Cross-Border Infrastructure in Africa

- Introduction
- Materials, Methods
  - Methodology
  - Data
  - Variables
  - Analysis
- Results
- Discussion & Conclusion

Introduction

- USA – Canada: one border crossing every 65km

- Mozambique – Tanzania: one border crossing every 350km

Introduction

- African Borders were drawn by colonial powers, adopted by OAU in 1964
- Today, the AU aims to both demarcate and overcome borders
- Cross-Border Infrastructure (CBI) is tangible proof of good relations
- There is no large scale research on CBI available
- Why are there many CBI on some borders, and almost none on others?

Materials, Methods - Methodology

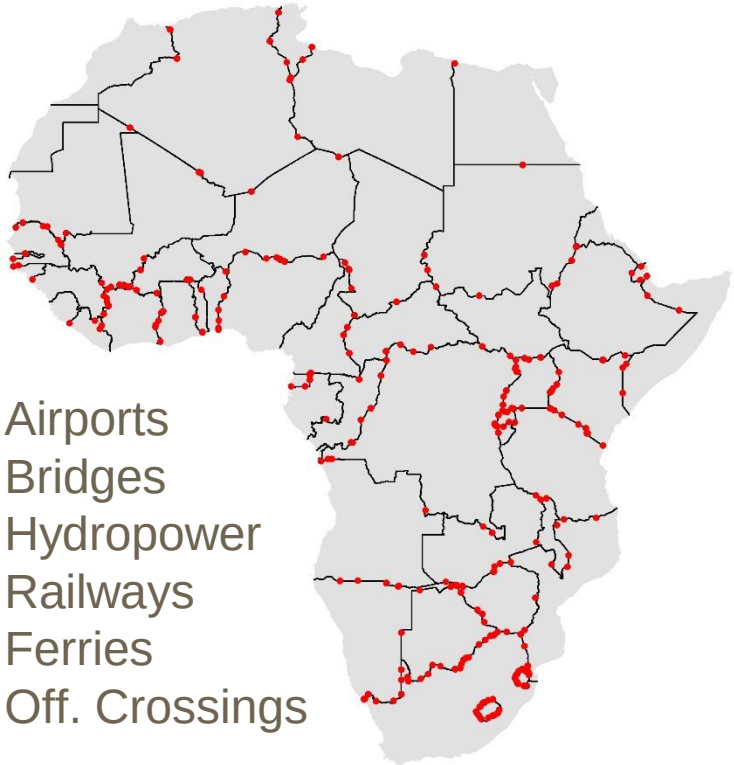
- Logistic Regression
  - Predicts the probability of an event to happen, e.g. 70% yes / 30% no
  - Event = raster cell contains CBI
  - Non-geographical analysis

- Not used: Linear Regression
  - Only if dependent variable is quantifiable, e.g. size, costs
- Not used: Geographically Weighted Regression
  - Only for spatially continuous phenomena, e.g. geologic layers

Materials, Methods - Data

- Dependent Variables:

Large CBI (298)

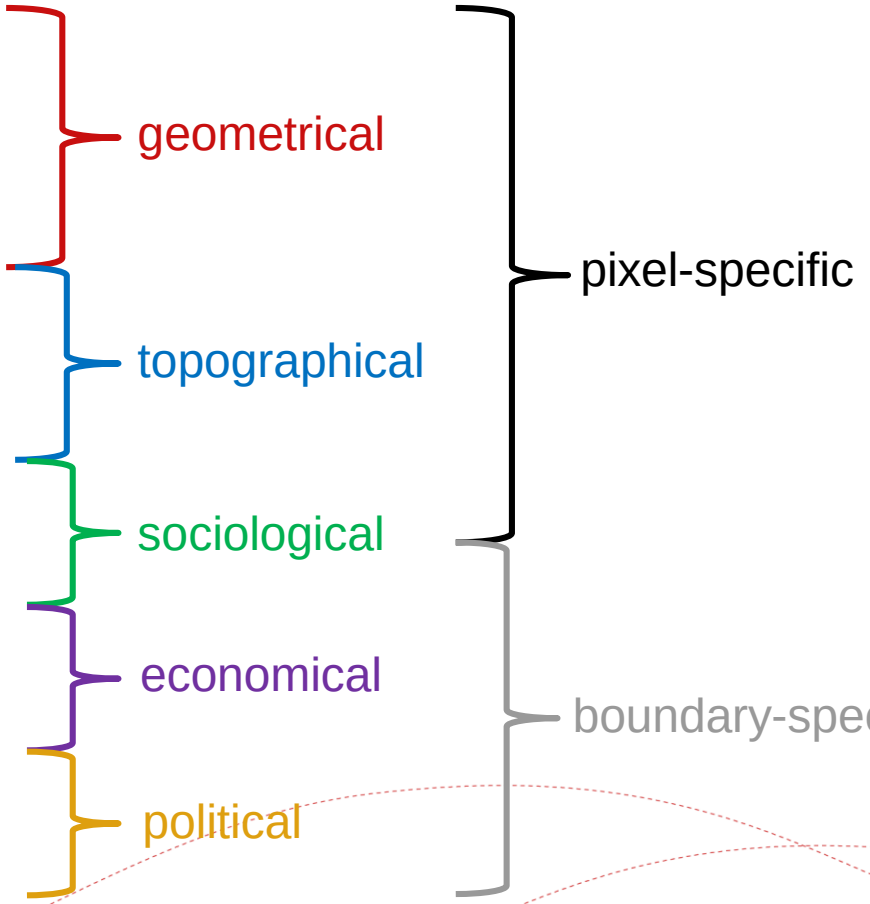


Airports
Bridges
Hydropower
Railways
Ferries
Off. Crossings

OSM roads (3328)

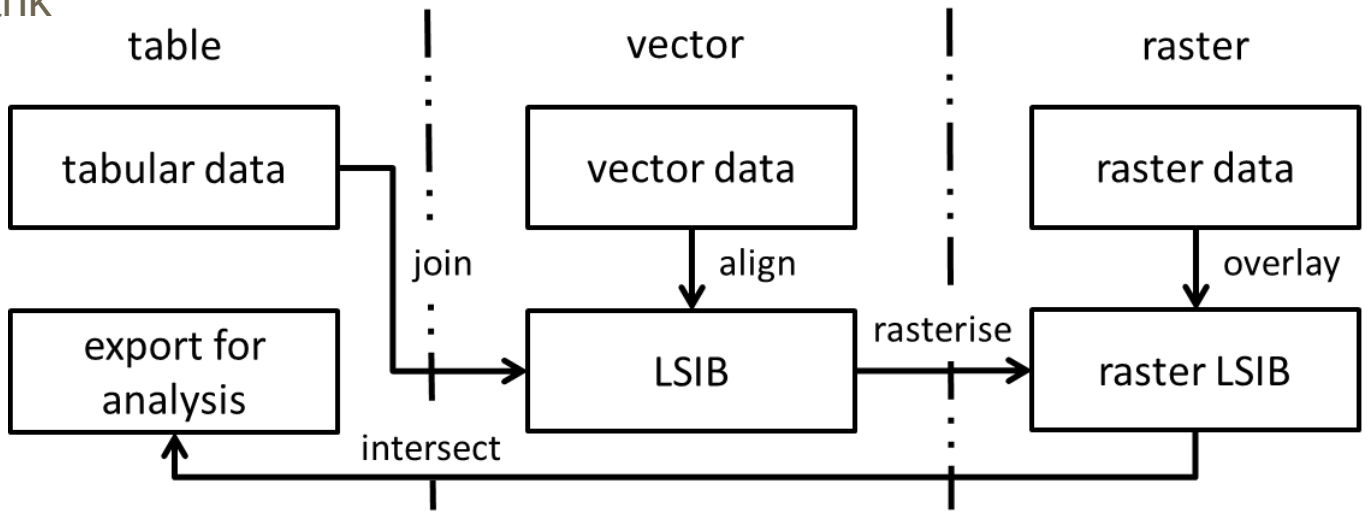
Materials, Methods - Data

- Independent Variables
  - Pixel Size
  - Border length
  - Distance from coast
  - Distance to nearest capital
  - Elevation
  - Slope
  - River size
  - Population Density
  - Fraternisation
  - GDP per Capita
  - Trade
  - Shared RECs memberships
  - Differing RECs memberships



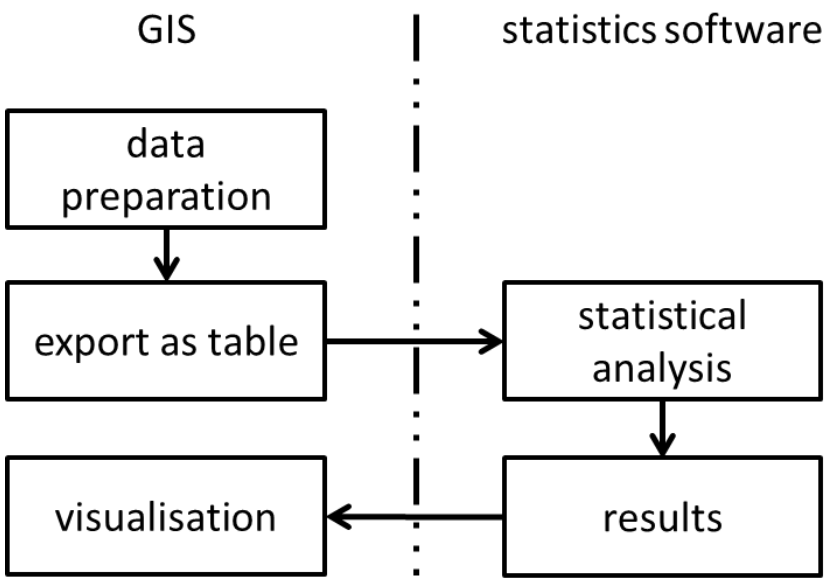
Materials, Methods - Data

- Data Sources
  - OSM
  - LSIB, US Govt
  - IOM
  - World Bank
  - FAO
  - WWF
  - VGI
  - etc.
- Data Formats
  - Table
  - Vector
  - Raster



Materials, Methods - Variables

- Reference Geometry: LSIB
- Rasterisation 15“ (ca. 460m)
- > 230‘000 raster cells
- One raster layer per variable
- 230‘000 x 2y x 13x = 3.5Mio values



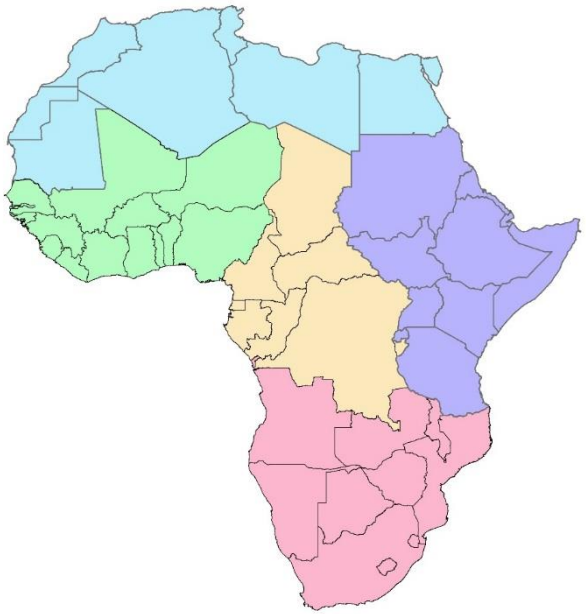
- Challenges: some data unavailable for the Sahrawi Republic (Western Sahara)
  - ➢ excluded from the analysis

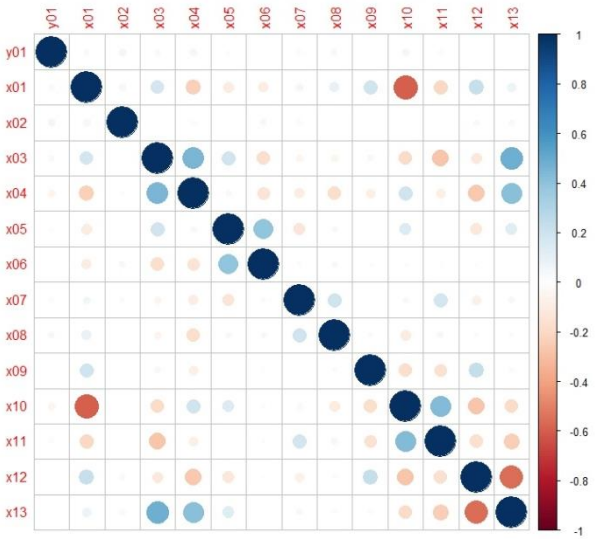
Materials, Methods - Variables

- Challenges (continued)
  - Choice of raster size: one, two or three CBI? Decision: 15“ (ca. 460m)
  - Phantom crossings. Solution: only one CBI per intersecting feature
  - Inconsistency between OSM and LSIB
  - Erronous OSM attributes
  - De jure vs. de facto boundaries
  - Other unexpected situations

Materials, Methods - Analysis

- Rule of 10
  - At least 10 events per variable
- Rare events
  - < 3% events vs. > 97% non-events
  - Under-prediction of events
- Variance Inflation Factor
  - Remove variables with VIF > 5
- Correlation
  - Analysis of high correlations between variables
- Stepwise regression
  - Forward / backward elimination of variables

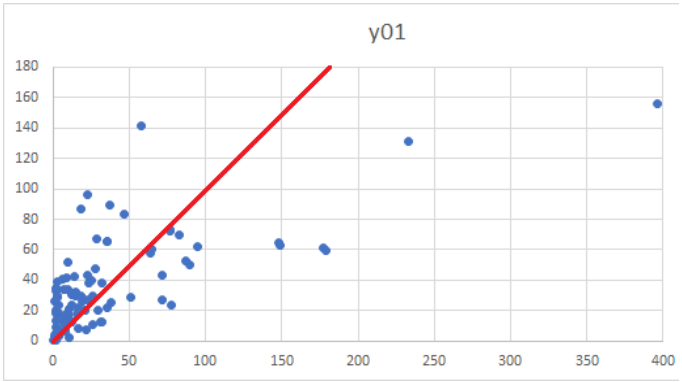


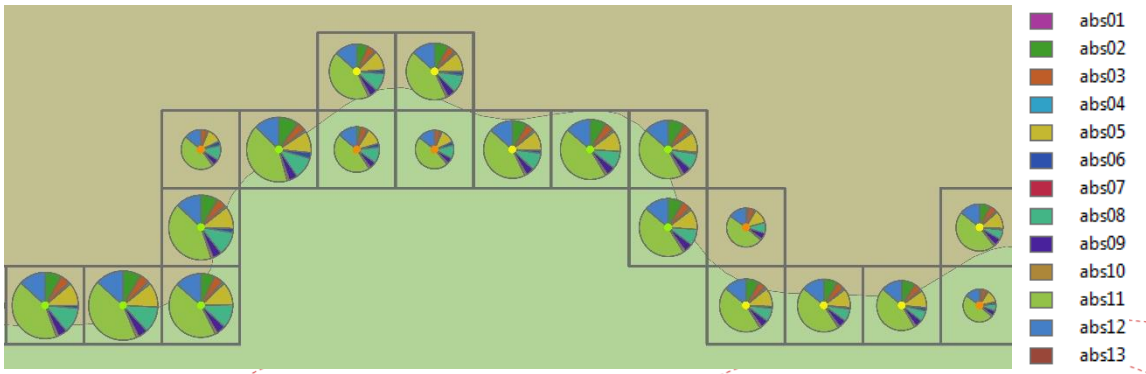


Results

- Large list of coefficients
  - Expected (green)
  - Unexpected (red)
  - Ambiguous (mixed)
- Pseudo-R2 between 5% – 21%
- Borders with more / less CBI than expected
- Impact per variable on overall probability

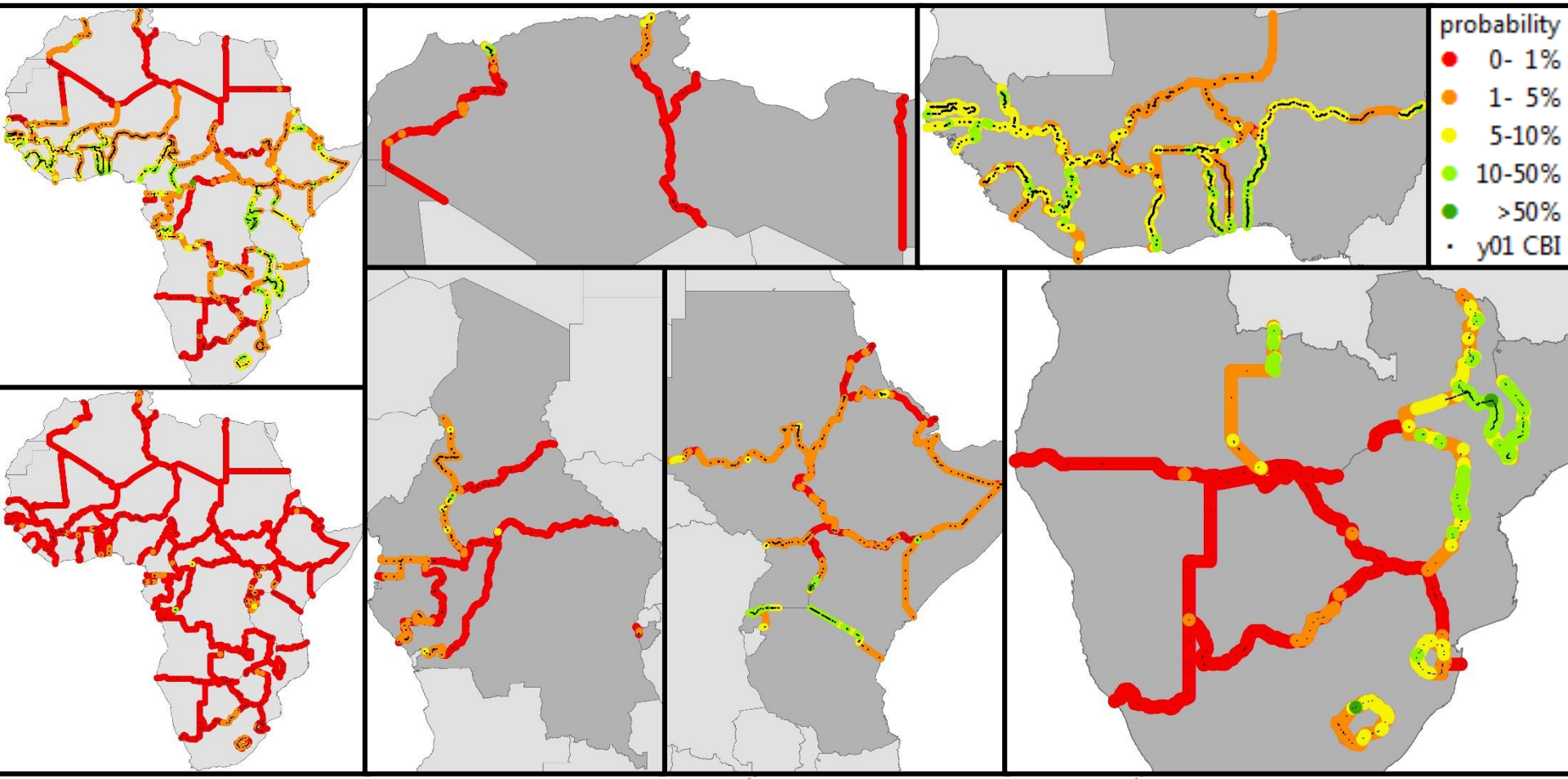
		y03	y01	y01n	y01w	y01c	y01e	y01s	50perc
Int.	Est	-2.6E+00	-3.4E+00	-4.5E+00	5.0E+01	1.9E+02	-4.6E+00	5.5E+00	-7.3E-01
	SE	1.5E+00	6.9E-01	7.7E-01	5.9E+00	2.2E+01	2.9E-01	8.8E-01	9.8E-01
	z	-1.689	-4.853	-5.939	8.544	8.551	-15.966	6.223	-0.742
	p	0.091206	1.22E-06	2.87E-09	< 2e-16	< 2e-16	< 2e-16	4.87E-10	0.45782
x01	Est	-2.0E-05	7.3E-06		-2.6E-04	-8.8E-04			1.4E-05
	SE	7.1E-06	3.2E-06		2.9E-05	1.0E-04			4.6E-06
	z	-2.763	2.264		-8.987	-8.593			2.996
	p	0.005736	0.0236		< 2e-16	< 2e-16			0.00273
x02	Est	2.3E-03	2.2E-03	2.3E-03	2.5E-03	1.9E-03	2.3E-03	2.6E-03	2.9E-03
	SE	3.3E-04	1.0E-04	7.5E-04	1.8E-04	4.3E-04	3.0E-04	2.3E-04	1.9E-04
	z	6.957	22.216	3.013	14.068	4.416	7.728	11.578	15.15
	p	3.49E-12	< 2e-16	2.59E-03	< 2e-16	1.00E-05	1.09E-14	< 2e-16	< 2e-16
x03	Est		-7.4E-04	-3.1E-03	-2.5E-03	-3.0E-03	7.1E-04	-1.5E-03	-7.8E-04
	SE		5.4E-05	9.9E-04	1.7E-04	4.6E-04	1.6E-04	2.6E-04	9.3E-05
	z		-13.538	-3.098	-14.152	-6.567	4.502	-5.588	-8.362
	p		< 2e-16	0.00195	< 2e-16	5.12E-11	6.74E-06	2.29E-08	< 2e-16
x04	Est	-2.6E-03	-1.3E-03				-2.4E-03	-2.1E-03	-1.1E-03
	SE	2.9E-04	9.9E-05				3.4E-04	2.9E-04	1.5E-04
	z	-8.936	-13.335				-6.925	-7.365	-7.547
	p	< 2e-16	< 2e-16				4.37E-12	1.78E-13	4.45E-14
x05	Est	3.2E-04	5.4E-04		1.6E-03	1.6E-03	9.1E-04	1.0E-03	4.5E-04
	SE	1.2E-04	4.1E-05		2.7E-04	4.1E-04	1.2E-04	9.8E-05	7.2E-05
	z	2.538	13.036		6.15	3.799	7.926	10.415	6.301
	p	0.011135	< 2e-16		7.76E-10	0.000145	2.27E-15	< 2e-16	2.96E-10
x06	Est	-1.3E-01	-1.5E-01	-1.5E-01	-1.7E-01	-1.8E-01	-1.9E-01	-1.2E-01	-1.4E-01
	SE	3.6E-02	1.2E-02	7.1E-02	3.7E-02	9.9E-02	3.0E-02	2.0E-02	1.8E-02
	z	-3.487	-12.298	-2.101	-4.512	-1.813	-6.22	-6.378	-7.589





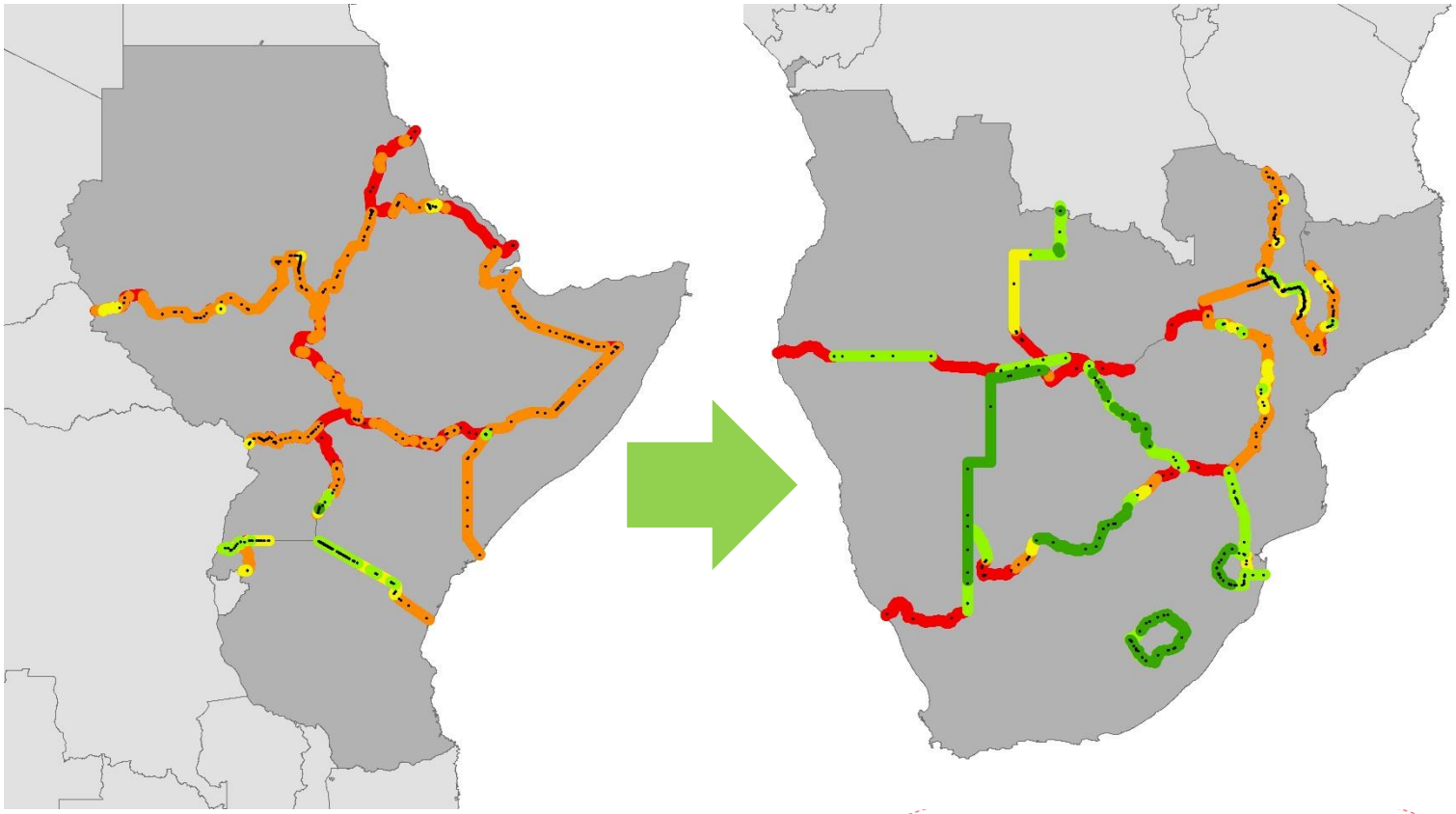
Results

- Prediction of CBI on continental and regional level



Results

- Prediction of CBI in Southern Africa, using coefficients from Eastern Africa



Discussion & Conclusion

- Large CBI as well as cross-border paved roads are most likely:
  - In areas with high population density
  - close to capitals
  - in flat terrain
  - on dry land or across small rivers
- Some challenges, such as
  - Missing Data on Sawhari Republic (Western Sahara)
  - Completeness and correctness of OSM
  - CBI are Rare Events

Discussion & Conclusion

- Pixel-specific variables are better than boundary-specific ones
- Borders of Regional Economic Communities have no impact on CBI
- Possibly better economic and sociological indicators available
- Models explain 5-21% of why a CBI is or isn‘t present in any cell
- Continental models are less accurate than regional ones
- Regional models shouldn‘t be applied to other regions