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Using Remote Sensing Data to Estimate the Effects of Land Reform in Developing Countries: Evidence from Zimbabwe

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Introduction and Rationale

- The reallocation of property or rights for the benefits of previously disadvantaged groups Adams (1995) and Zarin and Bujang (1994)
- 3 Motivations (Albertus et al.,2012, Warriner, 1964; Barraclough, 1999; Cotula et al, 2006)
- Strong political character
- Intricate relationship between poverty and landless; e.g PRSPs (Cotula et al., 2006)
- Land question is still alive
- Characterise political debate e.g. Namibia, RSA
- Strong relationship between food security and land

Study Contribution

- There is consensus on definition, not on (Tarisayi, 2013):
  1. What is the best approach?
  - To expropriate or stop preferential treatment in marketing and financing??
- Study setting is Zimbabwe because:

❖ It is the most relevant 21st Century case study

❖ Is the most progressive and expansive on African continent

❖ Previous studies small scale and qualitative

❖ We employ novel datasets

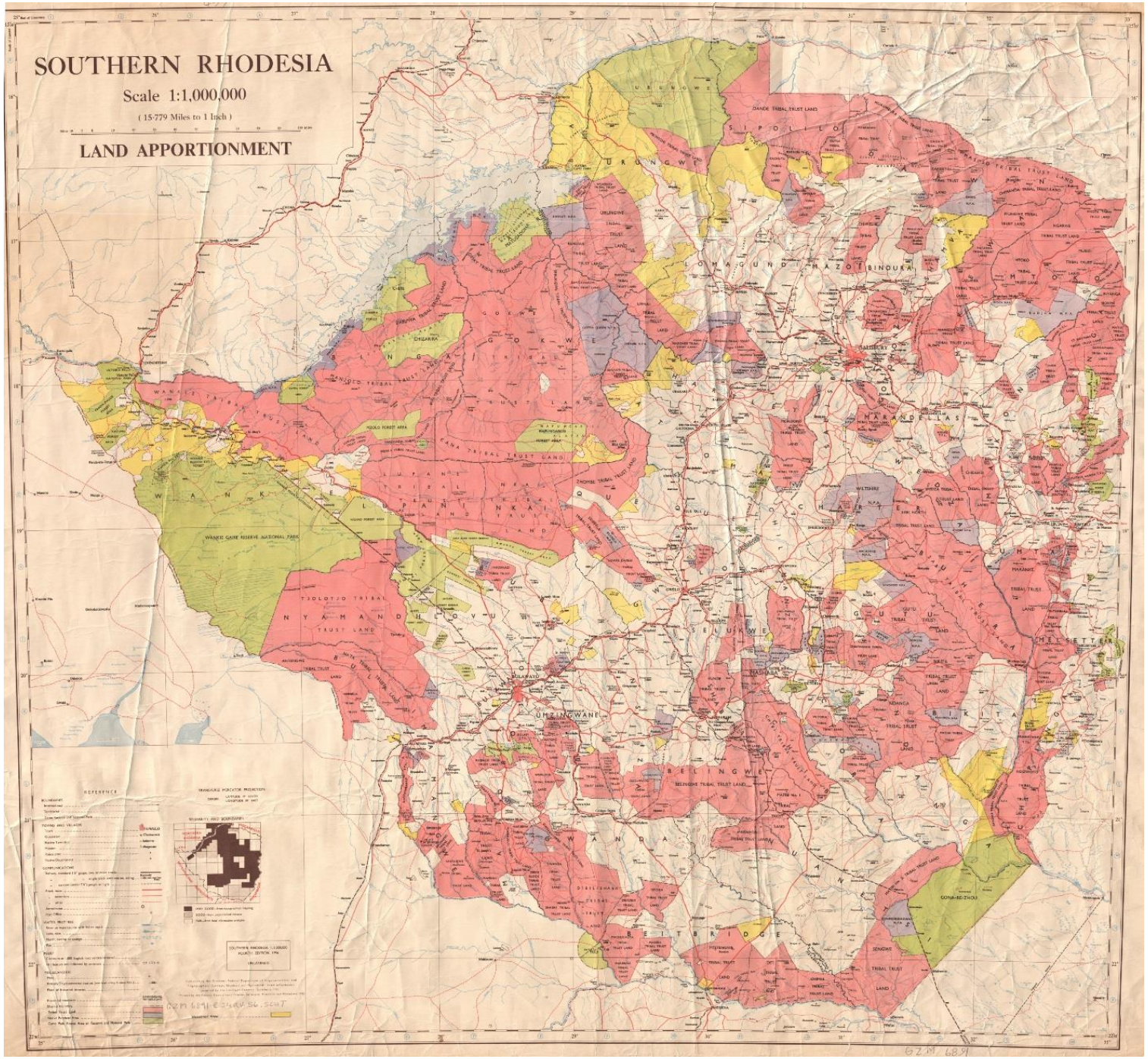
❖ Other countries can learn from Zimbabwe

The Most Progressive Agrarian Reform…

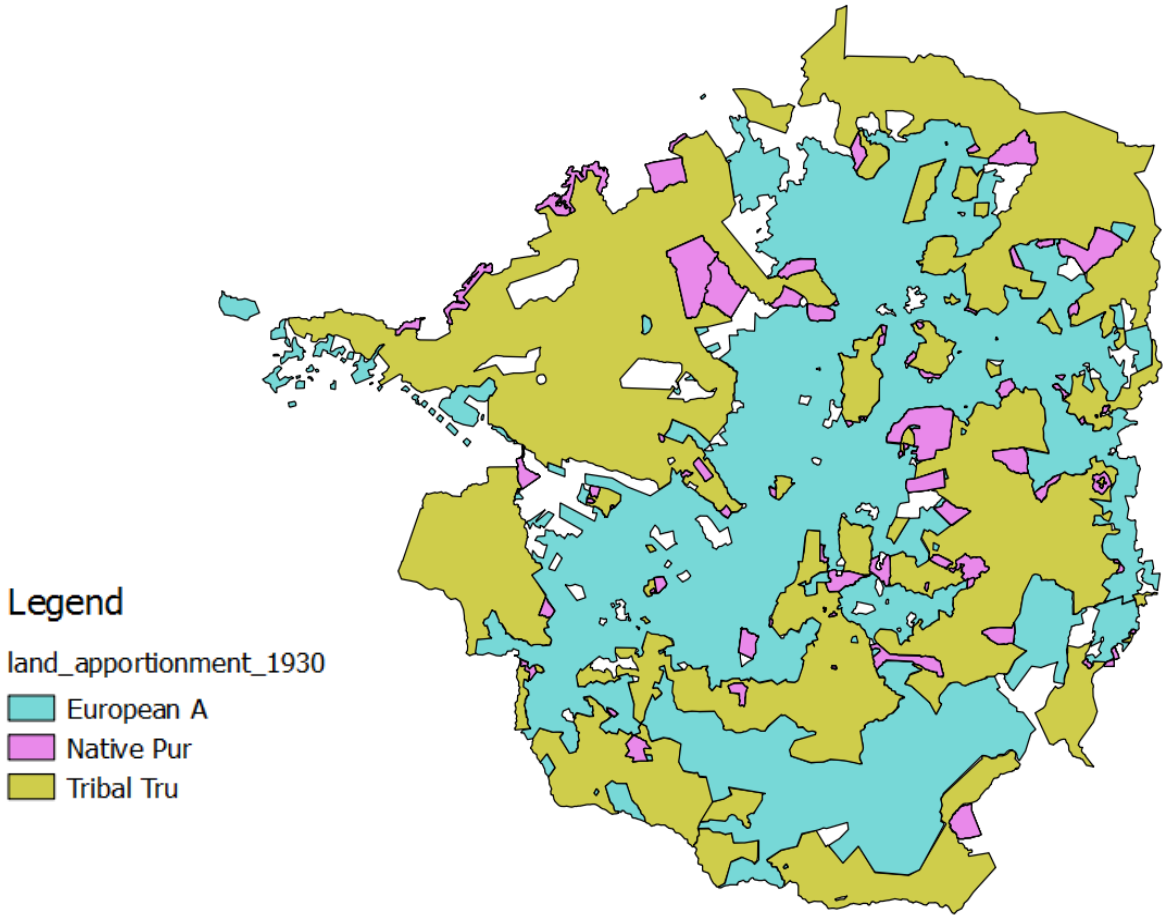
Land Category	1980	2000	2010
	Area (million ha)	Area (million ha)	Area (million ha)
Communal Areas	16.4	16.4	16.4
Old Settlement	0.0	3.5	3.5
New resettlement: A1	0.0	0.0	4.1
New resettlement: A2	0.0	0.0	3.5
Small-scale commercial farms	1.4	1.4	1.4
Large-scale commercial farms	15.5	11.7	3.4
State farms	0.5	0.7	0.7
Urban land	0.2	0.3	0.3
National parks and forest land	5.1	5.1	5.1
Unallocated land	0.0	0.0	0.7

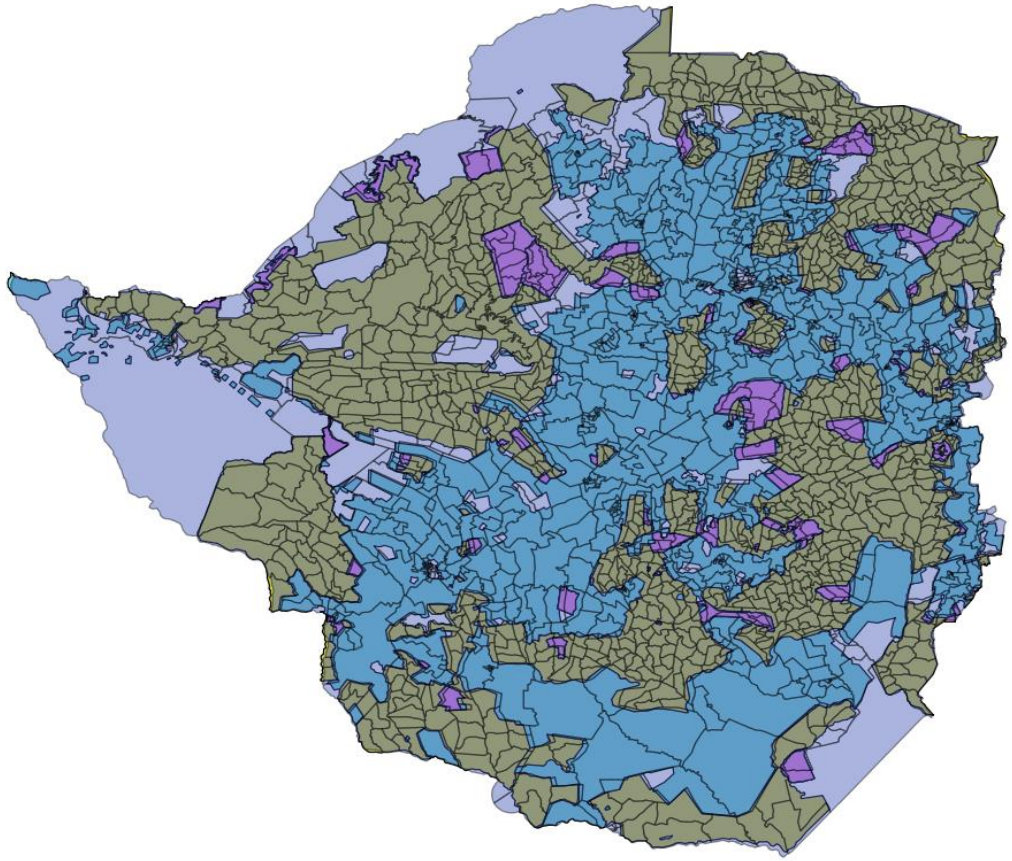
Source: (Scoones et al., 2011)

The Land Apportionment Act (1930)



Crux of the Study – Diff in Diff Analysis





Selected Empirical Findings

- **Improved Livelihoods** - Mandizadza, 2010; Mbereko, 2010; Moyo, 2010
- **Promoted Entrepreneurial** dynamism amongst the less priviledged – Scoones et al., 2011
- **Livelihoods badly affected** – people resorting to cutting wood (Mandizadza, 2010; Mbereko, 2010; Moyo, 2010)
- **Migration** - 18% of beneficiaries urbanites (Scoones et al., 2011).

- "Return to the country-side" (Moyo et al., 2013)

- **NB:** Majority of studies have been limited to small geographical areas

Data and Contribution

1. We investigate the effects of FTLRP for the whole country (Phimister Observation)
2. We use Remote Sensing or “unconventional datasets” from the perspective of FTLRP
    i) Night Lights Data (freely downlodable from https://www.ngdc.noaa.gov/eog/dmsp/downloadV4composites.html)
    ii) Landsat Imagery (freely downloadable at https://earthexplorer.usgs.gov/)
    iii) Normalised Difference Vegetation Index (freely downloadable at https://earthexplorer.usgs.gov/)
    iv) Census District Level Data (available from Zimstat)
3. We use a more robust identification approach

Findings – NLD Regression Results

	Raw Lights		
Dep. var lights ratio	1	2	3
Treatment	0.139	1.408***	0.159
	-0.106	(0.346)	-0.379
Post	-0.073	0.072	-0.306
	-0.109	-0.475	-0.503
treat#post	-0.158	-0.357	0.027
	-0.15	-0.488	-0.519
Ward Population	-1.125**	0*	-1.239
	(0.483)	(0.000)	-0.812
Average Calories	0	0.014	0
	0	-0.017	0
Ave. Temperature	0.018	0	0.014
	-0.011	-0.001	-0.018
Total Precipitation	0	0.125***	0
	0	(0.027)	-0.001
Imports Value	0.128***	0.103***	0.127***
	(0.016)	(0.017)	(0.029)
Exports Value	0.138***	0*	0.107***
	(0.010)	(0.000)	(0.018)
Constant	1.553	0.927	1.442
R-squared N	0.028 18499	0.021 9335	0.019 8772
p-value	0	0	0
Treatment	EAs	EAs	EAs Else
Control	TTLs	NPAs	EAs EH

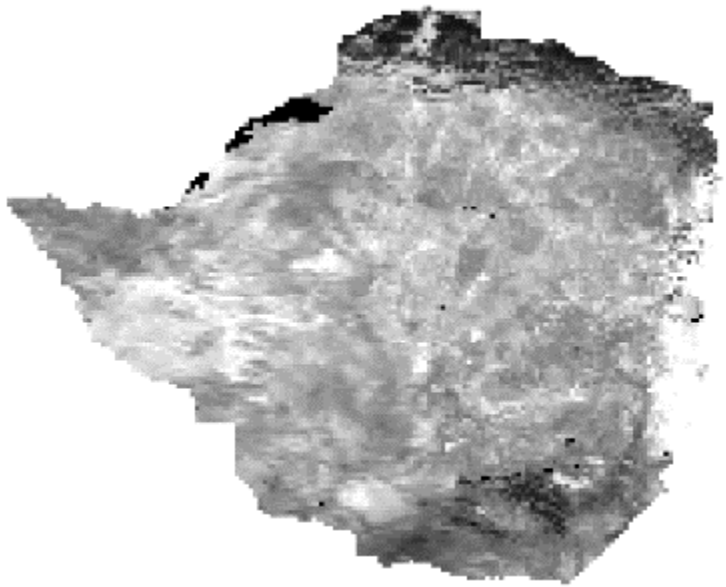
NOTES: * p<0.1, ** p<0.05, *** p<0.01.

Observation…

- In developing countries Nights Lights Data (NLD) is not viable in studying phenomenon that take place in rural areas

Night Lights

NDVI

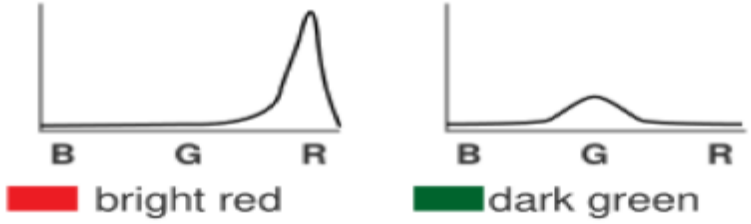


Landsat and NDVI

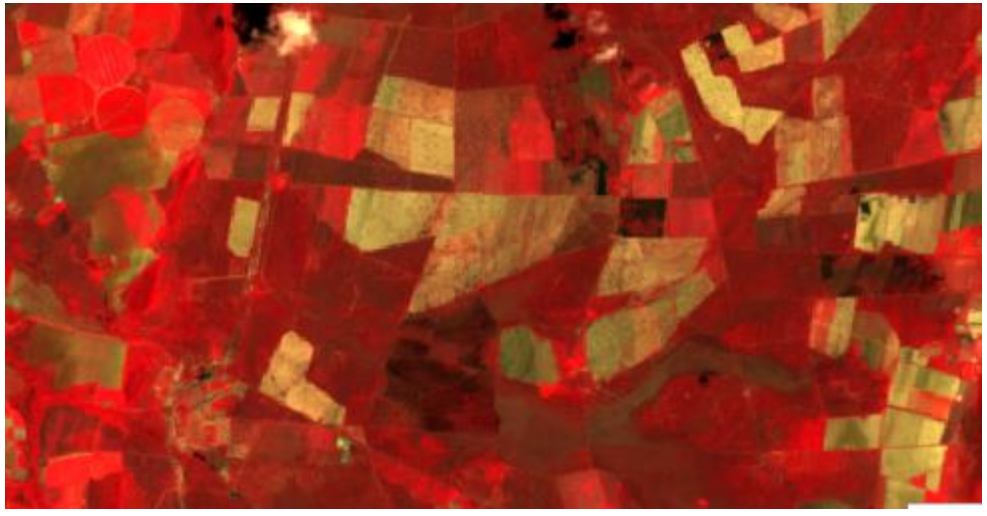
- These hold more promise than NLD for rural areas
- However, Less user friendly than NLD
- Need for Classification

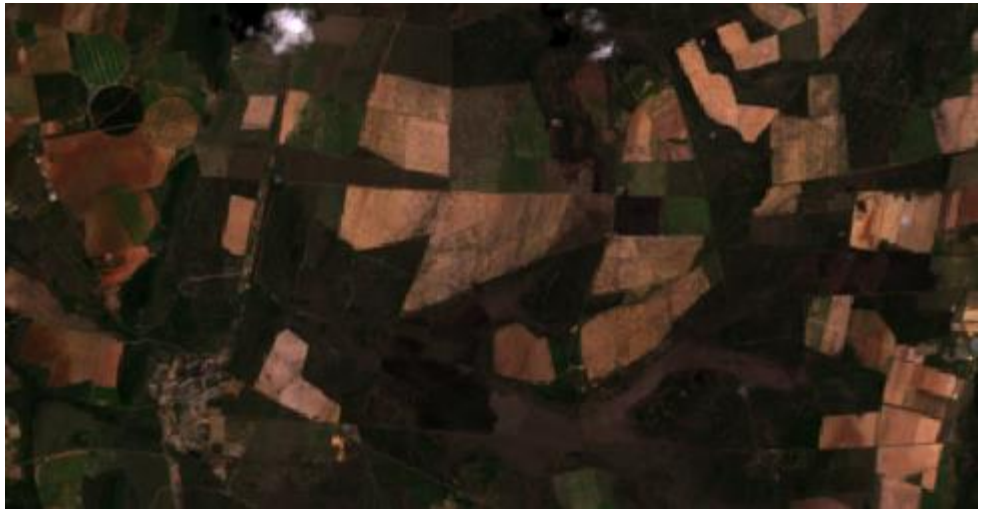
A brief on Classification

- Different spectral signatures for different bands allow classification (Eastman, 2003; Fernandes, 2015)



- For vegetation classification the best bands are 2-5 (Fernandes, 2015)

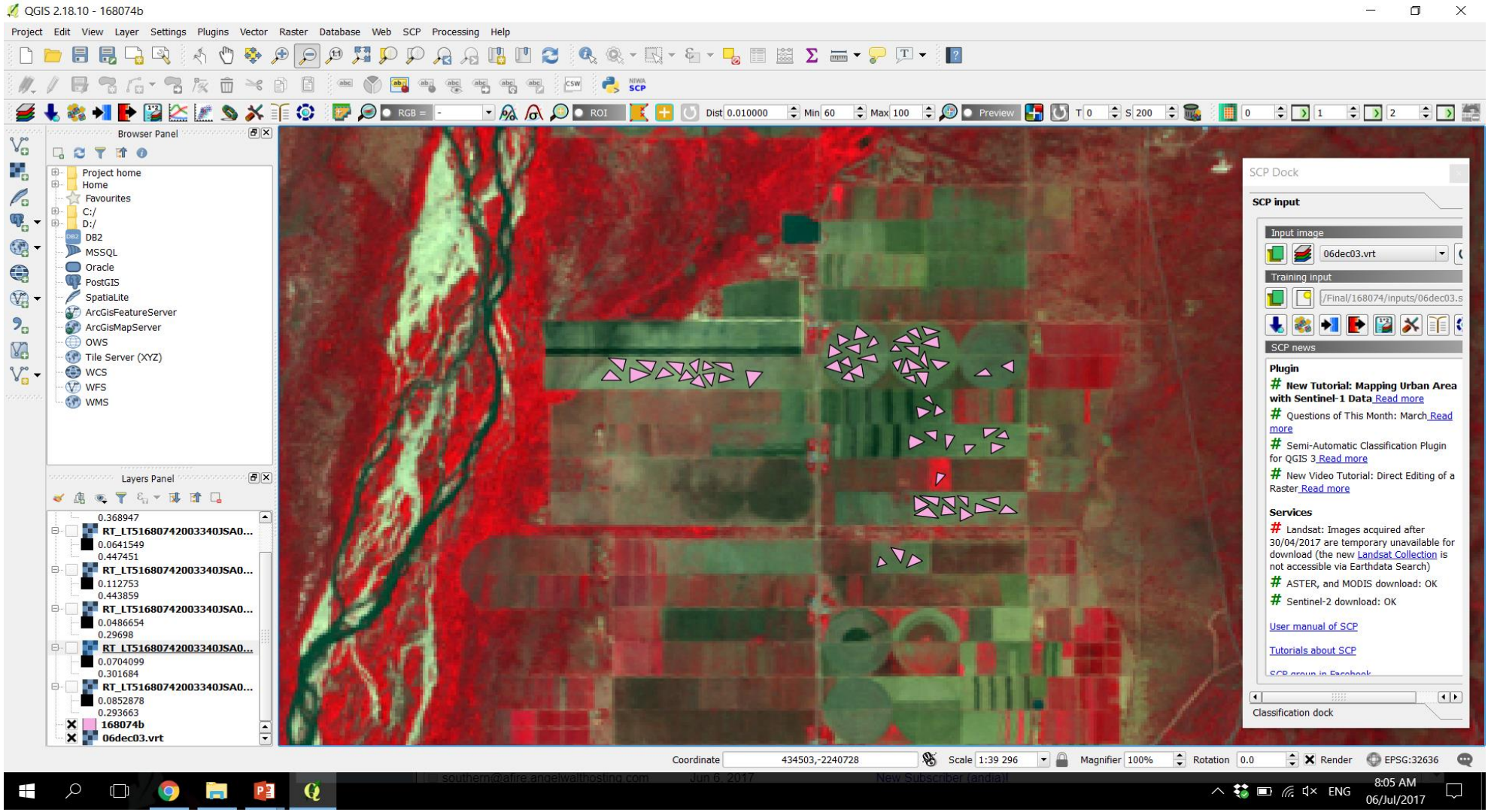




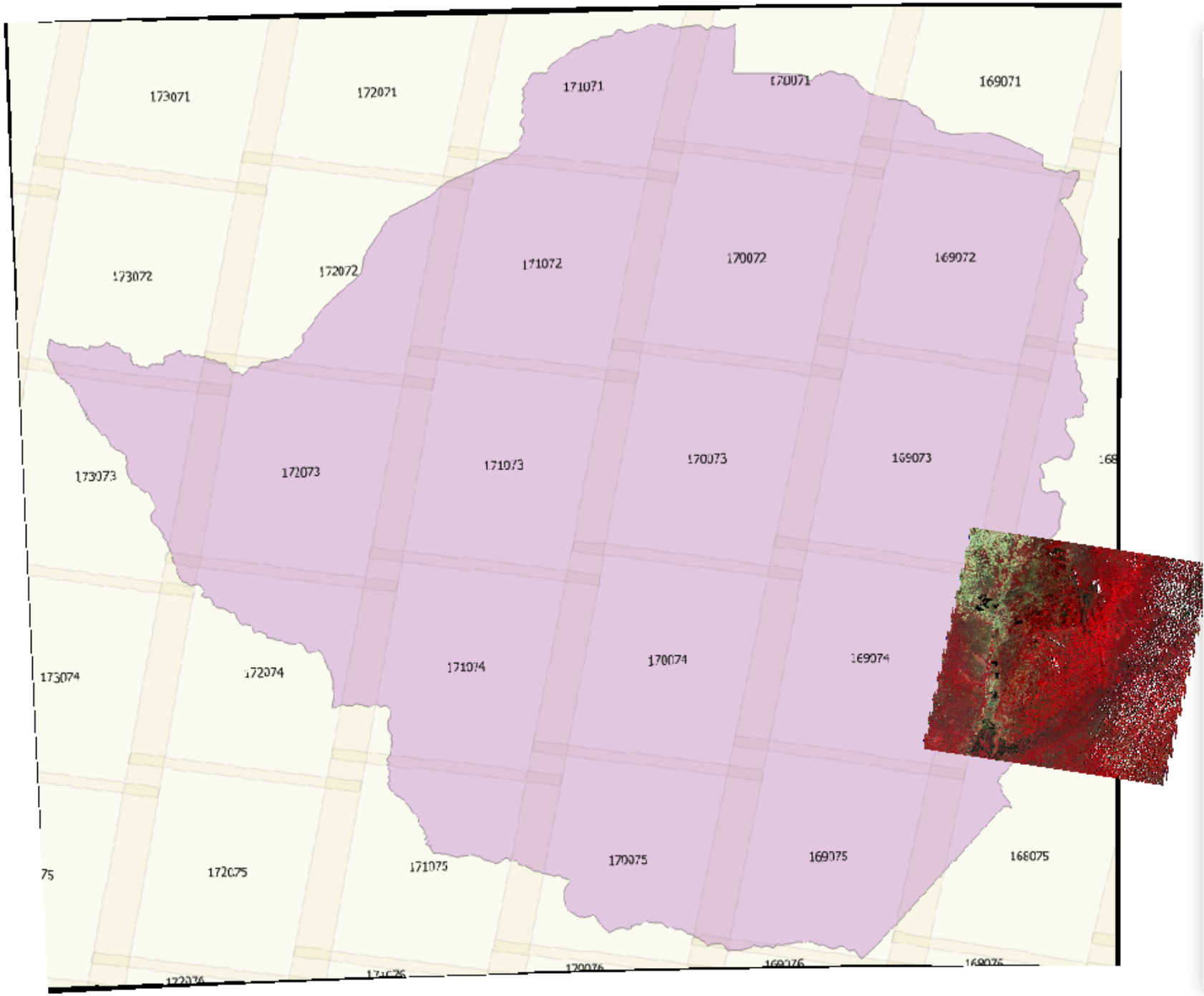
A brief on Classification (cont…)

- We obtain cloud-free Landsat images from Jan, Feb, Mar, Nov and Dec for the years 1997 – 2003
- We make Top of the Atmosphere (TOA) correction in QGIS so that image comparison over time and from different satellites is possible
- We identify >20k training points for all the footprints that make up Zimbabwe using QGIS Supervised Classification Plugin (SCP)
- We then carry out classification in R using the Support Vector Machines (SVM) algorithm (Vapnik, 1995; Huang et al., 2002 & Ustuner et al., 2014)

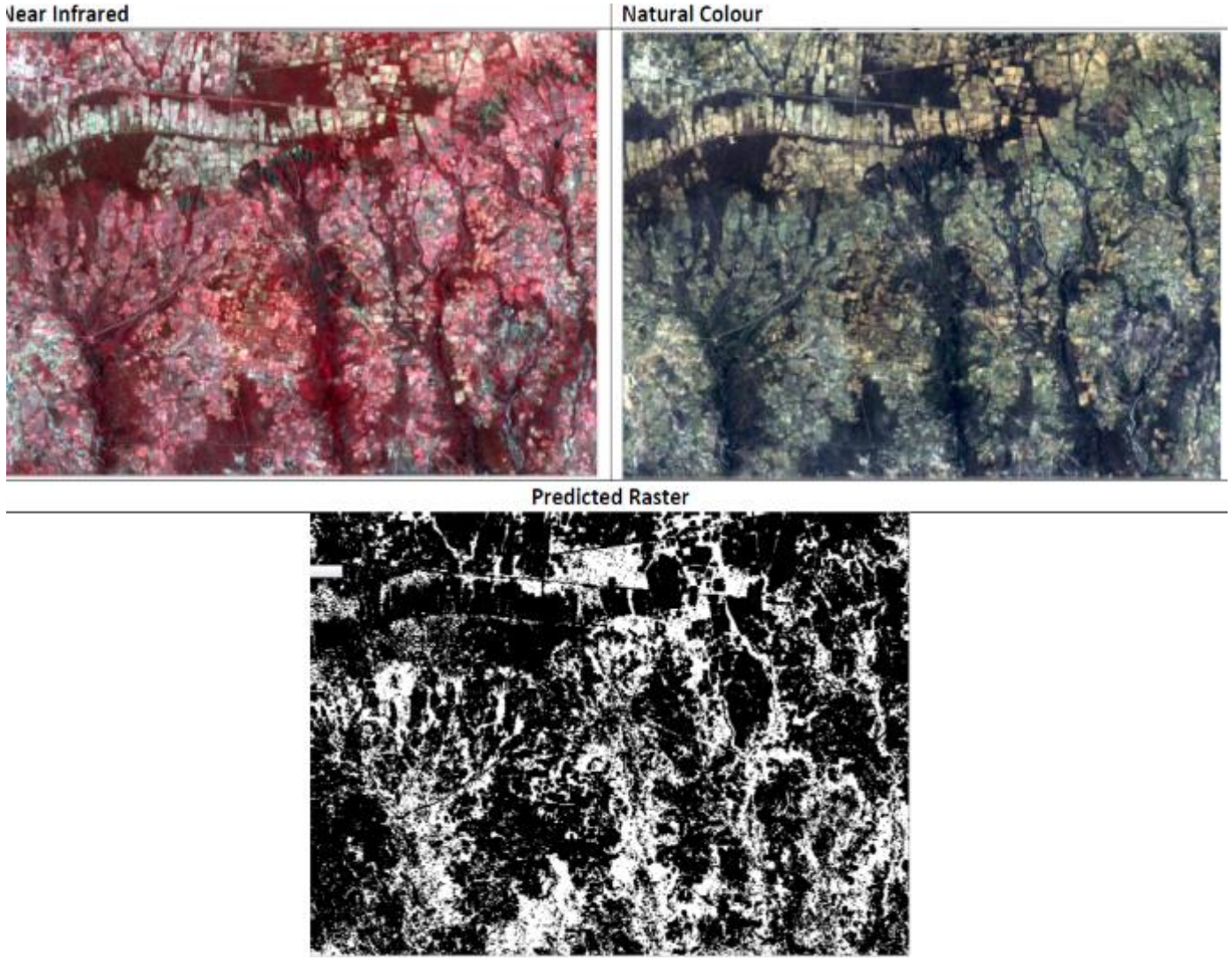
Image Training in QGIS Semi-Auto Plugin

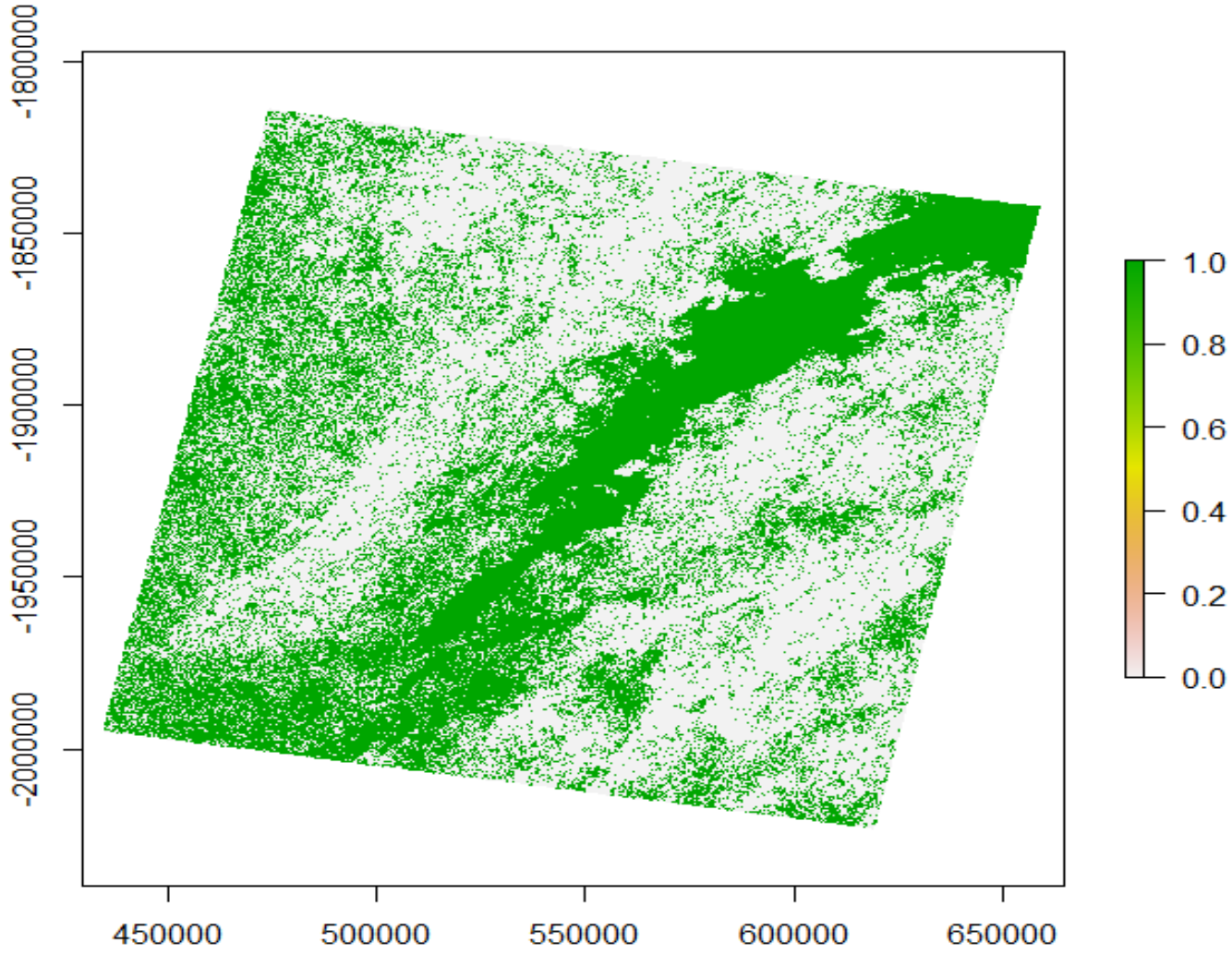


24 Footprints Every Year…



Visualising the SVM Classification




-1800000
-1850000
-1900000
-1950000
-2000000
450000
500000
550000
600000
650000
1.0
0.8
0.6
0.4
0.2
0.0

Deriving the Independent Variables

- Welfare is measured using 2 variables:
  i) Proportion of ward *sq_km* under cropland (Cropland=1, Forestland=0)
  ii) Vegetation Quality (Measured as NDVI)
- $NDVI = \frac{NIR-RED}{NIR+RED}$
- The disparity between NIR and RED frequencies increases as vegetation becomes denser Ahmad et al. (2010)
- To adjust for the natural forest captured in the NOAA Climate Data Record (CDR) NDVI, we multiply it by the Proportion of ward *sq_km* under cropland

Findings – Ward Crop Hectorage exc. Urban Areas

	DID1TT	DID2TT	DID3TT	DID4TT	DID5TT
	b/se	b/se	b/se	b/se	b/se
1.treatTT#1.post	-0.341	-0.34	-0.354	-0.345	-0.329
	(0.202)*	(0.202)*	(0.203)*	(0.203)*	(0.198)*
ward_pop	0	0	0	0	0
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
2.region	0.456	0.458	0.861	0.804	0.679
	(0.142)***	(0.142)***	-0.733	-0.736	-0.717
3.region	0.252	0.203	0.18	0.16	0.272
	-0.172	-0.175	-0.178	-0.179	-0.175
4.region	0.255	0.193	0.166	0.14	0.219
	-0.205	-0.209	-0.214	-0.215	-0.21
5.region	0.069	0.013	-0.008	-0.022	0.1
	-0.279	-0.282	-0.285	-0.285	-0.278
AverageCal		0	0	0	0
		0	0	0	(0.000)**
imvalue			0	0	0
			0	0	0
exvalue			0	0	0
			0	0	0
Average_Temp				0.029	0.018
				-0.019	-0.018
Total_Precip				0	0
				0	0
lights_ratio					0.086
					(0.008)***
Constant	-2.125	-2.692	-2.653	-2.904	-3.327
	(0.184)***	(0.415)***	(0.421)***	(0.482)***	(0.470)***
R-squared	0.021	0.022	0.023	0.024	0.075
N	2212	2212	2212	2212	2212
p-value	0	0	0	0	0

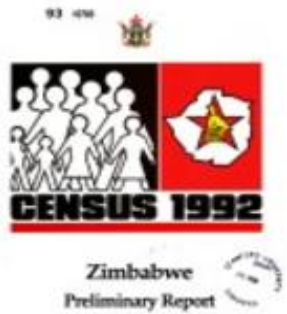
NOTES:
* p<0.1, ** p<0.05, *** p<0.01.

Findings – Ward NDVI exc. Urban Areas

	DID1TT	DID2TT	DID3TT	DID4TT	DID5TT
	b/se	b/se	b/se	b/se	b/se
1.treatTT#1.post	-0.507	-0.507	-0.494	-0.478	-0.463
	(0.264)*	(0.264)*	(0.264)*	(0.264)*	(0.259)*
ward_pop	0	0	0	0	0
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)***
2.region	1.32	1.322	2.526	2.396	2.257
	(0.185)***	(0.185)***	(0.951)***	(0.955)**	(0.937)**
3.region	1.051	1.007	0.982	0.942	1.064
	(0.225)***	(0.229)***	(0.233)***	(0.234)***	(0.230)***
4.region	1.315	1.259	1.181	1.132	1.216
	(0.269)***	(0.275)***	(0.281)***	(0.282)***	(0.277)***
5.region	0.884	0.835	0.751	0.723	0.858
	(0.365)**	(0.368)**	(0.371)**	(0.372)*	(0.365)**
AverageCal		0	0	0	0
		0	0	0	(0.000)*
imvalue			0	0	0
			(0.000)**	(0.000)**	(0.000)**
exvalue			0	0	0
			0	0	0
Average_Temp				0.044	0.031
				(0.024)*	-0.024
Total_Precip				0	0
				-0.001	-0.001
lights_ratio					0.097
					(0.010)***
Constant	-2.809	-3.308	-3.205	-3.466	-3.936
	(0.241)***	(0.544)***	(0.550)***	(0.630)***	(0.620)***
R-squared	0.04	0.04	0.045	0.046	0.083
N	2188	2188	2188	2188	2188
p-value	0	0	0	0	0

NOTES:
* p<0.1, ** p<0.05, *** p<0.01.

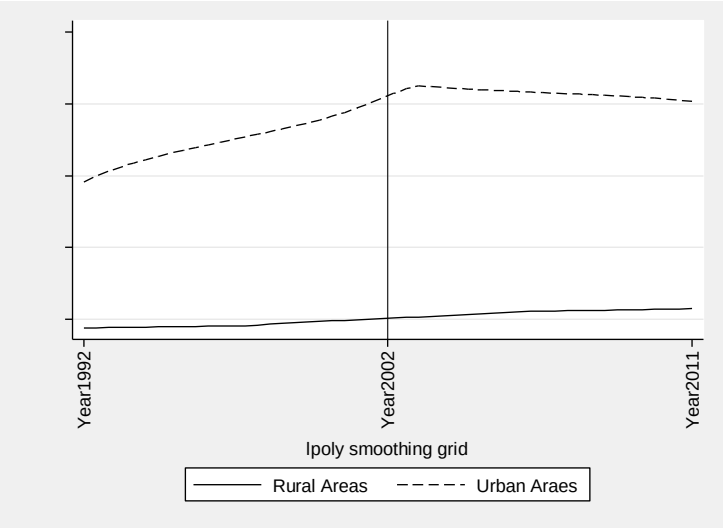
Census Data for Migration Analysis

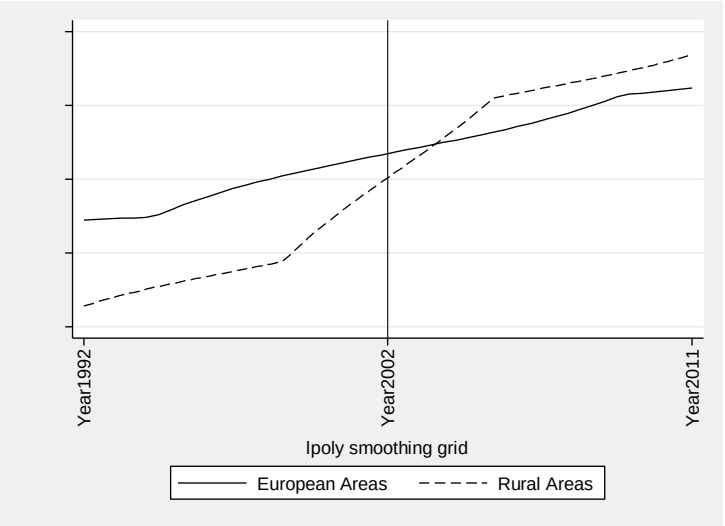


Findings – Internal Migration Patterns

	Urban-Rural Areas	Rural EAs-TTLs
	1	2
Treatment	-0.757***	-0.122***
	(0.047)	(0.030)
Post	0.086***	0.056**
	(0.026)	(0.027)
Treat##Post	0.507***	0.096***
	(0.058)	(0.036)
Constant	11.769	11.755
R-squared	0.064	0.013
N	5490	4444
p-value	0	0
Treatment	Urban Areas	Tribal Trust Lands
Control	Rural Areas	European Farms

NOTES: * p<0.1, ** p<0.05, *** p<0.01.





Preliminary Conclusions

- FTLRP had a negative Effect of welfare
- It altered intra rural patterns of migration
- NLD data is not viable in rural areas, other land cover products such as Landsat and NDVI have better explanatory power

Thank you!!

Contact: tchingozha@gmail.com