

# The Irrigation Frontline: Examining Land Use Change and Resource Rights Fueling the Michoacán Berry Boom

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# Outline

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

Collaborators





# 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)

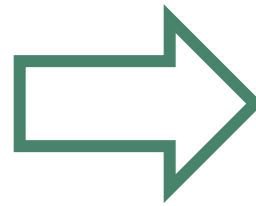
## Legal History

**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

US Berry Imports from World



**In 2020...**

23% of blueberries

98% of blackberries

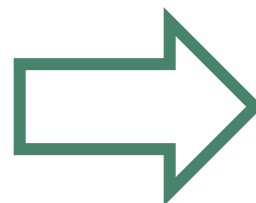
99% of strawberries

99% of raspberries

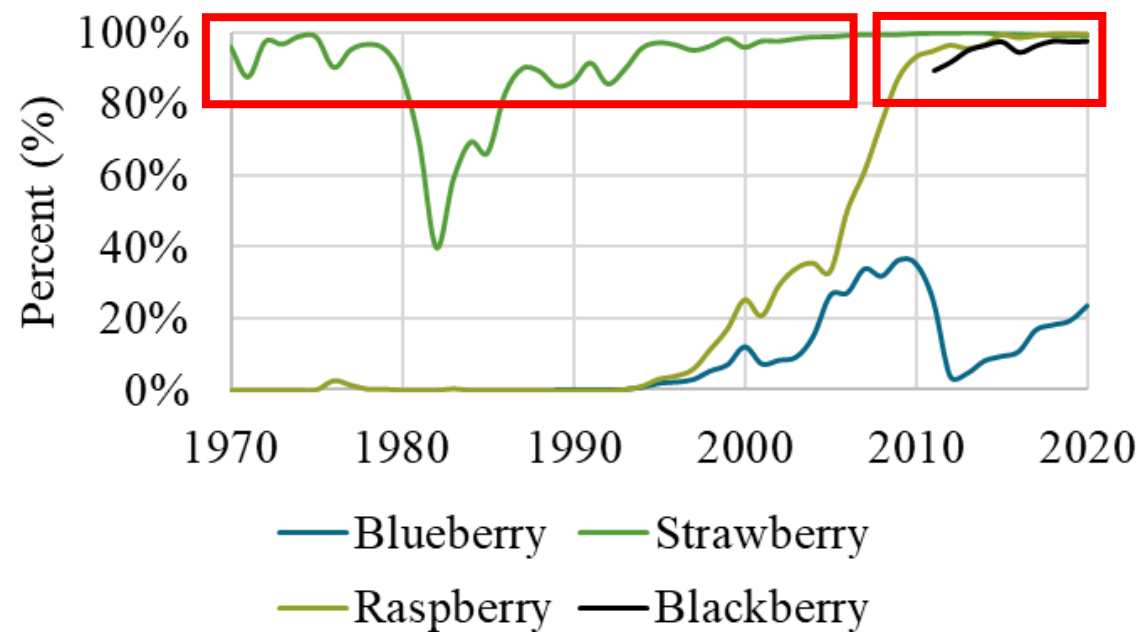
**that the U.S. imported  
were from Mexico.**



# US Berry Imports from World

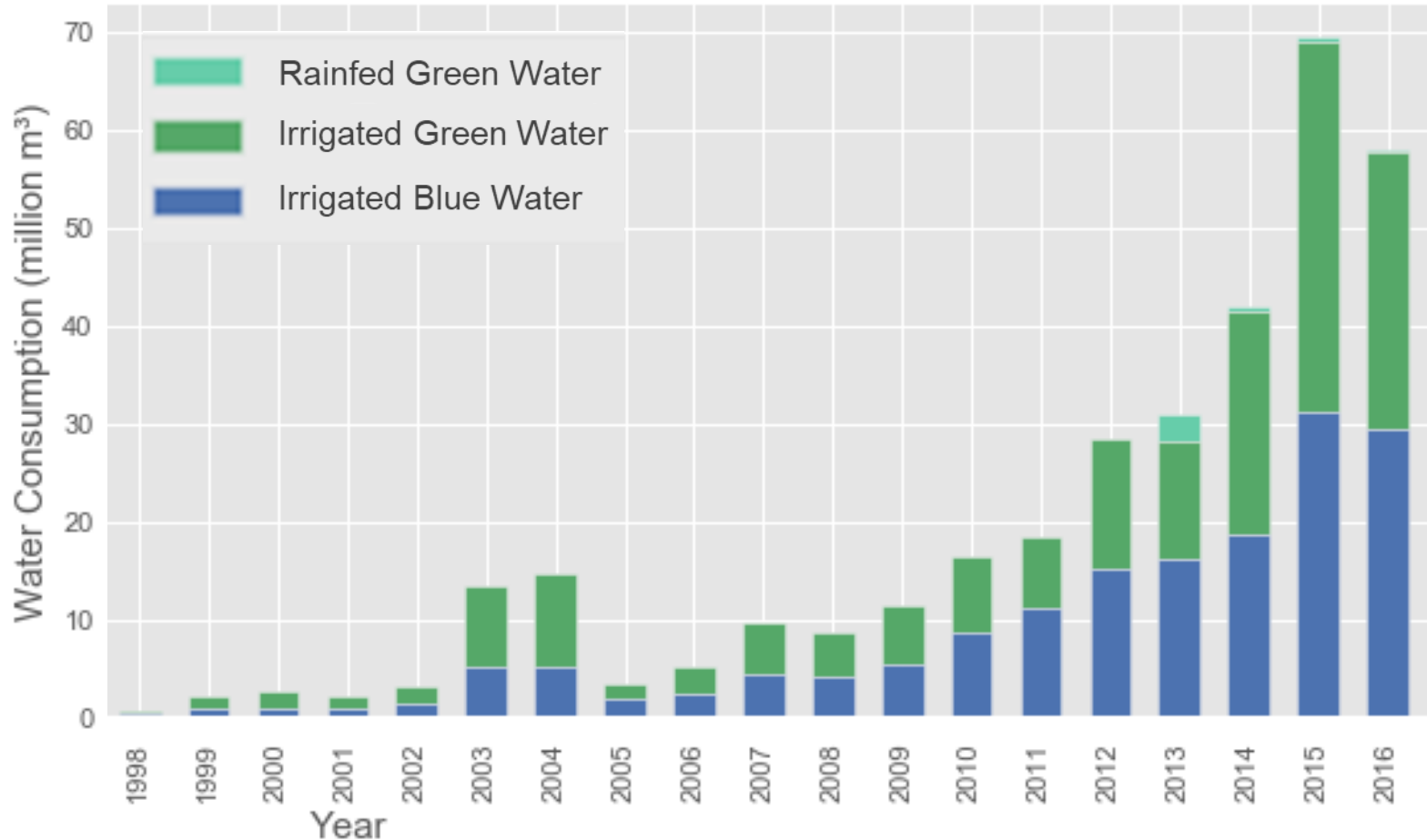


# Fraction of US Berry Imports from Mexico



*rapid market integration*

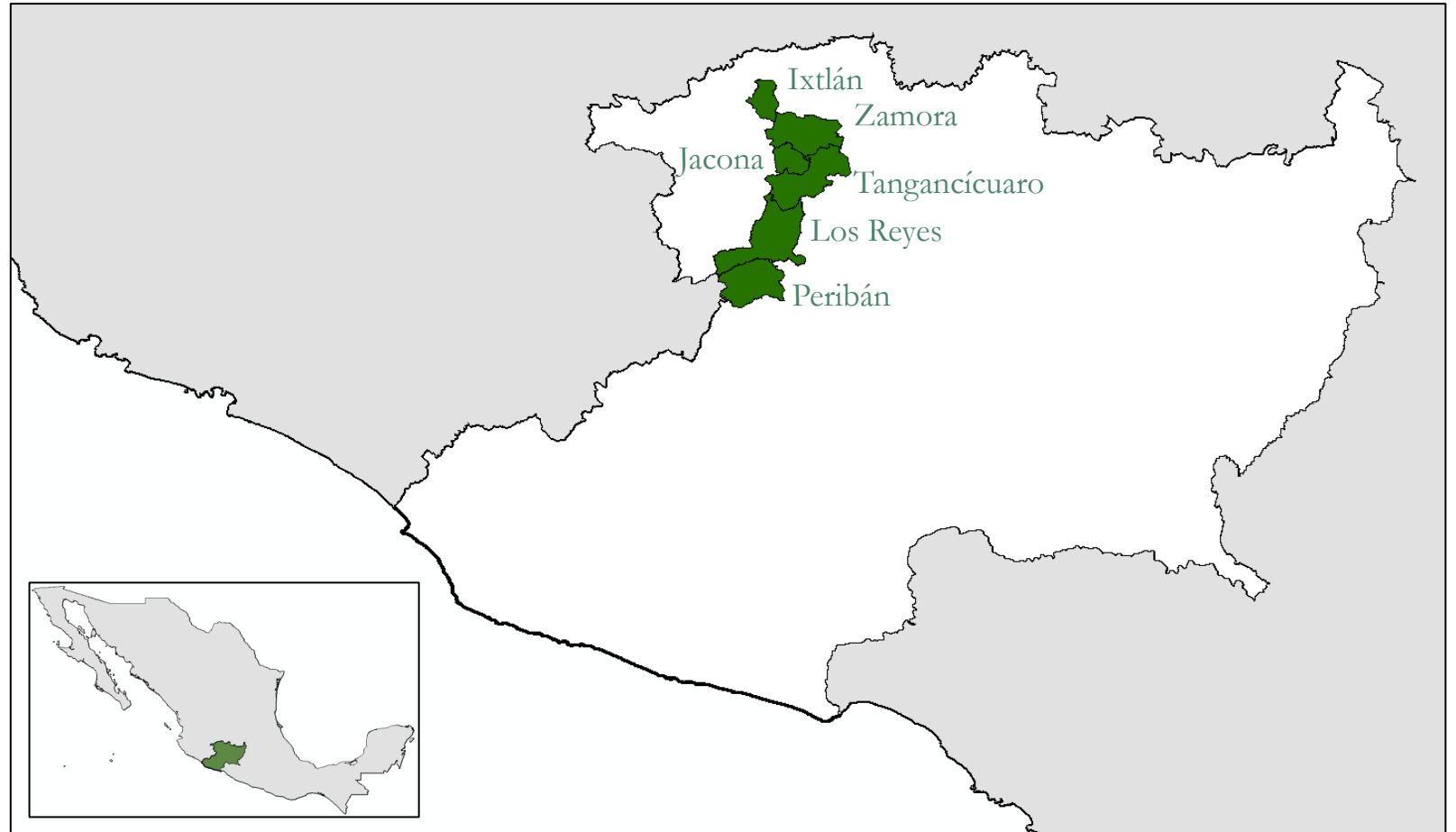
## Annual Crop Water Requirements for Berry Export to the US



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

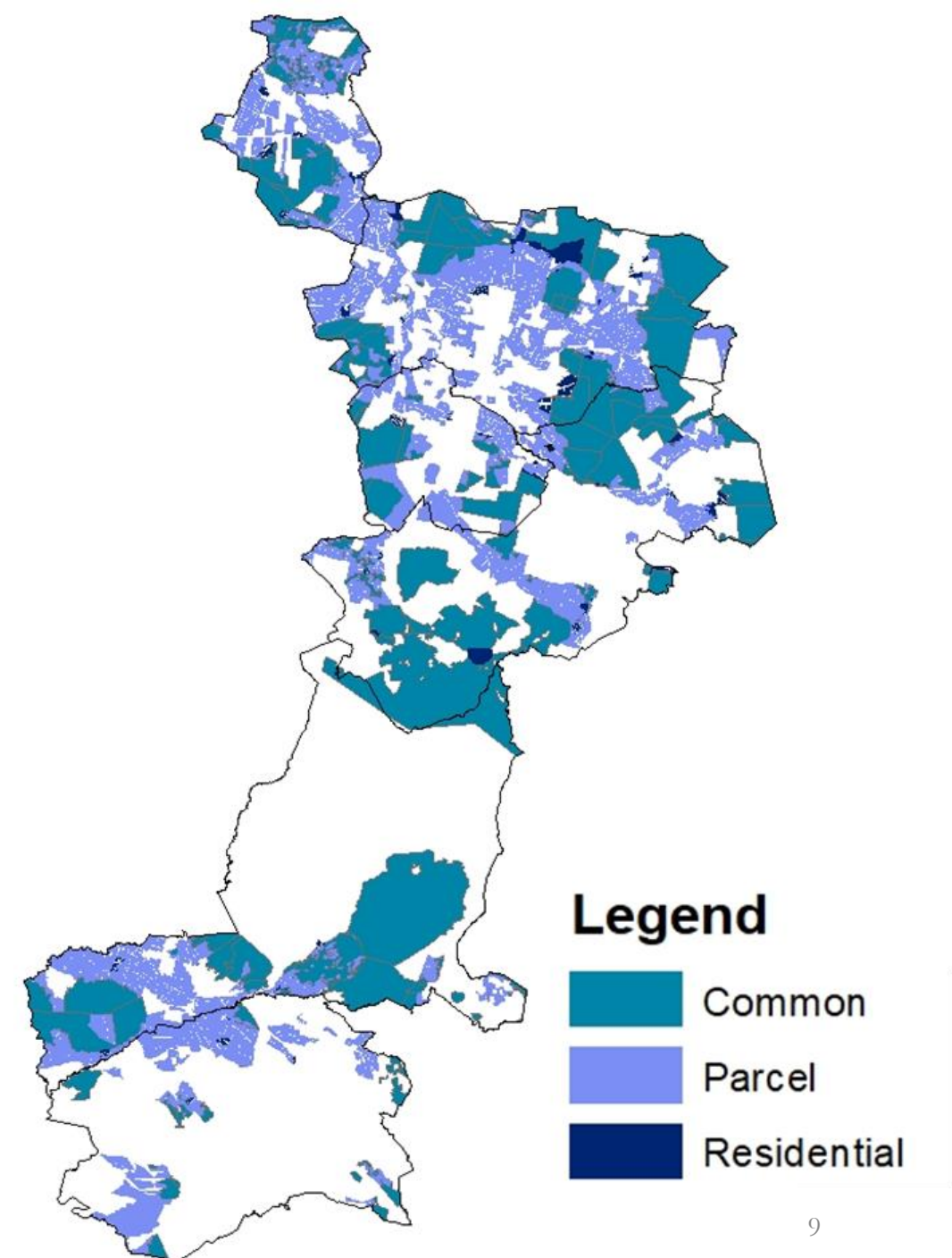
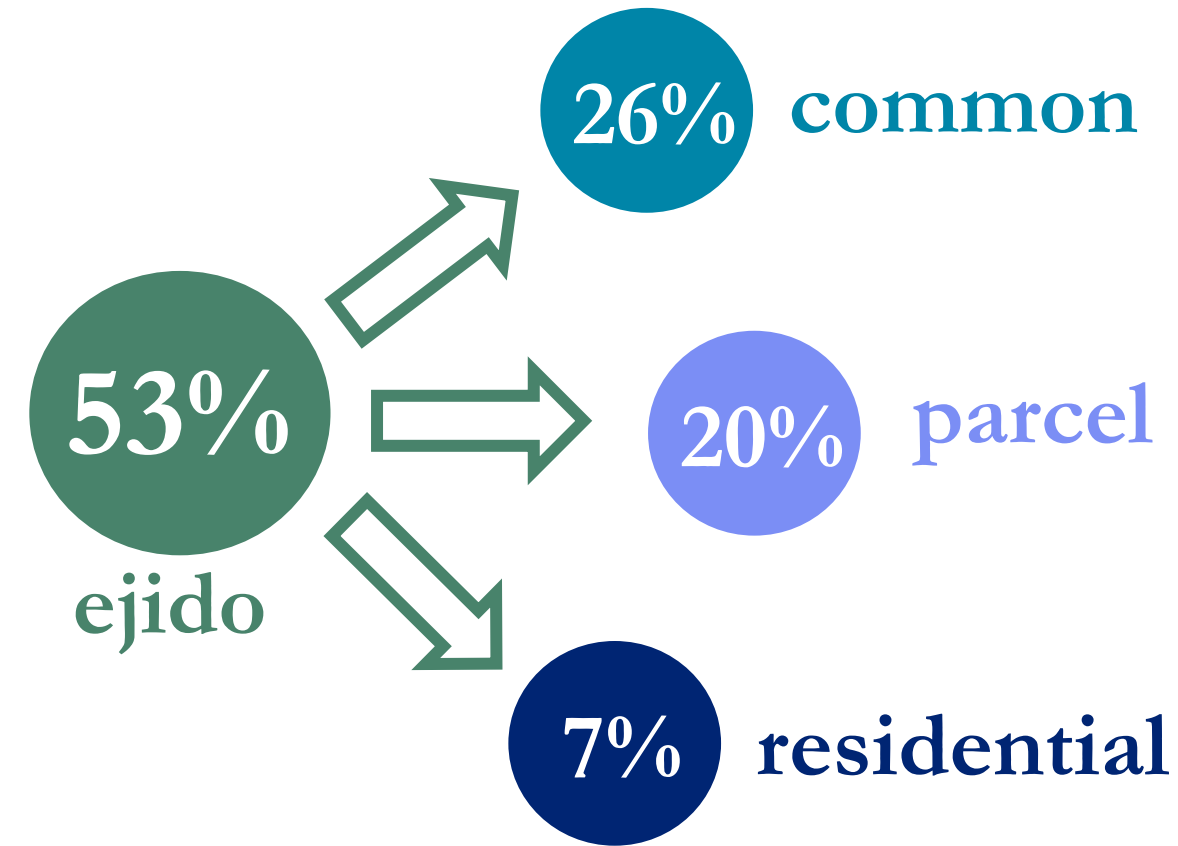
# Study Site

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



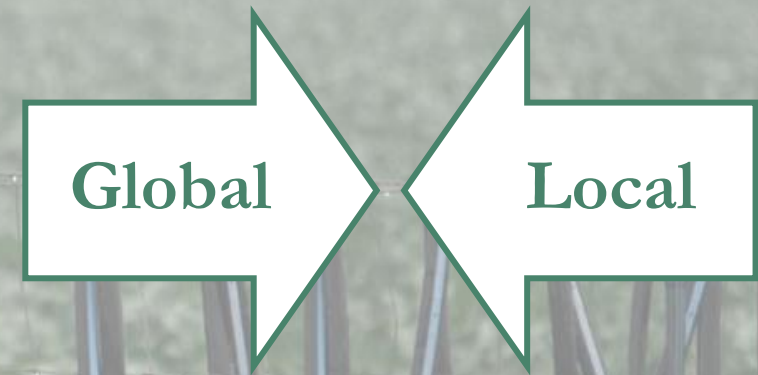


# Ejidal Land by Use



# 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



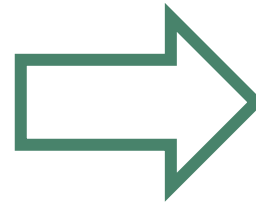


# Technology Revolution

Open Air

Protected Agriculture

Rainfed



Irrigated

River Water

Groundwater &/or  
Water Treatment

Non-Drip Irrigation

Drip Irrigation

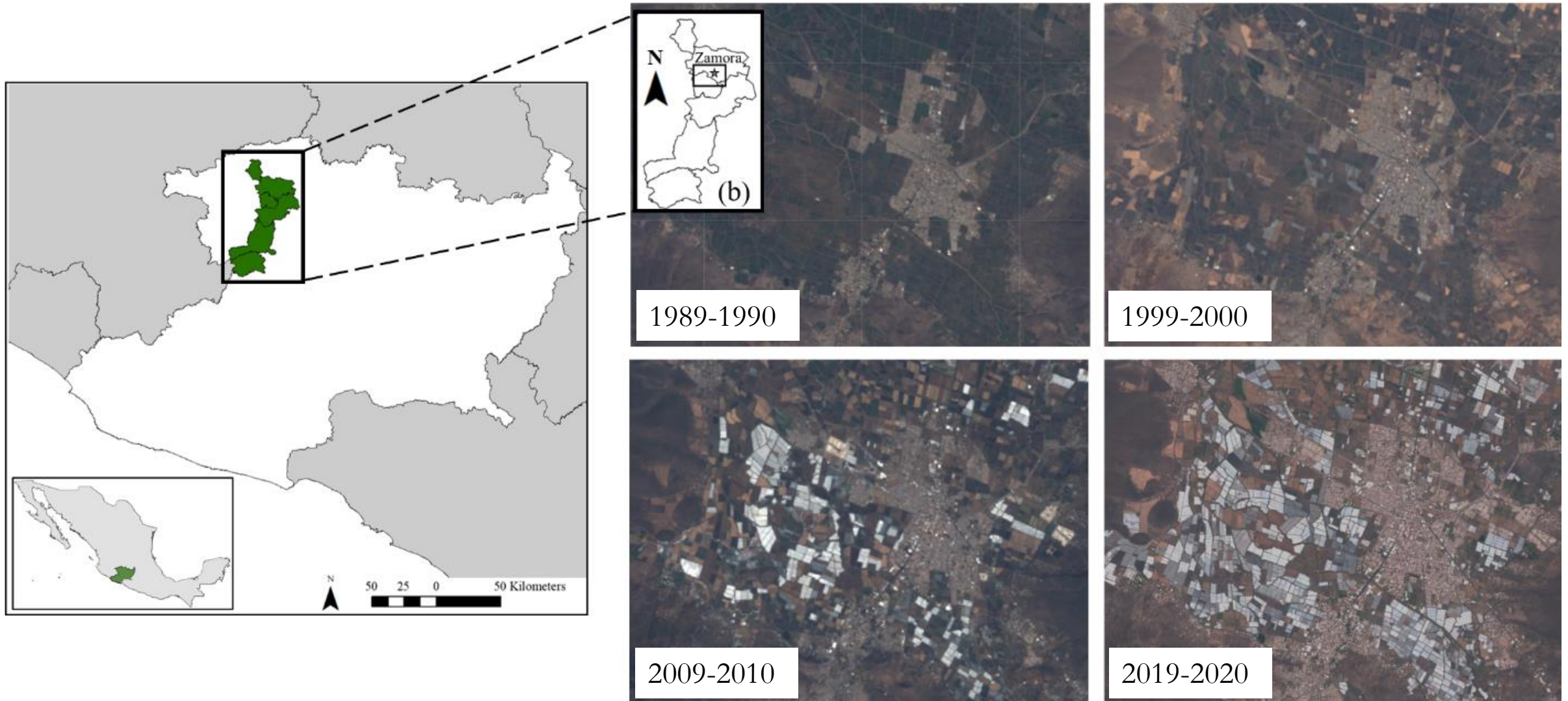




# Remote Sensing Methods



# Mapping berries using satellite imagery

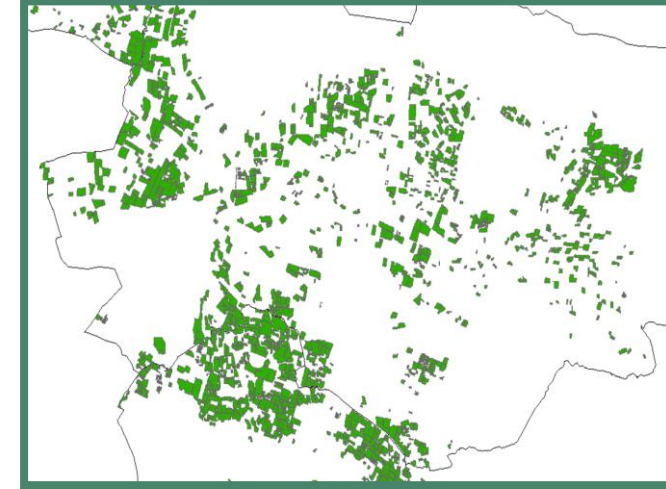
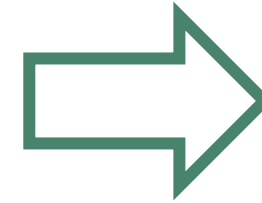


Landsat 5 (1989-2010) and Sentinel 2 (2019-2020) imagery: 90<sup>th</sup> percentile annual composites.

# Methods



+



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

1. **Select:** Cloudy Pixel Percentage < 20%
2. **Compute:** 90<sup>th</sup> 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

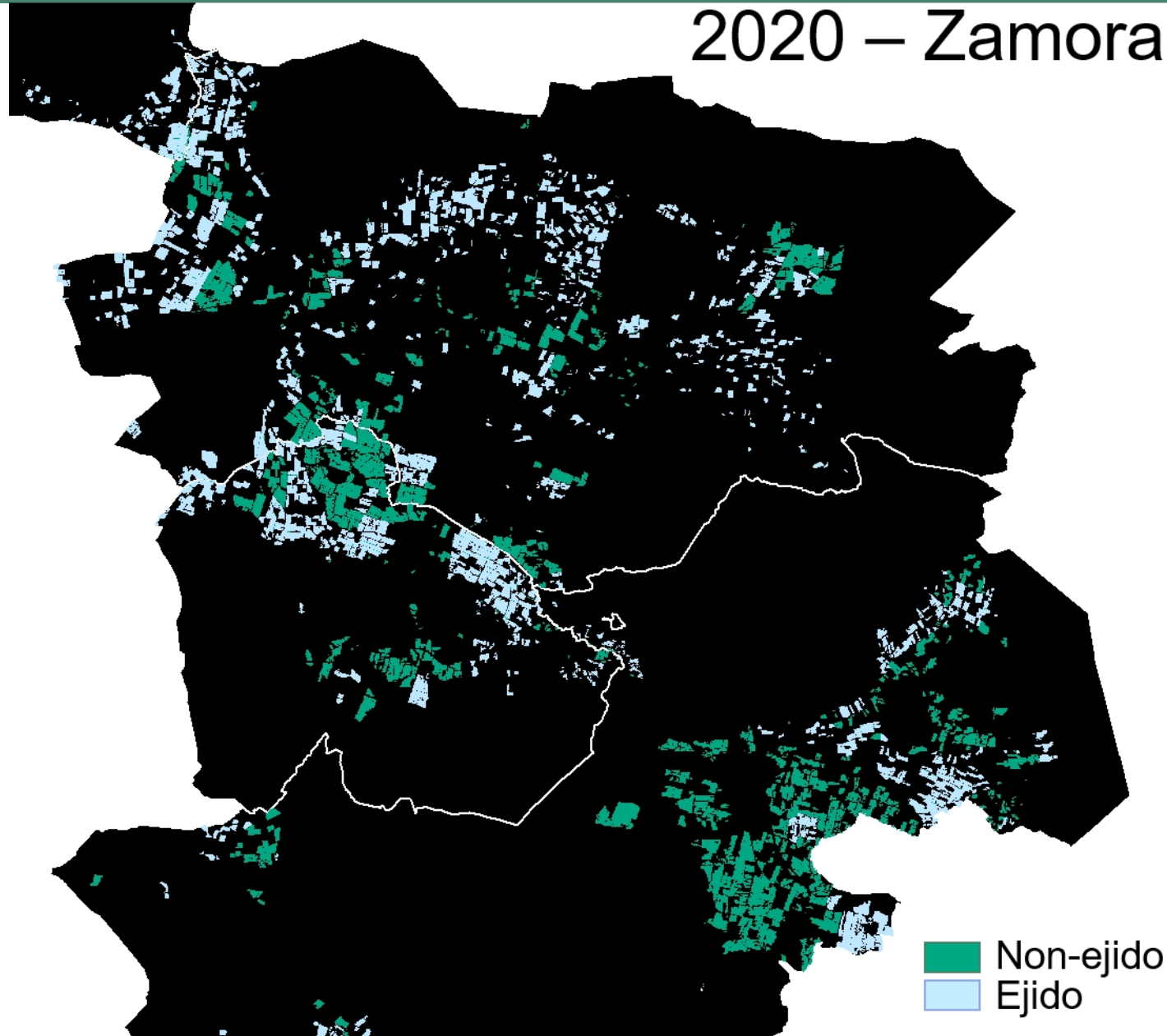




# Results

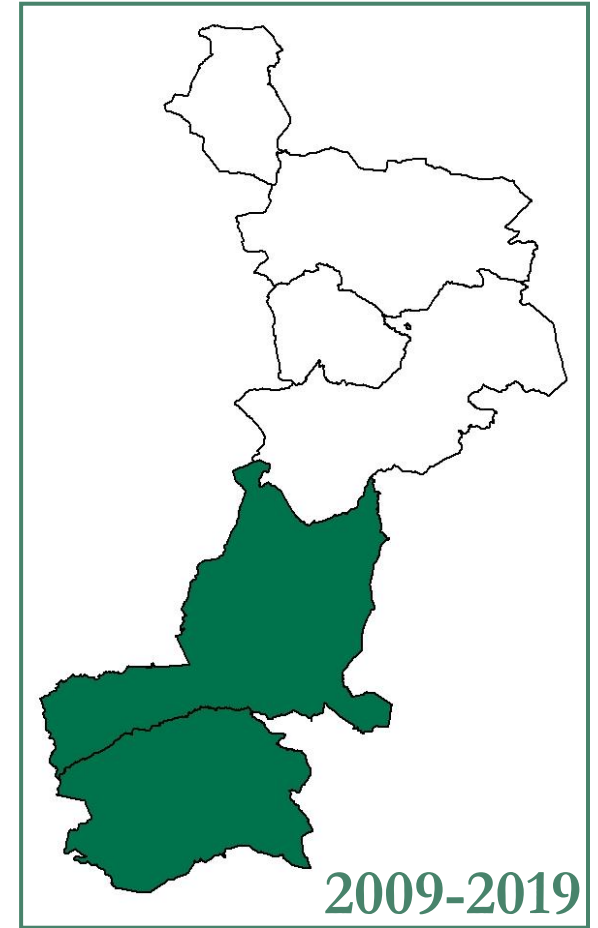
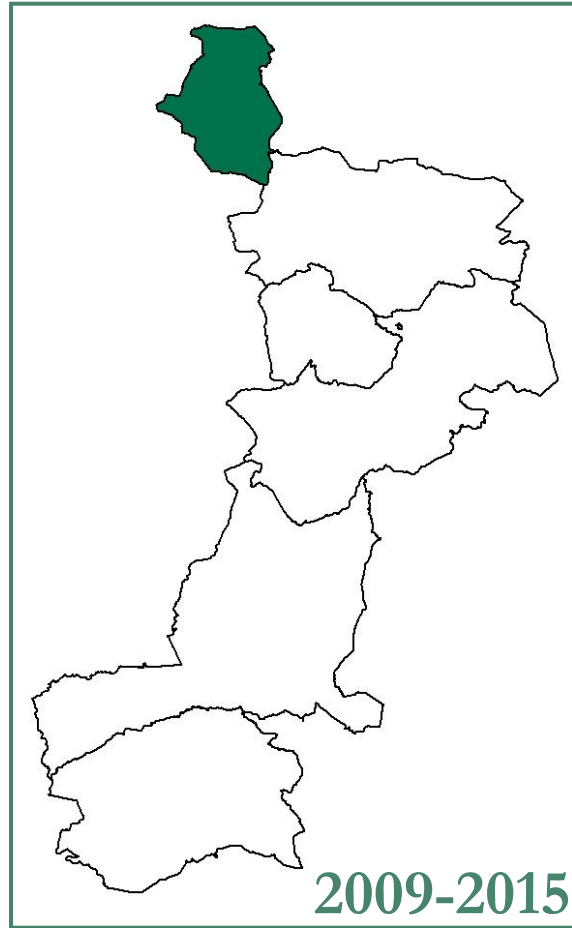
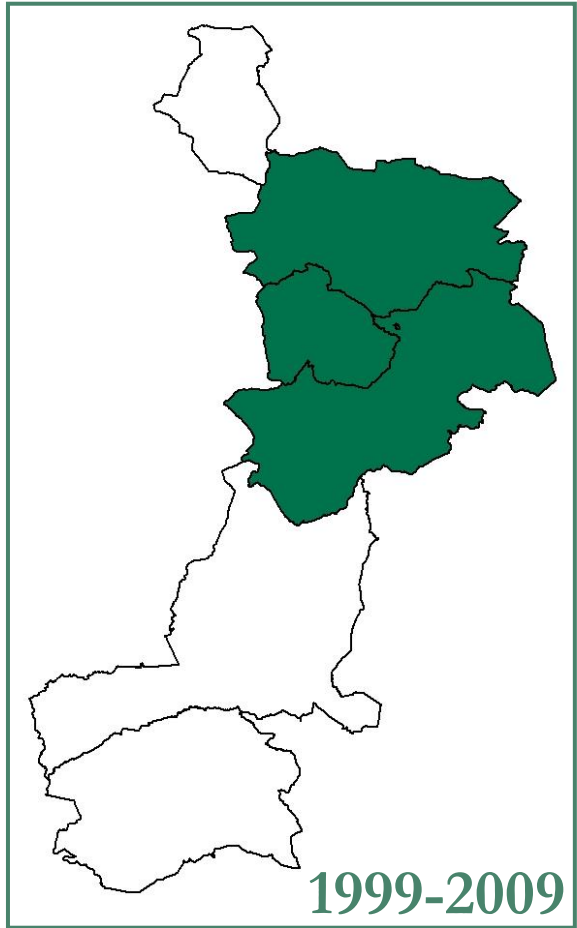
# Annual Maps

2020 – Zamora

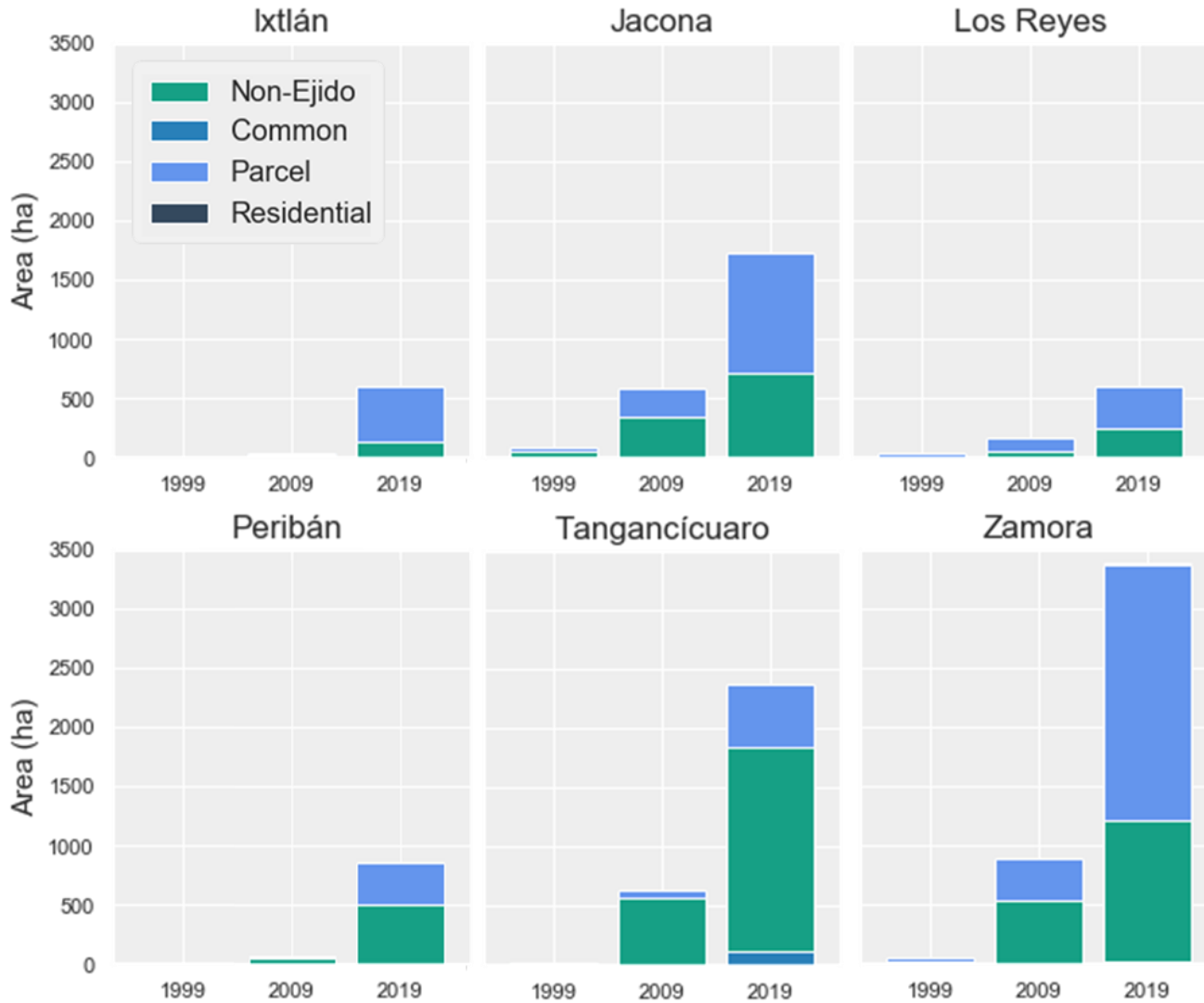




# Annual Maps



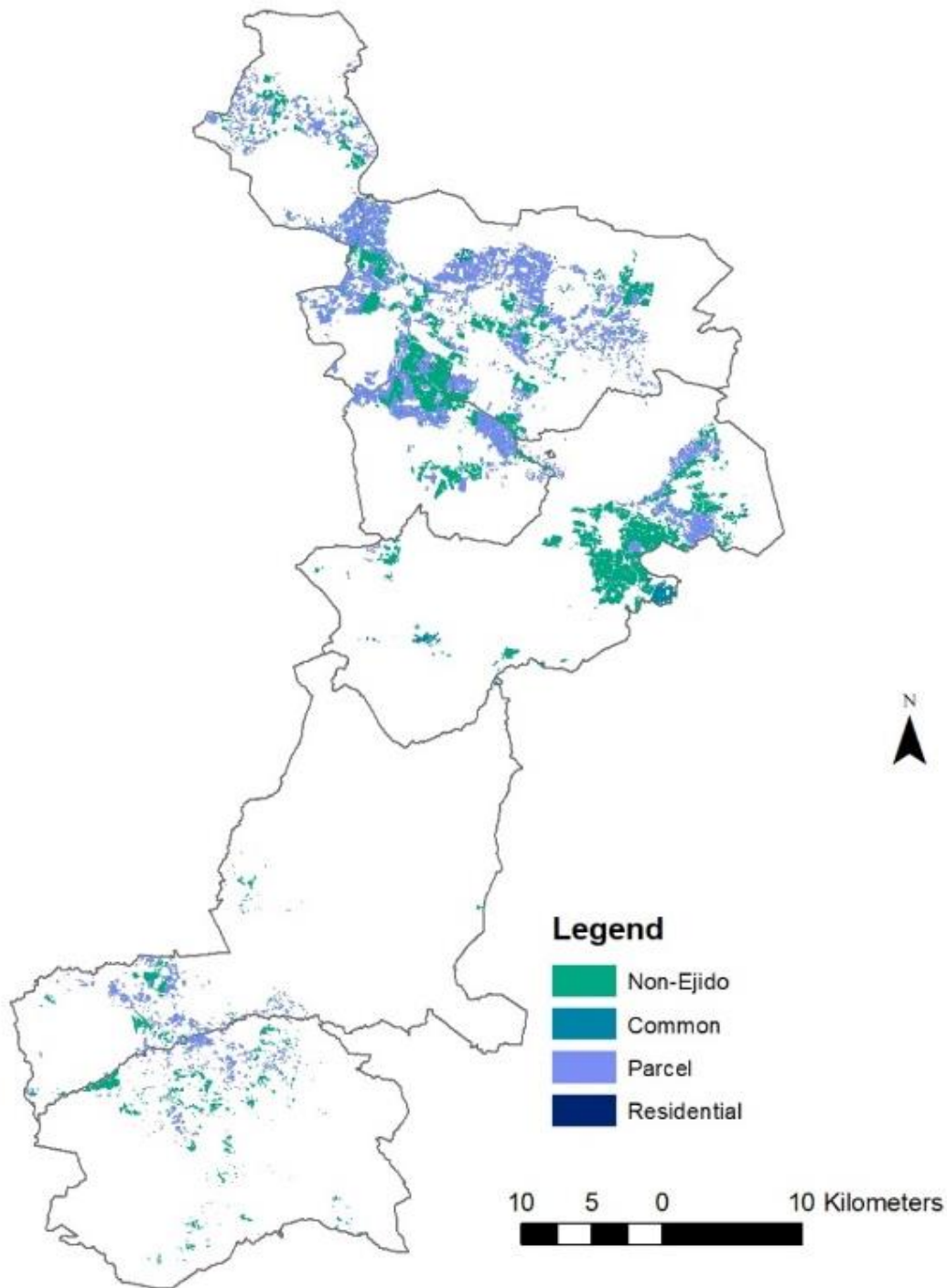
# Annual Maps



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

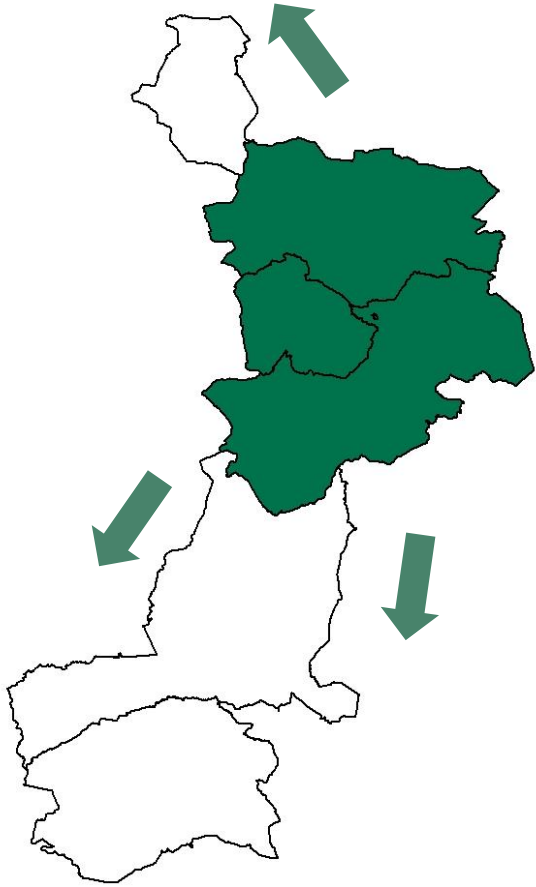


Area of study site municipalities and area of detected protected agriculture (PA) by land tenure.

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	9.0	2.8	11.4	4.9	307.6	114.6	450.3
Use							
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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