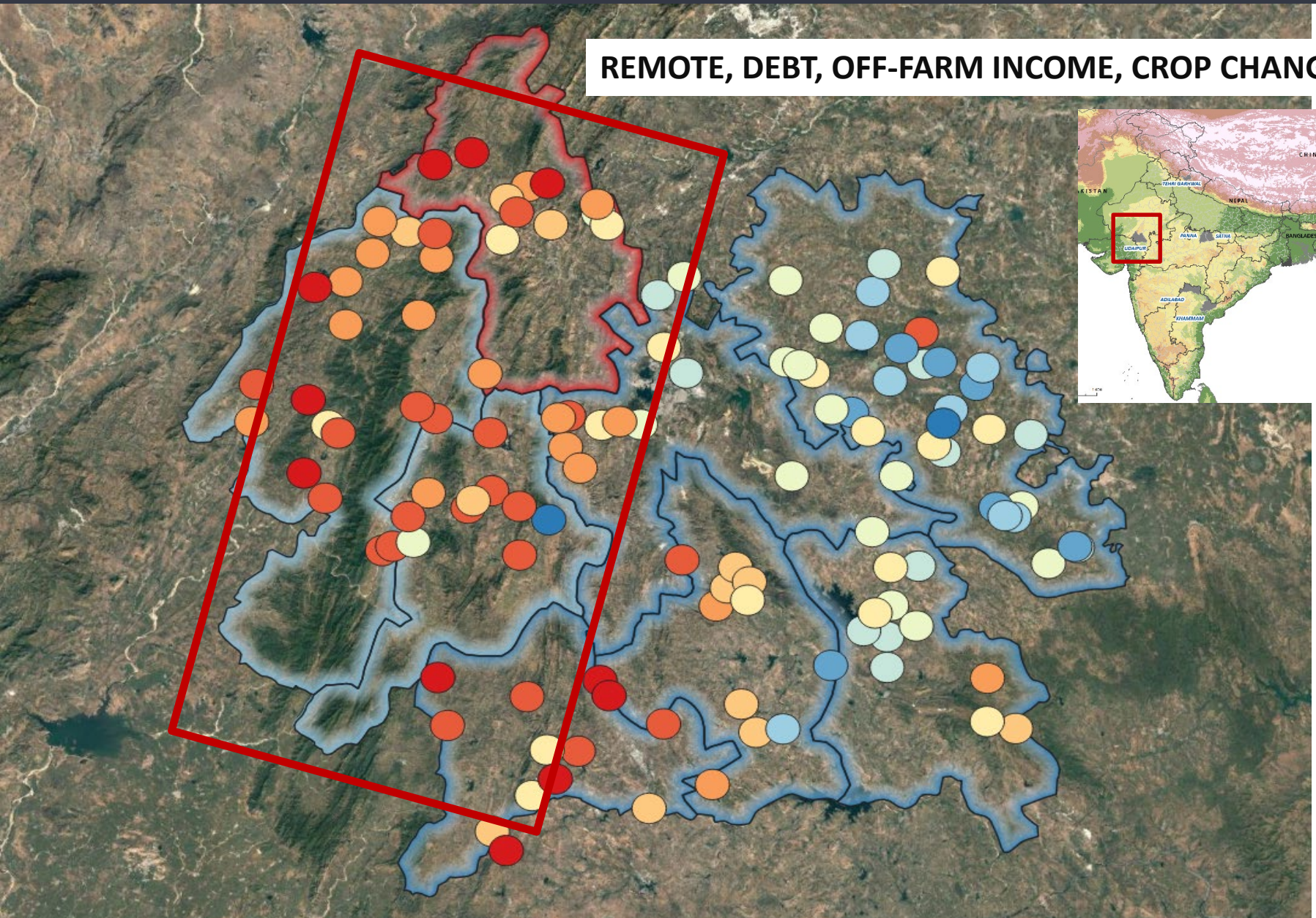
These findings agree well with a general understanding of poverty – food insecurity relationships.
However:

- **What are spatial patterns?**
- **Are there differences in (strengths of) relationships across states?**
- **Are these patterns related to LCLUC**

Preliminary findings: Udaipur, Rajasthan

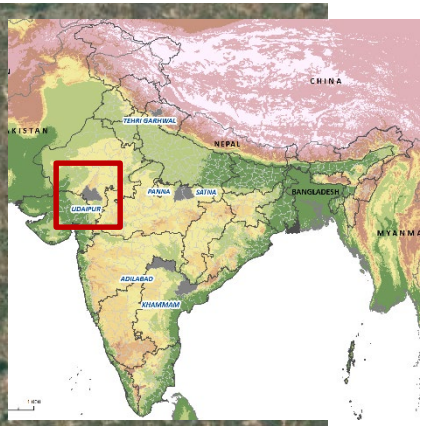


Preliminary findings: Udaipur, Rajasthan



Preliminary findings: Udaipur, Rajasthan

FOOD AVAILABILITY, FOREST CHANGE



Thank you! Questions?

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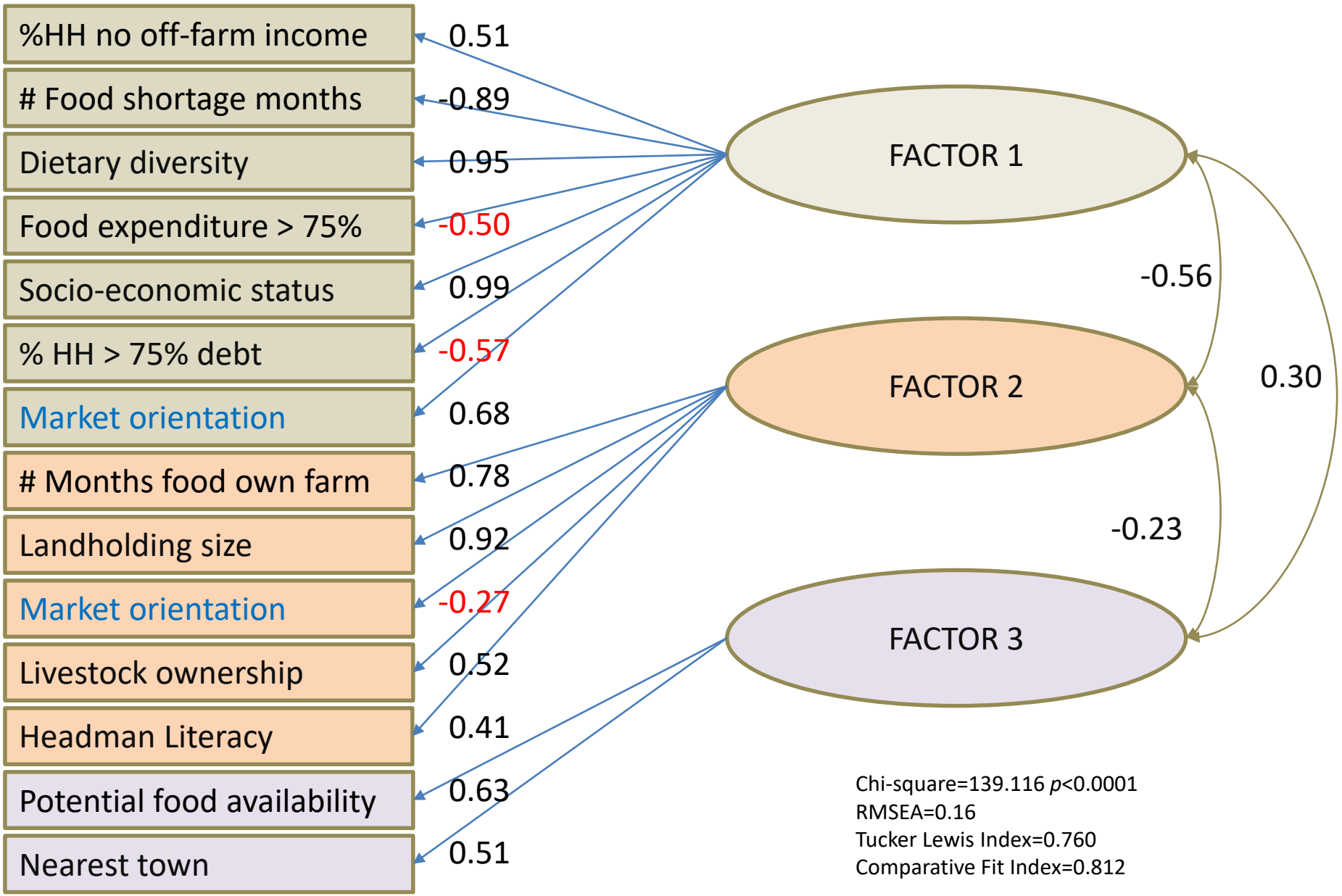
SEM Preliminary findings: Panna, Madhya Pradesh



Chi-square=139.116 p<0.0001
RMSEA=0.16
Tucker Lewis Index=0.760
Comparative Fit Index=0.812

Preliminary findings: Panna, Madhya Pradesh

Take-home points

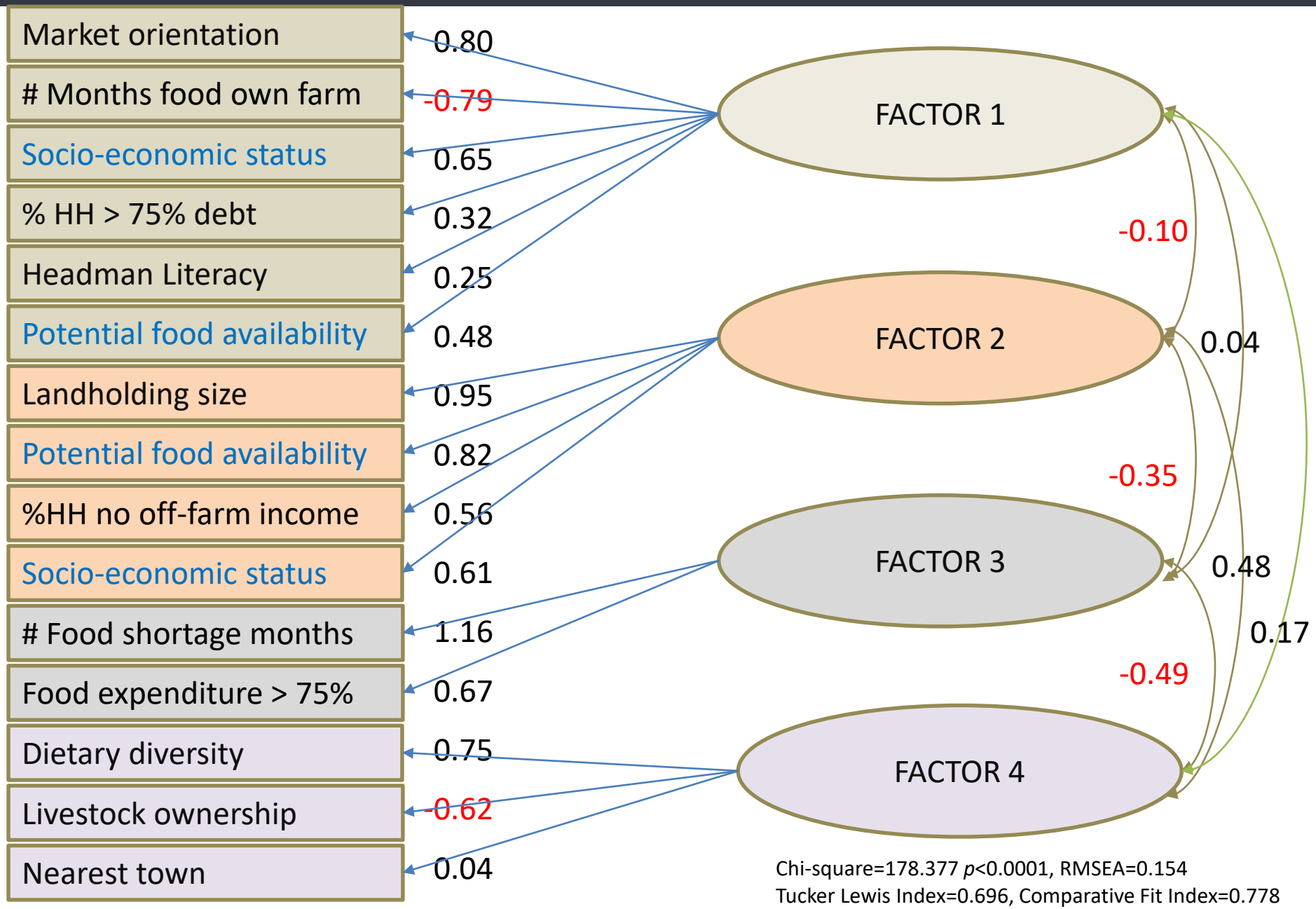
In Panna:

1. Socio-economically well-off households are associated with high dietary diversity and less food shortage frequency.

2. Higher proportion of households dependent solely on off-farm income living in villages unlike in Udaipur. Households dependent solely on on-farm income have high proportion of large landowners with higher market orientation.

3. Overall, households lower on the socio-economic scale have lower literacy and on-farm resources but not necessarily lower food availability. Potential food availability is more closely linked to on-farm resources than socio-economic status although the relationship is not strong.

SEM Preliminary findings: Satna, Madhya Pradesh



Preliminary findings: Satna, Madhya Pradesh

Take-home points

In Satna:

1. Unlike Panna and Udaipur, households in Satna do not have a mix of income from on-farm and off-farm activities. Households in 35% of villages have income **only from on-farm activities** while 37% of villages have income **only from off-farm activities.** This is reflected in the cross-loading of food availability and socio-economic status in the same 2 factors which roughly splits households with income from either on-farm or off-farm activities.
2. Satna has the lowest incidence of months with food shortage (< 1 month annually). However, the low income diversity also results in lower potential food availability.