Irrigation as climate-change adaptation in the Cerrado biome of Brazil

evaluated with new quantitative methods, socio-economic analysis, and scenario models

2023 – 2026

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MAPBIOMAS

Research objectives

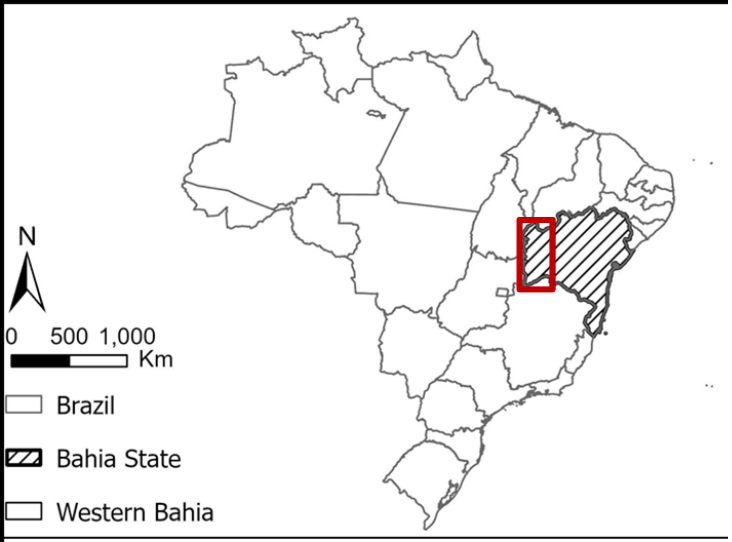
Our research focuses on the hotspot of land change in the **Cerrado** biome region of the Brazilian state of Bahia with three main objectives.

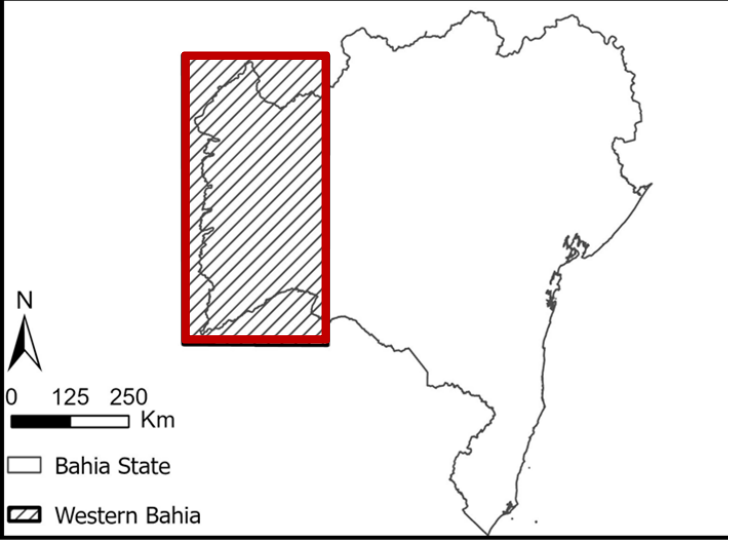
1. The first is to develop generally applicable methods with accompanying software to quantify and analyze land change and its associated socio-economic drivers and impacts.

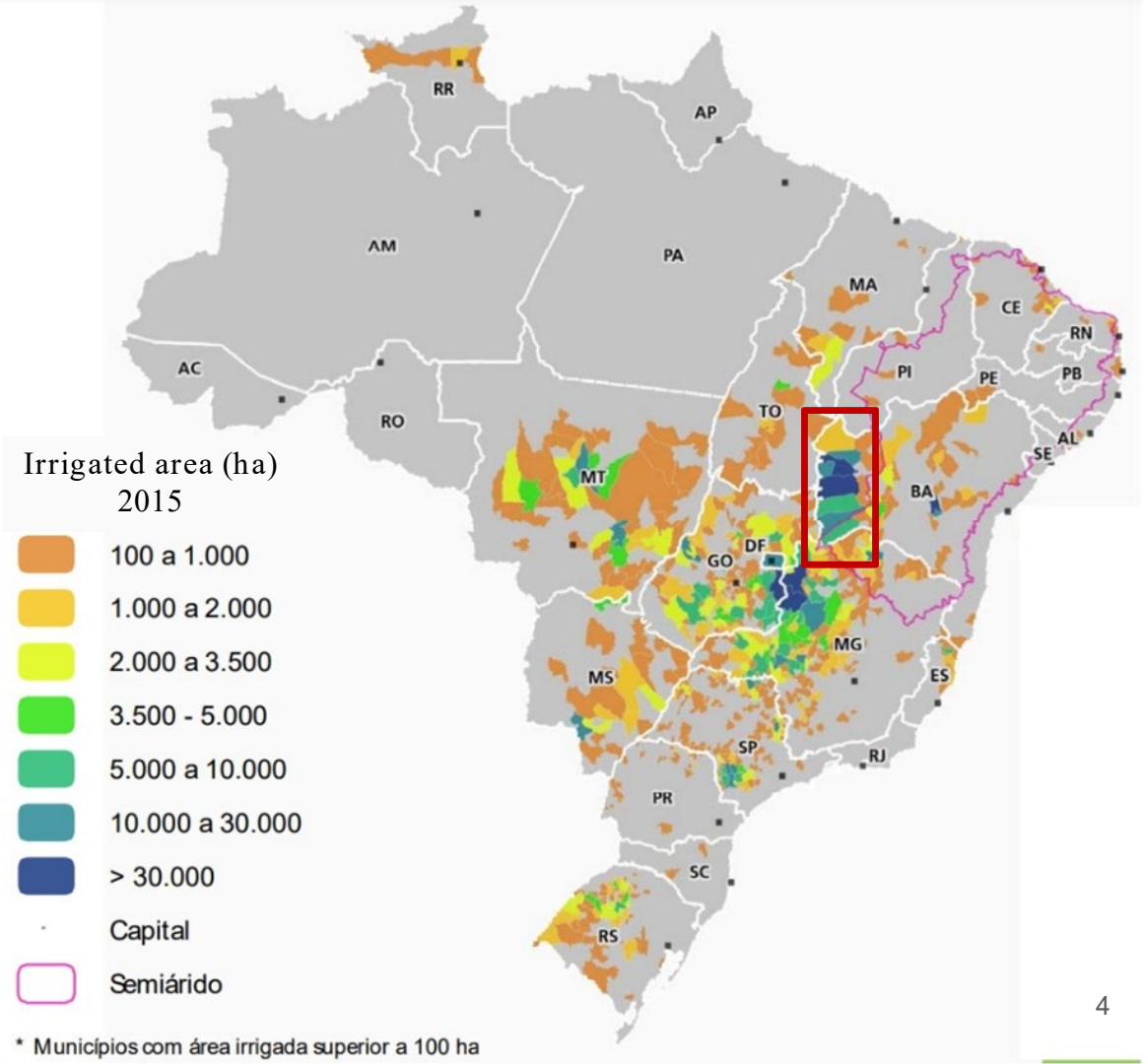
2. The second is to **examine the expansion of irrigated agriculture as a form of adaptation to climate change**.

3. The third is to develop spatially explicit scenario models that inform policy concerning agrarian development, water regulations, and climate change adaptations.

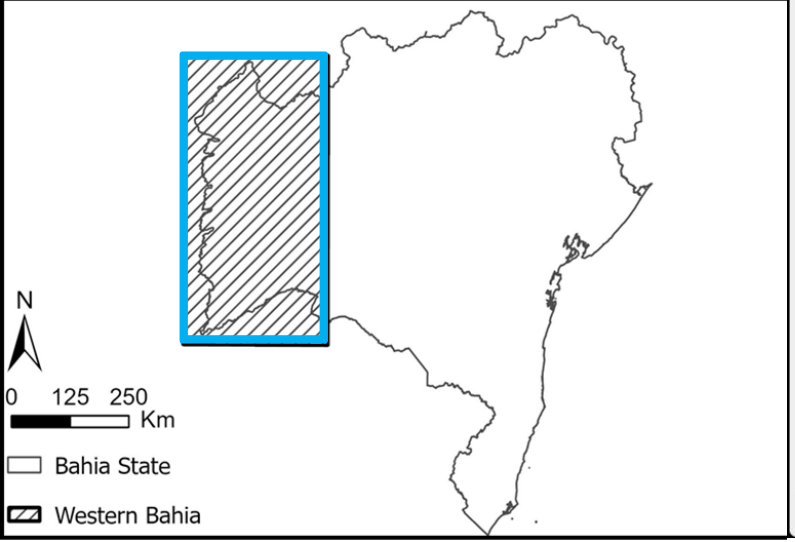

Municipalities in western Bahia were among the most deforested in Brazil during 2019-2020 when 98% of land clearing was illegal (Azevedo, Shimbo, and de Oliveira 2021).
Source: WWF





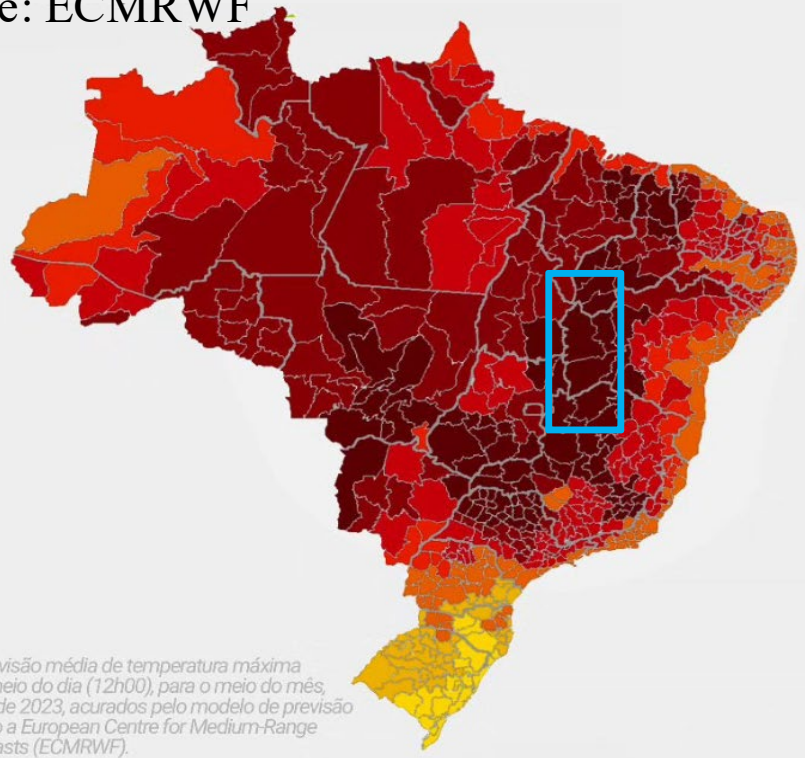


* Municípios com área irrigada superior a 100 ha



Heatwave on Nov. 2023 in ºC

Source: ECMRWF

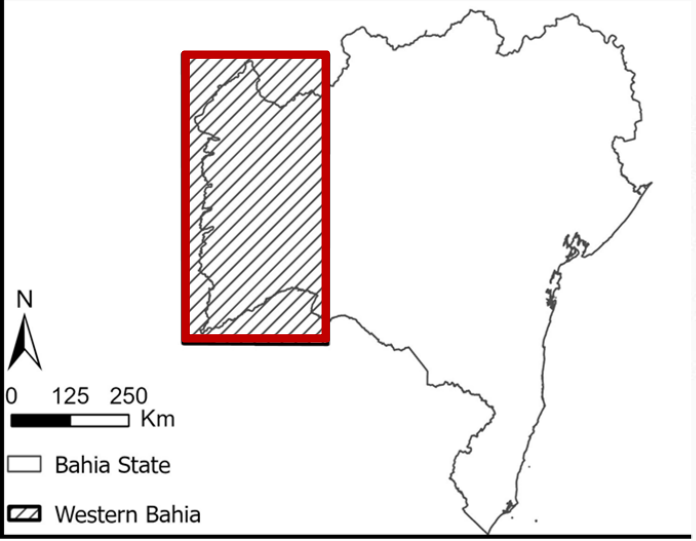


Referente a previsão média de temperatura máxima registrada no meio do dia (12h00), para o meio do mês, 15 de Outubro de 2023, acurados pelo modelo de previsão a 9km segundo a European Centre for Medium-Range Weather Forecasts (ECMRWF).

21° 24° 27° 30° 33° 36° > 40°

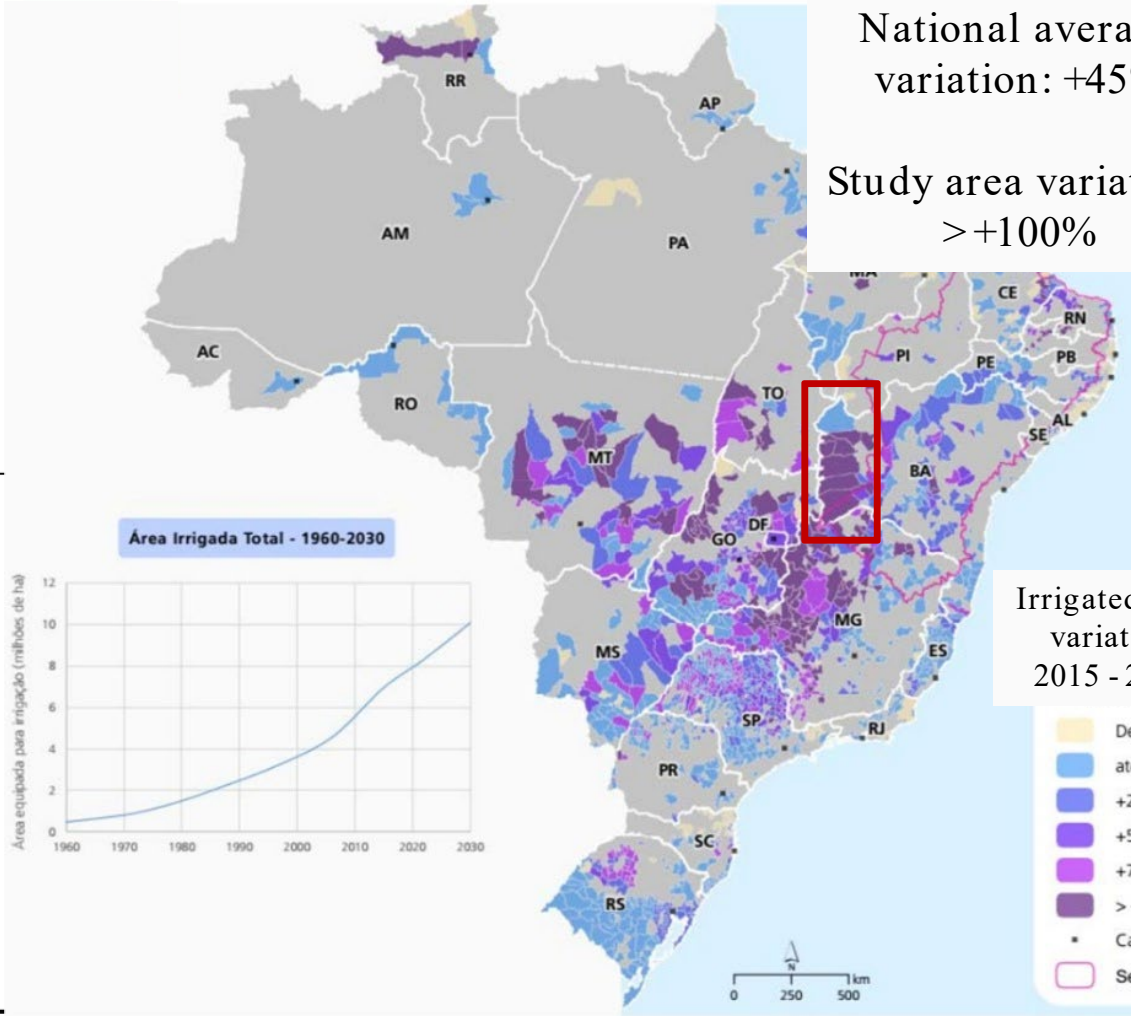
fonte: ECMRWF (ecmrwf.int) dia 15 de Nov, 2023 às 12h00. • CCBY

BrasilemMapas.com



2015 – 2030
National average variation: +45%

Study area variation: >+100%

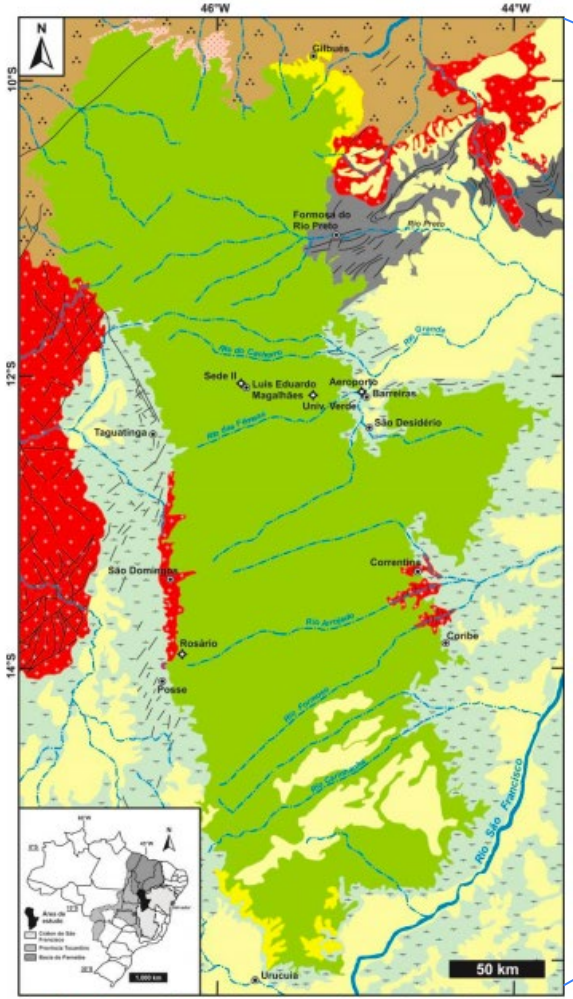


“Irrigation accounts for about **70%** of global freshwater withdrawals and about **90%** of consumptive water use.”
(McDermid et al. 2023)

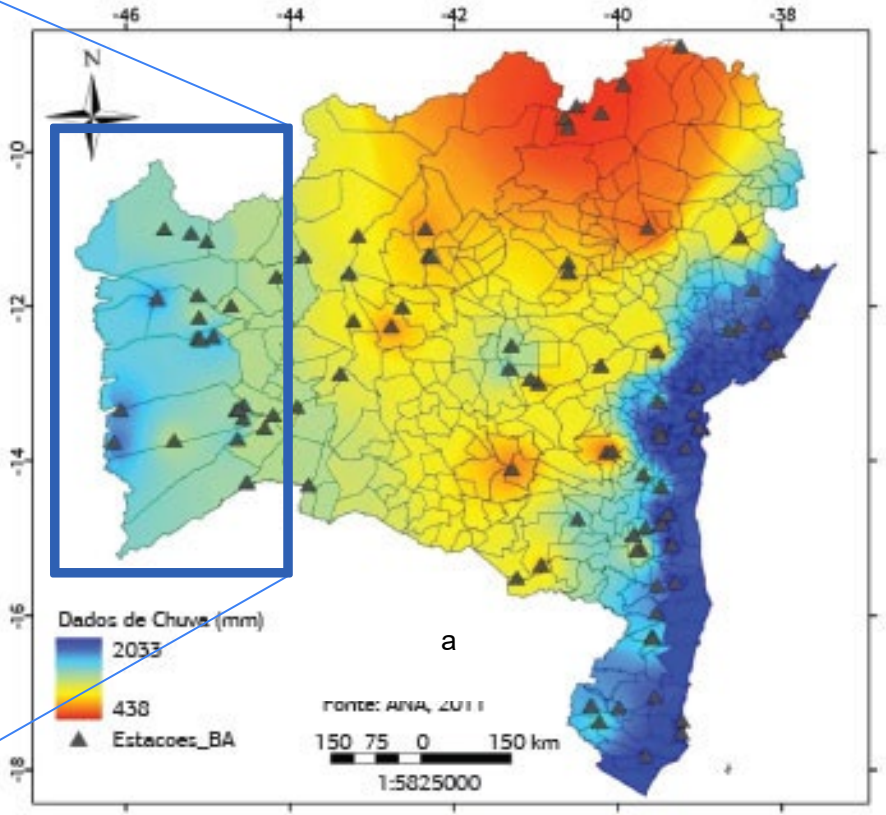
Climate change has already pushed **28%** of current agricultural lands in the Cerrado **out of their optimum climate space**, while models project that 51% of the region’s agriculture will move out of that space by 2030 and 74% by 2060.
(Rattis et al. 2021)

Agribusinesses frame western Bahia’s irrigation as **a model to be reproduced in the rest of Brazil** and have aspirational claims to become the largest irrigation center in Latin America.

Urucuia Aquifer and rainfall in Bahia state

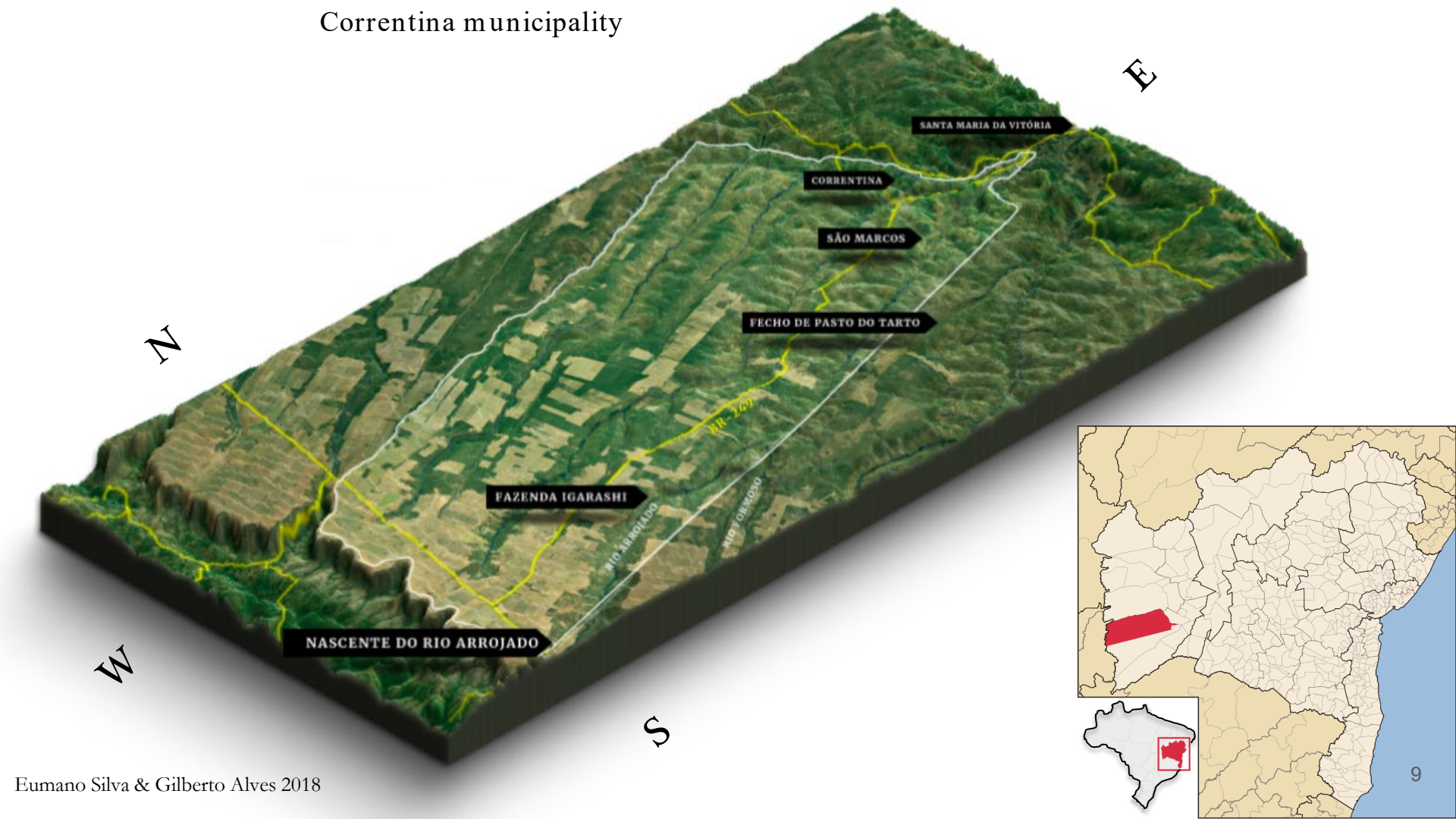


Barbosa et al. 2014



Dourado et al. 2013

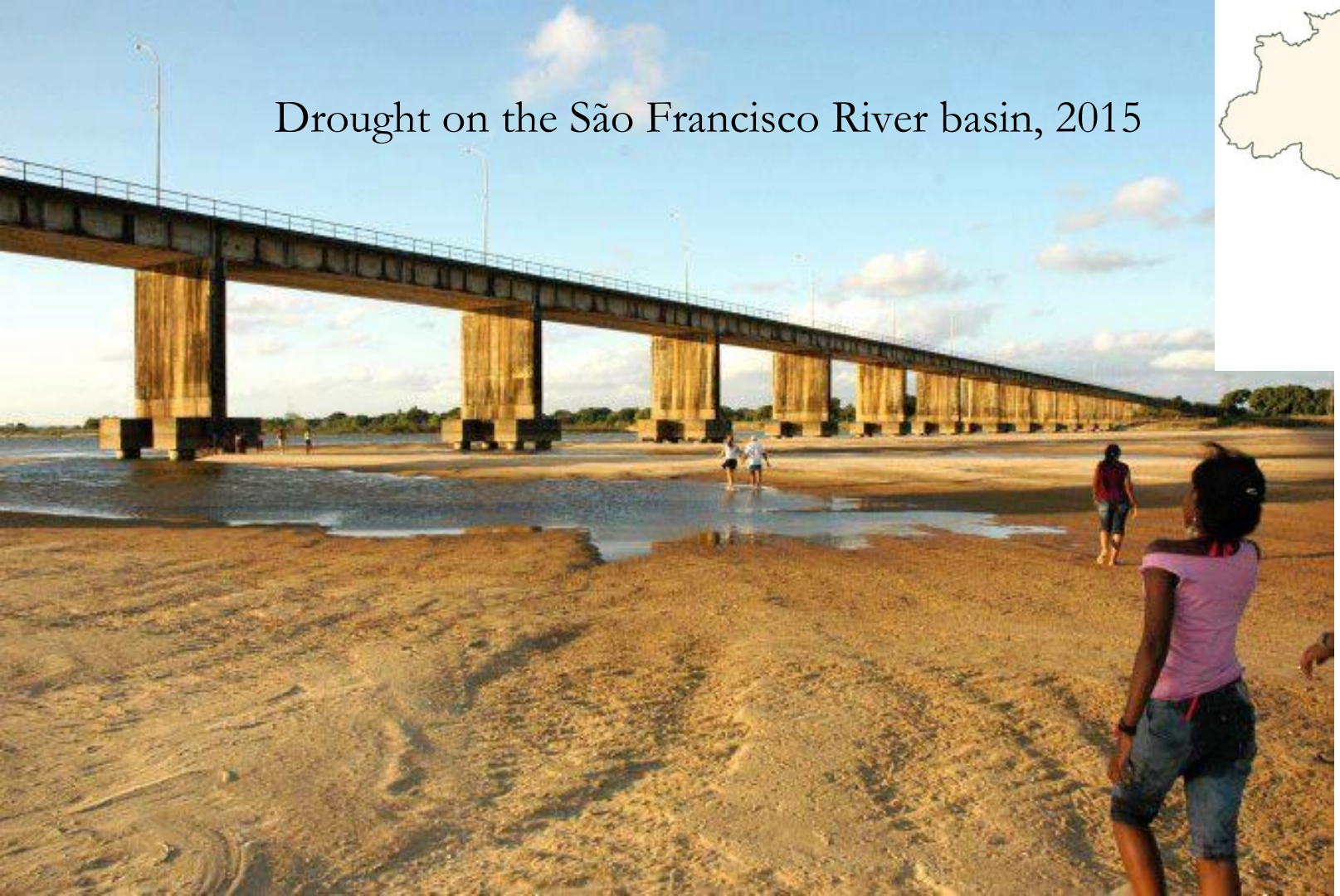
Correntina municipality



Eumano Silva & Gilberto Alves 2018

Fazenda Rio Claro, Lavoura e Pecuária Igarashi, Correntina (BA)

Drought on the São Francisco River basin, 2015



Eumano Silva
&
Gilberto Alves
2018

Eumano Silva & Gilberto Alves 2018

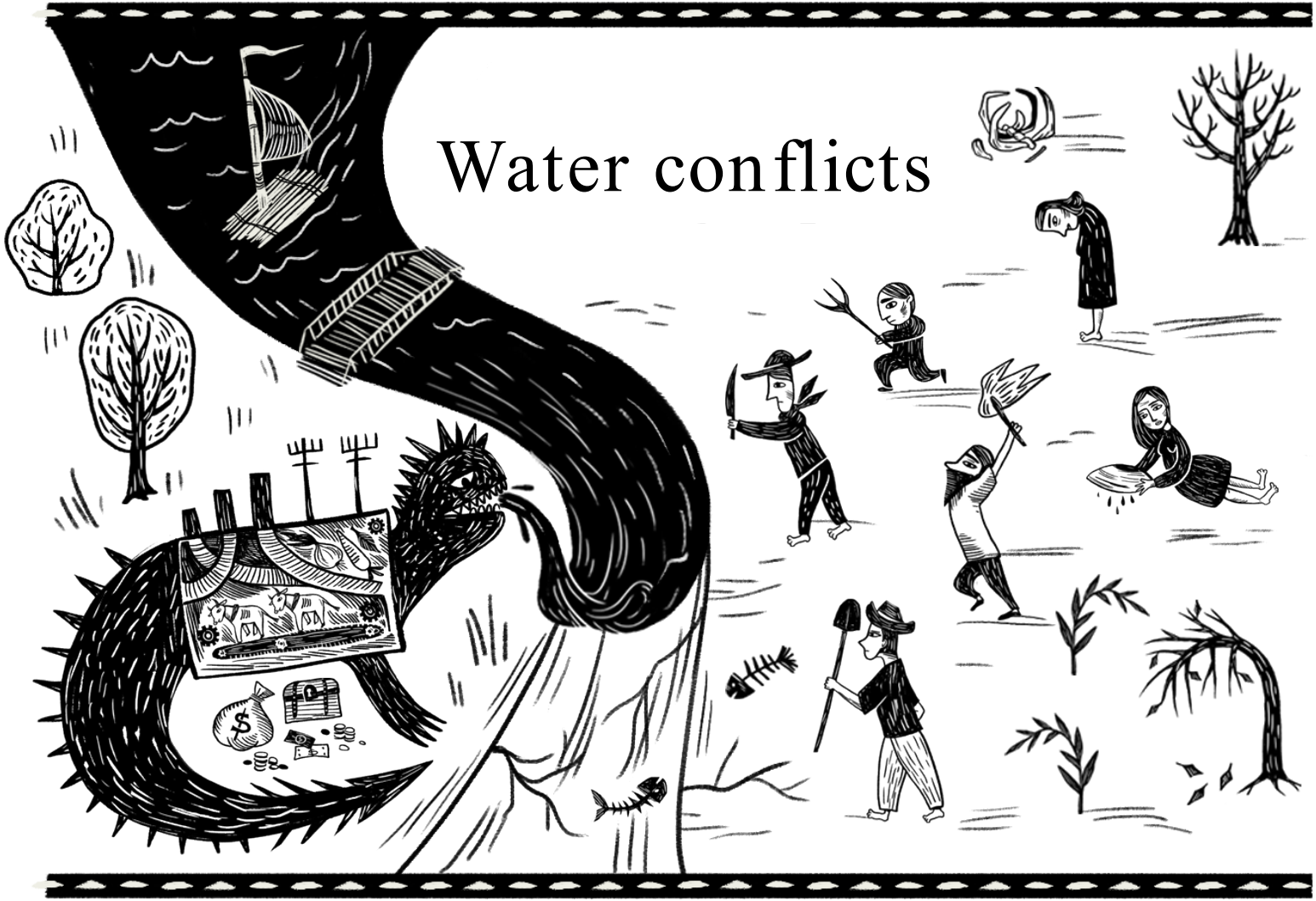
Peasants driving cattle onto common pastures on the highland plateau, Correntina (BA)

Eumano Silva
&
Gilberto Alves
2018

Surface water suction pumps for irrigation, Correntina (BA), 2018

Photo:
Michael Melo,
Metropolis 2018

Water conflicts



Eumano Silva
&
Gilberto Alves
2018

Peasants destroy irrigation pumps and occupy a large-scale farm in Correntina (BA)

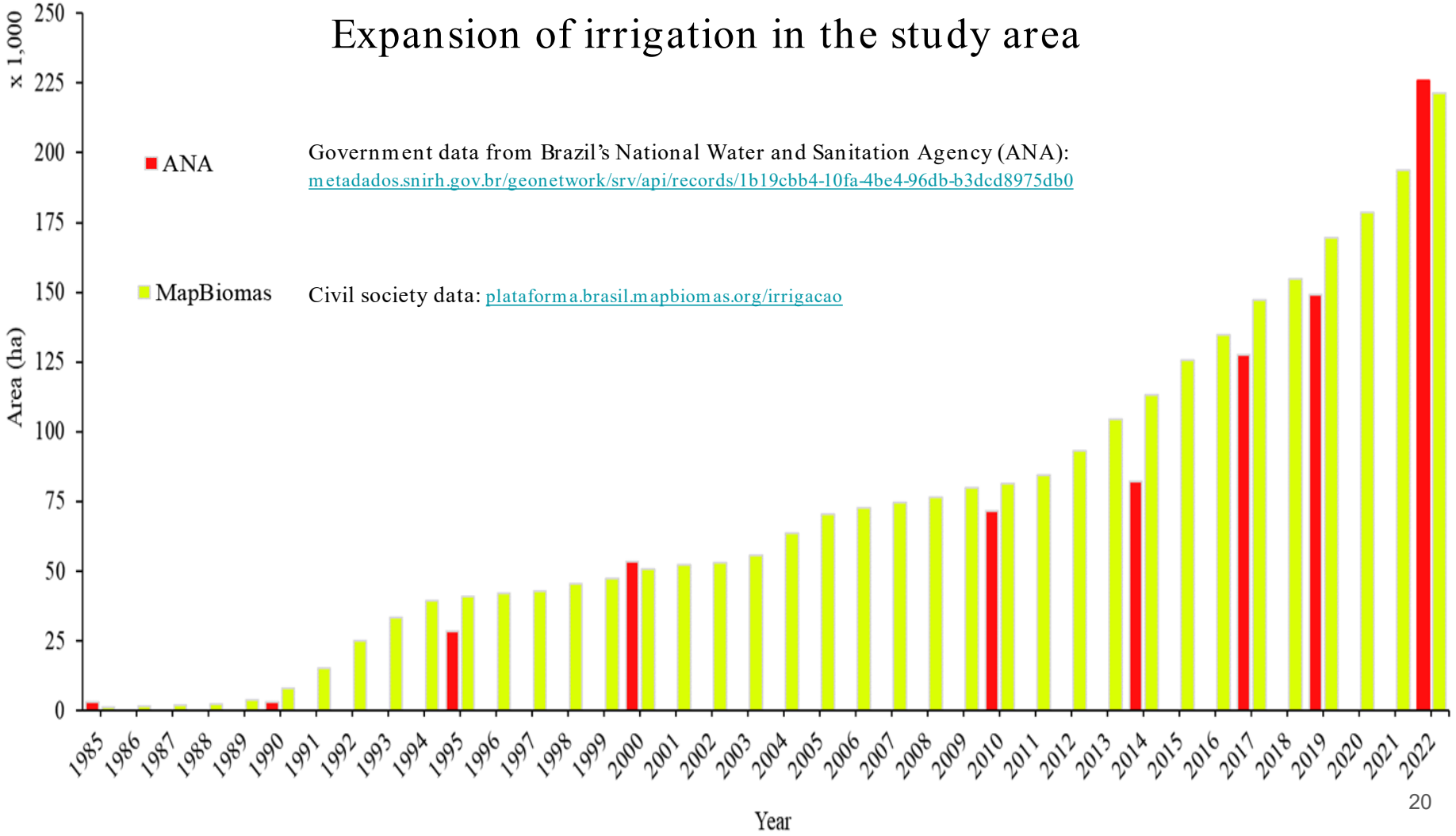
Photo: Gilberto Alves, Metropolis 2018

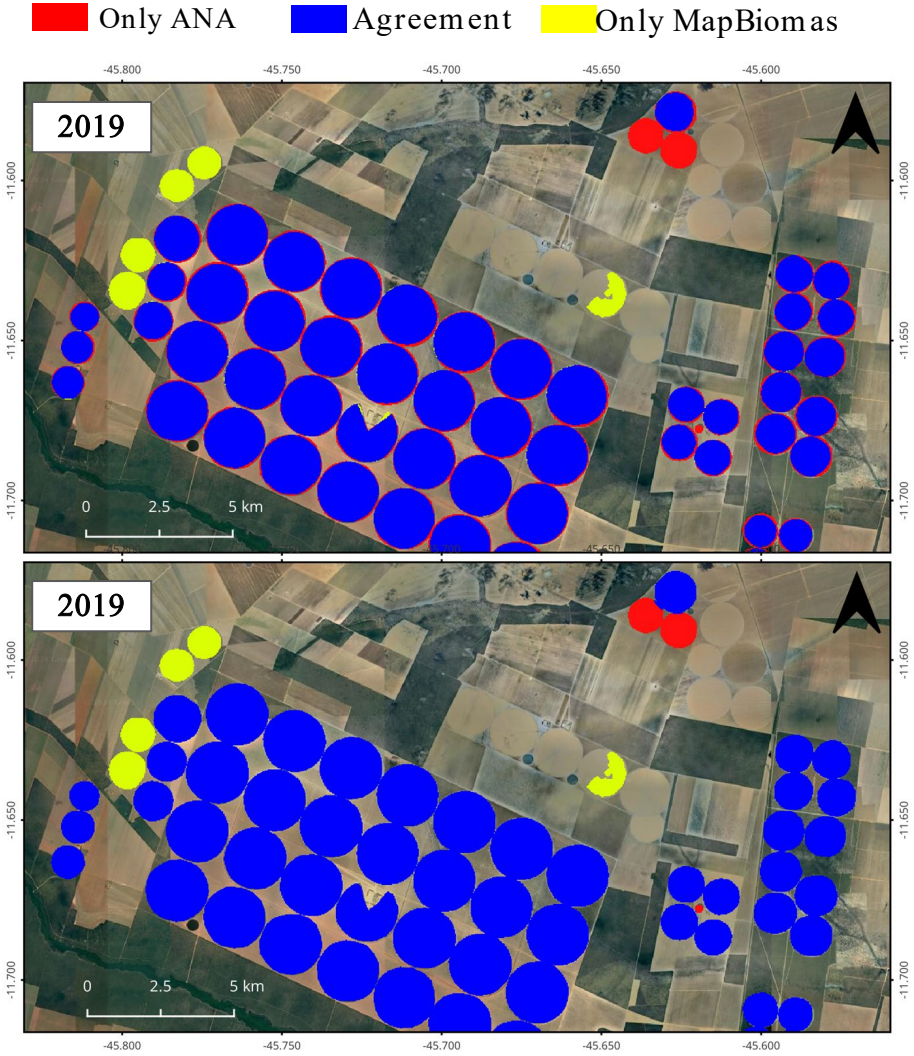
Peasants destroy irrigation pumps and occupy a large-scale farm in Correntina (BA)

Photo:
Gilberto Alves,
Metropolis 2018

Photo:
Gilberto Alves,
Metropolis 2018

Expansion of irrigation in the study area





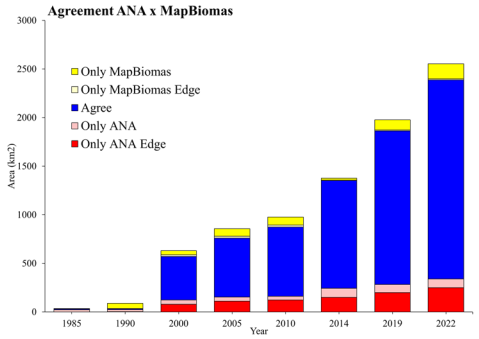
Comparison of ANA and MapBiomas spatialized data reveals agreement and disagreement in maps of pivot irrigation in our study area.

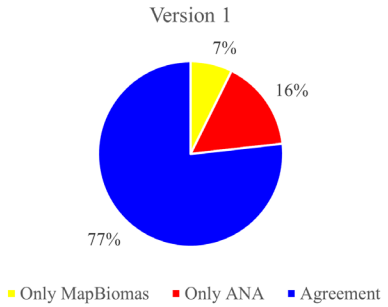
ANA and MapBiomas data show some **allocation** difference in pivot areas.

Even when ANA and MapBiomas detect the same pivot there is a **quantitative difference of irrigated area** (i.e., the ring around the edges), which we then adjust.

Adjustment of the disagreement on pivot size reduces the quantity differences between MapBiomas and ANA

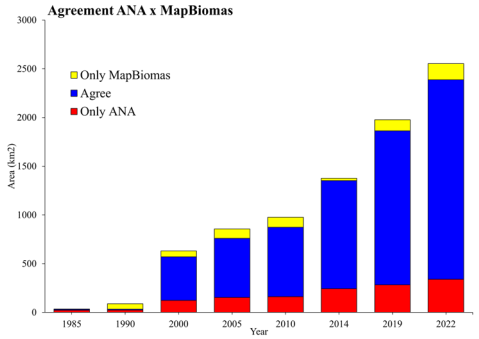
Dataset without adjustment



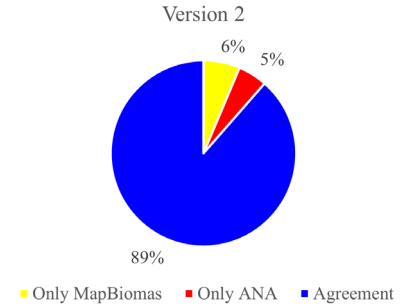


Without adjustment, there is **23%** of area disagreement in the time series between ANA and MapBiomas.

Dataset with adjustment



Agreement increased by 12%



Adjusting the areas of quantitative disagreement for all the years, the total disagreement is only **11%.**

MAPBIOMAS v. 8.0

ESTATÍSTICAS

Área - 2022

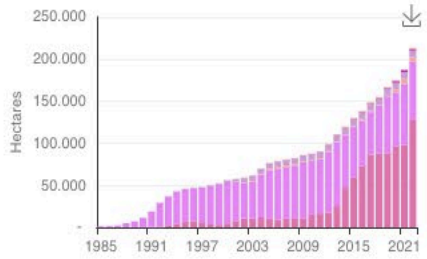
212.307 ha
Total

Máximo 212.307 ha

Média 76.854 ha

Mínimo 1.322 ha

Área anual por classe



Proporção da área anual por classe

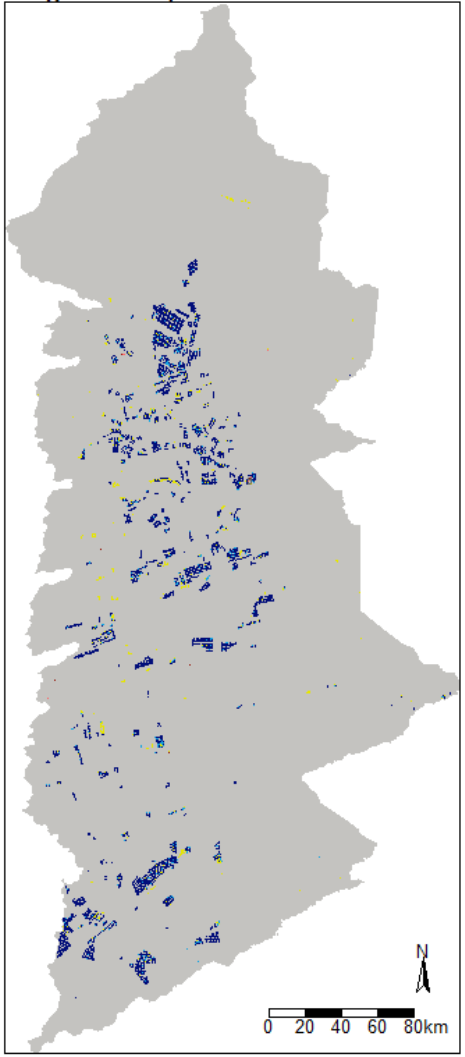
2022 - Valor selecionado para o mapa

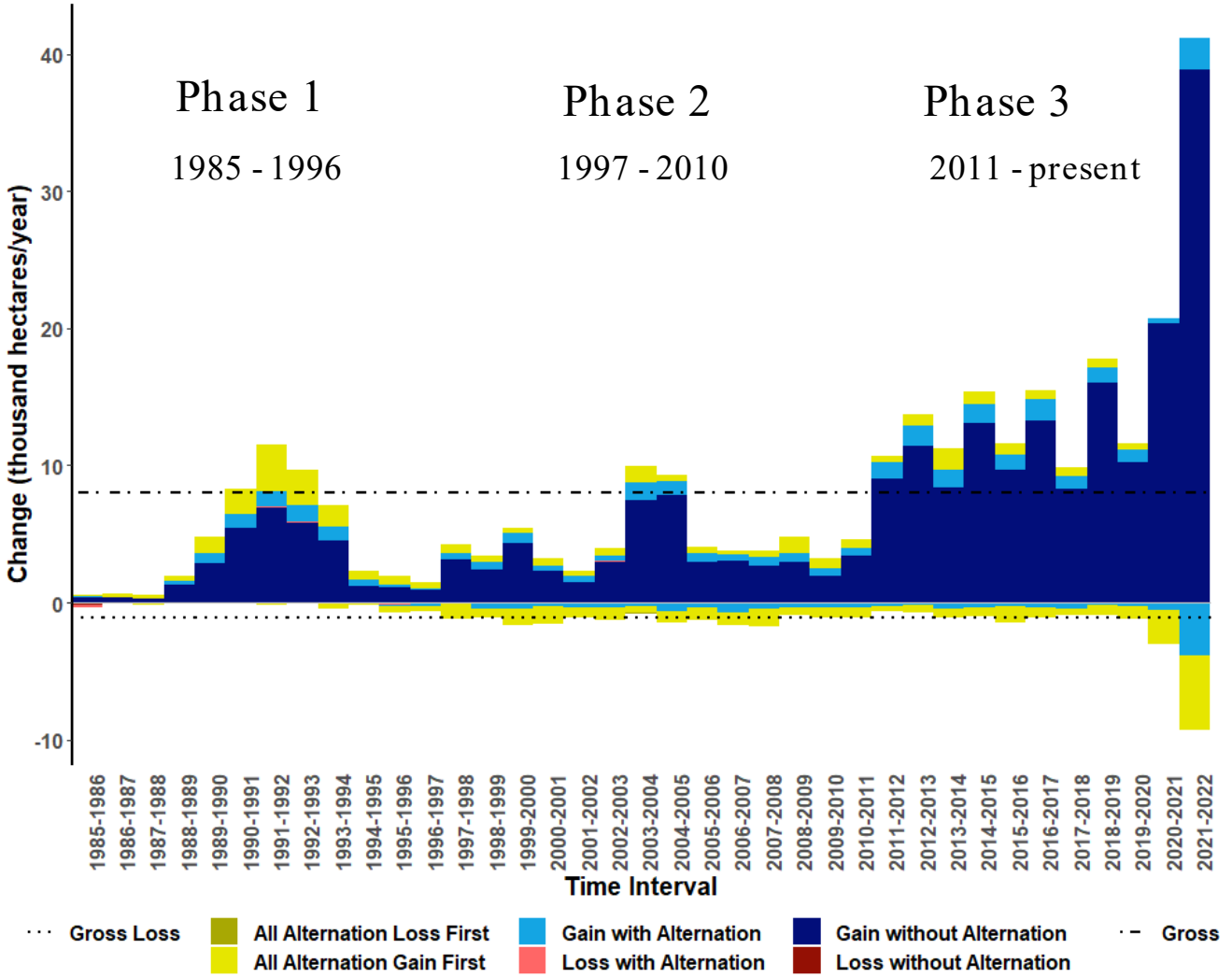
-12.84, -44.73

20 km

1985 - 2022

Leaflet | © OpenStreetMap contributors


N
0 20 40 60 80km


Phase 1
1985 - 1996
Phase 2
1997 - 2010
Phase 3
2011 - present
Change (thousand hectares/year)
40
30
20
10
0
-10
1985-1986
1986-1987
1987-1988
1988-1989
1989-1990
1990-1991
1991-1992
1992-1993
1993-1994
1994-1995
1995-1996
1996-1997
1997-1998
1998-1999
1999-2000
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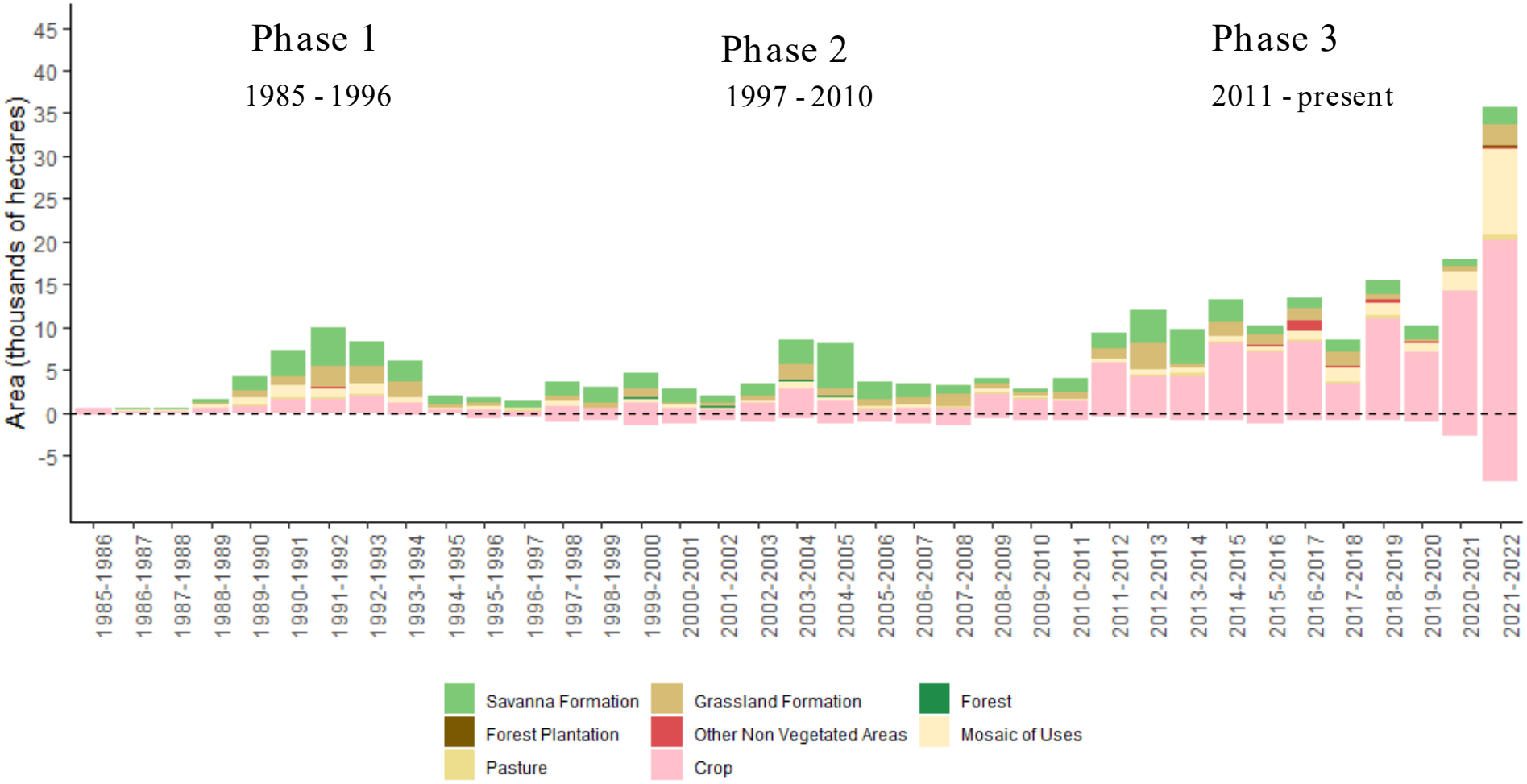
2004-2005
2005-2006
2006-2007
2007-2008
2008-2009
2009-2010
2010-2011
2011-2012
2012-2013
2013-2014
2014-2015
2015-2016
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
2021-2022
Time Interval
Gross Loss
All Alternation Loss First
All Alternation Gain First
Gain with Alternation
Loss with Alternation
Gain without Alternation
Loss without Alternation
Gross


Phase 1
1985 - 1996
Phase 2
1997 - 2010
Phase 3
2011 - present
Area (thousands of hectares)
45
40
35
30
25
20
15
10
5
0
-5
1985-1986
1986-1987
1987-1988
1988-1989
1989-1990
1990-1991
1991-1992
1992-1993
1993-1994
1994-1995
1995-1996
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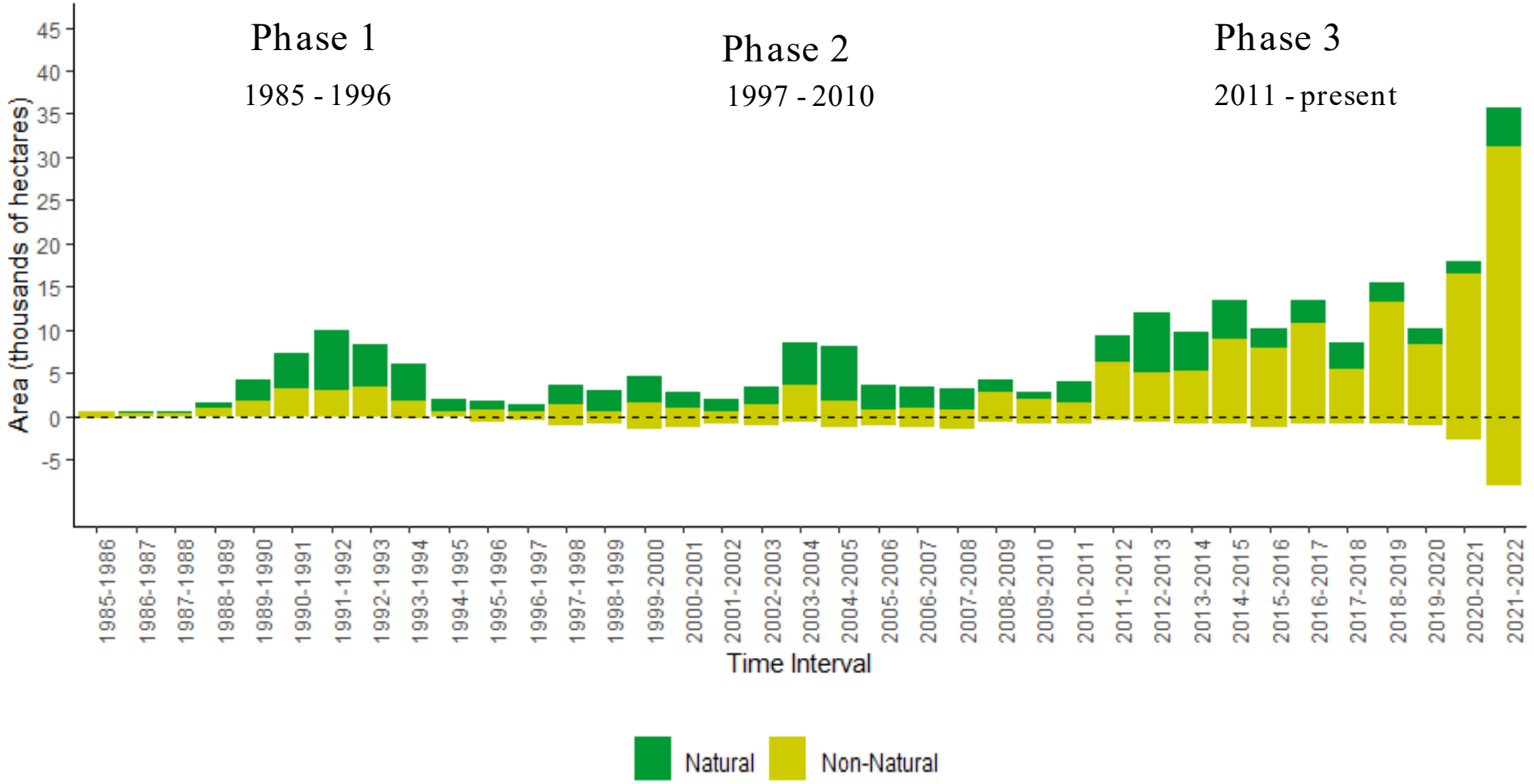
2011-2012
2012-2013
2013-2014
2014-2015
2015-2016
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
2021-2022
Savanna Formation
Grassland Formation
Forest
Forest Plantation
Other Non Vegetated Areas
Mosaic of Uses
Pasture
Crop


Phase 1
1985 - 1996
Phase 2
1997 - 2010
Phase 3
2011 - present
Area (thousands of hectares)
45
40
35
30
25
20
15
10
5
0
-5
1985-1986
1986-1987
1987-1988
1988-1989
1989-1990
1990-1991
1991-1992
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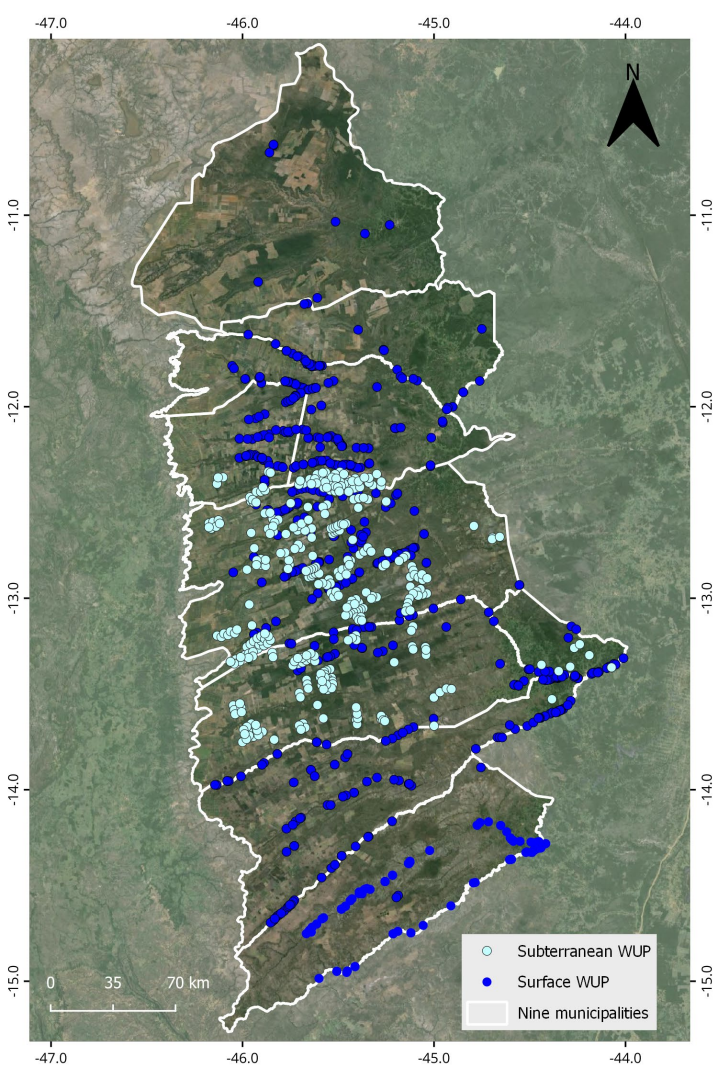
2010-2011
2011-2012
2012-2013
2013-2014
2014-2015
2015-2016
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
2021-2022
Time Interval
Natural
Non-Natural



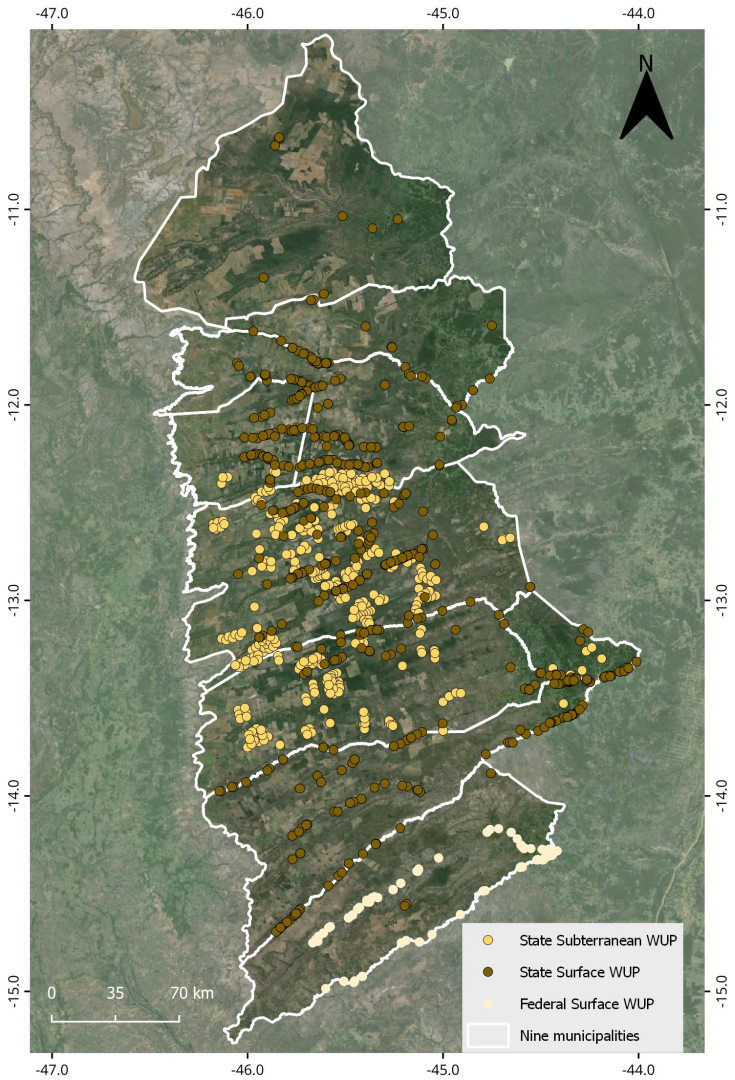
1,152 Water Use Permits (WUPs) for irrigation on record

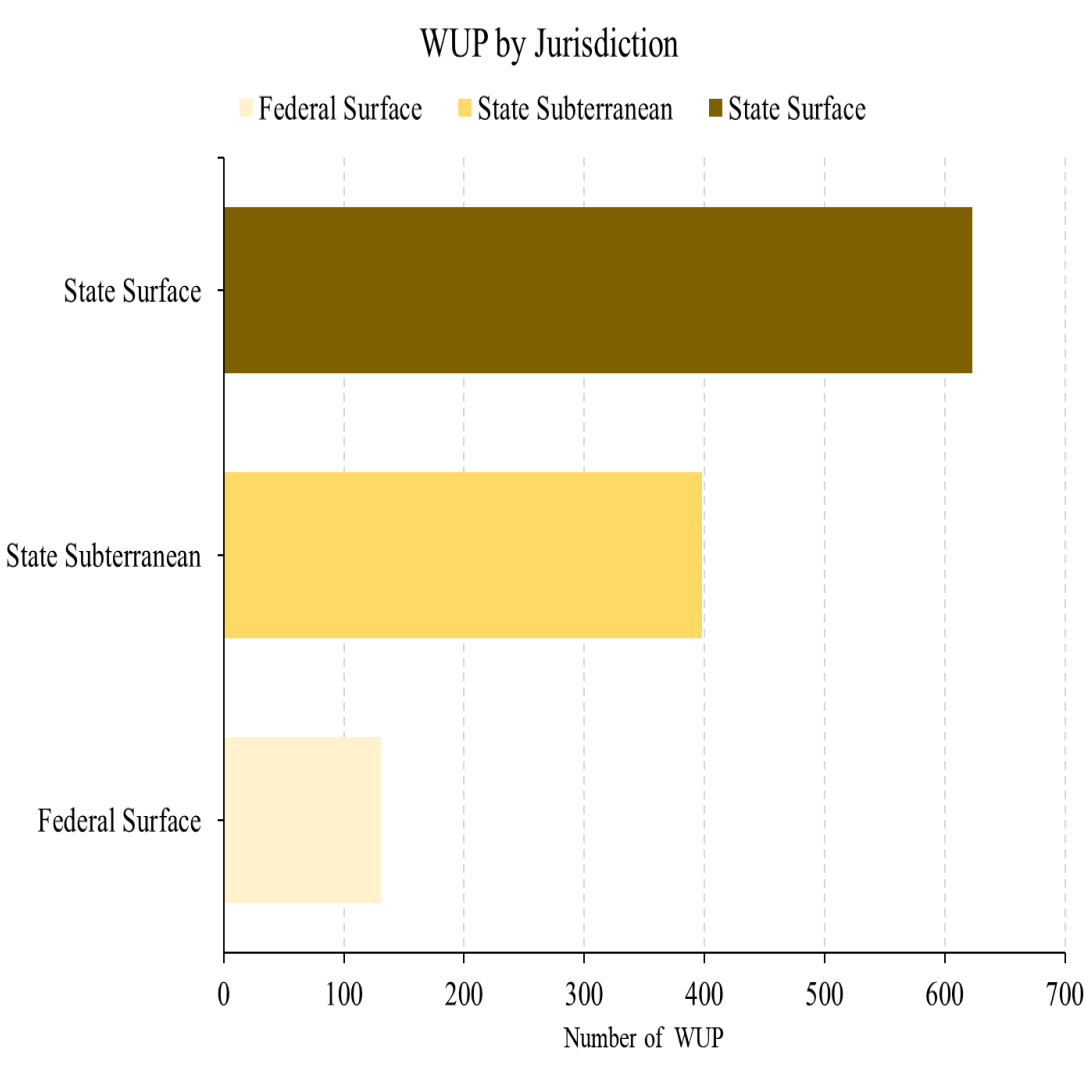
State WUPs: **1,021** (89%)

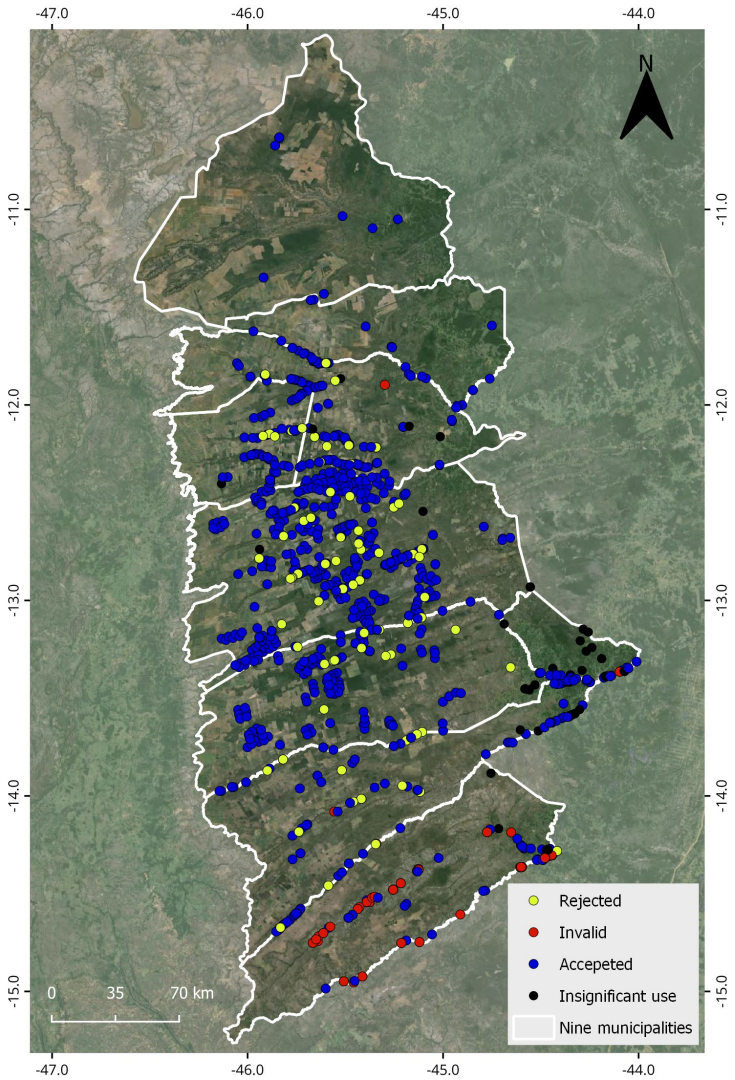
- Superficial: 623
- Subterranean: 398

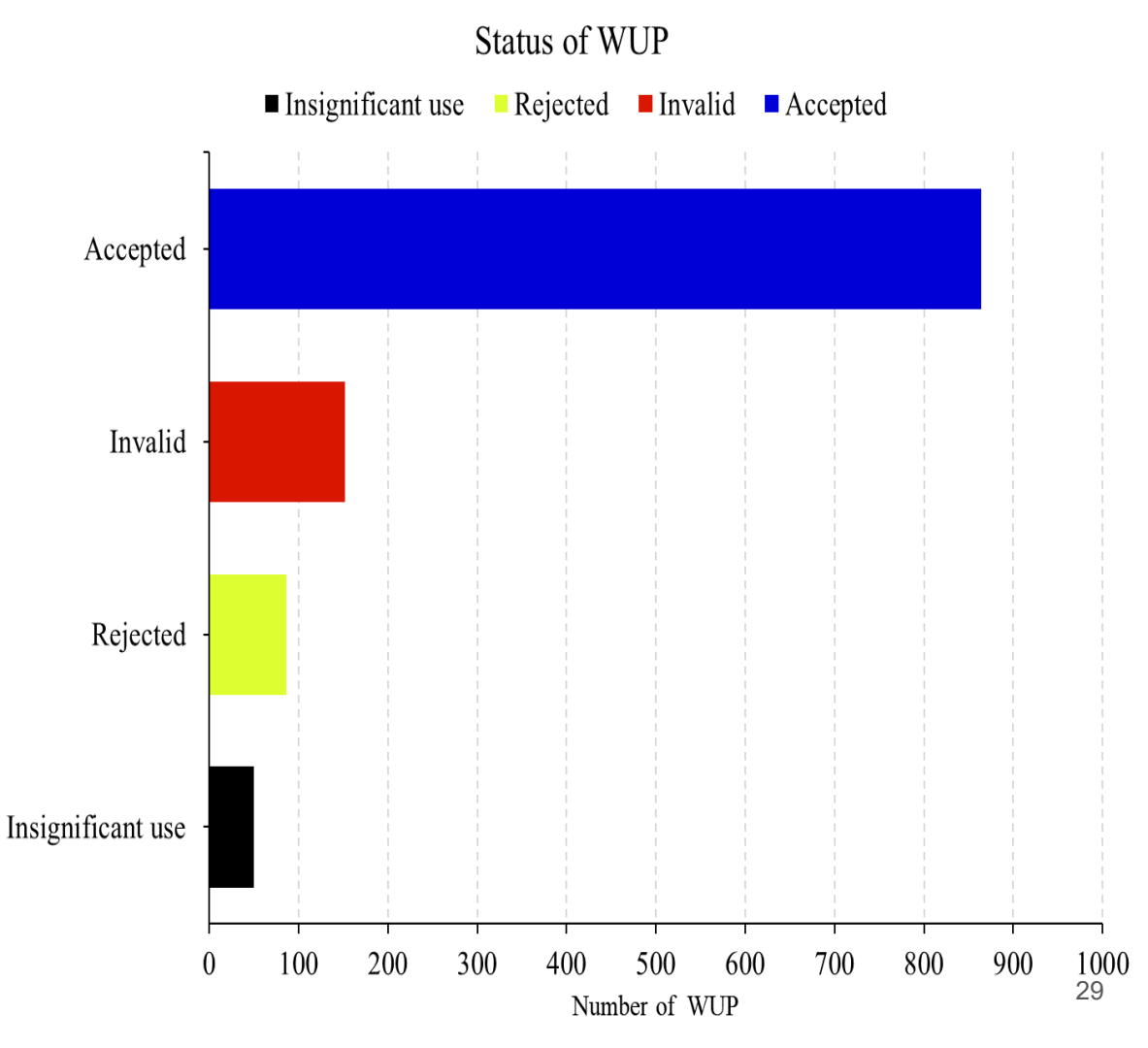
Federal WUPs: **131** (11%)

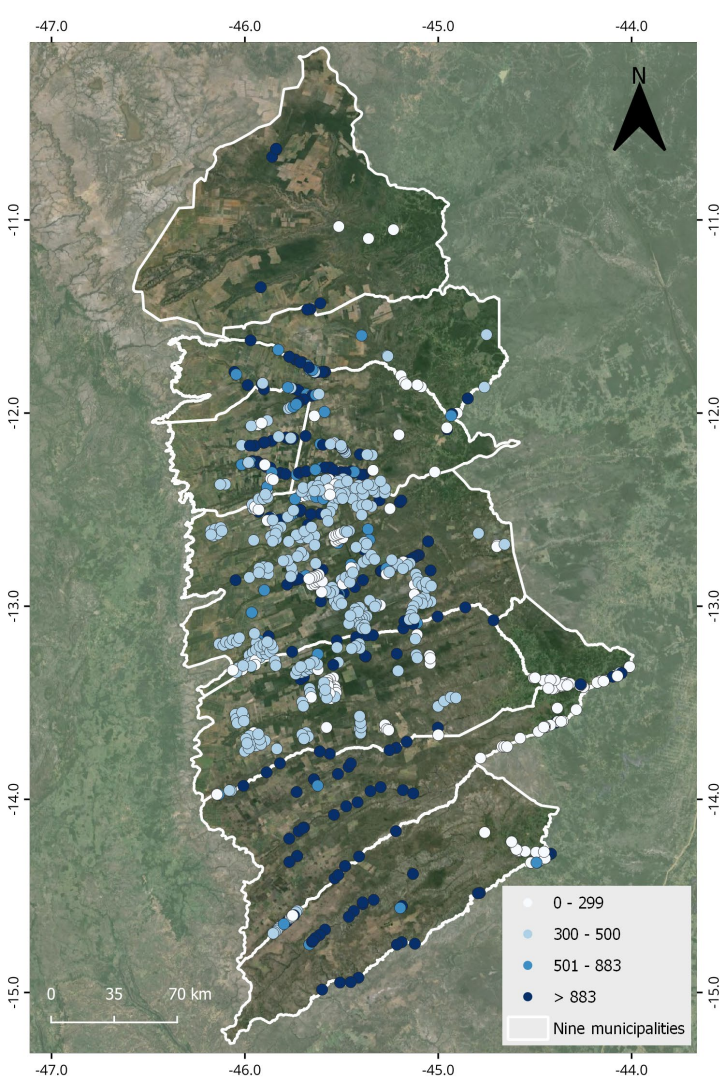
- Superficial: 131
- Subterranean: 0

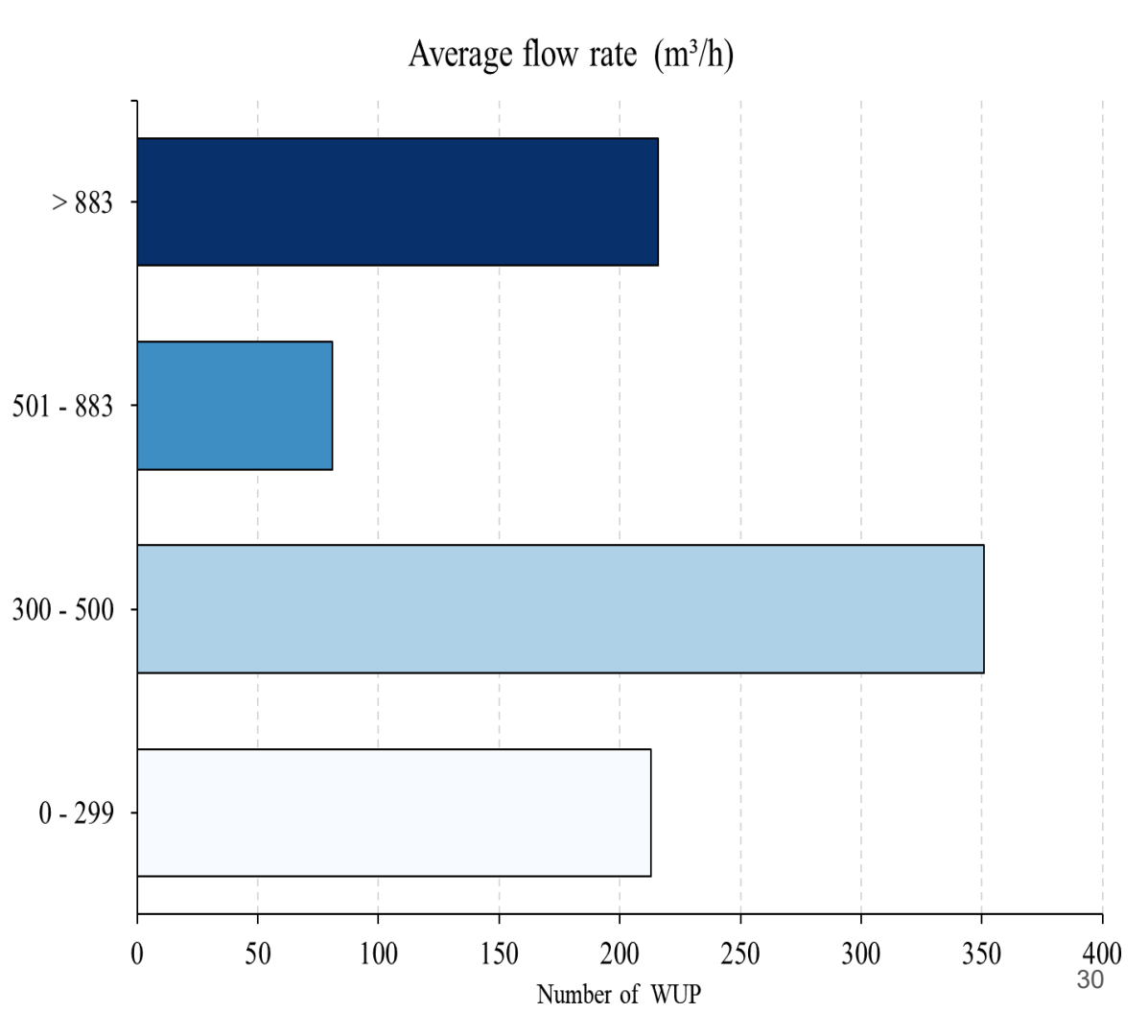

-47.0
-46.0
-45.0
-44.0
-11.0
-12.0
-13.0
-14.0
-15.0
N
State Subterranean WUP
State Surface WUP
Federal Surface WUP
Nine municipalities
0
35
70 km

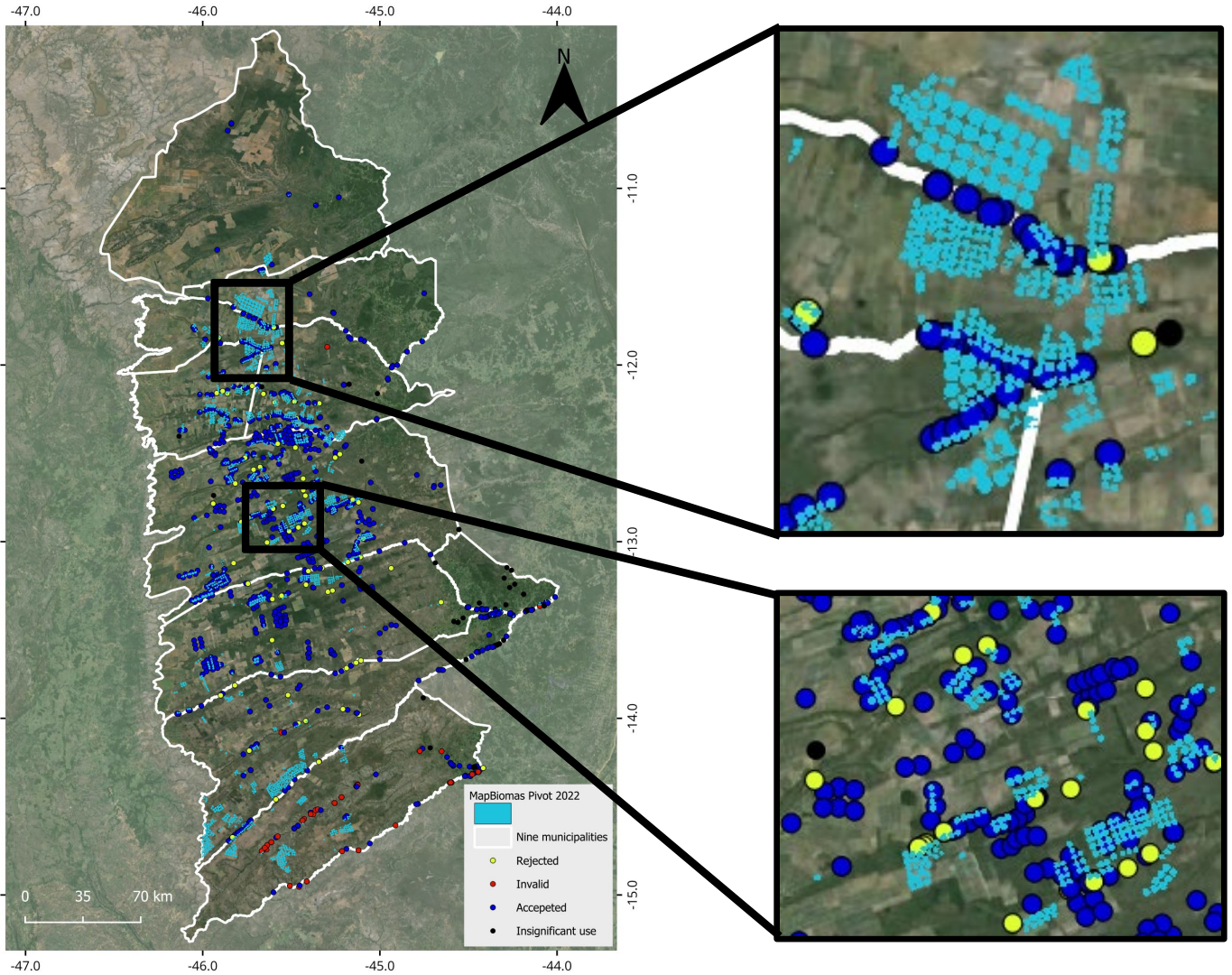

WUP by Jurisdiction
Federal Surface
State Subterranean
State Surface
State Surface
State Subterranean
Federal Surface
0
100
200
300
400
500
600
700
Number of WUP


-47.0
-46.0
-45.0
-44.0
-11.0
-12.0
-13.0
-14.0
-15.0
N
Rejected
Invalid
Accepeted
Insignificant use
Nine municipalities
0
35
70 km


Status of WUP
Insignificant use
Rejected
Invalid
Accepted
Accepted
Invalid
Rejected
Insignificant use
0
100
200
300
400
500
600
700
800
900
1000
Number of WUP


-47.0
-46.0
-45.0
-44.0
-11.0
-12.0
-13.0
-14.0
-15.0
N
0 - 299
300 - 500
501 - 883
> 883
Nine municipalities
0
35
70 km


Average flow rate (m³/h)
> 883
501 - 883
300 - 500
0 - 299
0
50
100
150
200
250
300
350
400
Number of WUP



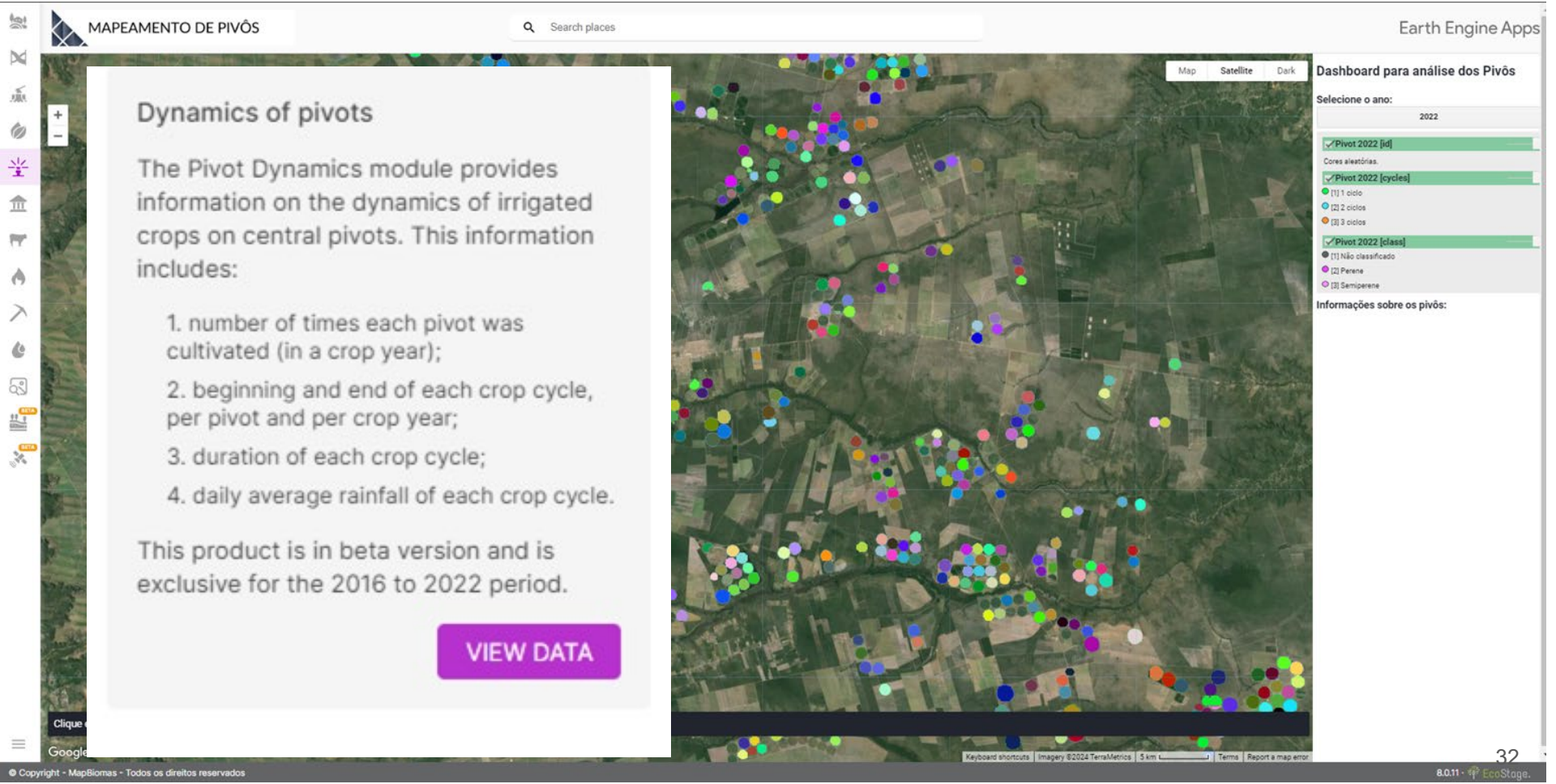
Pattern A

- Surface water capture
- Higher flow averages
- Greater distance from water source to pivots

Pattern B

- Ground water capture
- Lower flow averages
- Shorter distance from water source to pivots

MapBiomas has a second data set that provides **intra-anual** patterns of irrigation use.

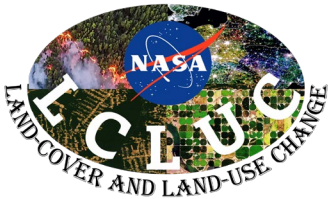


Main research outputs so far:

1. Bilintoh, Thomas. (2024). R package *timeseriesTrajectories* https://github.com/bilintoh/timeseriesTrajectories

2. Bilintoh, Thomas, R. Gilmore Pontius and Gustavo de L. T. Oliveira. (2024). "Comparison of Time Series Trajectories at Multiple Temporal Resolutions: A Case Study of Soybeans in Western Bahia, Brazil." SpaceWeek Nordeste.

3. Tanner Honnef. (2023) "The Total Operating Characteristics requires improvements to its use and software." BSc. Thesis in Geography, Worcester, MA, Clark University.



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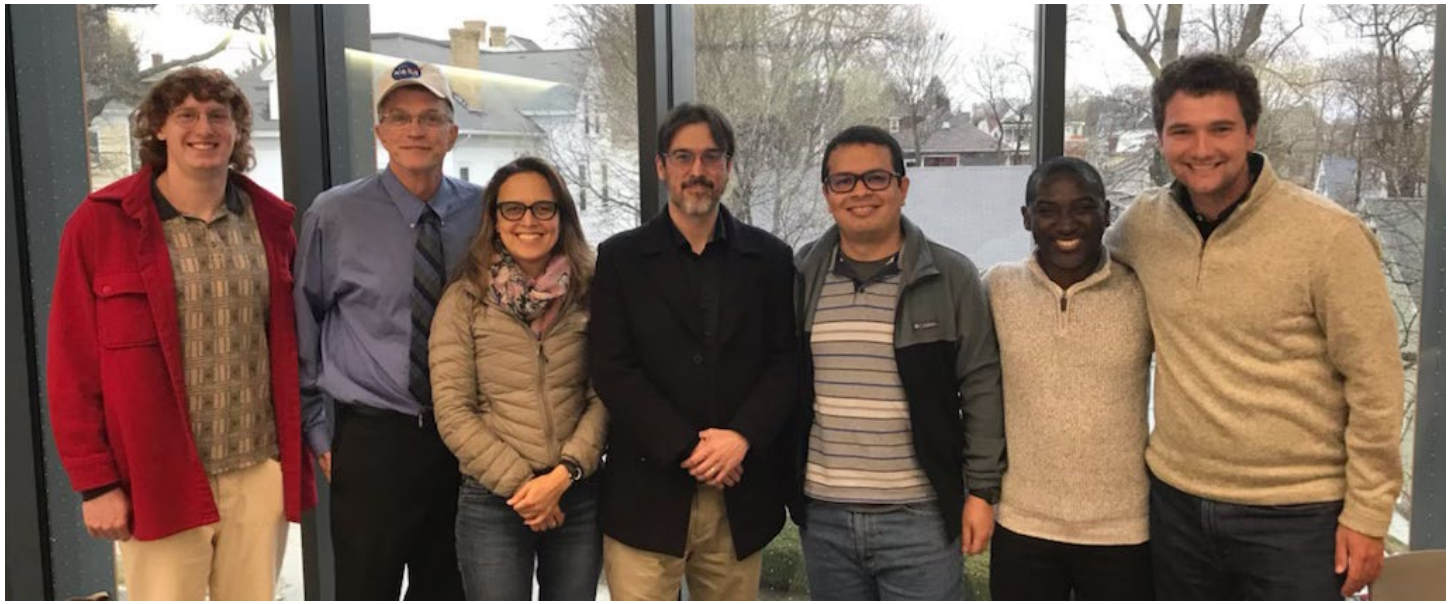
Rowan Compton BA student Dr. Julia Shimbo (Collaborator) Antonio Fonseca (PhD student, RA) Tanner Honnef MA student



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