

A Needle In A Pineapple Field

Study of the Current State of Pineapple Leaves Valorisation in the Context of Circular Bioeconomy in Costa Rica

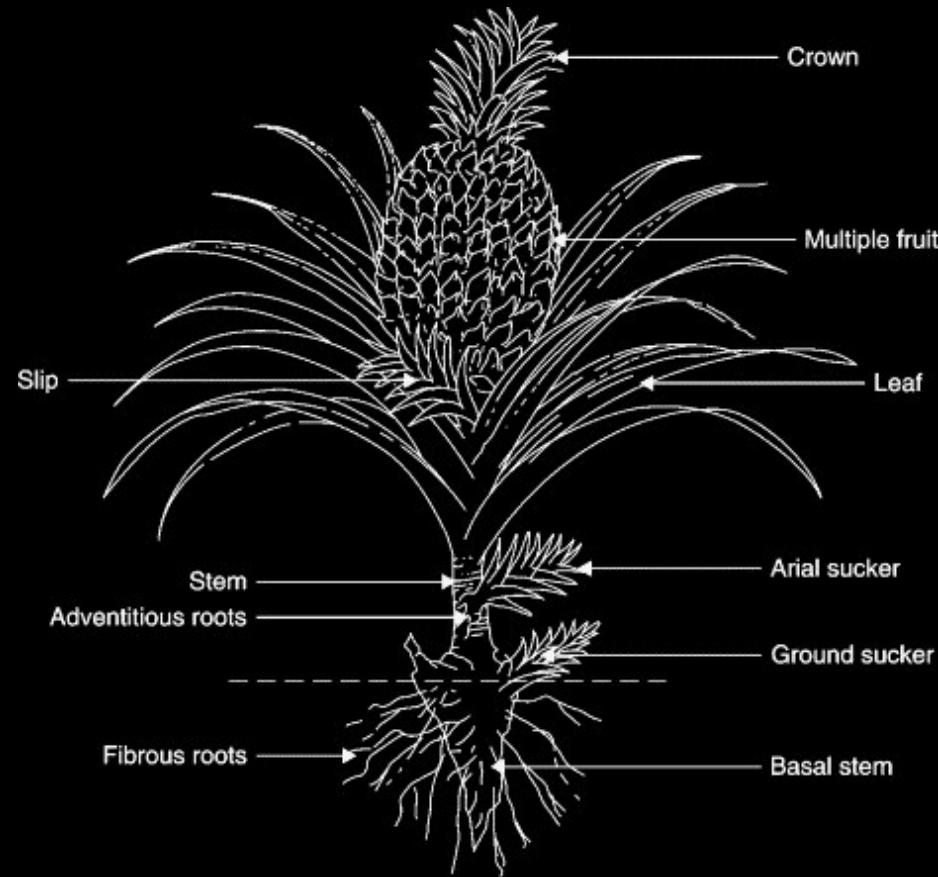
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May 17, 2023

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MSc Climate Studies
Wageningen University & Research

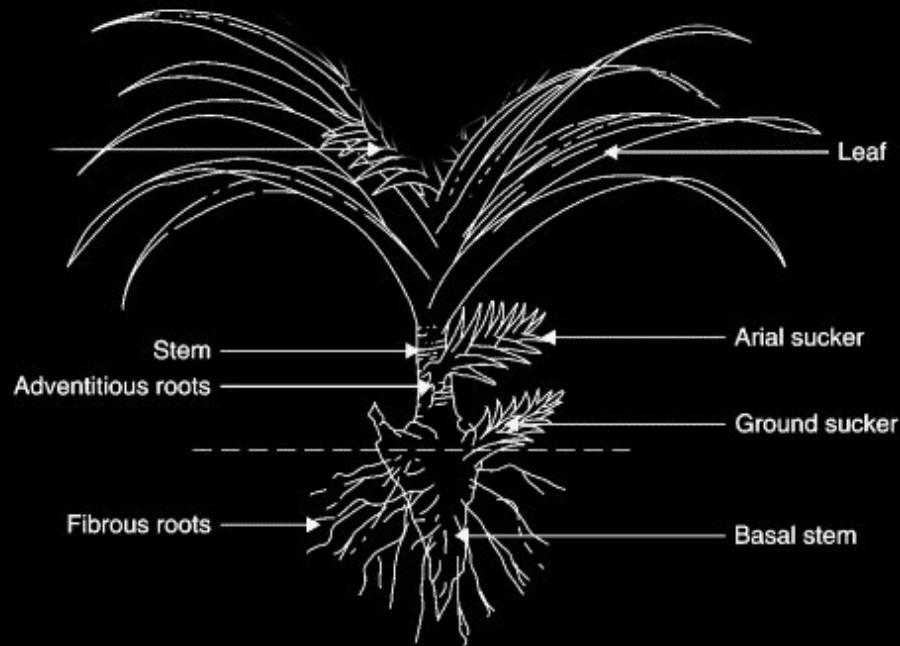
Outline

1. Problem statement
2. Aim and Research Questions
3. Current state of Pineapple Leaves (PAL) valorisation in Costa Rica (CR)
4. Analysing barriers and opportunities of PAL valorisation
5. Facility Location Problem for PAL valorisation
6. Q&A

Problem statement



Problem statement



Problem statement

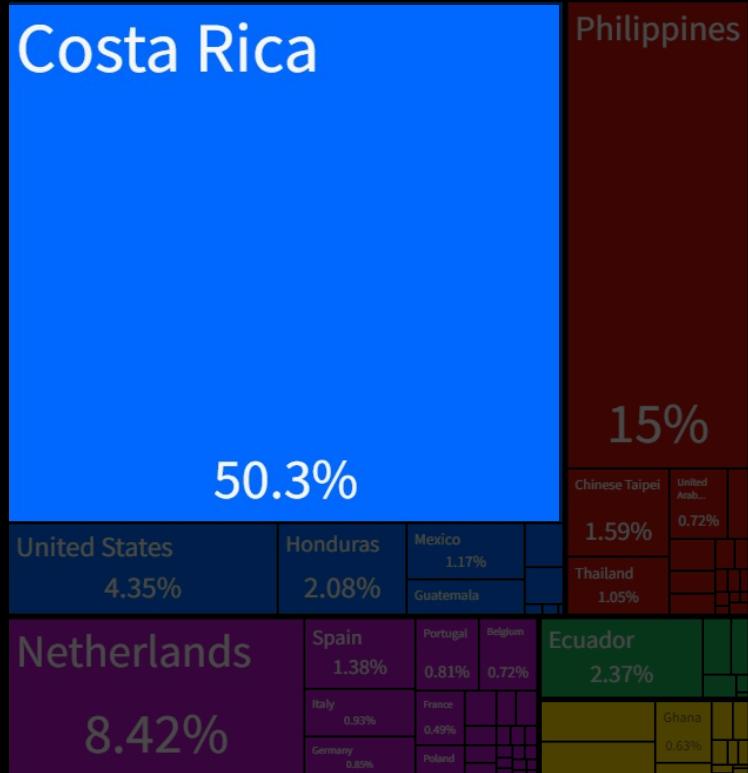


Problem statement

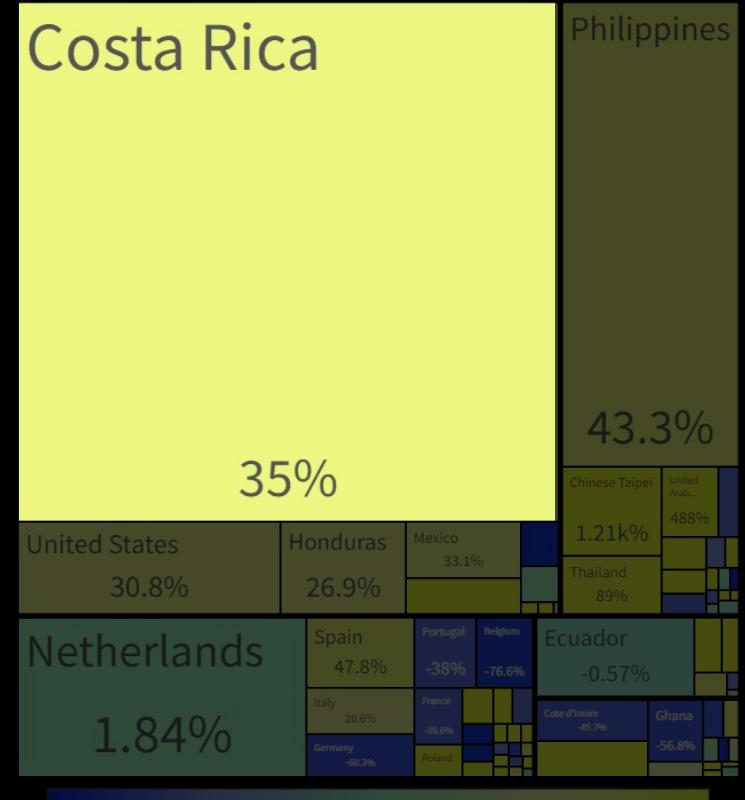


Exporters of pineapple, 2021

Problem statement

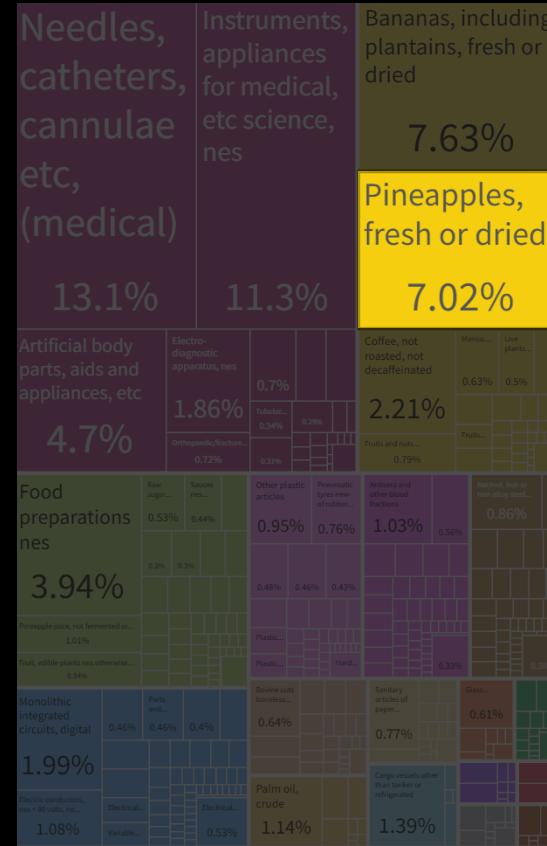


Exporters of pineapple, 2021



Exports Growth, 2011 - 2021

Problem statement



Costa Rica Exports, 2021

Problem statement

monoculture + waste/plant ratio + stable fly



Problem statement

monoculture + waste/plant ratio + stable fly



40%



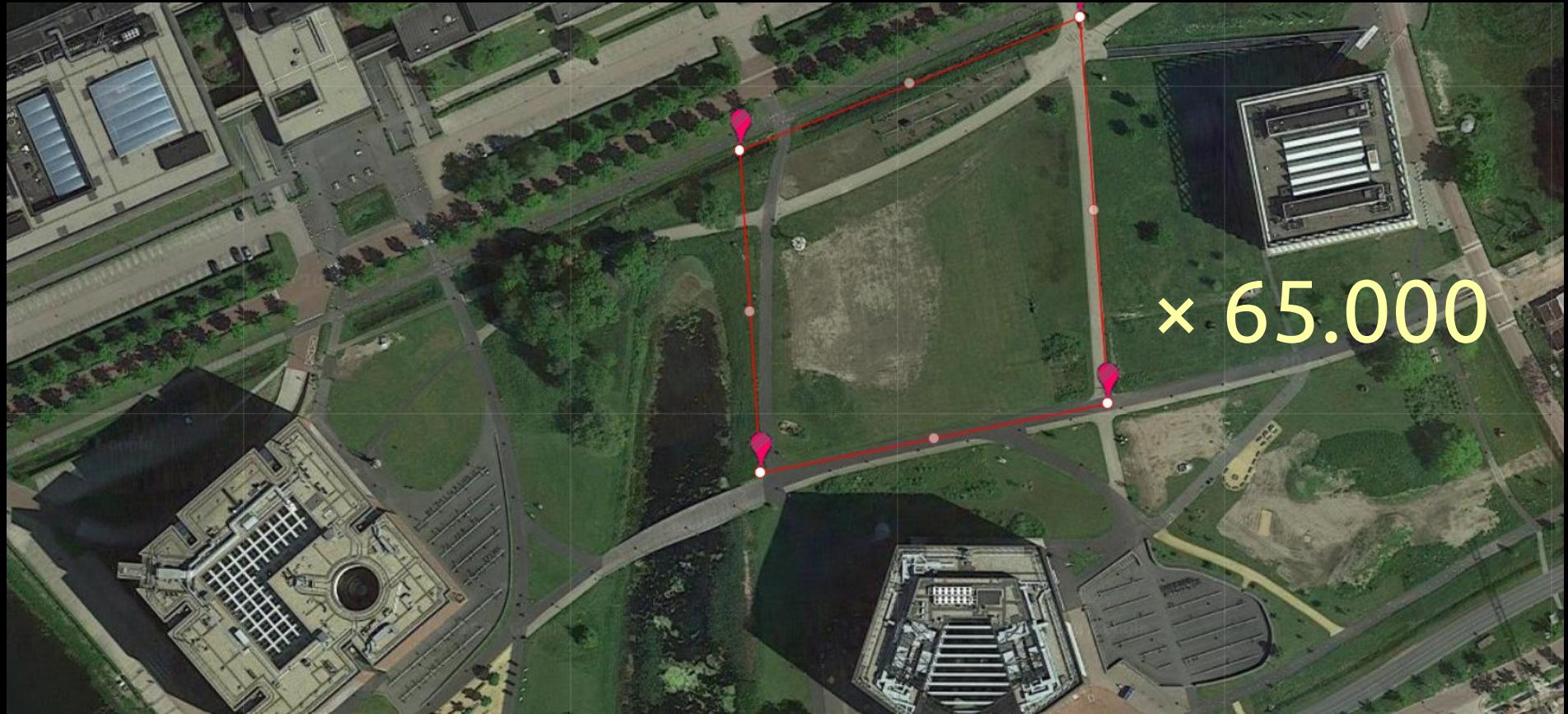
~165 tonnes/ha

Problem statement

monoculture + waste/plant ratio + stable fly



Problem statement



Problem statement

Current practices:

Current practices:

↑ GHG emissions

Current practices:

- ↑ GHG emissions
- ↑ Pollution of water → Communities

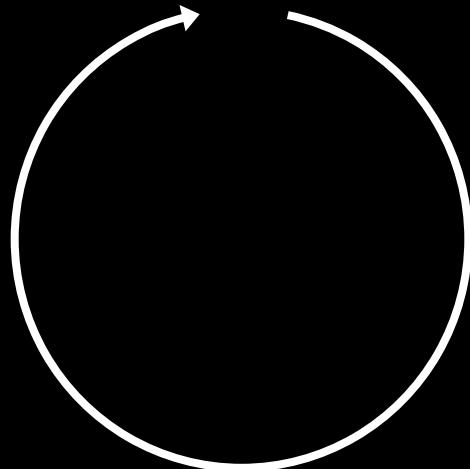
Current practices:

- ↑ GHG emissions
- ↑ Pollution of water → Communities
- ↓ Productivity and quality of pineapple

Problem statement



Problem statement



Aim and Research Questions

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Aim and Research Questions

Aim: To help increase the sustainability of the pineapple industry in CR by introducing circular bioeconomy principles.

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RQ1: What is the current state of PAL valorisation in the country?

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RQ1: What is the current state of PAL valorisation in the country?

RQ2: What are the barriers and benefits of PAL valorisation?

Aim and Research Questions

Aim: To help increase the sustainability of the pineapple industry in CR by introducing circular bioeconomy principles.

RQ1: What is the current state of PAL valorisation in the country?

RQ2: What are the barriers and benefits of PAL valorisation?

RQ3: How can a large-scale valorisation process be carried out?

Current state of PAL valorisation in CR

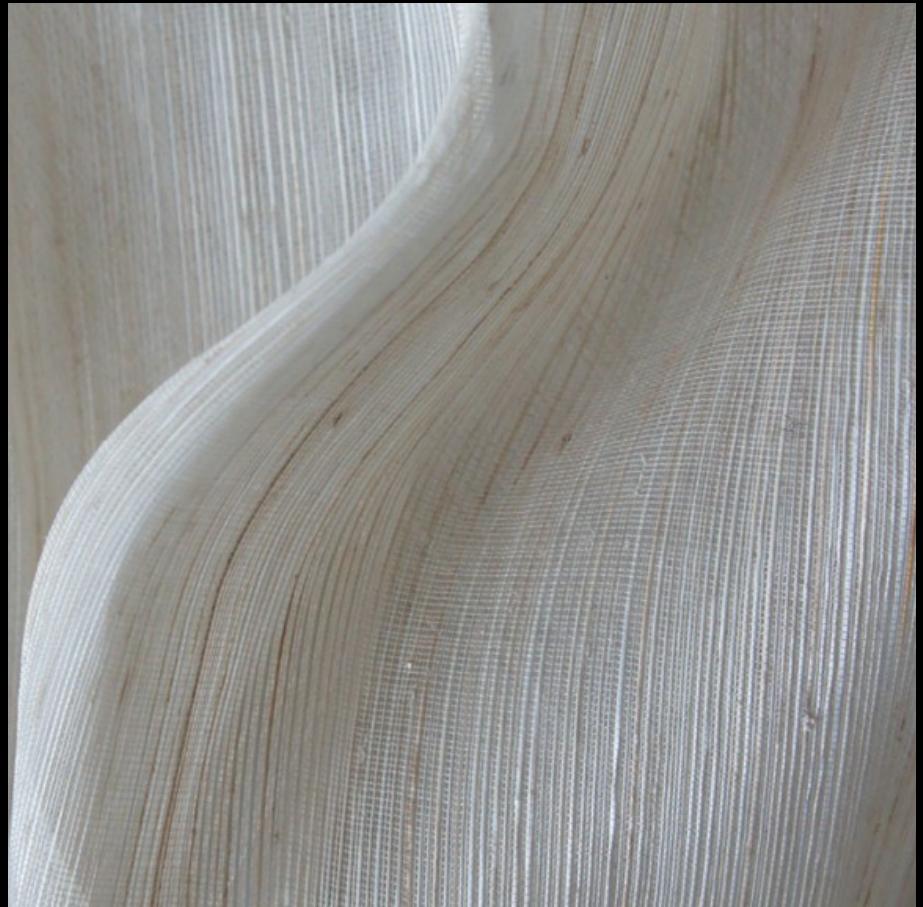
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A lot of ideas...



A lot of ideas...

Fabrics



A lot of ideas...

Fabrics
Bio-packaging



Current state of PAL valorisation in CR

A lot of ideas...

Fabrics
Bio-packaging
Energy



Current state of PAL valorisation in CR

But only 1 in place

Fabrics

Bio-packaging

Energy

Animal feed



Current state of PAL valorisation in CR

Extraction is rough... literally



Extraction is rough... literally

Hilly and muddy terrain
Dirt roads

High volume
Divide plant



Partial Mechanical Solution



Analysing barriers and opportunities of PAL valorisation

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Analysing barriers and opportunities of PAL valorisation

Method

Method

Fuzzy Cognitive Map (FCM)

Method

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Quasi-quantitative model

Method

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Quasi-quantitative model

Elicit knowledge from stakeholders

Method

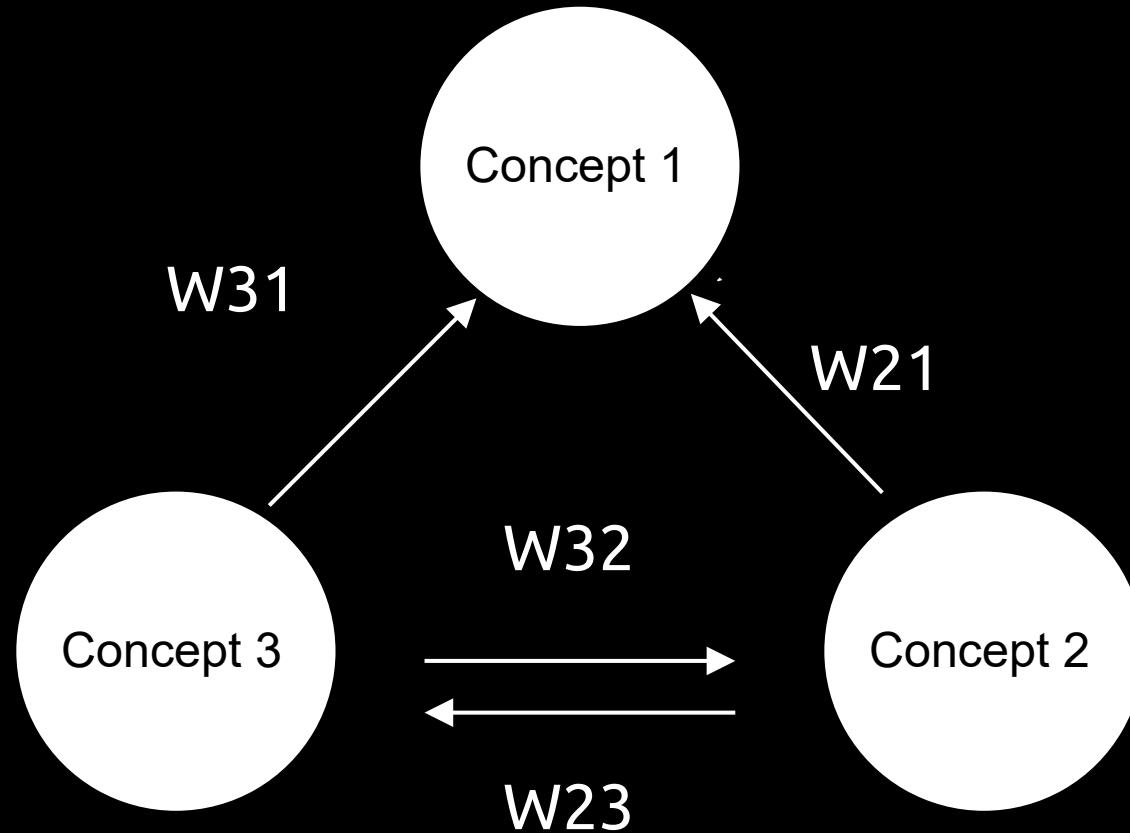
Fuzzy Cognitive Map (FCM)

Quasi-quantitative model

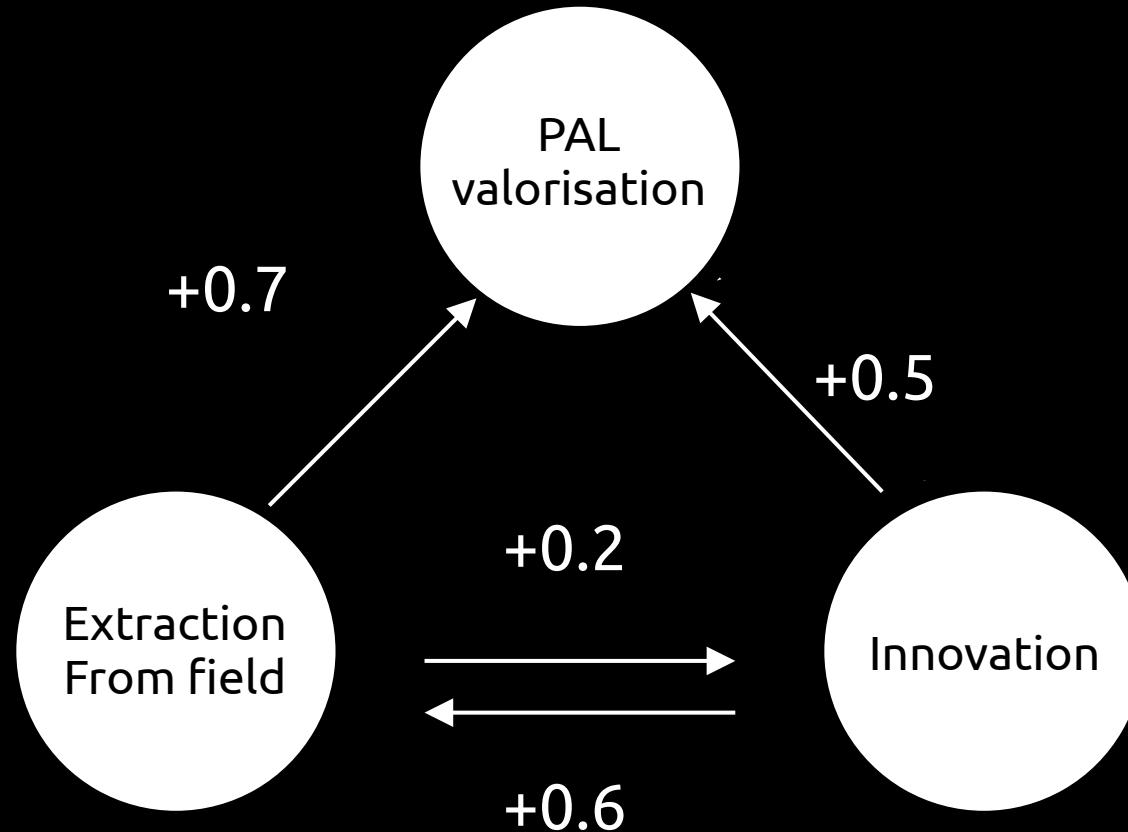
Elicit knowledge from stakeholders

Analyse interconnected variables in a system

Analysing barriers and opportunities of PAL valorisation



Analysing barriers and opportunities of PAL valorisation



Analysing barriers and opportunities of PAL valorisation

FCM Process

FCM Process

1. 14 Interviews

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2. Aggregate knowledge

FCM Process

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2. Aggregate knowledge
3. Generate the FCM: 32 concepts and 52 connections

FCM Process

1. 14 Interviews
2. Aggregate knowledge
3. Generate the FCM: 32 concepts and 52 connections
4. (Quasi)Dynamic Analysis: “What if” questions

Steady state of the system



Senders (Policy Drivers)

Green consumers

Government presence

Import regulations

Industry transparency

Receivers (Outcome Variables)

Ranchers' productivity

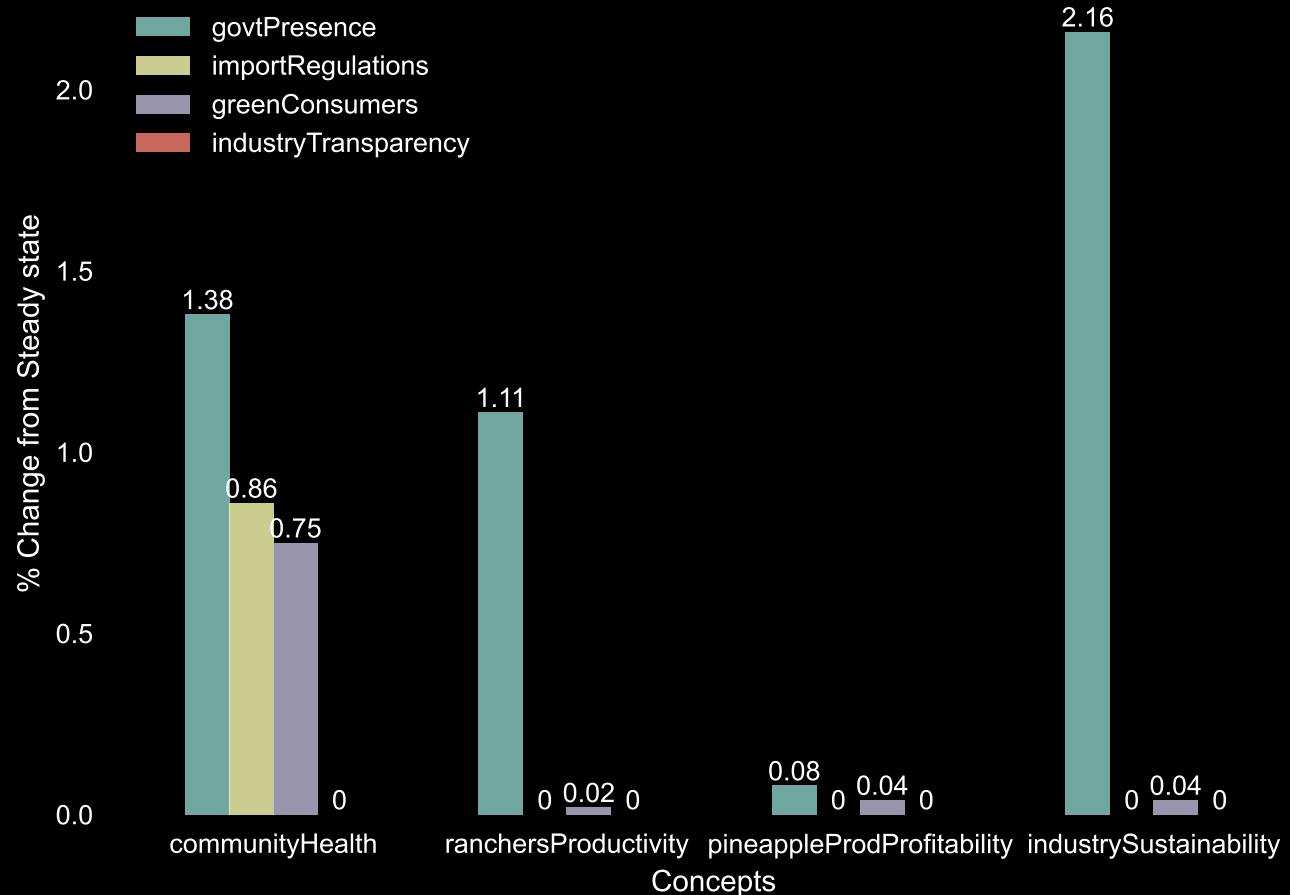
Producers' profitability

Community's well-being

Industry sustainability

Analysing barriers and opportunities of PAL valorisation

Drivers & outcome variables



Analysing barriers and opportunities of PAL valorisation

Effect on transmitters

Concepts	govtPresence	Intervened Concepts		
		importRegulations	greenConsumers	industryTransparency
academia	0.0028	0.0013	0.0017	2.4e-05
agrochemicalsUse	-7.6	-49	-41	-0.014
businessRisk	-0.049	0	-2.2	-4.2e-05
collabComms	24	0	0	22
communityHealth	1.4	0.86	0.75	0.0016
costFFmaterials	0	0	0	0
employment	0.088	5.9e-07	0.04	0.0014
fieldExtraction	0.051	6.7e-06	0.019	0.012
funding	0.02	0.0085	0.011	0.00014
industryCustoms	0.01	2.6e-08	0.0046	0.00017
industryImage	0.17	0.11	0.097	0.00027
industrySustainability	2.2	6.6e-07	0.042	0.0015
innovation	0.48	0.00013	0.11	0.25
laborProductivity	0.069	2e-05	0.017	0.036
landAvailable	0.098	6.7e-07	0.044	0.0016
palProductsDemand	0.18	2.4e-08	8	0.00013
palValorization	0.69	6.1e-06	0.31	0.011
pineappleProdProductivity	0.012	3.1e-08	0.0054	0.0002
pineappleProdProfitability	0.084	5.7e-07	0.038	0.0013
pollution	-0.44	-2.9	-2.4	-0.00086
ranchersProductivity	1.1	1e-07	0.022	0.0008
soilFertil	-0.14	-9.1e-07	-0.065	-0.0023
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Analysing barriers and opportunities of PAL valorisation



Analysing barriers and opportunities of PAL valorisation



Analysing barriers and opportunities of PAL valorisation

Results

Results

Barriers:

Results

Barriers:

Industry customs

Results

Barriers:

Industry customs

Mobilisation of funding

Results

Barriers:

Industry customs

Mobilisation of funding

Risk aversion

Results

Barriers:

Industry customs

Mobilisation of funding

Risk aversion

Little collaboration

Results

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Topography of the fields

Results

Barriers:

Industry customs

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Topography of the fields

Access to input material

Analysing barriers and opportunities of PAL valorisation

Results

Results

Drivers of change:

Results

Drivers of change:

Transparency & Openness → Collaboration & Communication

Results

Drivers of change:

Transparency & Openness → Collaboration & Communication

Government agencies as intermediaries

Results

Drivers of change:

Transparency & Openness → Collaboration & Communication

Government agencies as intermediaries

Applied research

Results

Drivers of change:

Transparency & Openness → Collaboration & Communication

Government agencies as intermediaries

Applied research

Partnerships with organisations

Analysing barriers and opportunities of PAL valorisation

Results

Results

Benefits:

Results

Benefits:

- ↓ Agrochemicals

Results

Benefits:

↓ Agrochemicals

↓ Stable fly

Results

Benefits:

↓ Agrochemicals

↓ Stable fly

↑ Profitability

Results

Benefits:

↓ Agrochemicals

BUT...

↓ Stable fly

↑ Profitability

Results

Benefits:

↓ Agrochemicals

↓ Stable fly

↑ Profitability

BUT...
Not all stakeholders perceive agree

Analysing barriers and opportunities of PAL valorisation

Results

Results

Challenges:

Results

Challenges:

Research on market demand and scalability

Results

Challenges:

Research on market demand and scalability

Create a collaborative network

Results

Challenges:

Research on market demand and scalability

Create a collaborative network

Increase the awareness about the benefits

Results

Challenges:

Research on market demand and scalability

Create a collaborative network

Increase the awareness about the benefits

Find an intermediary

Analysing barriers and opportunities of PAL valorisation

Conclusions & Recommendations

Conclusions & Recommendations

Barriers are common in circular bioeconomy transitions

Conclusions & Recommendations

Barriers are common in circular bioeconomy transitions

Periodic analyses are recommended

Conclusions & Recommendations

Barriers are common in circular bioeconomy transitions

Periodic analyses are recommended

Focus on challenges instead of barriers

Research on scalability

Facility Location Problem for PAL valorisation

1. Problem statement
2. Aim and Research Questions
3. Current state of PAL valorisation in CR
4. Analysing barriers and opportunities of PAL valorisation
5. Facility Location Problem for PAL valorisation
6. Summary
7. Q&A

Optimisation problem

Best location to place PAL processing facilities

Facility Location Problem for PAL valorisation

Choice variable: Location and number of facilities

Choice variable: Location and number of facilities

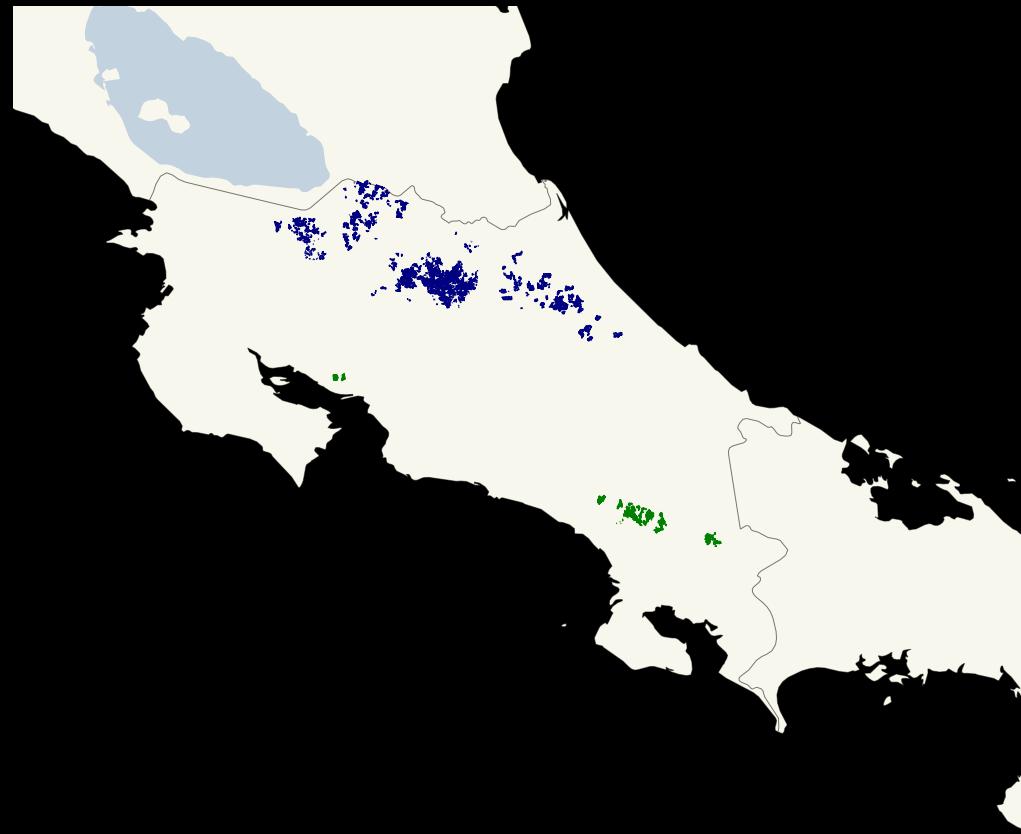
Constraints: Facility capacity and operational state

Choice variable: Location and number of facilities

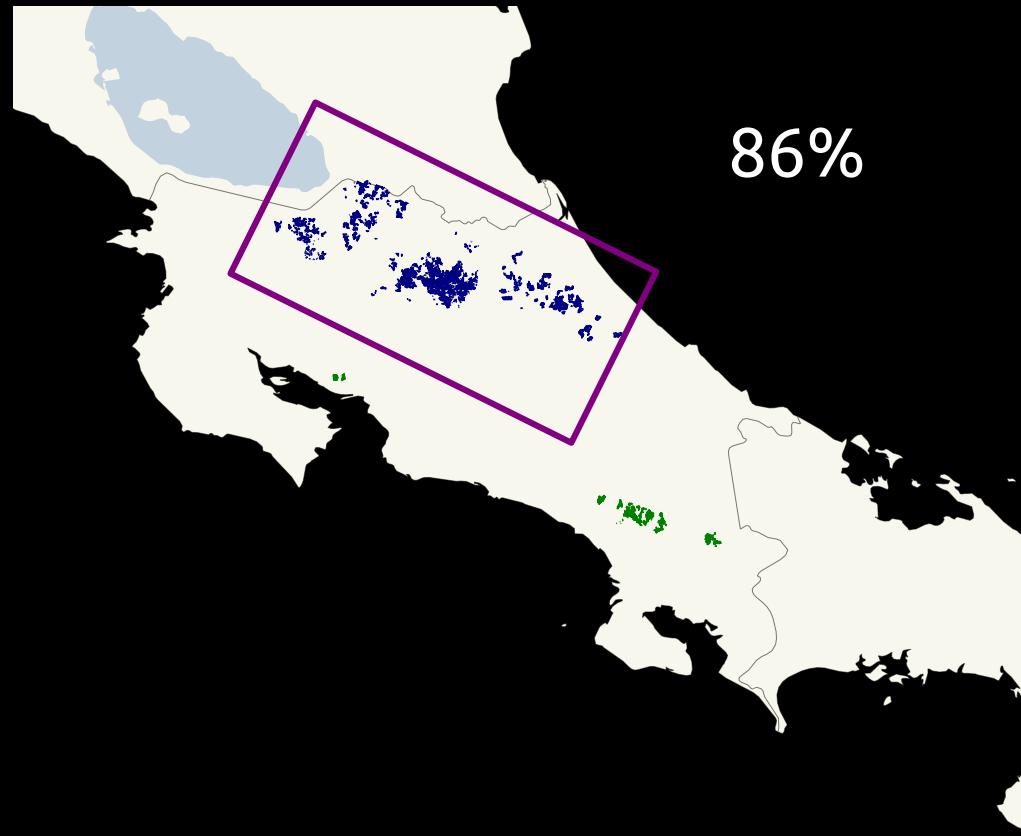
Constraints: Facility capacity and operational state

Objective function: minimise costs

Facility Location Problem for PAL valorisation



Facility Location Problem for PAL valorisation



PAL valorisation option: Biogas

PAL valorisation option: Biogas

Balance between most feasible and large scale option

PAL valorisation option: Biogas

Balance between most feasible and large scale option

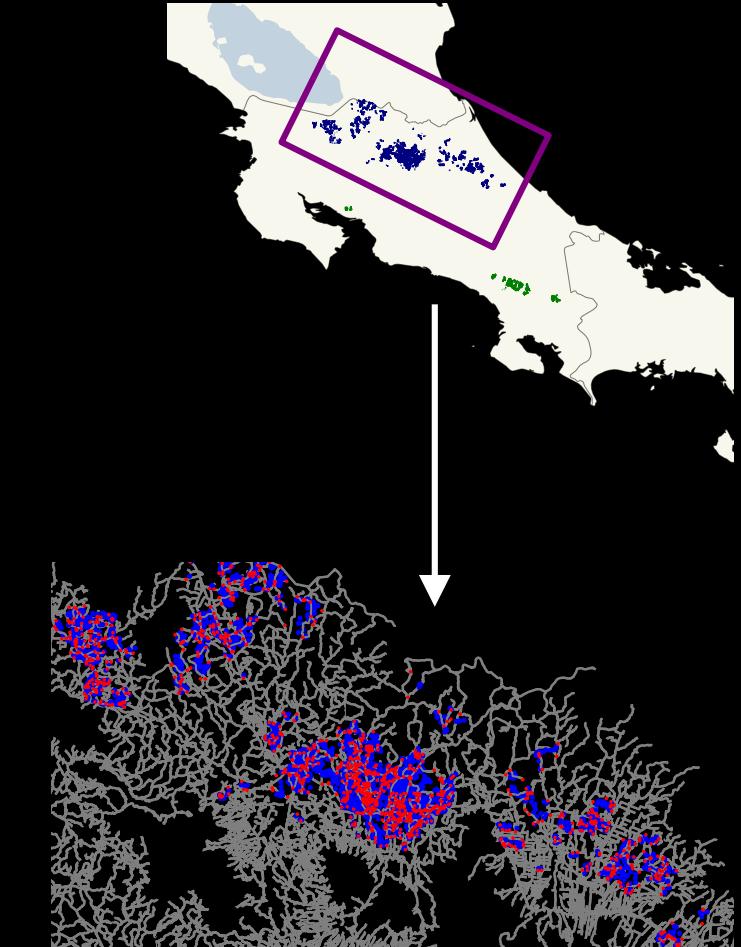
Easy to complement with other options

Materials

Facility Location Problem for PAL valorisation

Materials

Source of PAL & Road Network



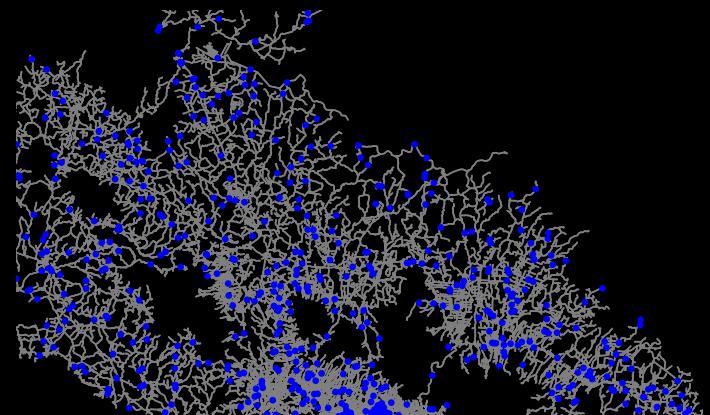
Materials

Source of PAL & Road Network

Candidate Locations

Planning rules (zoning) is ideal
But no data

Restrict candidates to 500 accessible locations



Facility Location Problem for PAL valorisation

Materials

\$0.20 and \$0.35
tonne-kilometre

Source of PAL & Road Network

Truck with a load
capacity of 8 tonnes

Candidate Locations

Costs of transport

Facility Location Problem for PAL valorisation

Materials

Source of PAL & Road Network

Candidate Locations

Costs of transport

Facility costs

1 MW biogas plant

Capital costs:
\$2 to \$4 MM

Operational costs:
\$250 to \$450 M/year

15 years lifespan

Facility Location Problem for PAL valorisation

Results

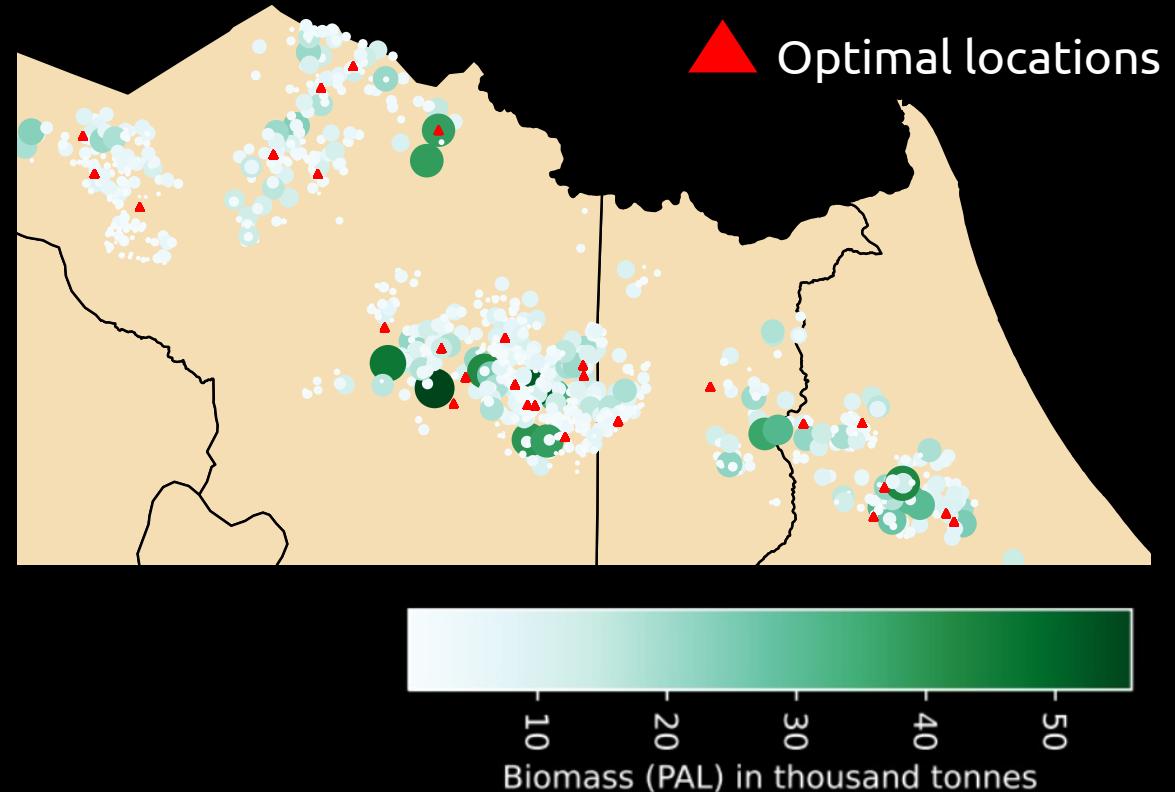
30 biogas plants

4.5 MM tonnes/year

Annual costs

Biogas facilities: \$16.5 MM
Transportation: \$13.6 MM

Scenarios to account for
costs uncertainty



Cost-Benefit

Annually:

Average biogas solution costs: 30 MM

Current stubble management costs: 28 MM min.

Revenues from generated electricity: 30 MM

(Costs of extraction and revenues from earlier planting not considered)

Conclusions

Conclusions

Economically reasonable and attractive

Conclusions

Economically reasonable and attractive

Adaptable to several (cascading) solutions

Conclusions

Economically reasonable and attractive

Adaptable to several (cascading) solutions

Extension including environmental costs

Conclusions

Economically reasonable and attractive

Adaptable to several (cascading) solutions

Extension including environmental costs

Decentralised solution is preferable for biogas

Support **Open Science**: All the data and code can be found at
github.com/isaldiviagonzatti/MscThesis

Q&A