Livelihood profiling and sensitivity of livelihood strategies to land cover dynamics and agricultural variability

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Click on the boxes if you want to learn more.

RATIONALE

For rural households, whose livelihoods are mainly based on agriculture, a decrease in the area of land cultivated can have significant consequences on their **livelihood strategies**, thus on their livelihood outcomes. However, it is still unclear **how changes in cultivated area and agricultural productivity influence households' livelihood systems**, including community capitals and households' livelihood strategies.

This study investigates **how agricultural unpredictability relates to livelihood systems**.

CASE STUDY

The majority of Odisha's population depend directly or indirectly on agriculture for their livelihoods (60%), which means they are **highly exposed to climate variability**.

FRAMEWORK

This research uses an adapted version of the **Sustainable Livelihood Framework** to characterise livelihood systems.

METHODS

AGRICULTURAL VARIABILITY

LIVELIHOODS

This study combines together earth observation from space, national census and participatory qualitative data into a community-wise **analysis of the relationships between predictability in agricultural production and livelihood capitals.**

LINKS WITH SDG

This approach provides a new lens to inform policies on the **role of livelihood capitals for poverty reduction** and produces new insights for **early warning of crop failures** and for **sustainable development** in rural areas of the Global South.

RESULTS

AGRICULTURAL PREDICTABILITY

SENSITIVITY ASSOCIATION

There is a relationship between the set of livelihood capitals a community has access to and the **level of predictability** of their agricultural production based on climate indicators. It is argued that **climate-crop yield models should integrate frameworks from both climate and social sciences** to take into consideration the **actions of communities on their environment**, which modifies the impact of climate on ecosystems.

ABOUT

If you want to learn more about the **team** and about our research **project**.

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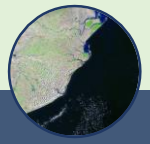
Work carried out within: DECCMA

With financial support from: IDRC | CRDI Canada, UKaid, ESRC Economic & Social Research Council

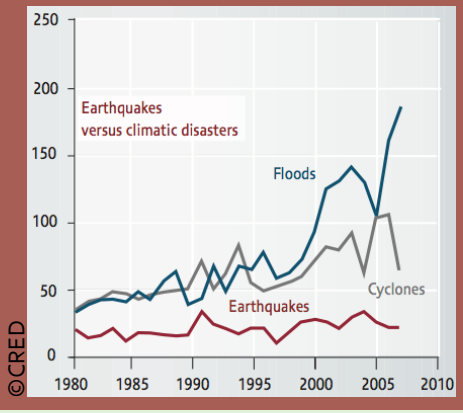
RATIONALE



Deltaic landforms are formed by a combination of rivers, which make them **very exposed to sea-level rise and floods** from both rivers and oceans. Their low gradient facilitates the spreading of floods across plains. They also are the draining endpoint of 42% of global terrestrial runoff (Ericson et al. , 2006).

Rural people in deltas **rely on the environment** for ensuring their food security and their economic incomes (MEA, 2005). However, hydro-meteorological hazards lead to crop and livestock losses, thus they have a **direct negative impact on food security and households' livelihoods** (FAO, 2015).

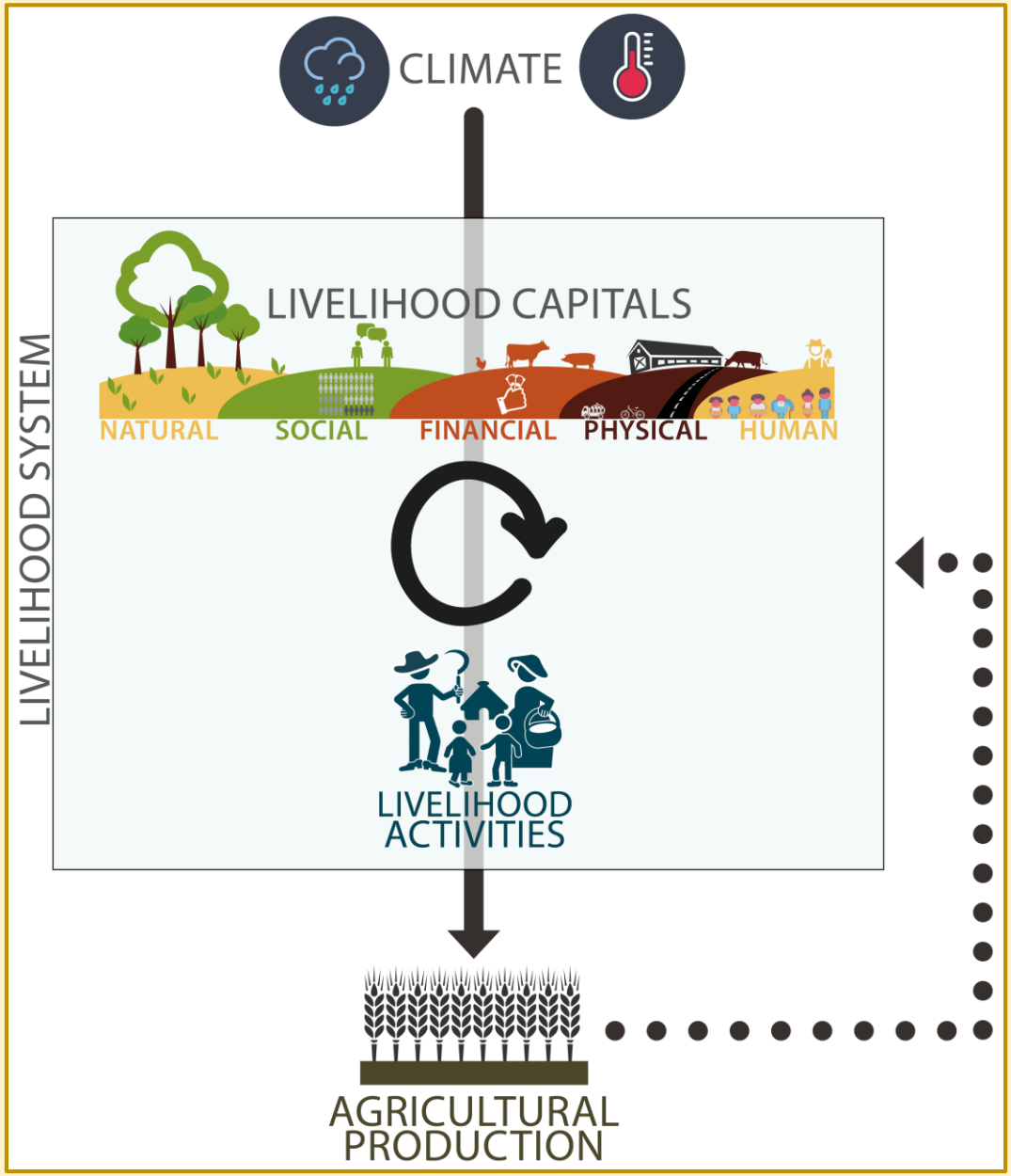
The projected increase of the average mean temperature is going to modify precipitation patterns. It will lead to a **higher frequency and intensity of hydro-meteorological hazards** such as floods, cyclones and droughts (IPCC, 2013).



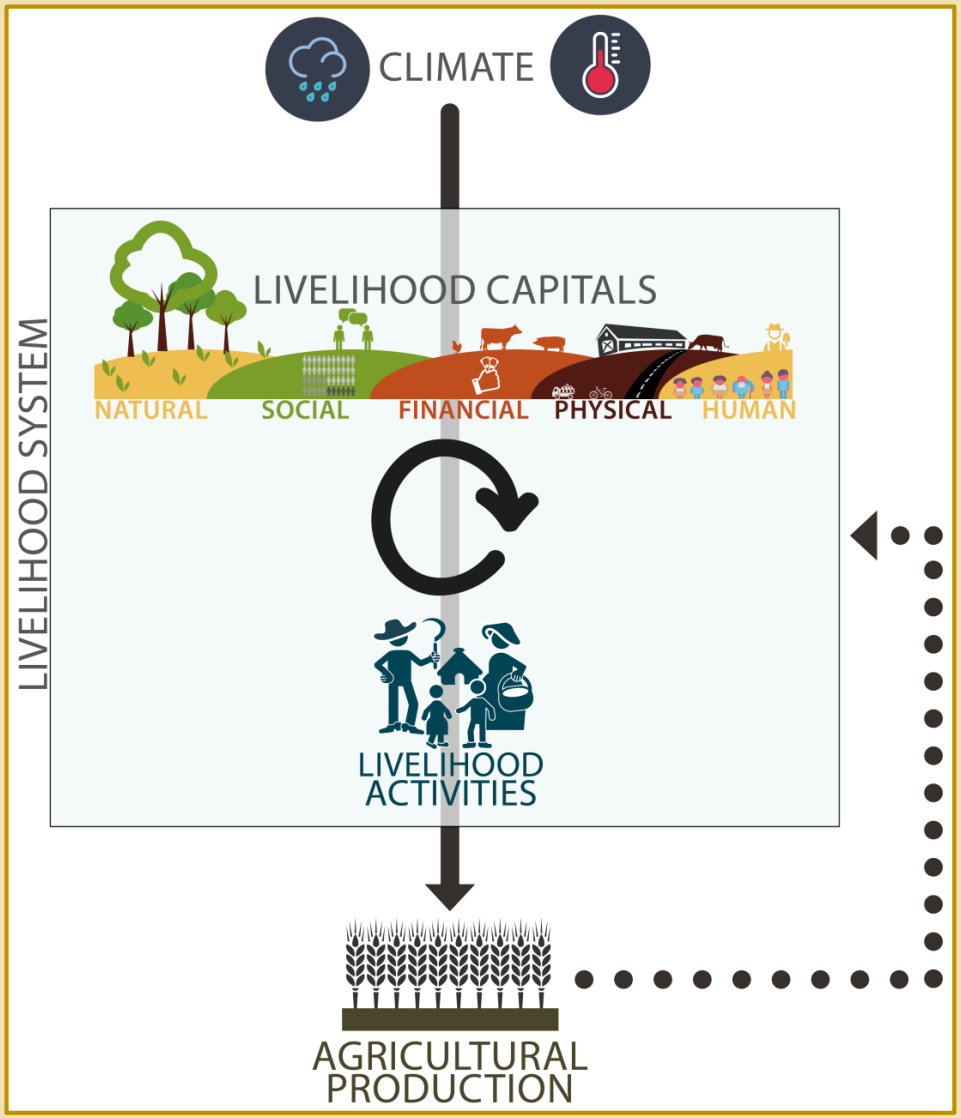
Despite the importance of agriculture for livelihoods in developing countries, **there is no clear understanding of the impacts of hazards on livelihood systems.** There is a need for better understanding of the quantitative impacts of hydro-meteorological hazards on the livelihoods of populations affected (FAO, 2015).

FRAMEWORK

Learn more about the Sustainable Livelihood Framework



FRAMEWORK



The link between climate stress and loss of agricultural production is complex and involves agricultural practices that cannot be tackled without taking into account the socio-economical context. As an example, having access to some resources such as a drainage canal might mitigate the effects of a flood. Thus, it appears necessary to take into account the **mitigating effect of community resources while studying the sensitivity of agriculture to climate variability**.

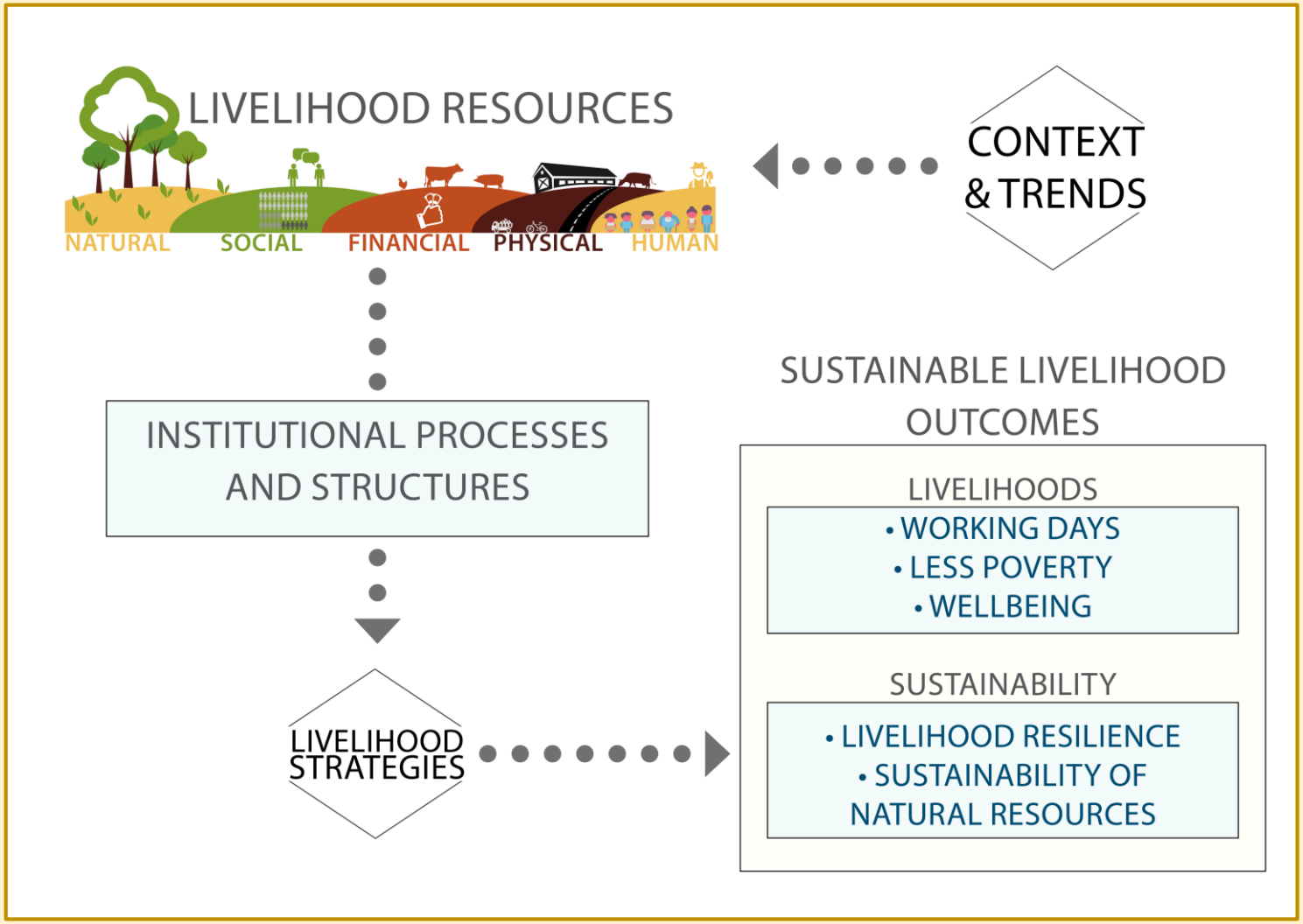
There is no consensus on the concept of poverty and that most attempts to build poverty indicators are reductive. On the contrary, **livelihood approaches provide an integrated lens** by which to understand relationships between human communities and the environment in the broader context of **rural development**.

It also appears that rural households put in place livelihood activities based on their access to livelihood capitals. Characterising such links is a mandatory step towards a better understanding of rural communities needs, thus to adapt rural development strategies in the light of **achieving the Sustainable Development Goals.**

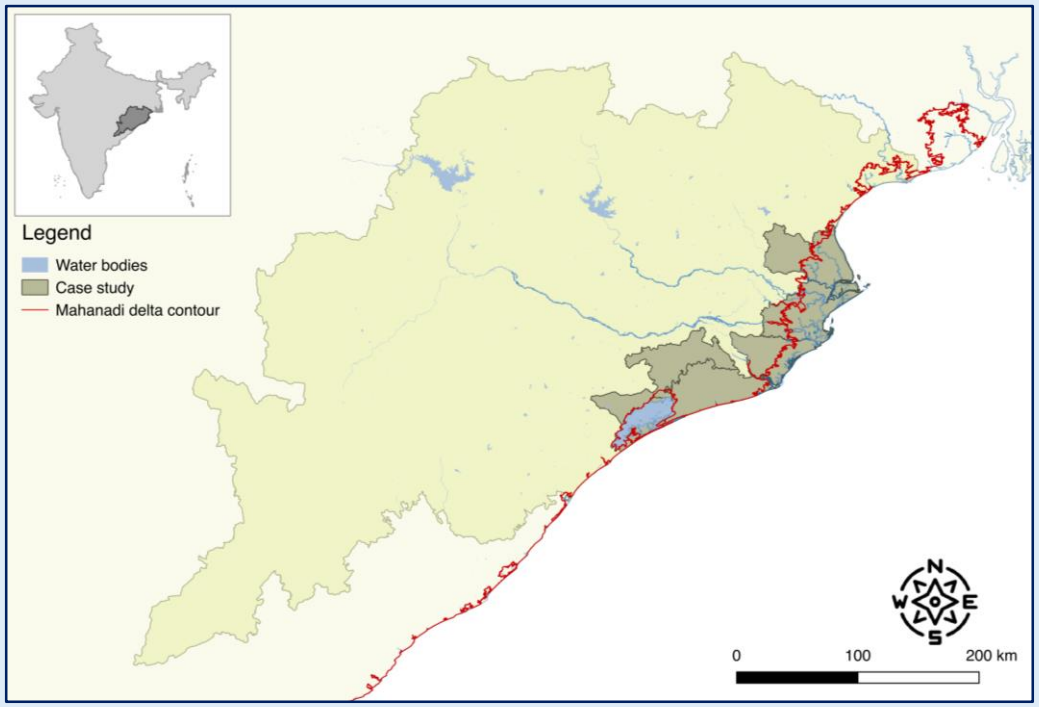
FRAMEWORK

Households have access to different **assets**; this relationship can be modified by the **institutions, social networks** and **organisations** at both local and national levels.

Assets to which households have access are called **livelihood capitals**, and are transformed into **outcomes** (improved food security, increased well-being) by its members through a different panel of **livelihood activities.**



CASE STUDY

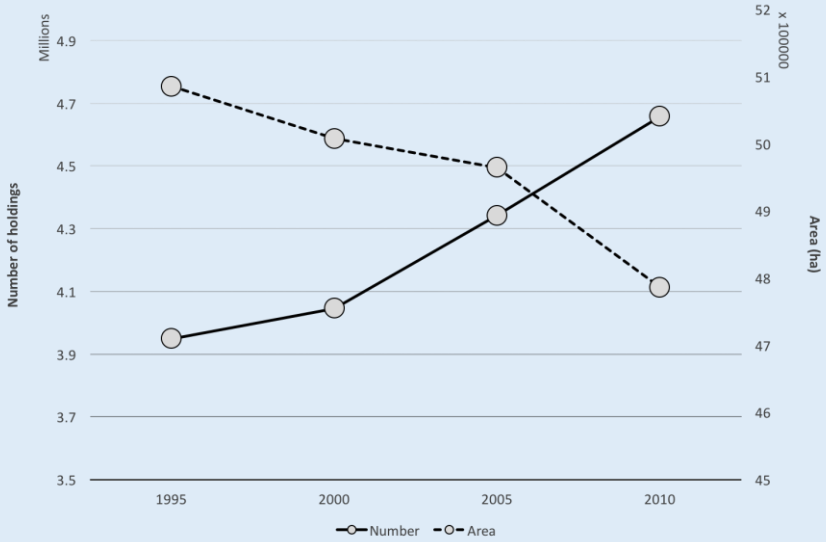


Map of the case study

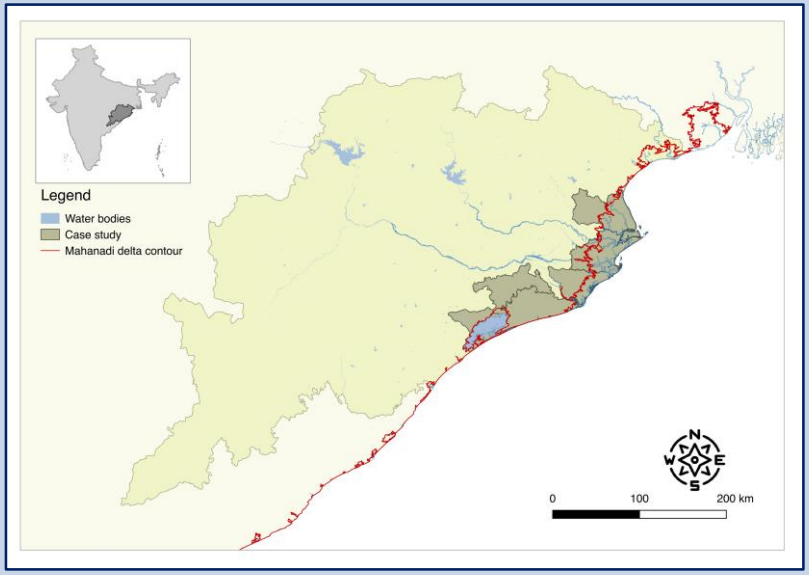
Year	Main climate stress
1999	Severe cyclone
2000	Drought, flood
2001	Flood
2002	Severe drought
2003	Flood
2004	Moisture stress
2005	Moisture stress
2006	Moisture stress, flood
2007	Flood
2008	Flood, moisture stress
2009	Flood, pest attack
2010	Drought, unseasonal rain
2011	Flood, drought
2012	Drought
2013	Sever cyclone
2014	Cyclone, flood

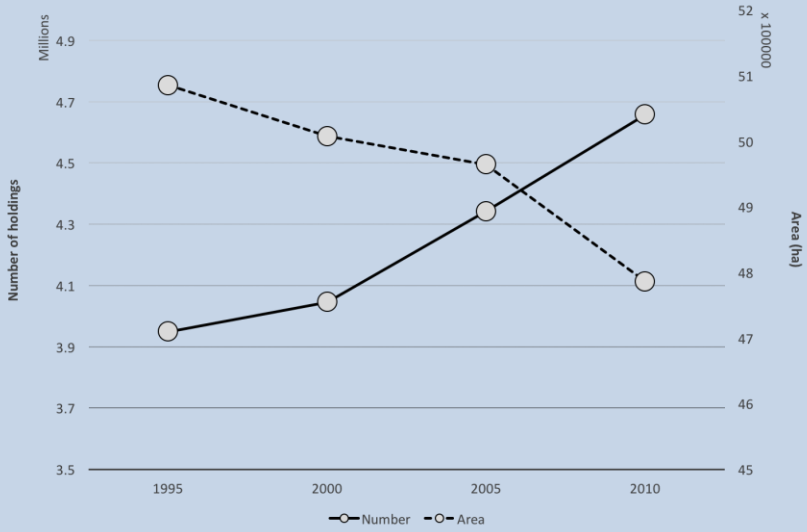
Timetable of the natural hazards that affected the State of Odisha

Click here if you want to know more



Evolution of the number of holdings and farm area in the case study





Coastal plains are one of the most vulnerable geographical zones to climate variability and natural hazards. In these regions, the level of poverty is very high, due to the **marginalisation of rural people** and to the **high density of population**. Considering the fact that most rural dwellers rely on agriculture for their livelihoods, land pressure leads to the scarcity of arable land in coastal plains thus farmers intensify their farming systems, which leads to the over-exploitation of the environment (Dixon *et al.*, 2001).

On the long-term, such dynamics will lead to a decrease in food production and in water availability, negatively affecting human health and livelihoods, because of the **loss of ecosystem services**. Also, this increased **pressure on the environment** will increase exponentially the vulnerability to disasters because of the loss of some ecosystem services (Rosegrant & Cline, 2003).

We selected the Mahanadi delta located within the state of Odisha in East India as a case study. Odisha is one of the poorest states in India, with a **high prevalence of poverty** and a **great climate vulnerability** with frequent impacts of floods and droughts (World Bank, 2008). This delta is **highly populated** with a population of 3.88 million people (Ericson *et al.*, 2006) and more than 70% of the total workforce is employed by the agricultural sector, thus with their **livelihoods relying on the environment** (Registrar General and Census Commissioner, 2011).

METHODS

2000 –> 2015

Surface reflectance
MOD09A1

Spatial resolution: 250m
Temporal resolution: 8 days

2000 –> 2012

Land Cover
MCD12Q1

Spatial resolution: 500m
Temporal resolution: Yearly

Crop mask

Quality check
Cleaning and smoothing

2000 –> 2015

WDRVI
α = 0.2

$$\mathrm{WDRVI} = \frac{\alpha.\rho_{NIR} - \rho_{RED}}{\alpha.\rho_{NIR} + \rho_{RED}}$$

Spatial resolution: 250m
Temporal resolution: 8 days

$$TSP = t_{[max_{\mathrm{WDRVI}}:\, max_{\mathrm{WDRVI}}+30]}$$

2000 –> 2015

$\sum_{\mathrm{TSP}}$ WDRVI

Spatial resolution: 250m
Temporal resolution: Yearly

Z-scores
Mean/Sum extraction

2000 –> 2015

$Z_{\sum_{TSP} WDRVI}$

Spatial resolution: Community
Temporal resolution: Yearly

2000 –> 2015

Temperature 2m
ECMWF

Spatial resolution: 1km
Temporal resolution: Daily

Inverse Distance
Weighting

2000 –> 2015

Temperature 2m
ECMWF

Spatial resolution: 1km
Temporal resolution: Daily

2000 –> 2015

$\sum_{\mathrm{TSP}} T_{2m}$

Spatial resolution: 1km
Temporal resolution: Yearly

Z-scores
Mean extraction

2000 –> 2015

$Z_{\sum_{TSP} T_{2m}}$

Spatial resolution: Community
Temporal resolution: Yearly

2000 –> 2015

Rainfall
CHIRPS

Spatial resolution: 1km
Temporal resolution: Daily

$$RSP = t_{[max_{\mathrm{WDRVI}}-100:\, max_{\mathrm{WDRVI}}+30]}$$

2000 –> 2015

$\sum_{\mathrm{RSP}}$ R

Spatial resolution: 1km
Temporal resolution: Yearly

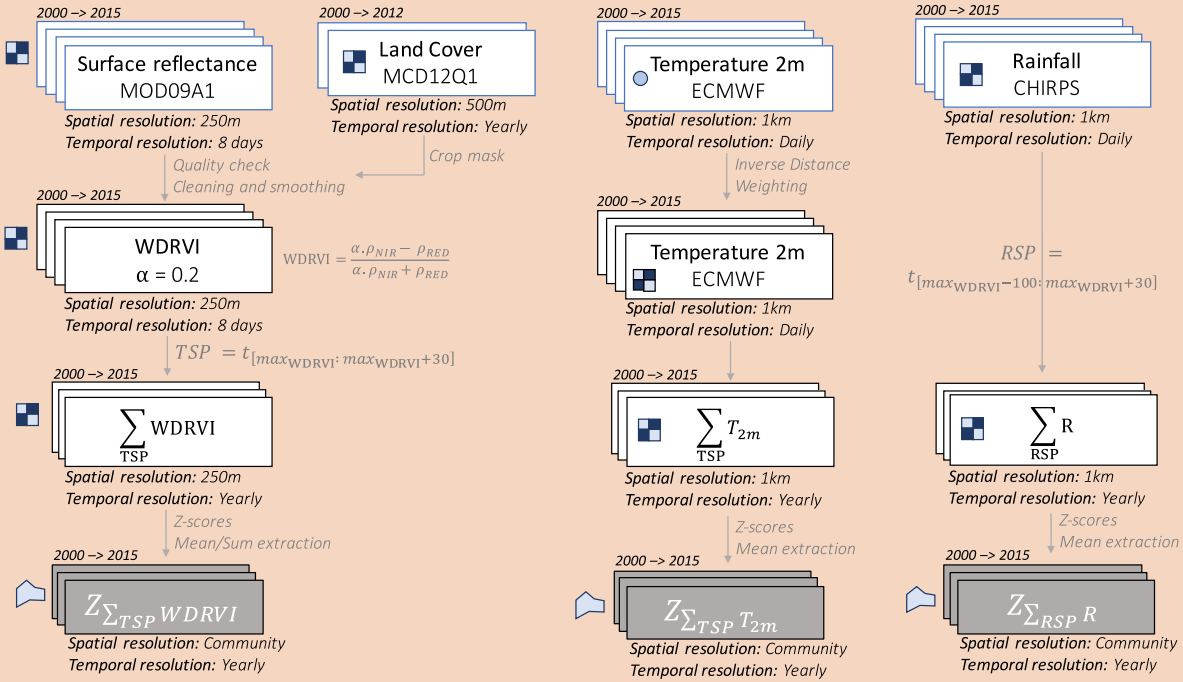
Z-scores
Mean extraction

2000 –> 2015

$Z_{\sum_{RSP} R}$

Spatial resolution: Community
Temporal resolution: Yearly

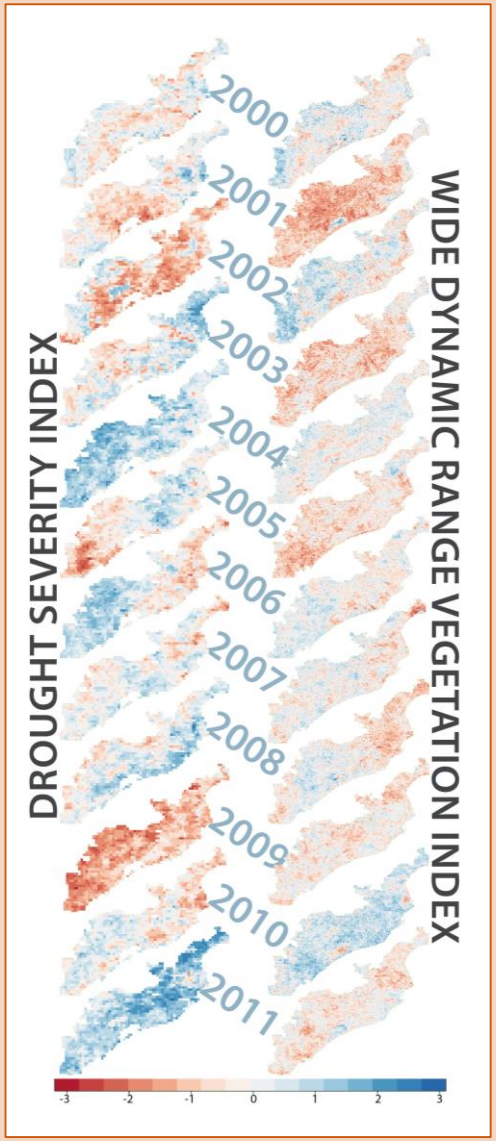
METHODS



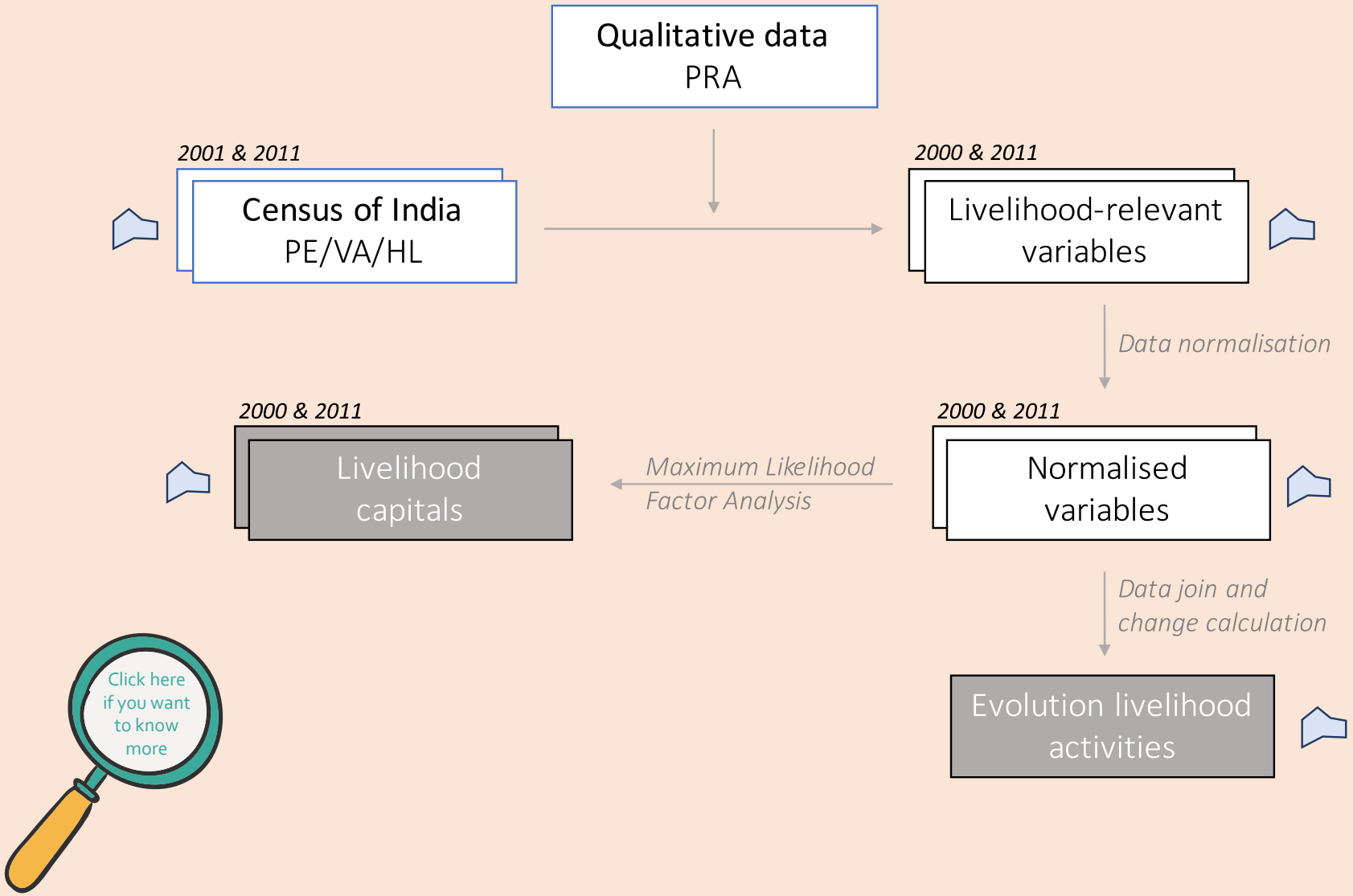
The main remote sensing data source is MODIS **surface reflectance** products. They are estimates of the surface reflectance for each one of the two following bands: band 1 (620-670 nm) and band 2 (841-876 nm).

The **Wide Dynamic Range Vegetation Index** developed by Gitelson (2004) preserves a linear relationship with the Leaf Area Index/vegetation fraction (Guindin-Garcia *et al.*, 2012). Duncan *et al.* (2015) found that the WDRVI was better than the Enhanced Vegetation Index (EVI) at estimating crop yield over the coastal plains of Odisha.

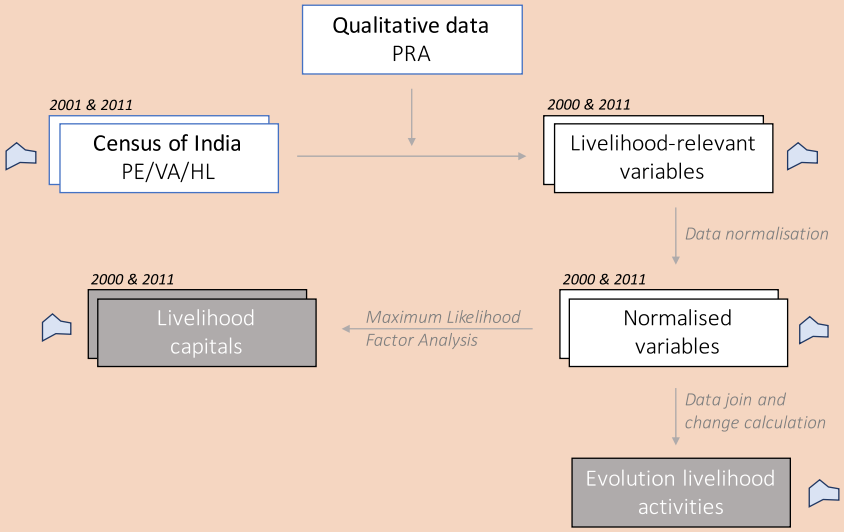
Z-scores are calculated for each pixel and for each year over the growing season. A positive z-score means that there is a greater amount of vegetation in croplands, while a negative z-score means that the agricultural production is lower than usual.



METHODS


Qualitative data
PRA
2001 & 2011
Census of India
PE/VA/HL
2000 & 2011
Livelihood-relevant variables
Data normalisation
2000 & 2011
Normalised variables
Maximum Likelihood Factor Analysis
2000 & 2011
Livelihood capitals
Data join and change calculation
Evolution livelihood activities
Click here if you want to know more

METHODS



The Census of India 2011 is the main source of high resolution data on demographic, social and economic indicators widely available in India.

Indicators were chosen based on an in-depth **participatory fieldwork** conducted in 10 communities and on a systematic review of the livelihood literature.

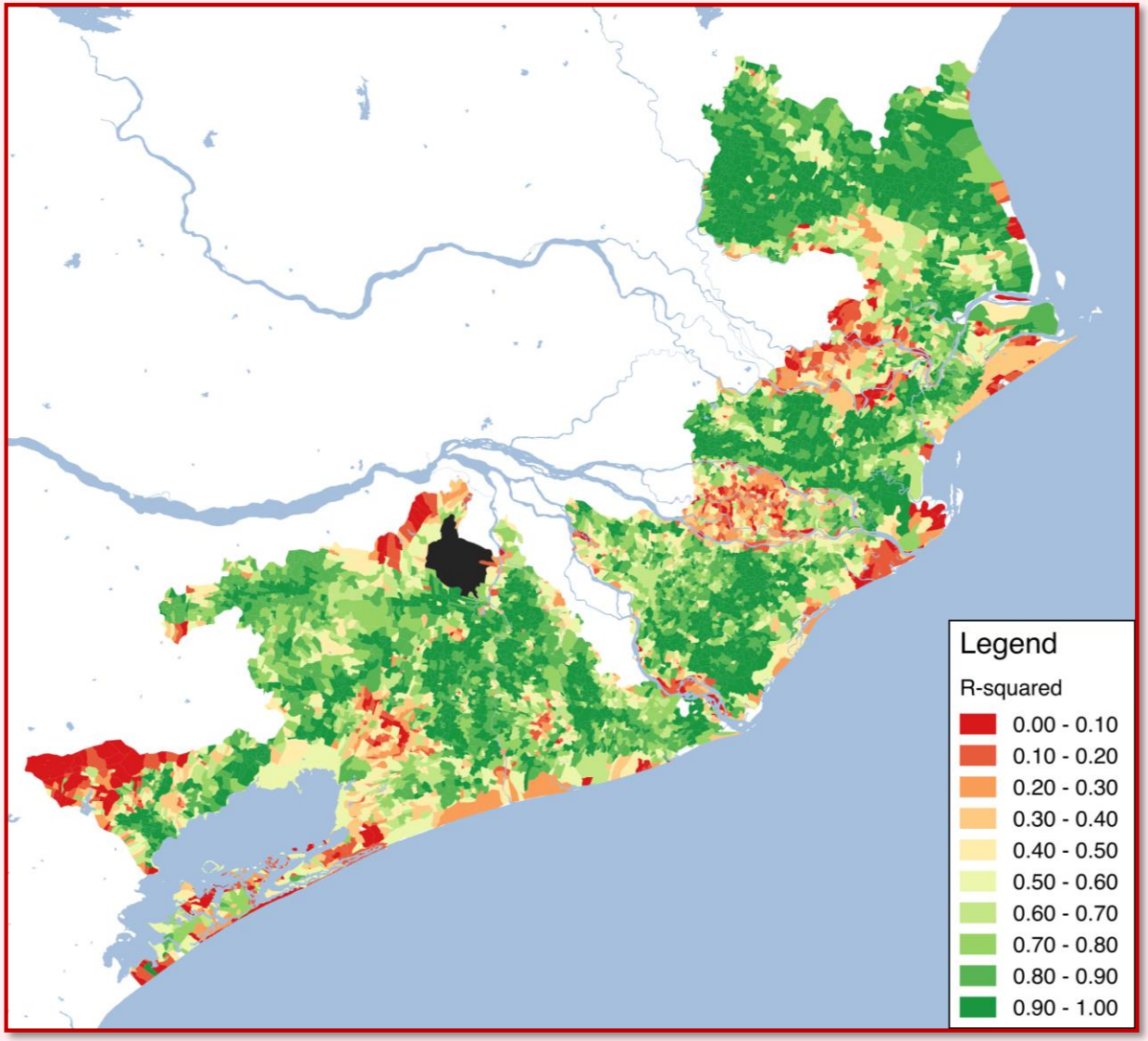
A **maximum likelihood factor analysis** was conducted to reduce the number of dimensions.
Each component extracted represents a set of variables.

Variables	Definition	Source	Type	Discrete variable coding
DEPENDENT VARIABLES				
Cultivators	*Owned or rented agricultural land and cultivated the land themselves*			
Main	Workers engaged in cultivation ≥ 6 months per year	PE	C	
Marginal	Workers engaged in cultivation [3 : 6[months per year	PE	C	
Minor	Workers engaged in cultivation [0 : 3[months per year	PE	C	
Agricultural labourers	*Engaged in agricultural work on another person's land for money, without right of lease or contract for the land*			
Main	Workers engaged in agricultural labour ≥ 6 months/y	PE	C	
Marginal	Workers engaged in agricultural labour [3 : 6[months/y	PE	C	
Minor	Workers engaged in agricultural labour [0 : 3[months/y	PE	C	
Entrepreneurs	*Any non-farm activity not registered under the Indian Factories Act*			
Main	Workers engaged in entrepreneurship ≥ 6 months/y	PE	C	
Marginal	Workers engaged in entrepreneurship [3 : 6[months/y	PE	C	
Minor	Workers engaged in entrepreneurship [0 : 3[months/y	PE	C	
Others	*Engaged in an economic activity but not classed as one of the three previous categories*			
Main	Workers engaged in any other activity ≥ 6 months/y	PE	C	
Marginal	Workers engaged in any other activity [3 : 6[months/y	PE	C	
Minor	Workers engaged in any other activity [0 : 3[months/y	PE	C	
INDEPENDENT VARIABLES				
Natural capital				
Potential cultivated area	Net area sown and fallow land per household	VA	C	
Pressure on agricultural land	Ratio of fallow land on potential cultivated land	VA	C	
Pasture and grazing	Permanent pastures and other grazing land area	VA	C	
Topography	Elevation of agricultural land	RS	C	
Soil quality	Soil fertility index	SD	C	
Forestry	Area of land under tree crops per household	VA	C	
Natural forest	Forest area per household	VA	C	
Fresh water	Distance to the closest fresh water resource	SD	C	
Rainfall	Annual average precipitation	SD	C	
Slope	Average slope	SD	C	
Physical capital				
Accessibility	Road density (weighted according to their quality)	SD	C	
Access to markets	Cost surface to closest market	SD	C	
Water	Availability of water infrastructures in the community	VA	D	
Power supply	Power supply for agriculture and commercial use	HL	D	0 if not available; 1 if available
Productive equipment	Means of transportation and agricultural equipment	HL	D	
Irrigated land	Ratio of agricultural irrigated land	VA	C	
Human capital				
Dependency ratio	Ratio of people who are working over dependent people	PE	C	
Male adults	Average number of men per household	PE	C	
Female literacy	Ratio of women ≥ 7 years old who could read and write	PE	C	
Access to education	Distance to the closest education facilities	VA	D	0 if within the premises; 1 if ≤ 5km; 2 if]5 : 10]km; 3 if ≥ 10km
Proximity to health facilities	Distance to the closest health facilities	VA	D	0 if within the premises; 1 if ≤ 5km; 2 if]5 : 10]km; 3 if ≥ 10km
Sanitation	Availability and distance to sanitation facilities	VA	D	0 if within the premises; 1 if ≤ 5km; 2 if]5 : 10]km; 3 if ≥ 10km
Drinking water	Number of water infrastructures per person	VA	C	
Financial capital				
Banking facilities	Distance to financial facilities	VA	D	0 if within the premises; 1 if ≤ 5km; 2 if]5 : 10]km; 3 if ≥ 10km
Financial services	Ratio of households with access to financial services	HL	C	
Protective assets	Ownership of electronics (TVs, radios, phones)	HL	C	
Social capital				
Castes	Ratio of SC and ST (% of total population)	PE	C	
Social groups	Availability and number of social groups per household	VA	C	
Communication	Availability of communication infrastructures	VA	D	
Population density	Ratio of population per unit area	PE	C	
Recreational facilities	Availability and distance to recreational facilities	VA	D	0 if within the premises; 1 if ≤ 5km; 2 if]5 : 10]km; 3 if ≥ 10km

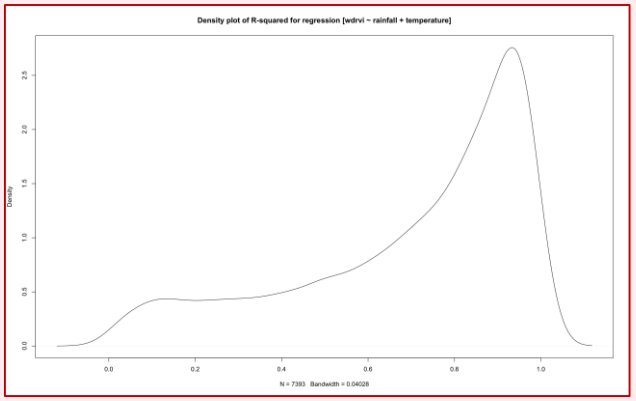
Data source: [PE] Census population enumeration data; [VA] Census community amenities data; [HL] Census house listing data; [SD] Other spatial data; [RS] Satellite remotely sensed data
Data type: [C] Continuous; [D] Discrete

RESULTS

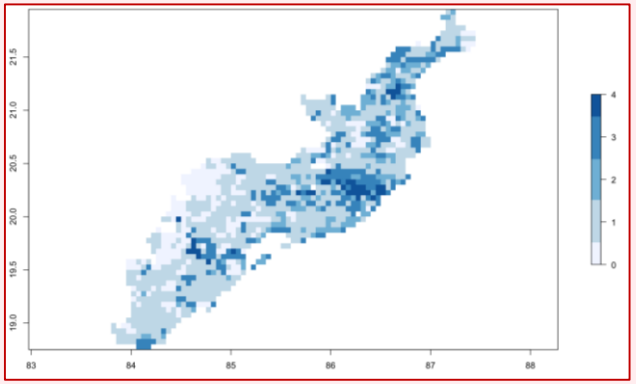
Correlation map of the regression between WDRVI standardised anomalies and standardised anomalies of rainfall and temperature



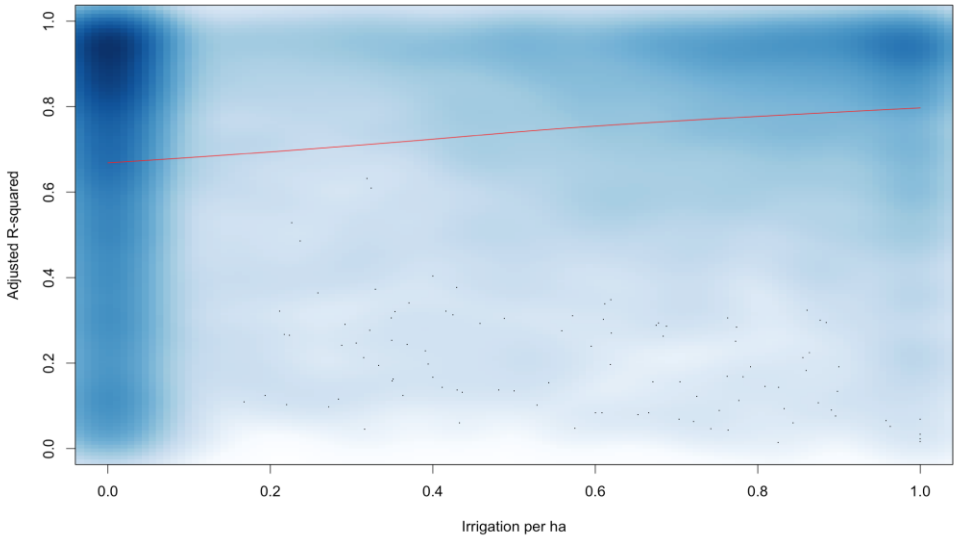
Density plot of R-squared for the regression [WDRVI ~ rainfall + temperature]

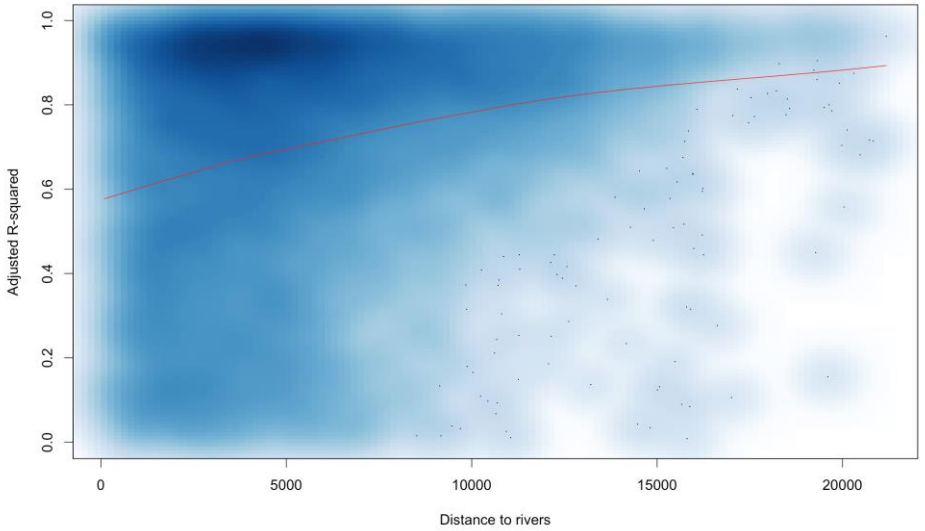


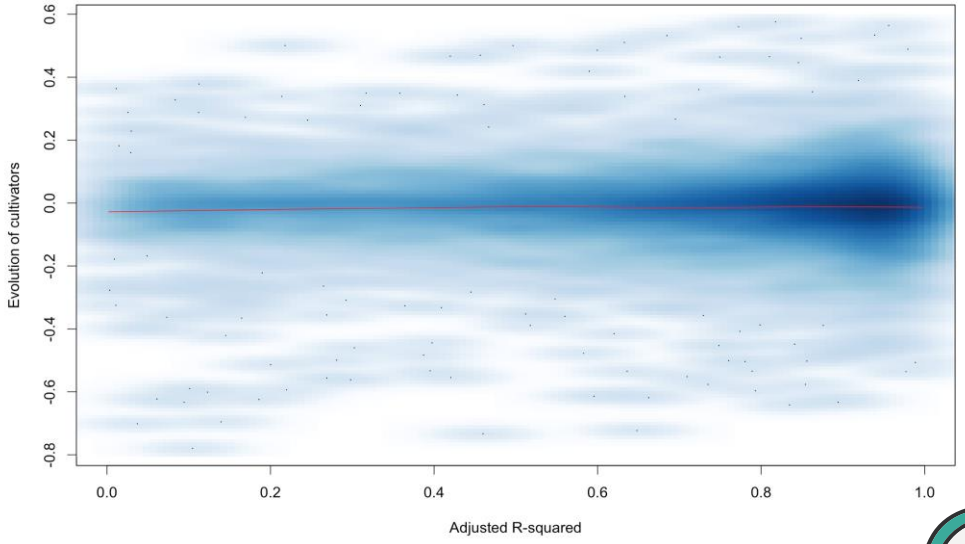
Unpredictability (low R-squared) is aggregated in clusters and seems associated with the **proximity to rivers** and to a **large forest area**. Results been checked upon agricultural shocks (negative breaks in time series representing floods – below) and unpredictability seems related to **flood-prone areas**.

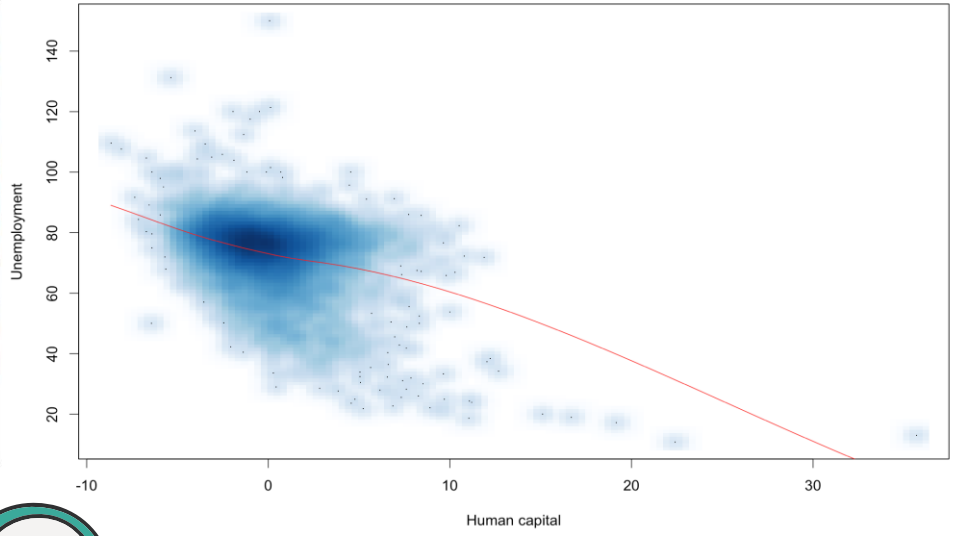


RESULTS



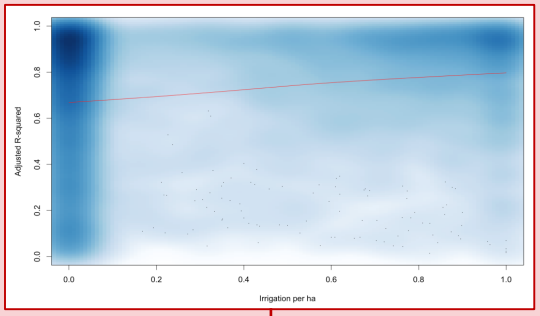




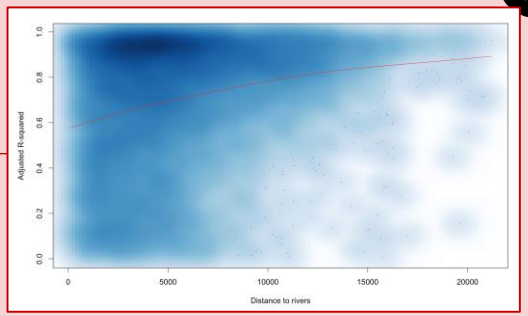


Click here if you want to know more

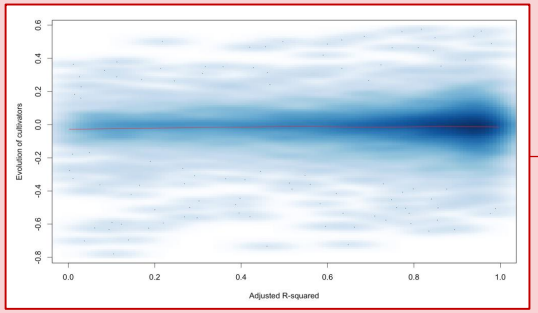
RESULTS



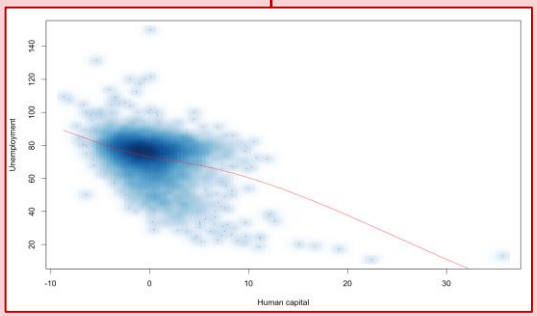
The greater the area of cultivated land is irrigated, the more predictable its agricultural production is



Proximity to rivers leads to a greater unpredictability of agricultural production



Communities with a high predictability of their agricultural production have seen an increase (or stabilisation) of their proportion of cultivators between 2001 and 2011



Unemployment is correlated with communities with low human capital

SDG

Unpredictability increases with

Proximity to rivers

Absence of irrigation systems

Unpredictability associated with

Increase in unemployment

Farm exit

Scientific implications

Interdisciplinary frameworks to characterise the impacts of climate change

Climate change research to integrate social sciences

Weather insurance to control for socio-economical variables

Migration and Employment policies

Need to control for unpredictability

Use of livelihood framework for creation of assets

Farm exit and NRLM

Support diversification to reduce vulnerability

Income-generating activities through social capital

Support to rural services

Further irrigation

Access to markets

ABOUT

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D E C C M A

DELTAS, VULNERABILITY AND CLIMATE CHANGE: MIGRATION AND ADAPTATION

DECCMA's aims are to evaluate the effectiveness of adaptation options -including migration- in deltas in Africa and Asia, and to deliver policy support for sustainable, gender-sensitive adaptation. The project analyses the impacts of climate change and processes of migration across contrasting deltas using survey, participatory research and economic methods. Study sites include the Ganges-Brahmaputra-Meghna delta in Bangladesh and India, Mahanadi delta in India and Volta delta in Ghana. **www.deccma.com**

This work was carried out under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), with financial support from the UK Government's Department for International Development (DFiD), the International Development Research Centre (IDRC) (Canada) and the UK Economic and Social Research Council [grant number 1501613]. The views expressed in this work are those of the creators and do not necessarily represent those of DFiD, IDRC and ESRC or its Board of Governors. Data used in this research come from the Census of India provided by the Office of the Registrar General & Census Commissioner of India.

CARIAA Collaborative Adaptation Research Initiative in Africa and Asia | IDRC | CRDI Canada | UKaid from the British people | E·S·R·C Economic & Social Research Council