The Irrigation Frontline – Examining Land Use Change and Resource Rights Fueling the Michoacan Berry Boom

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November 26, 2022

Abstract

Year-round demand for luxury food crops, such as berries, has rapidly increased for high income populations in the last twenty years. For example, the United States per capita import of berries has increased tenfold in twenty years, with at least 98% of its imported strawberries, raspberries, and blackberries being sourced from Mexico. In the Mexican state of Michoacan, agricultural areas have transformed to satisfy the global demand, altering local water and land resource patterns. While previous studies have examined the water resource sustainability of export agriculture, more research is needed to understand how export-oriented agriculture competes with or complements common pool resource systems previously established in production regions. In this study, we combine a national dataset on communal-tenured land (ejidal land) with geospatial agricultural data to quantify the water and land use resource changes of Michoacan – the booming heart of Mexican berries. This study captures the berry boom that occurred in the state between 2010 and 2020 using machine learning algorithms on satellite images, land cover change mapping, and biophysical modelling. It asks to what extent the communal land, with its associated natural resources, has been incorporated into the agro-export crop industry. This study adds to the existing commons literature by assessing local land use and resource use change within an increasingly globalized world.

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AGU Fall Meeting 2021

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NSF GRFP NSF GRADUATE RESEARCH FELLOWSHIP PROGRAM

IIS Institute of International Studies University of California, Berkeley

INFEWS

Outline

1. Background on Mexican Land Rights and Berries
2. Research Question
3. Remote Sensing Methods
4. Results
5. Conclusion

Collaborators

Universidad de Guanajuato

WAGENINGEN UNIVERSITY & RESEARCH

Background:

Mexican land rights and berries

Ejidos: Mexico's Common Lands

Cultural Concept

- Common Pool Resources: cultural and natural resources sustainably held and self-governed by a community. (Ostrom, 1990)
- Concept of communal property existed in prehispanic times.
- *'Ejido'* was introduced by the Spanish to represent the land endowments for towns. (INEGI, 2007)

How They Work

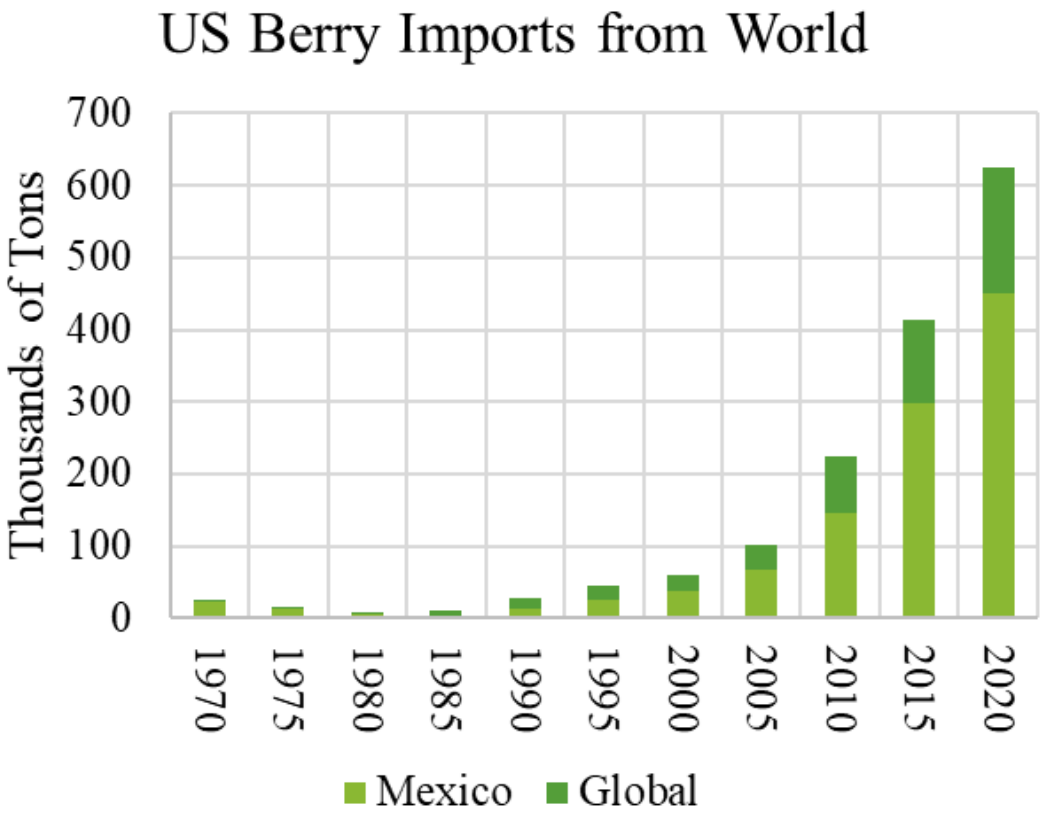
- 3 categories: common use, parcel, and residential.
- Common use lands are owned and managed collectively by multiple *ejiditarios*.
- Parcels can be owned by individual *ejiditarios*. (RAN, 2021)
- Ejidal land tenure covers **over half of Mexico's lands.** (Morett-Sanchez, 2017)

Legal History

1917: Article 27 of the Mexican Constitution specified the principles that govern the ejido.

1980-90s: Market-oriented reforms: agricultural policies that promote export crops; PROCEDE and other reforms allow for privatization (Hoogesteger, 2018; Morett-Sanchez, 2017).

Market Transformation



In 2020…

23% of blueberries

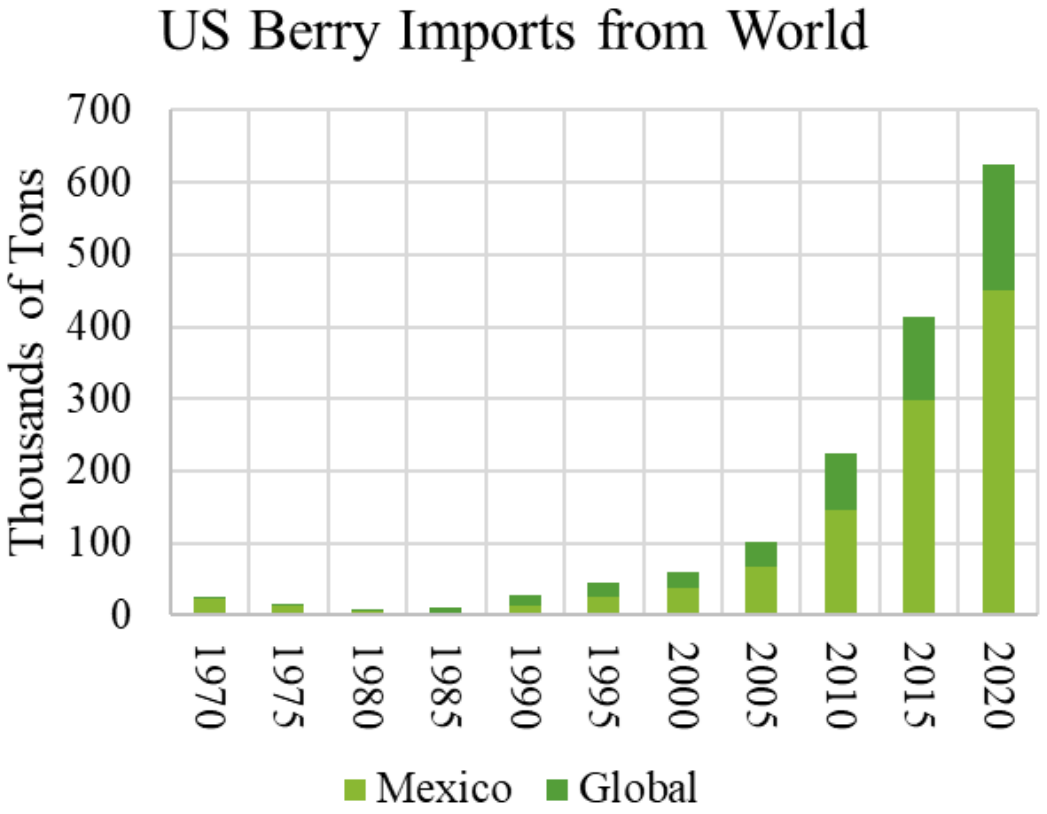
98% of blackberries

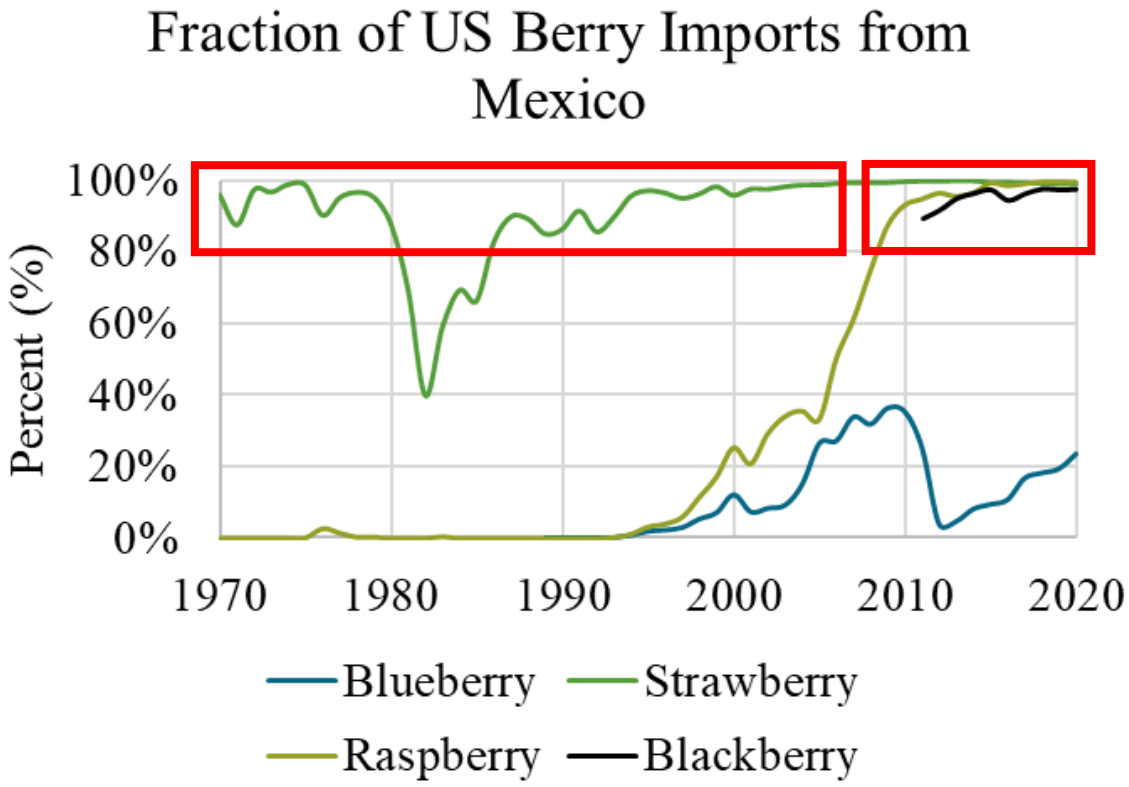
99% of strawberries

99% of raspberries

that the U.S. imported were from Mexico.

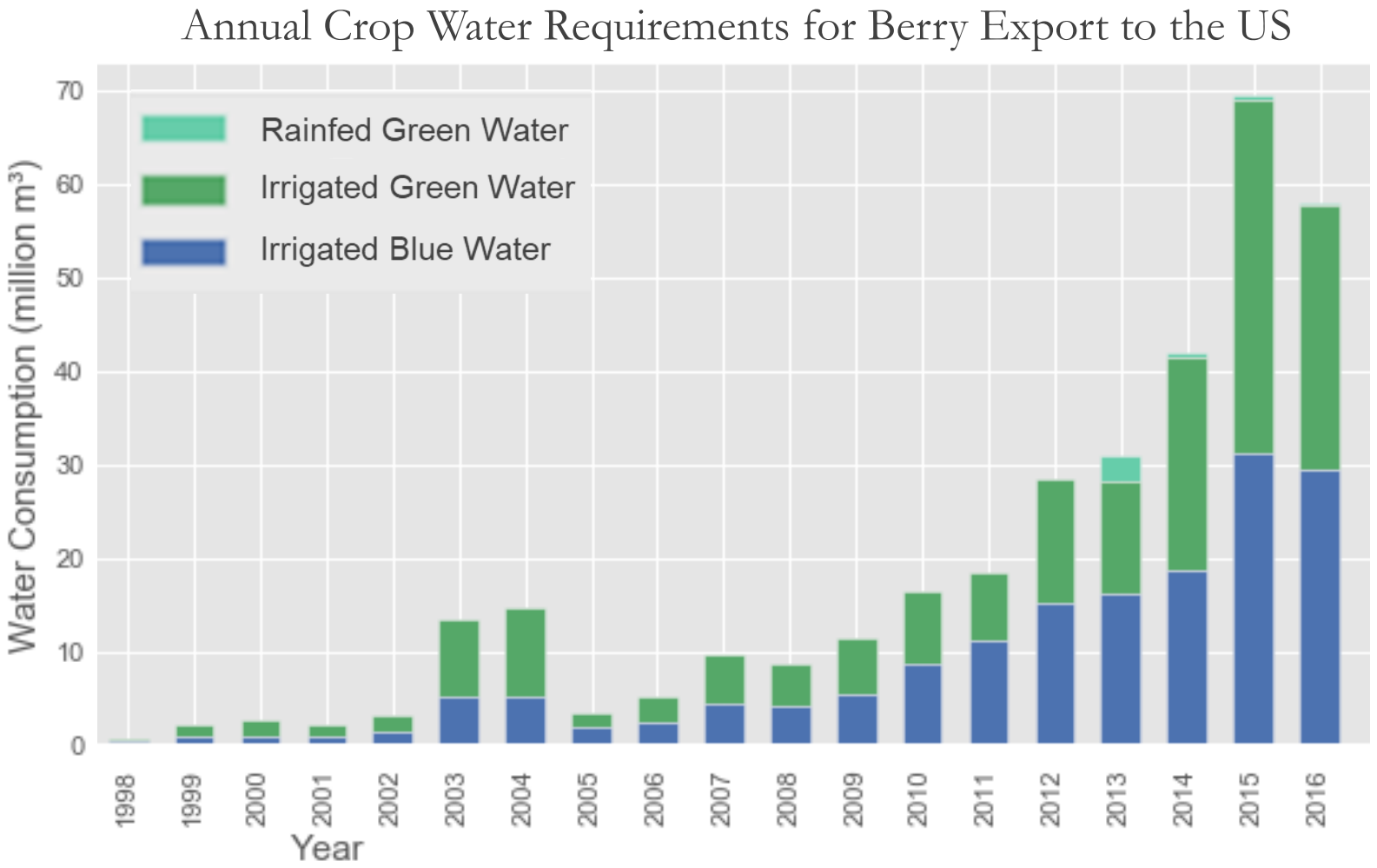
Data from USDA FAS GATS, 2021.





rapid market integration

Data from USDA FAS GATS, 2021.

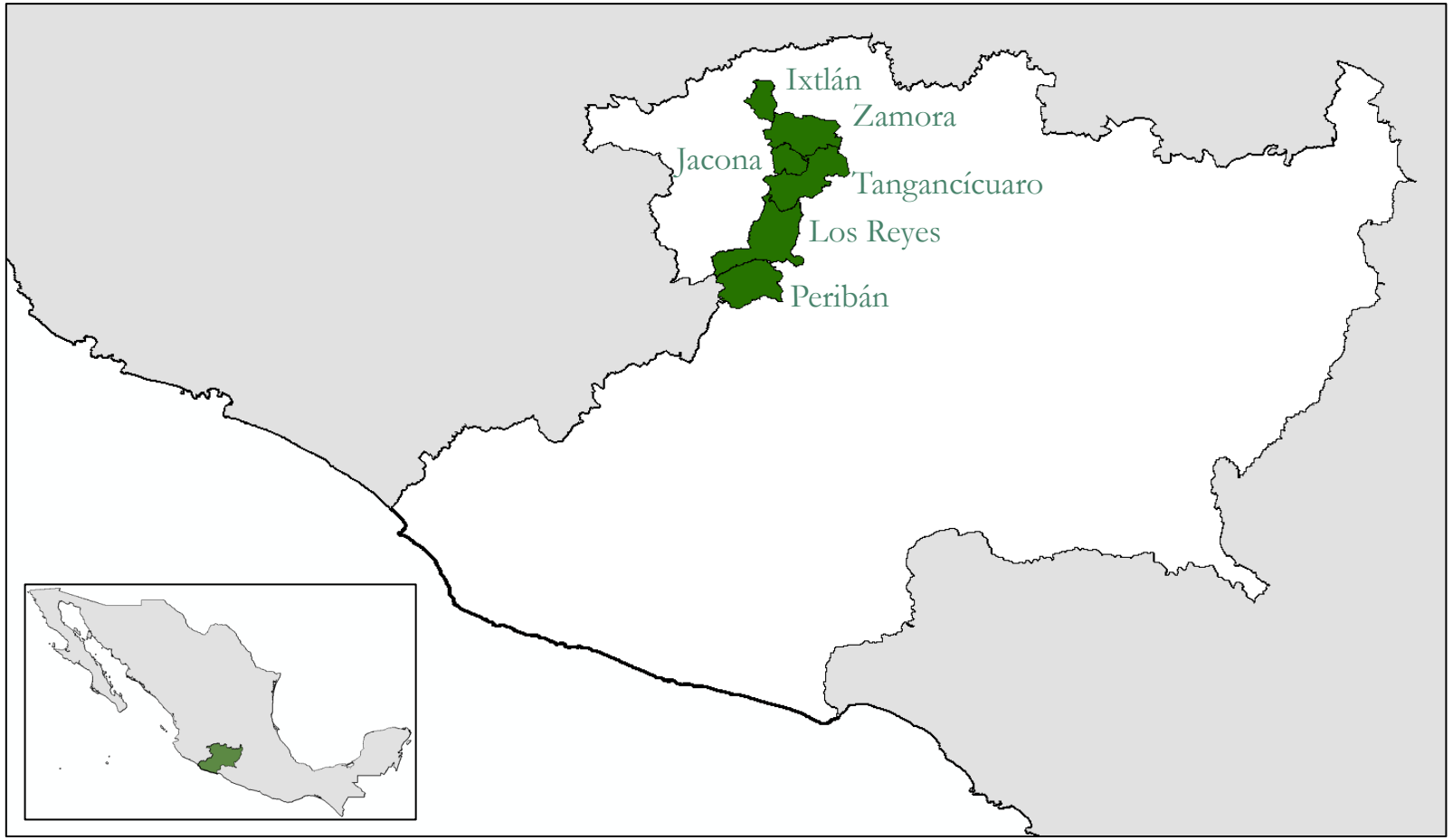


In 2015, 3/5 of Mexico's domestic irrigated berry water consumption was used for exports to the US.

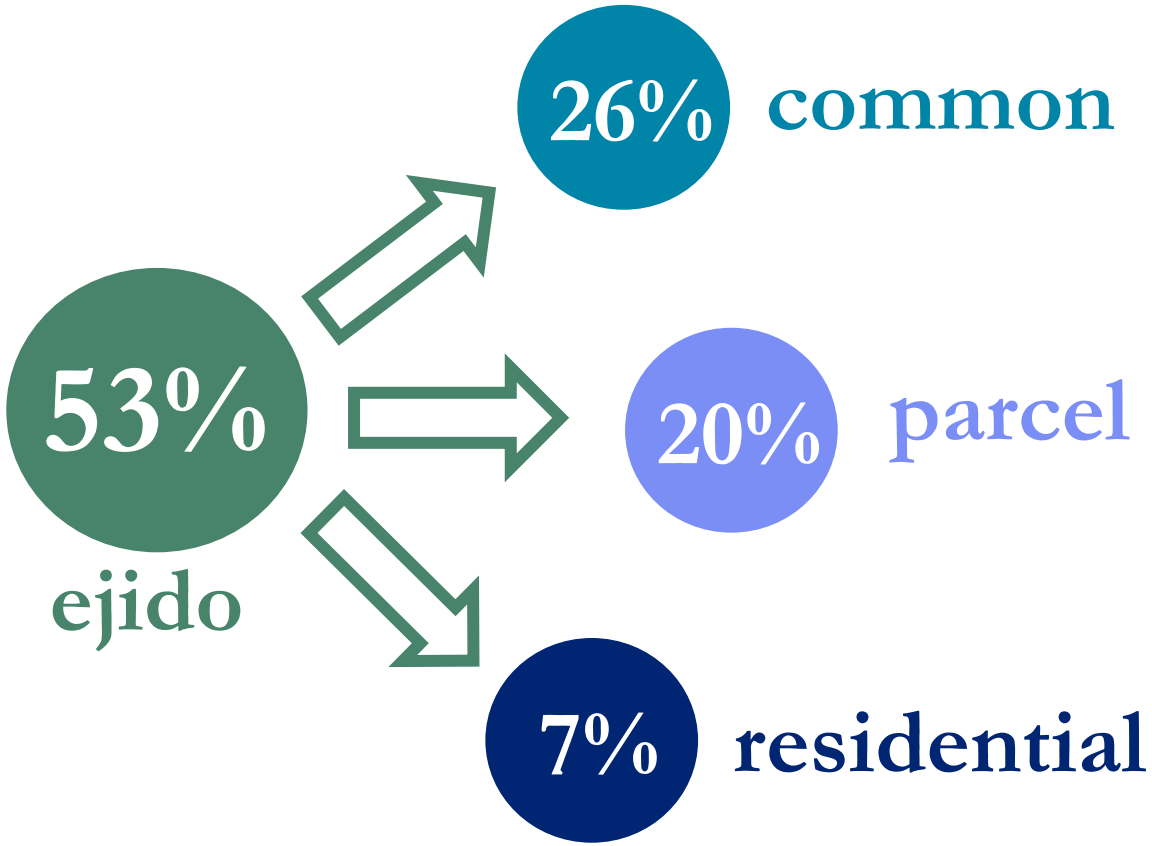
Hartman et al., *Environmental Research Letters*, 2021.

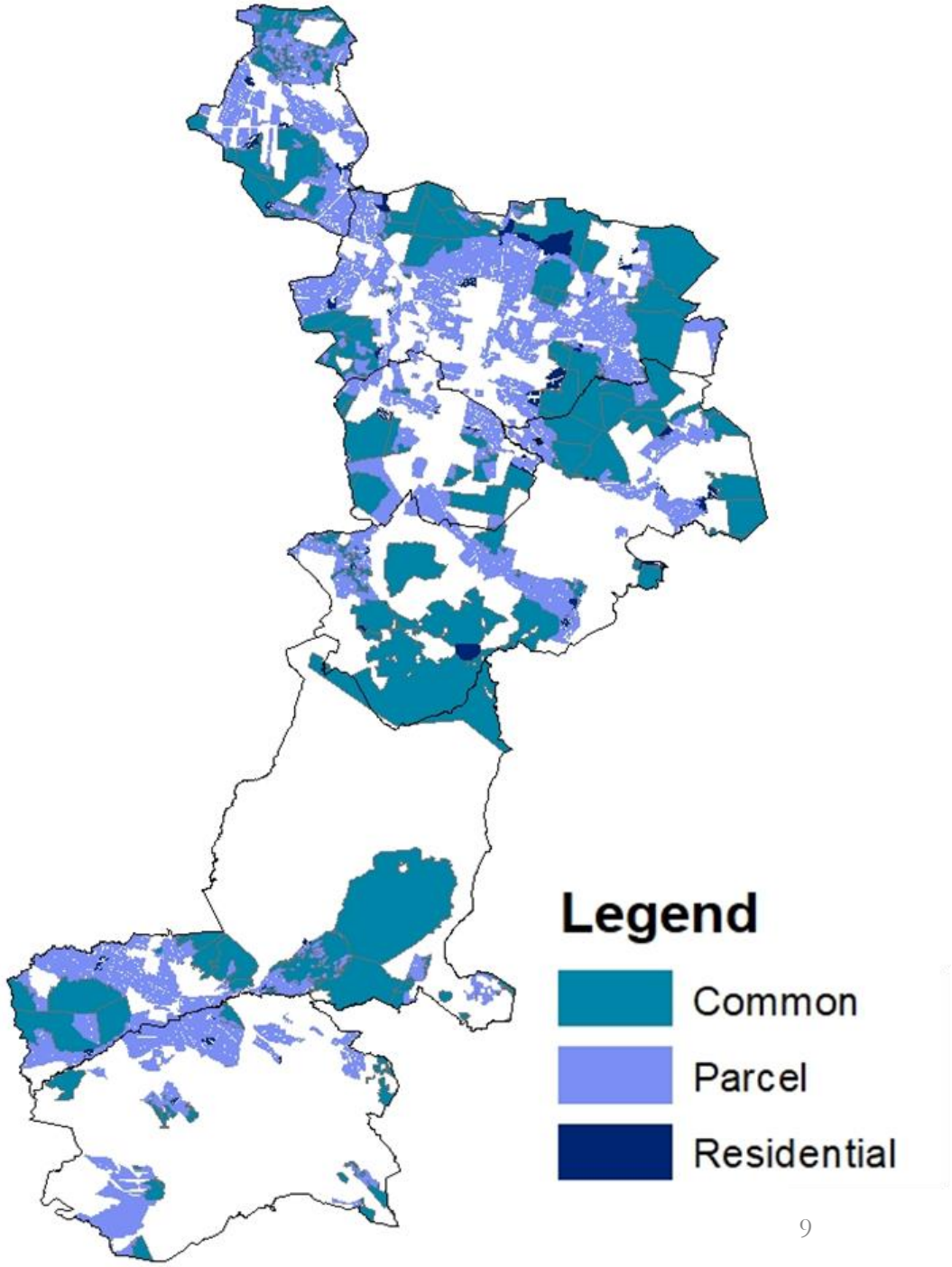
Study Site

Six Municipalities: Ixtlán, Jacona, Los Reyes, Peribán, Tangancícuaro, and Zamora



Ejidal Land by Use

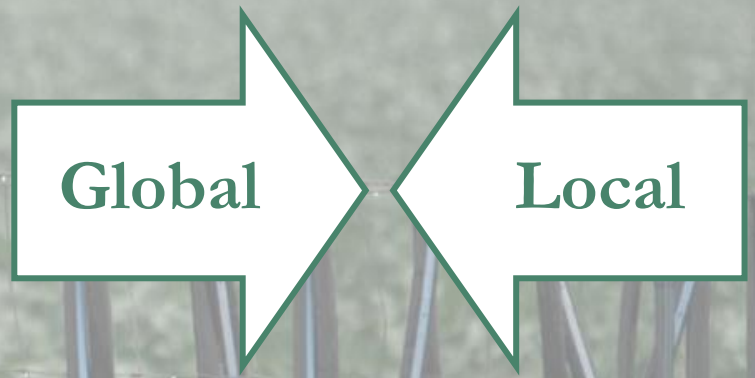




Data from Registro Agrario Nacional, 2021.

Research Question

1. How can remote sensing show the long-term agricultural change for berries?
2. To what extent are commons integrated into the export-oriented Berry Boom?
    1. Ejidal resources incorporated into the global market
    2. Technology revolution

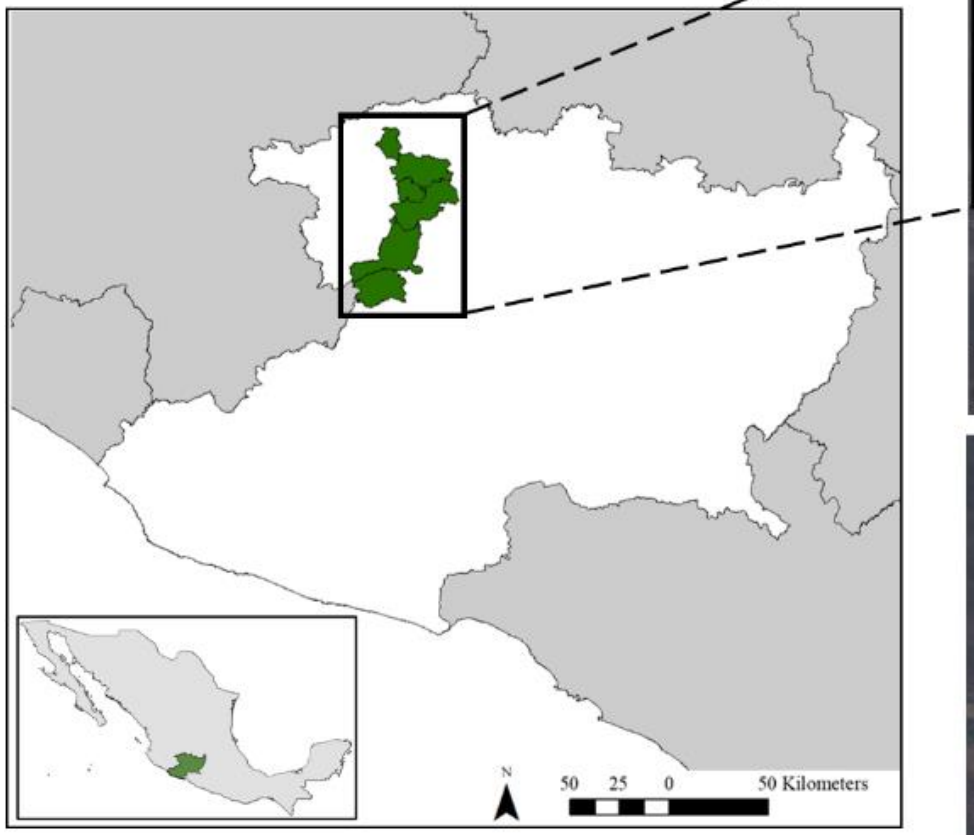


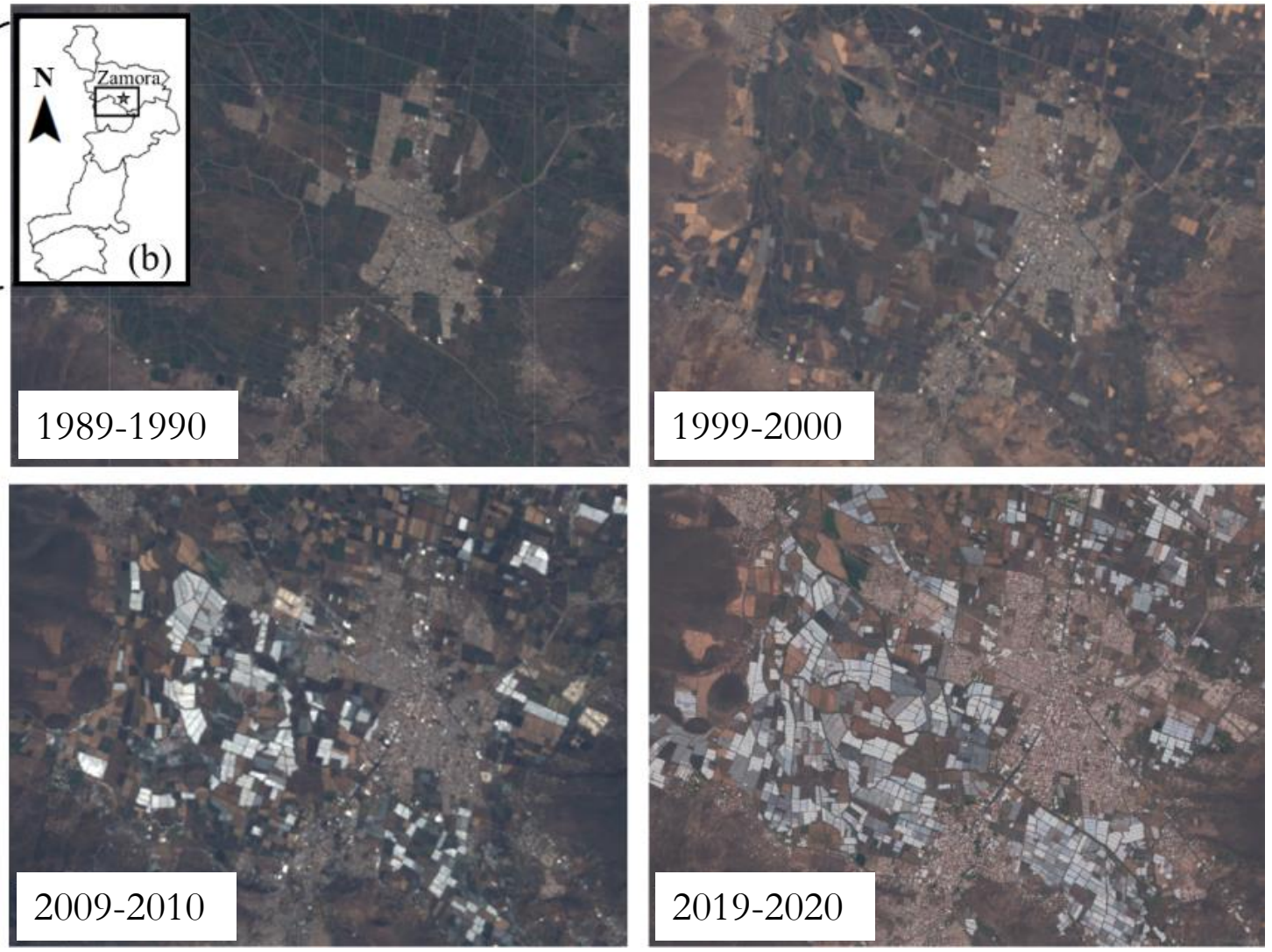
Technology Revolution

Open Air		Protected Agriculture
Rainfed	⇨	Irrigated
River Water		Groundwater &/or Water Treatment
Non-Drip Irrigation		Drip Irrigation

Remote Sensing Methods

Mapping berries using satellite imagery



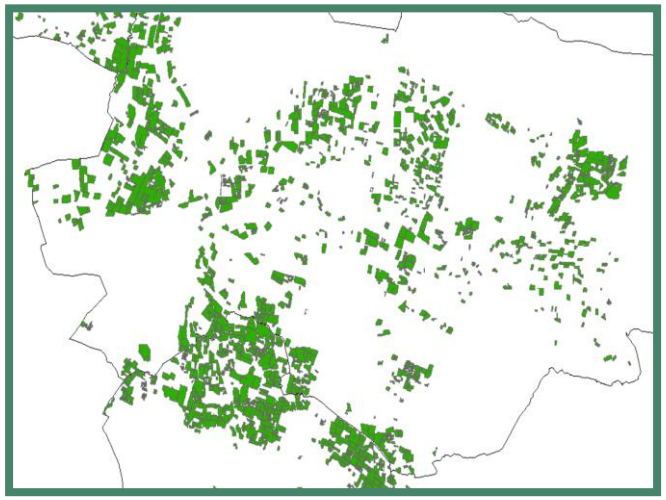


Landsat 5 (1989-2010) and Sentinel 2 (2019-2020) imagery: 90th percentile annual composites.

Methods

+

Google Earth Engine



Landsat 5 (1989 – 2010)
Sentinel 2 (2015 – present)

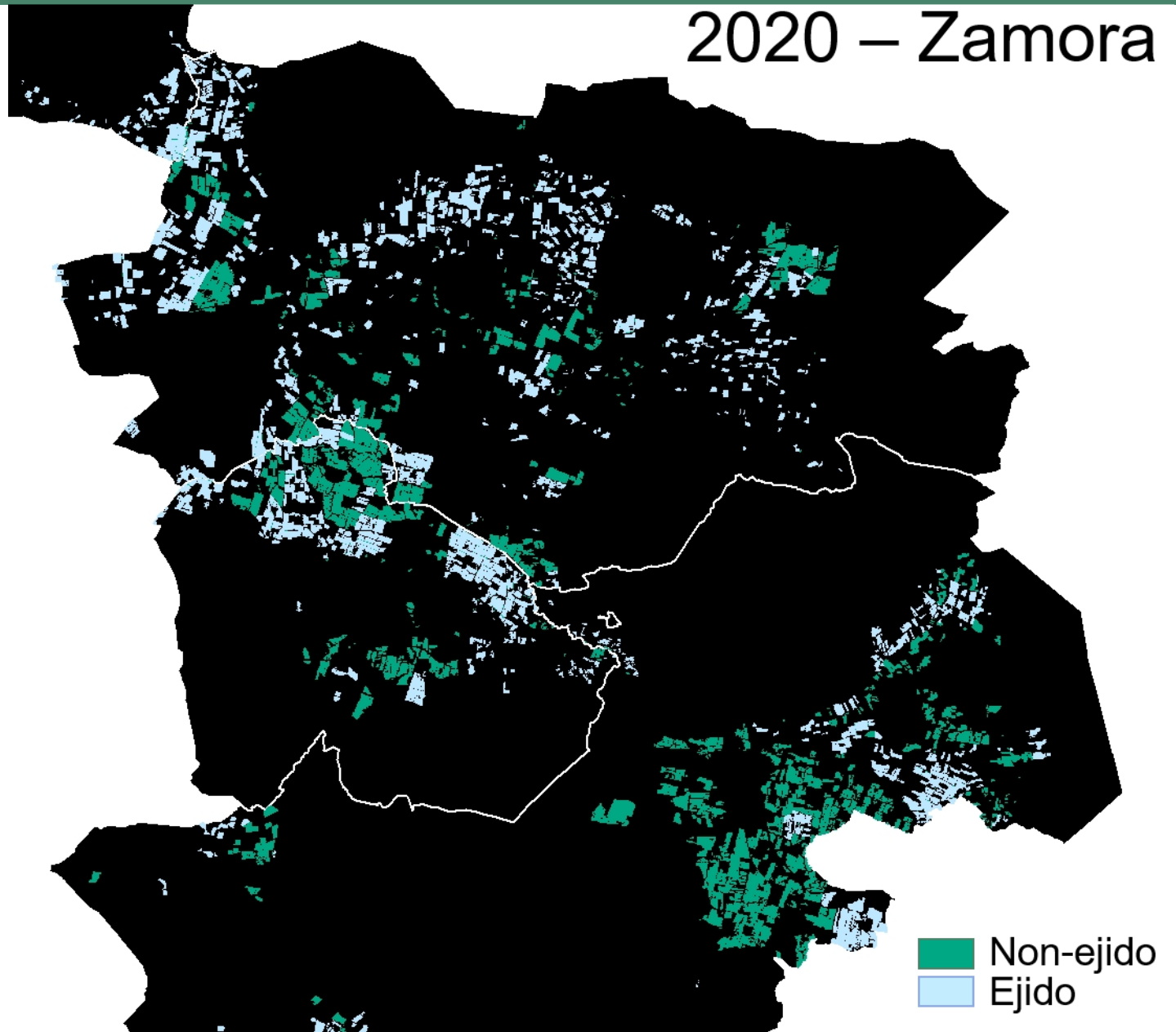
1. **Select:** Cloudy Pixel Percentage < 20%
2. **Compute:** 90th Percentile Image Composite
3. **Mask:** Water, Plastic Greenhouse Index
4. **Classify:** Support Vector Machine Learning
5. **Train:** stratified random sampling of 6000 points
6. **Test:** 3:2 sample split for accuracy assessment
7. **Overall Accuracy:** > 94%

Classified maps for 1989, 1999, 2009, 2015, 2016, 2017, 2018, 2019, and 2020

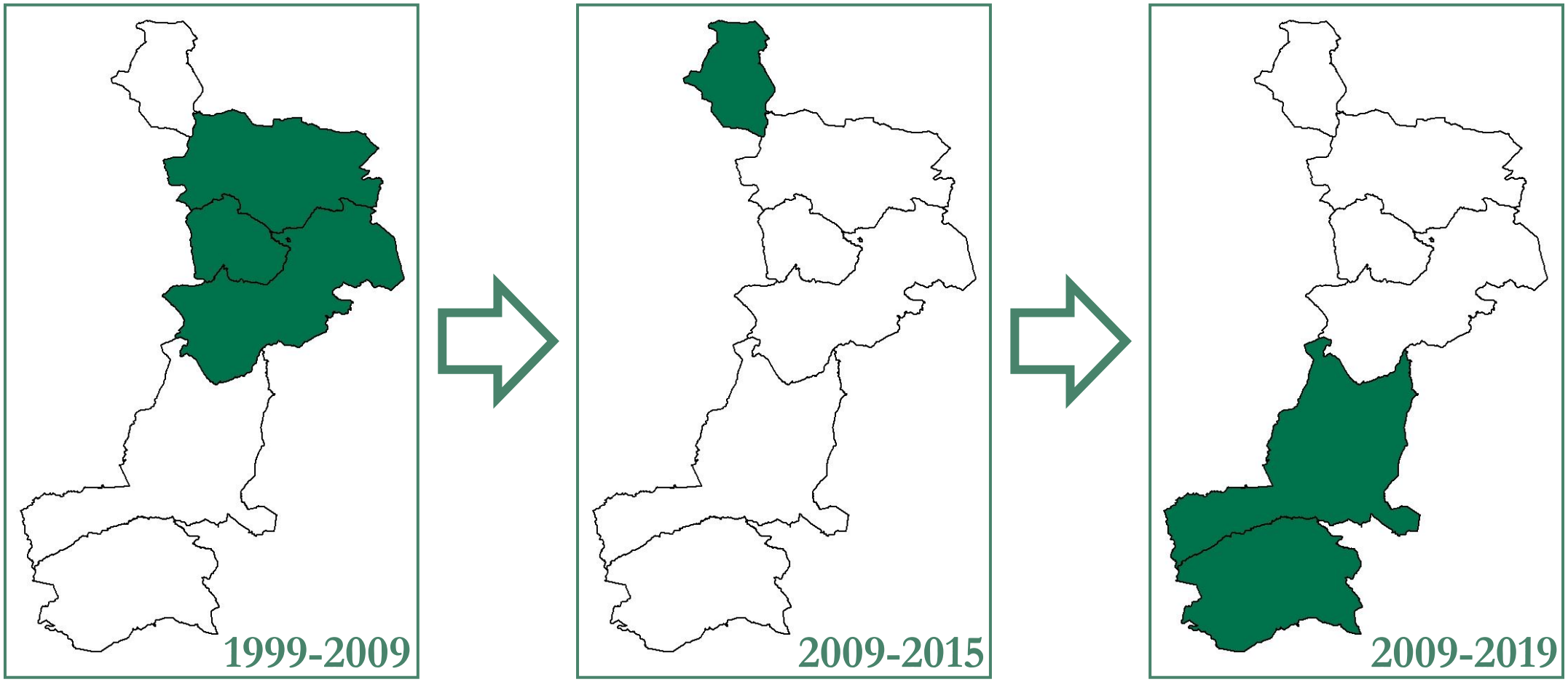
Maximum extent map

Results

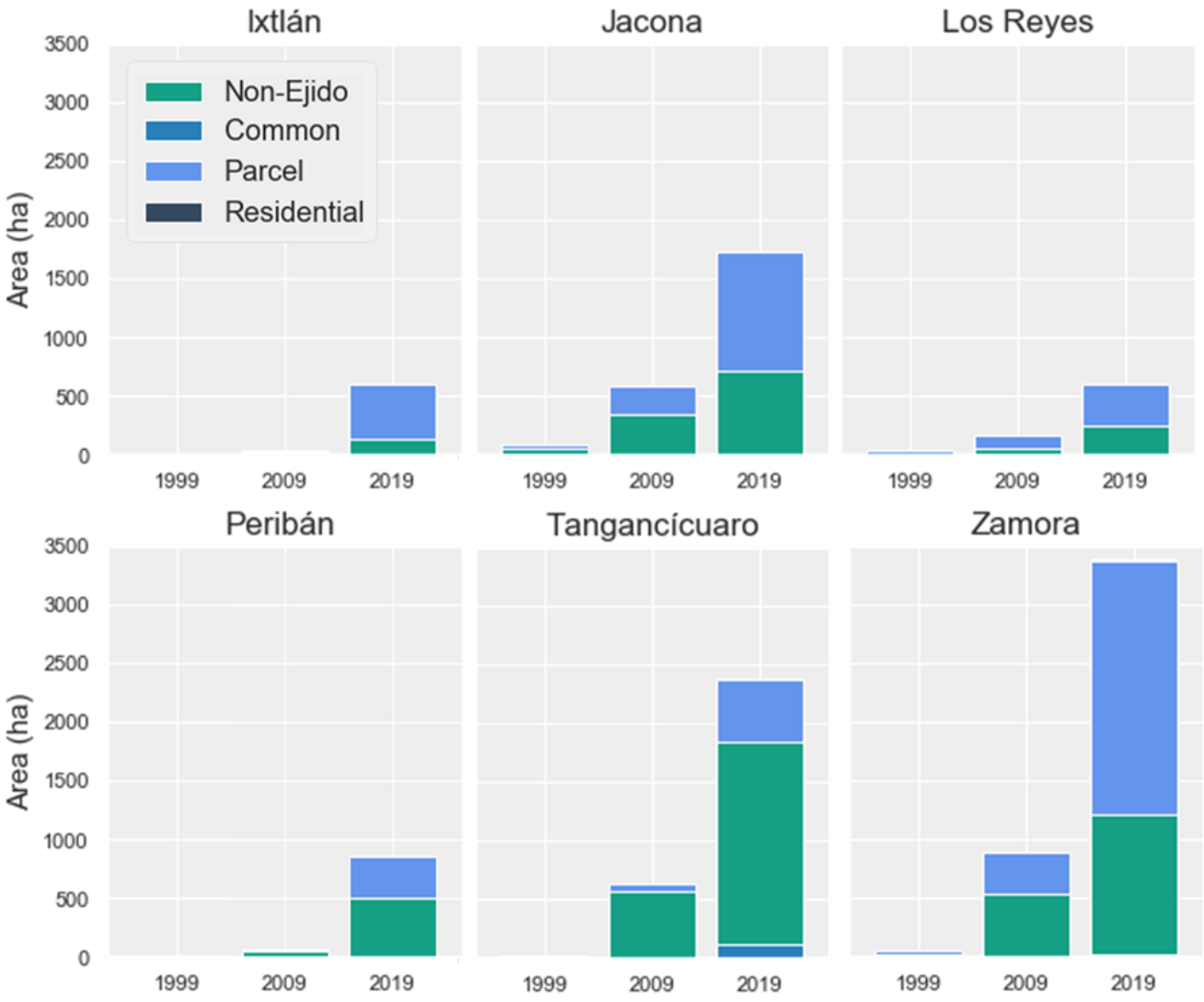
Annual Maps



Annual Maps



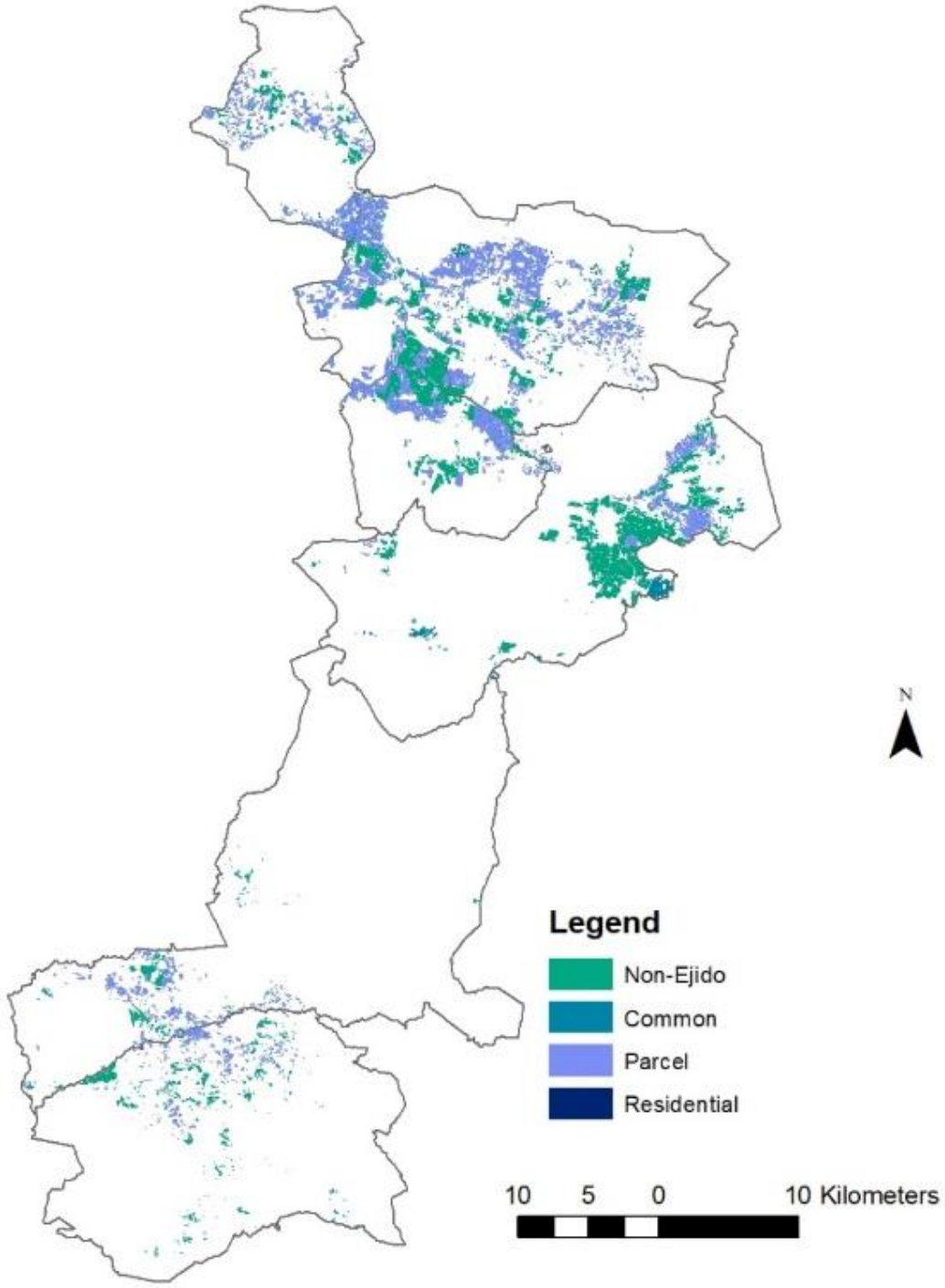
Annual Maps



Harvest season protected agriculture (hectares) extent by land tenure.

Area (hectares)	Total	Non-Ejido	Parcel	Residential	Common Use
1989	-	-	-	-	-
1999	189.2	86.7	102.5	-	-
2009	2389.9	1573.1	816.7	-	-
2019	9526.2	4464.8	4895.9	7.6	157.9

Maximum Extent

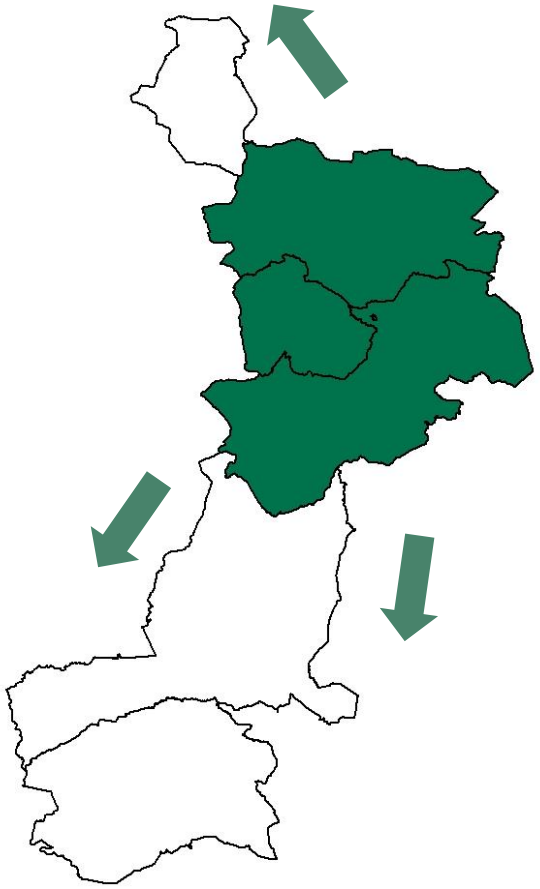


Area of study site municipalities and area of detected protected agriculture (PA) by land tenure.

Area (hectares)	Ixtlán	Jacona	Los Reyes	Peribán	Tangancícuaro	Zamora	Total
Total Municipality	12,403.4	11,883.8	48,142.6	33,212.7	38,563.0	33,545.1	177,750.60
Total PA	1,767.3	2,804.0	1,223.8	1,466.5	4,474.2	7,834.7	19,570.5
Parcel	1,269.0	1,523.0	764.5	592.9	1,080.1	5,151.3	10,380.8
Common Use	9.0	2.8	11.4	4.9	307.6	114.6	450.3
Residential	0.3	0.3	1.9	2.4	7.9	6.1	18.9
Non-ejidal	489.0	1,278.0	446.0	866.3	3,078.6	2,562.7	8,720.6

Non-Ejidal	28%				69%	33%	45%
Ejidal	72%				31%	67%	55%

Conclusions



Q1. How can remote sensing show the long-term agricultural change for berries?

Q2. To what extent are commons integrated into the export-oriented Berry Boom?

- Stringent rules of export-industry have changed the landscape.
- *Ejidal* parcel lands have been used comparably to private lands.
- *Ejidal* common use lands have remained relatively separate.
- The berry industry's spatial expansion follows the classic location theory of Johann Heinrich von Thünen.

Thank you!

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