Establishing *Post* Lithium Landscapes

Spatial Transformations for Evolving Circular Economies in Portugal

Tim van Oorspronk

1st mentor: Nikos Katsikis

2nd mentor: Alexander Wandl

Delegate: Willem Korthals Altes

P5 presentation / Transitional Territories Studio / June 2024

[basis / **starting point**]

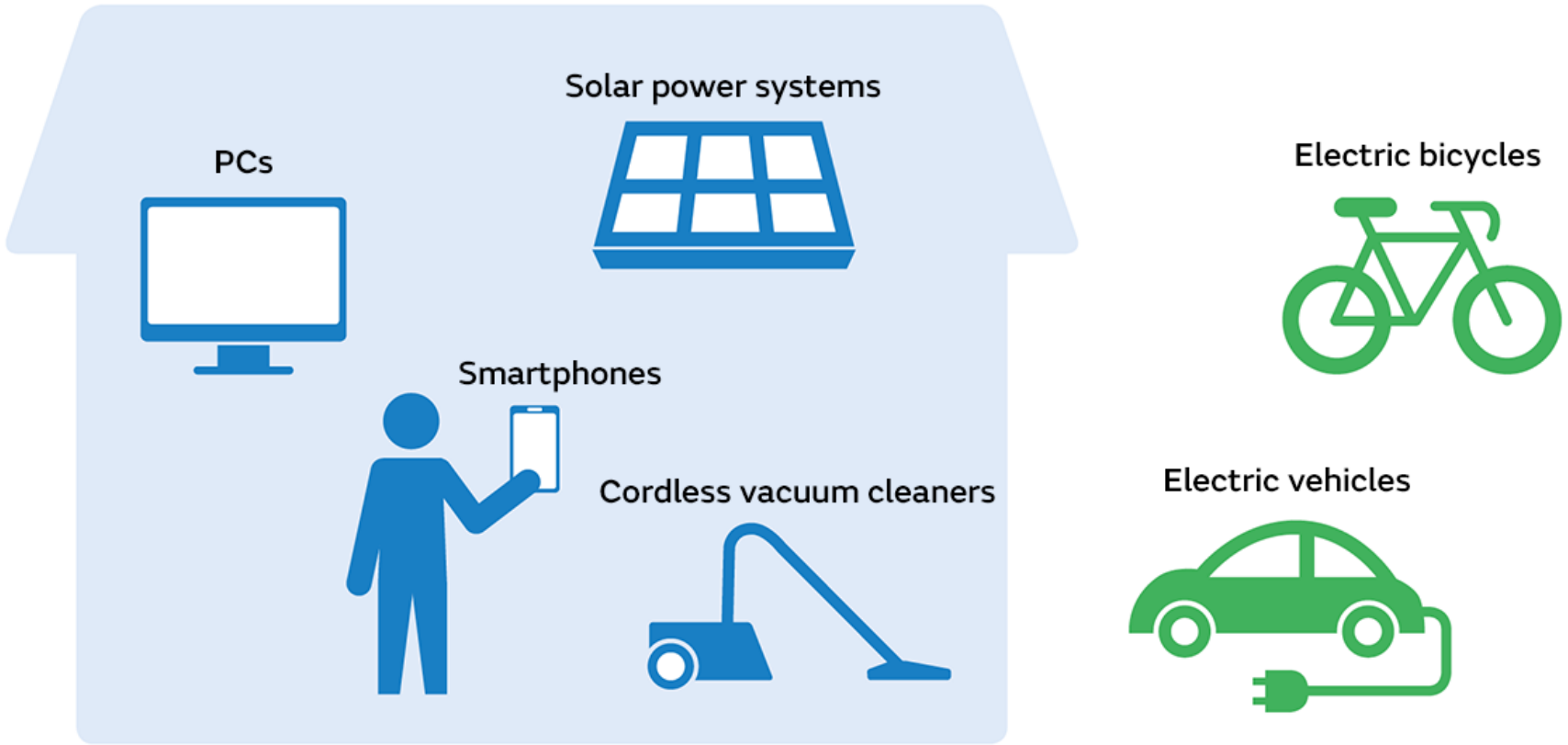
Protest fossil fuels (Euronews, photo by Bryan Woolston, 2023)

[basis / **starting point**]

Renewable energy (Euronews, photo by Michael Sohn, 2023)

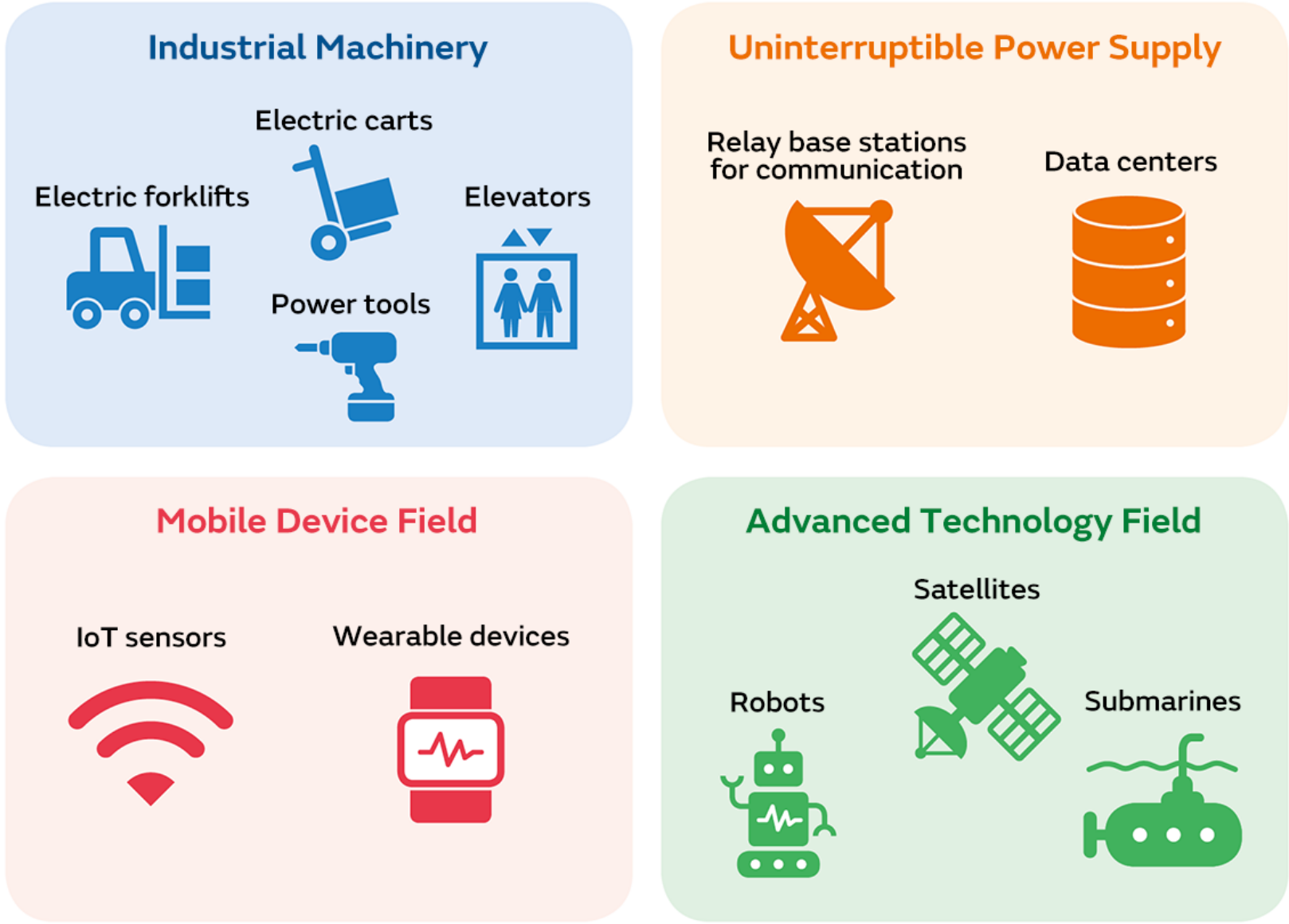
[basis / **starting point**]

Lithium in spodumene rock formations (ABC News, photo by Rachel Pupazzoni)



[basis / **starting point**]

Uses of lithium-ion batteries in daily life (Illustration by Murata Electronics, 2022)

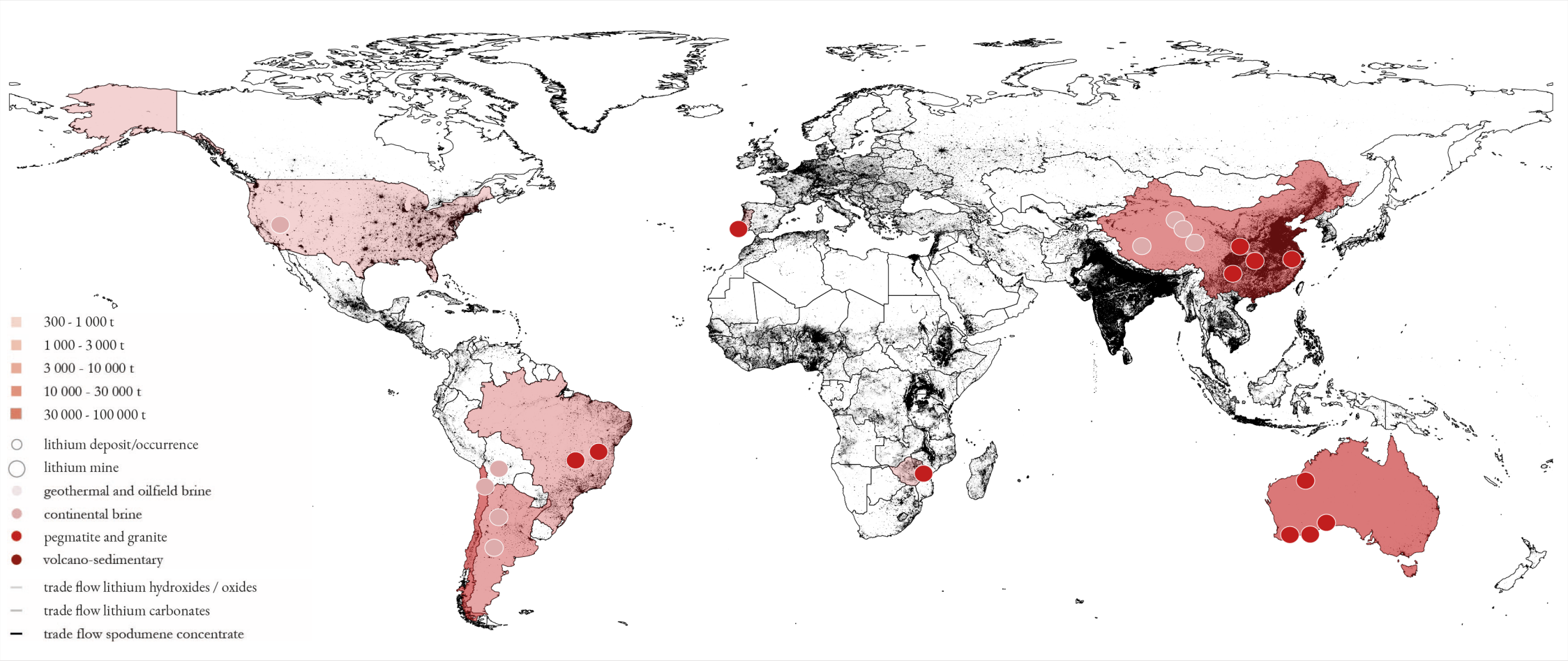


[basis / **starting point**]

uses of lithium-ion batteries in industrial fields (Illustration by Murata Electronics, 2022)

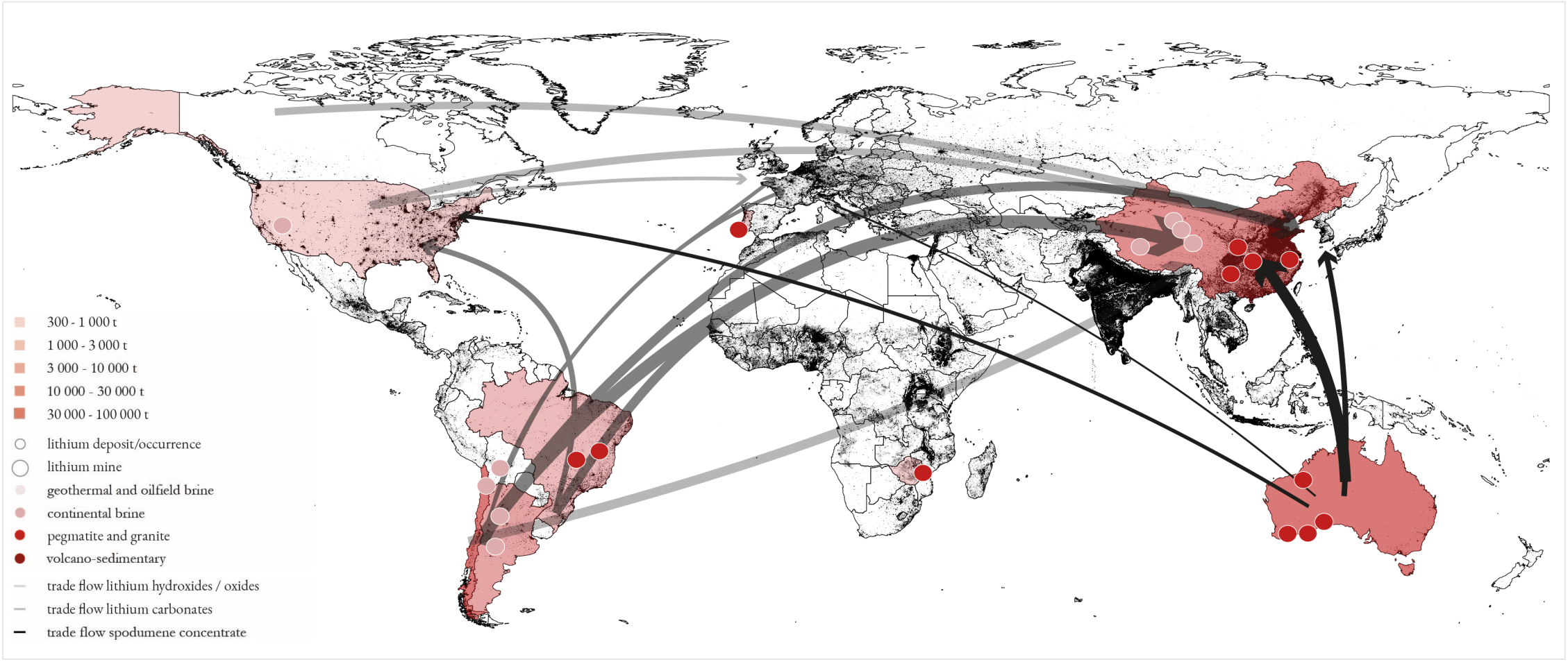
[basis / **starting point**]

Inside the quarry at the Pilgangoora Project in Western Australia (New York Times, 2023)



[basis / problem field **/ geopolitics of sourcing lithium**]

Global lithium production and trade (by Author)



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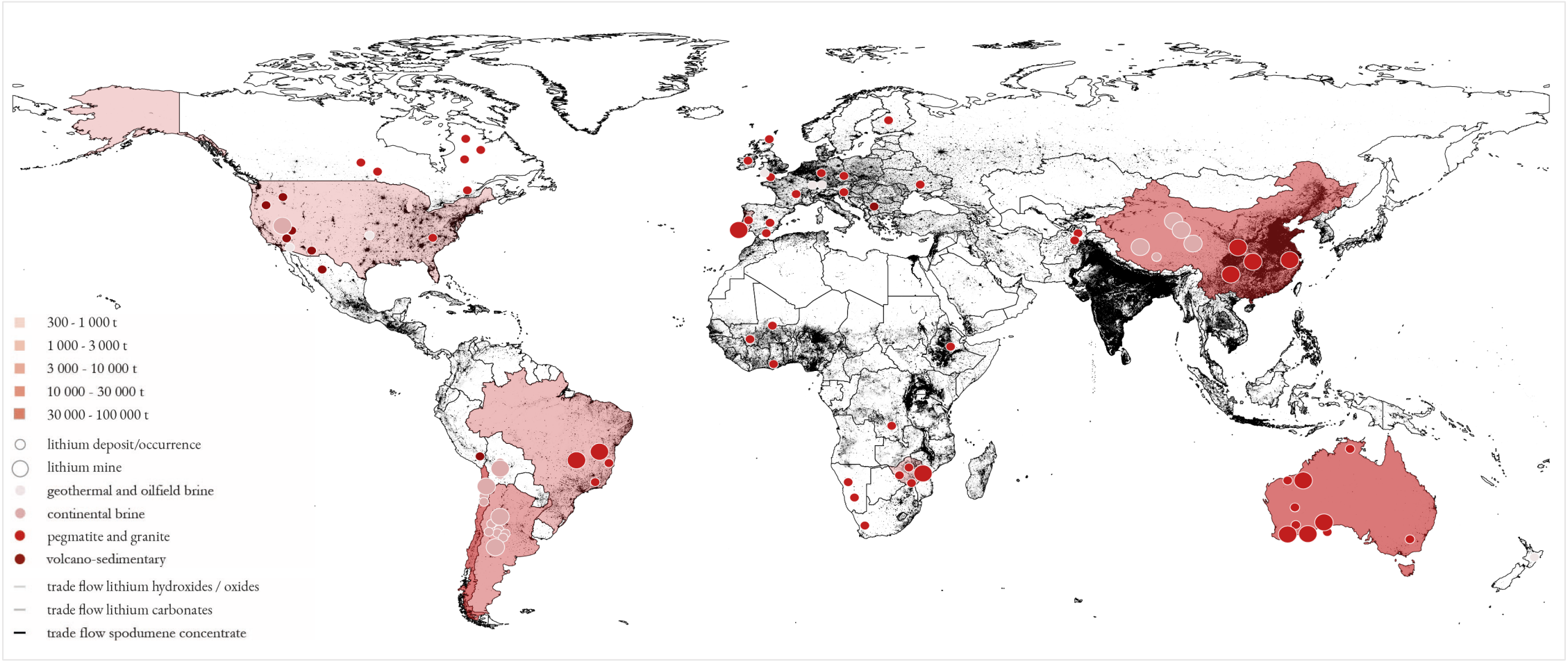


Global lithium production and trade (by Author)

[basis / **starting point**]

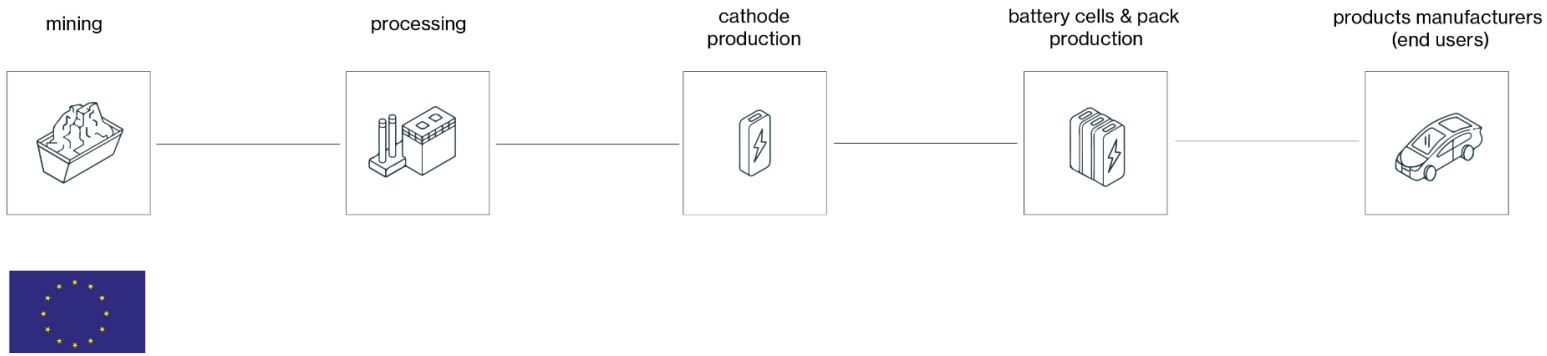
Demonstrators protest against lithium mining (by TPN: Lusa, 2021)

[basis / **starting point**]

Lithium-Ion Battery Recycling (photo retrieved from Li-Cycle Canada)

Therefore, the research focuses on establishing extractivist landscapes in a non-traditional manner, by

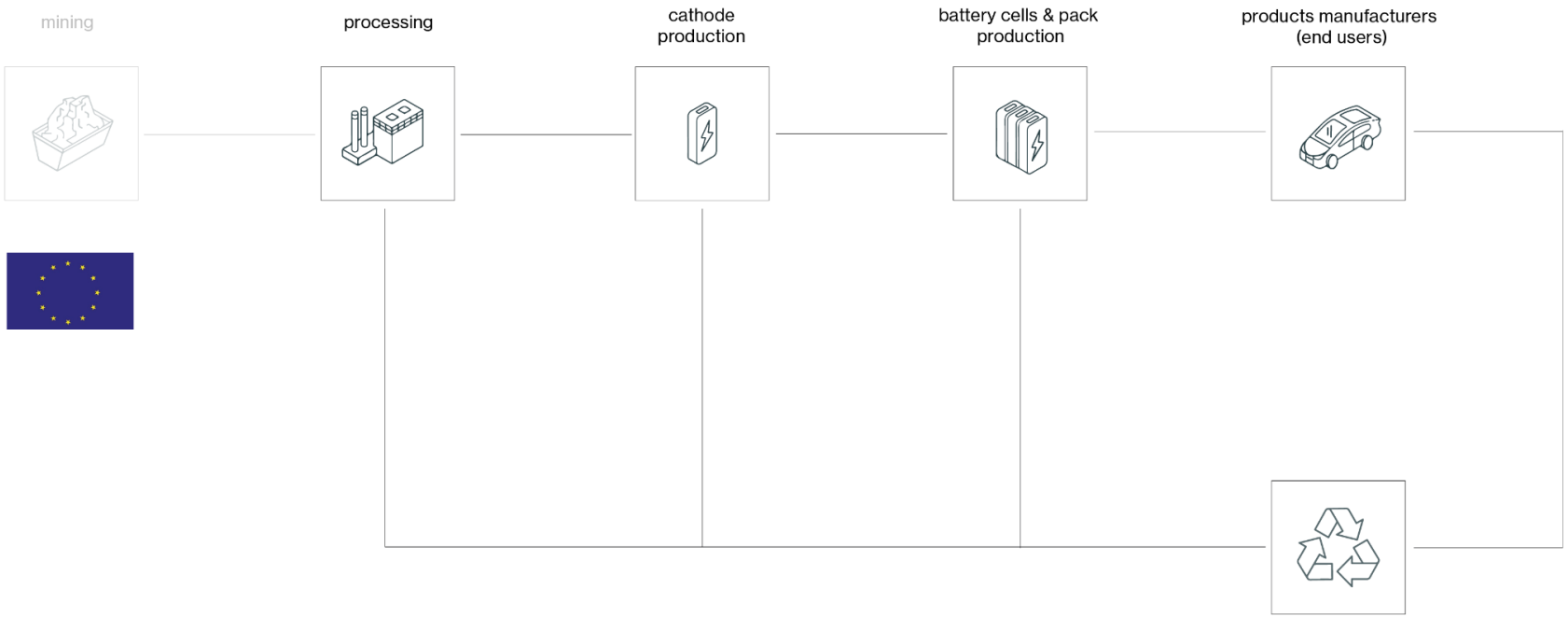
(1) focusing not merely on the mine sites itself, but as well on the other facilities in the related supply chain

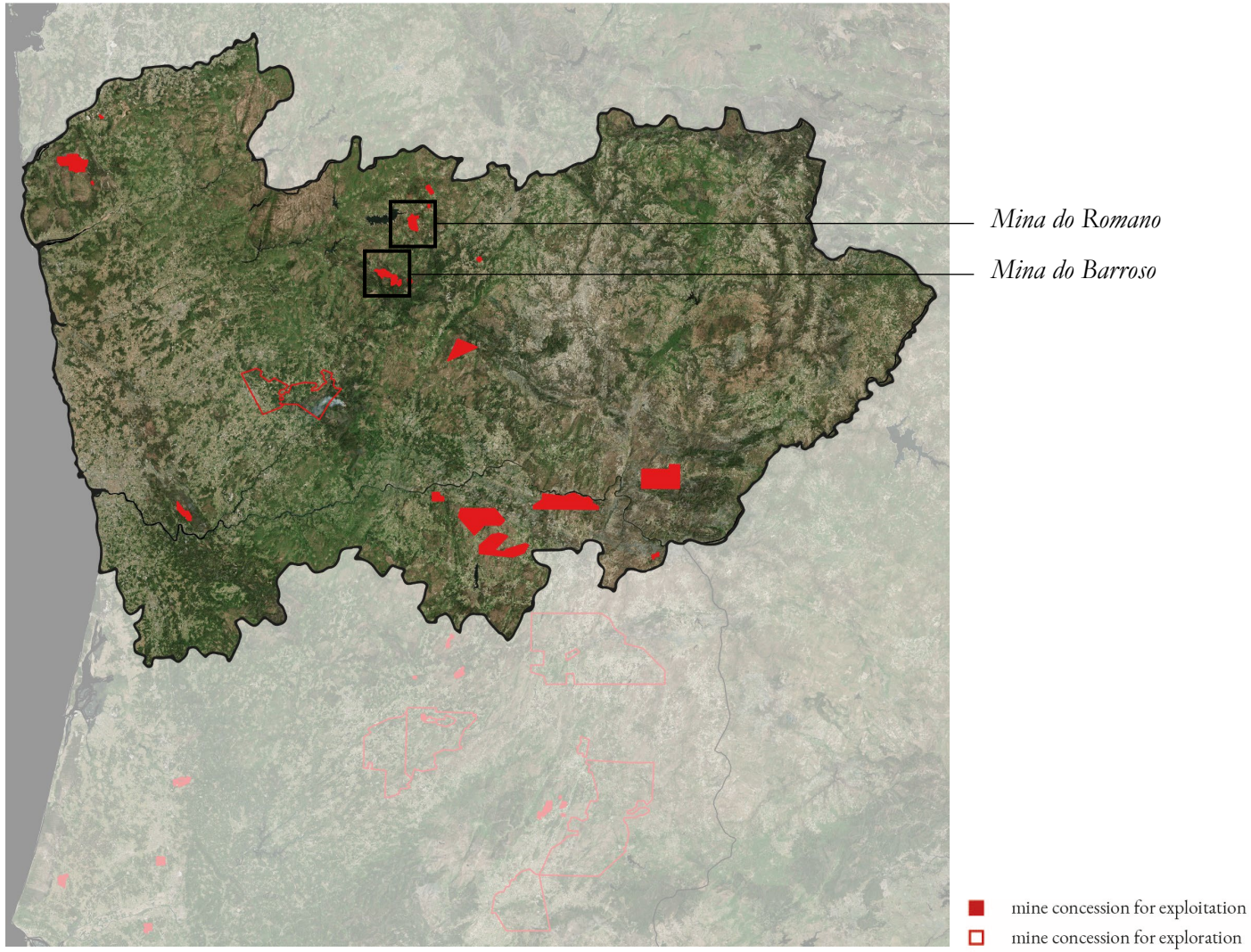


Therefore, the research focuses on establishing extractivist landscapes in a non-traditional manner, by

(1) focusing not merely on the mine sites itself, but as well on the other facilities in the related supply chain

(2) by including planning for a post-extractivist future that includes circular – recycle-based lithium practices




Mina do Romano
Mina do Barroso
mine concession for exploitation
mine concession for exploration

[research aim & projected outcome]

The thesis aims to develop a spatial strategy that guides the establishment of lithium landscapes in Portugal's Norte region. This strategy should not only address the challenges of the extractive state but also envision a recycle post-extractive state to ensure just long-term development of the evolving lithium economy in the region, while considering the local socio-environmental vulnerabilities and the broader economic impact.

[research aim & projected outcome]

The thesis aims to develop a spatial strategy that guides the establishment of lithium landscapes in Portugal's Norte region. This strategy should not only address the challenges of the extractive state but also envision a recycle post-extractive state to ensure just long-term development of the evolving lithium economy in the region, while considering the local socio-environmental vulnerabilities and the broader economic impact.

[research question]

How to design a spatial strategy that guides the transformation of Portugal's Norte region through an evolving lithium economy from an extractive mode to an recycle post-extractive mode, while considering the socio-environmental and economic vulnerabilities?

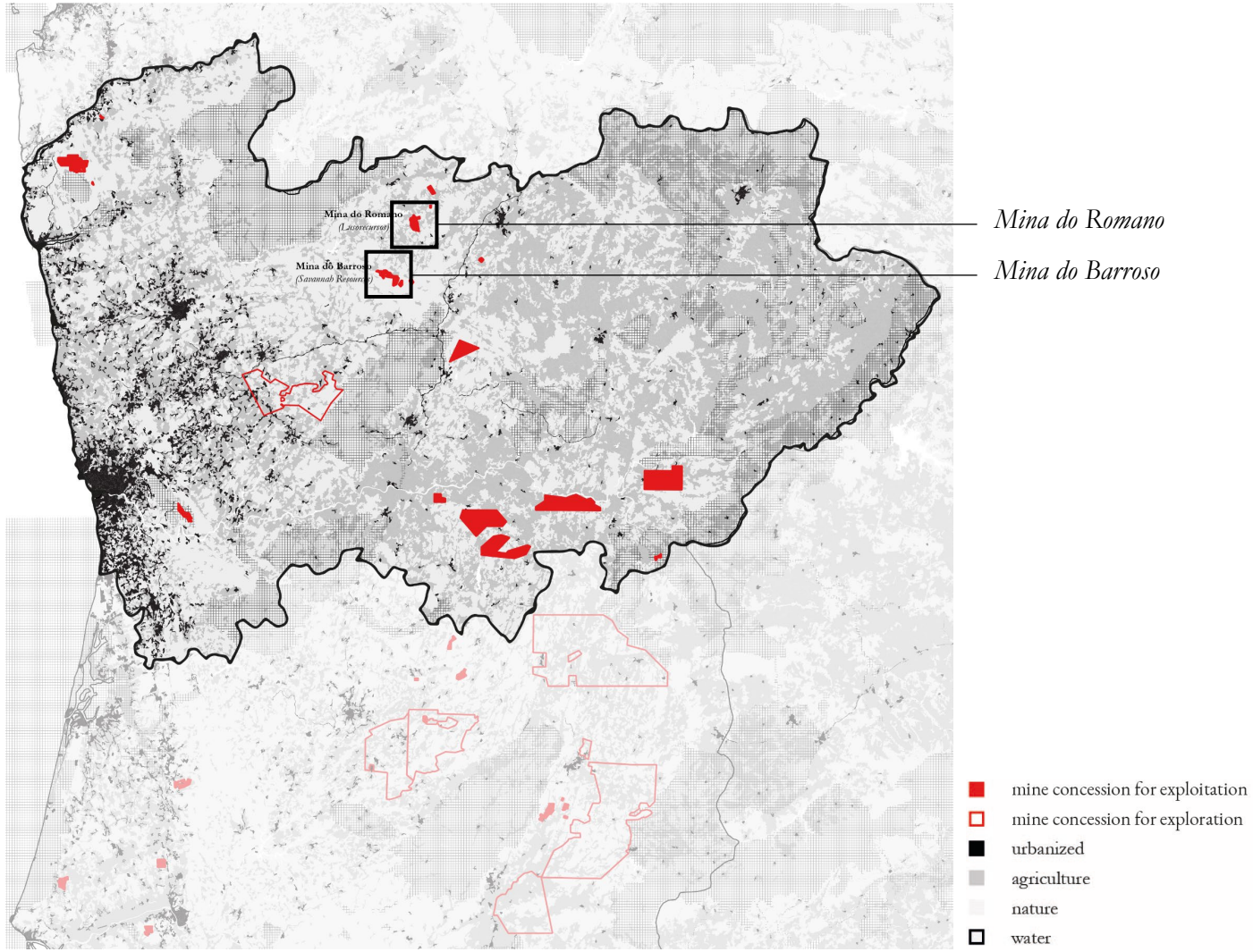
Part 02 – Investigating & Anticipating *(acnalyse)*

Site visit (photograph by Author)

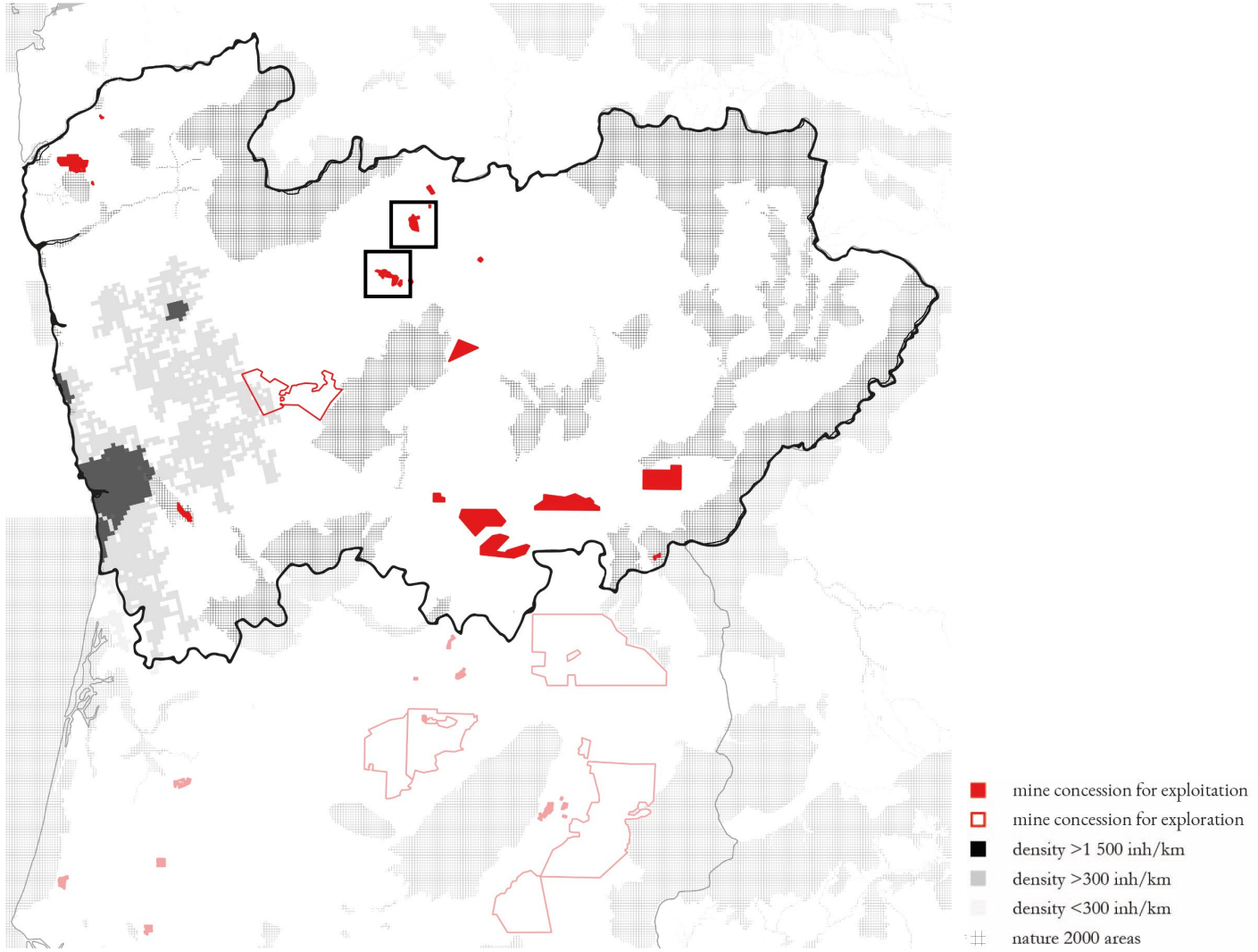
Site visit (photograph by Author)

[investigating and anticipating / **site**]

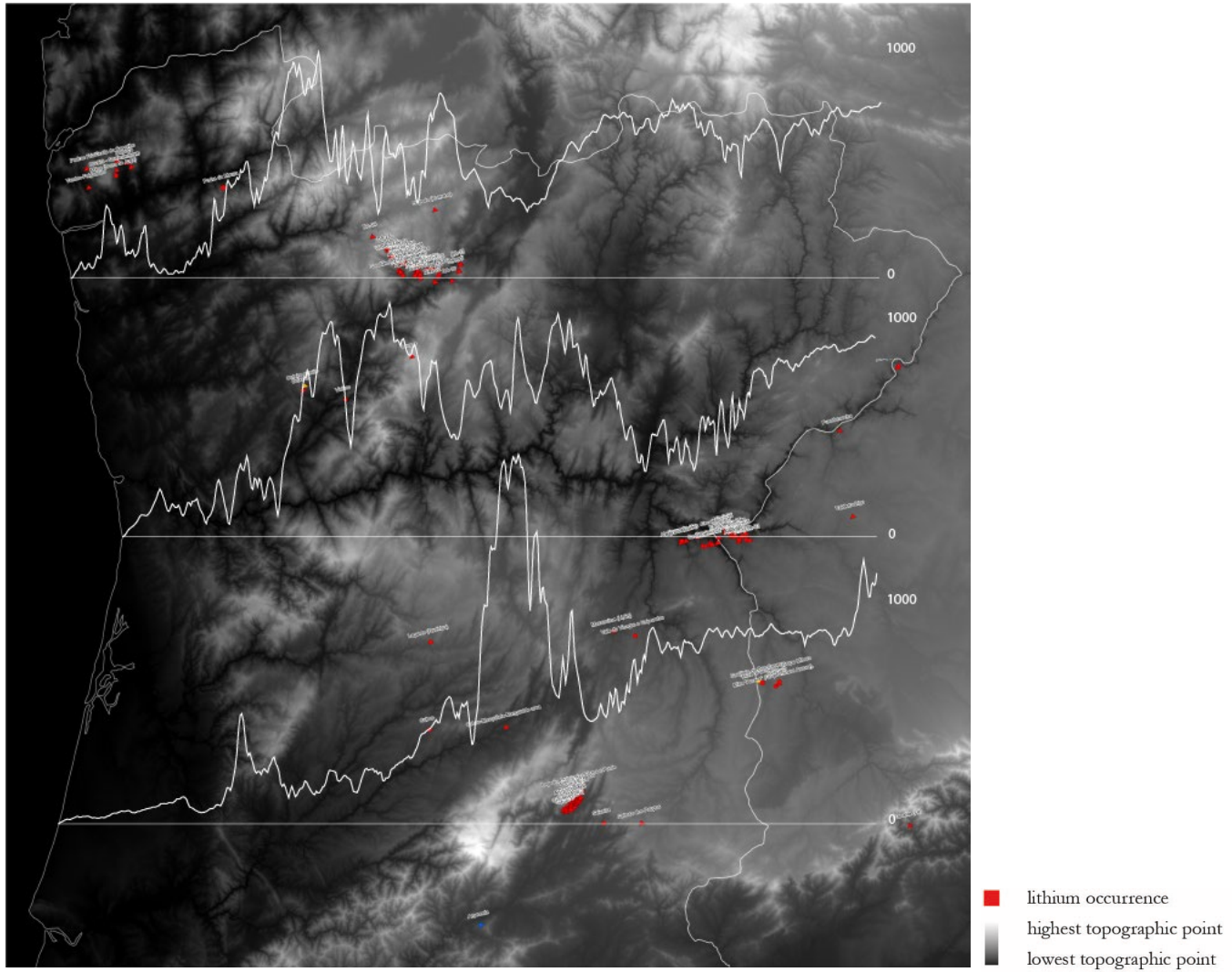
Site visit (photograph by Author)



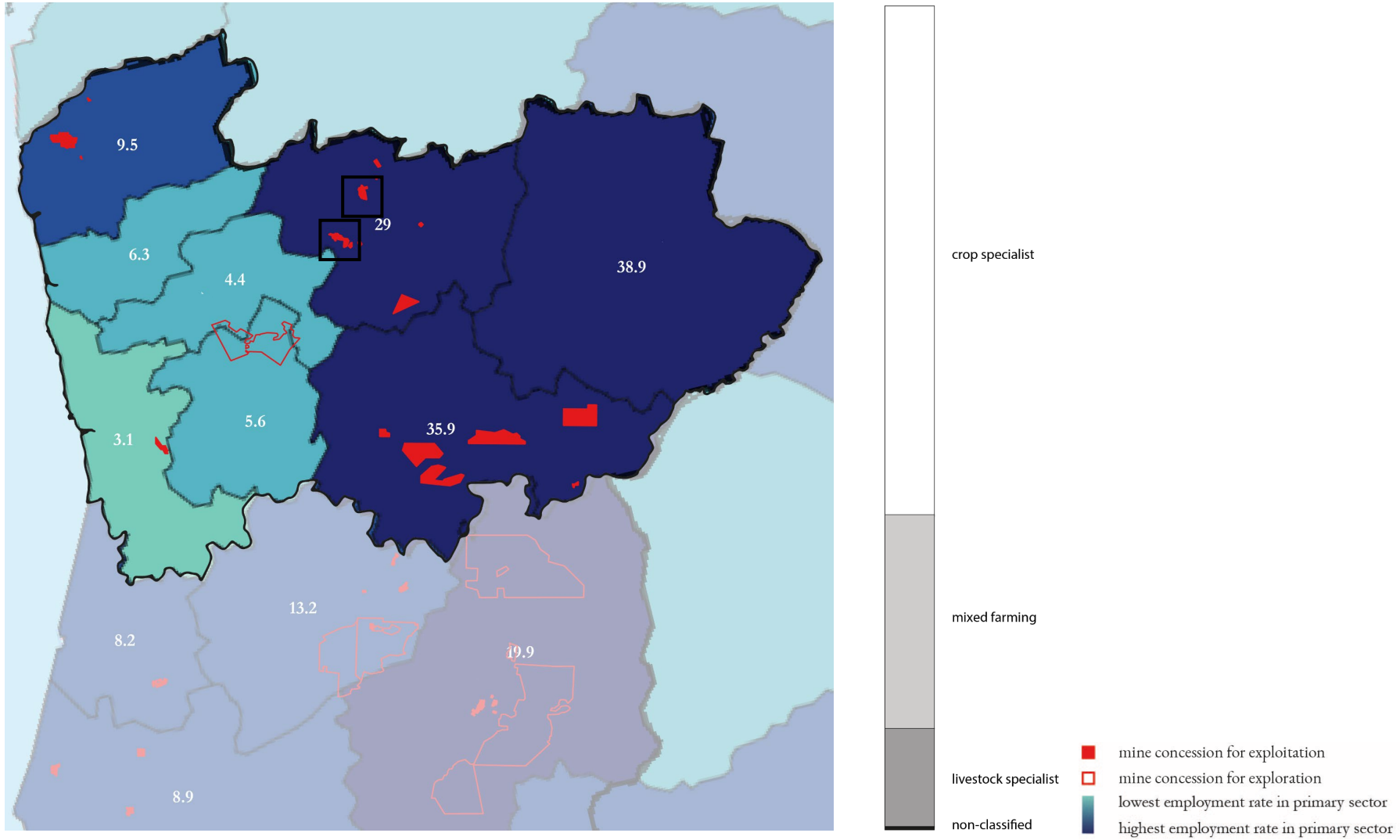
Lithium concessions in relation to land use Portugal's Norte region (by Author)



Urban density Portugal's Norte region (by Author)



Topography Portugal's Norte region (by Atuthor)

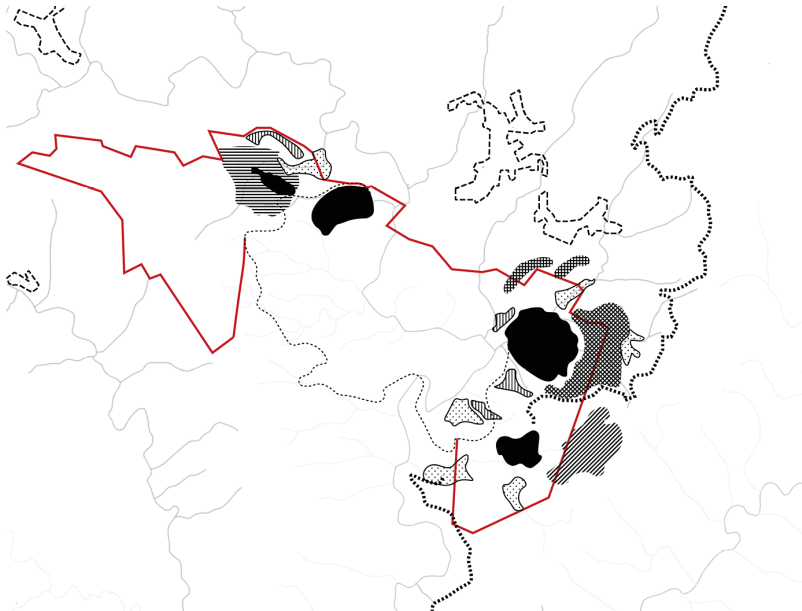


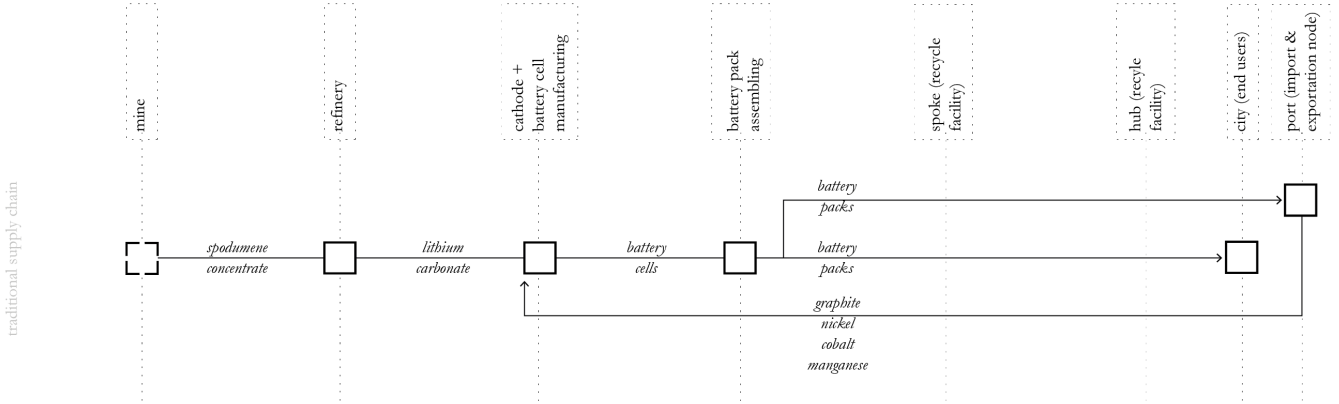
[investigating and anticipating / **site**]

Employment in agriculture, fishing and forestry Portugal's Norte region (by Eurostat, 2020)

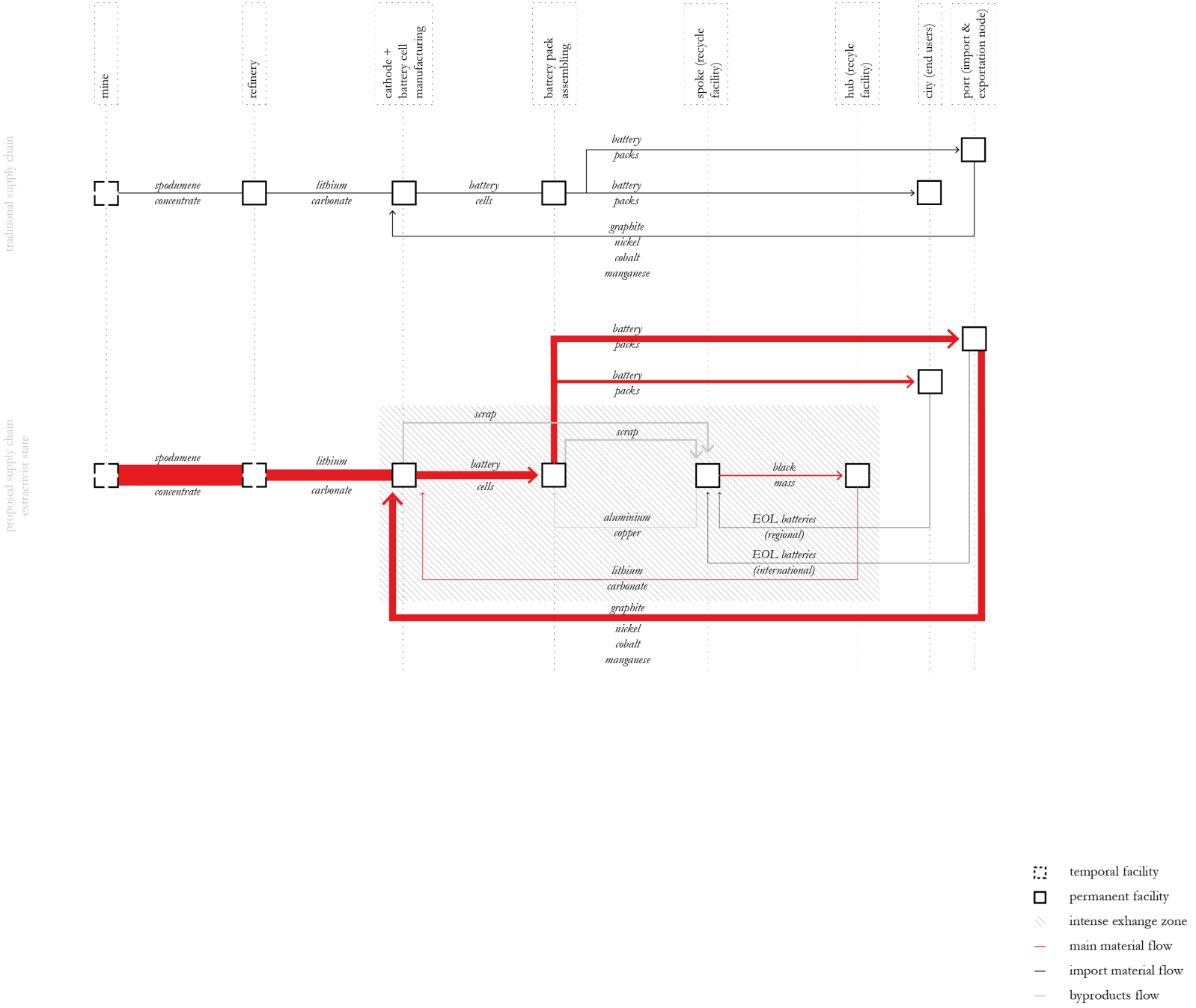
LITHIUM LANDSCAPE PROFILE:
MINE BARROSO

[Overview industry]	
Name:	Mina do Barroso by Savannah Resources
Location:	Covas do Barroso, Boticas, Portugal
Form	open-pit mining
[Key features]	
Deposit type:	hard rock/pegmatite-aplite
Deposit capacity:	27 Mt pegmatite
Extraction capacity:	1,500,000 t spodumene concentrate
Spatial dimension:	542 ha
[Operationalization]	
Start construction:	2025
Start mining operation:	end 2026
End mining operation:	2038
[Employment impact]	
Direct jobs:	300 construction phase, 215 extractivist state
[Input]	
Material:	spodumene ore
Energy:	electricity to power equipment, machinery, and buildings
Water:	water for mining operations
[Output]	
Material:	spodumene concentrate 1,500,000 t/y
Water:	wastewater
Byproducts:	quartz and feldspar (input for ceramic and glass industry), waste rock and tailings





temporal facility
permanent facility
intense exhange zone
main material flow
import material flow
byproducts flow


mine
refinery
cathode + battery cell manufacturing
battery pack assembling
spoke (recycle facility)
hub (recycle facility)
city (end users)
port (import & exportation node)
traditional supply chain
spodumene concentrate
lithium carbonate
battery cells
battery packs
battery packs
graphite
nickel
cobalt
manganese
proposed supply chain
extractivist state
battery packs
battery packs
scrap
scrap
spodumene concentrate
lithium carbonate
battery cells
black mass
aluminium
copper
EOL batteries (regional)
EOL batteries (international)
lithium carbonate
graphite
nickel
cobalt
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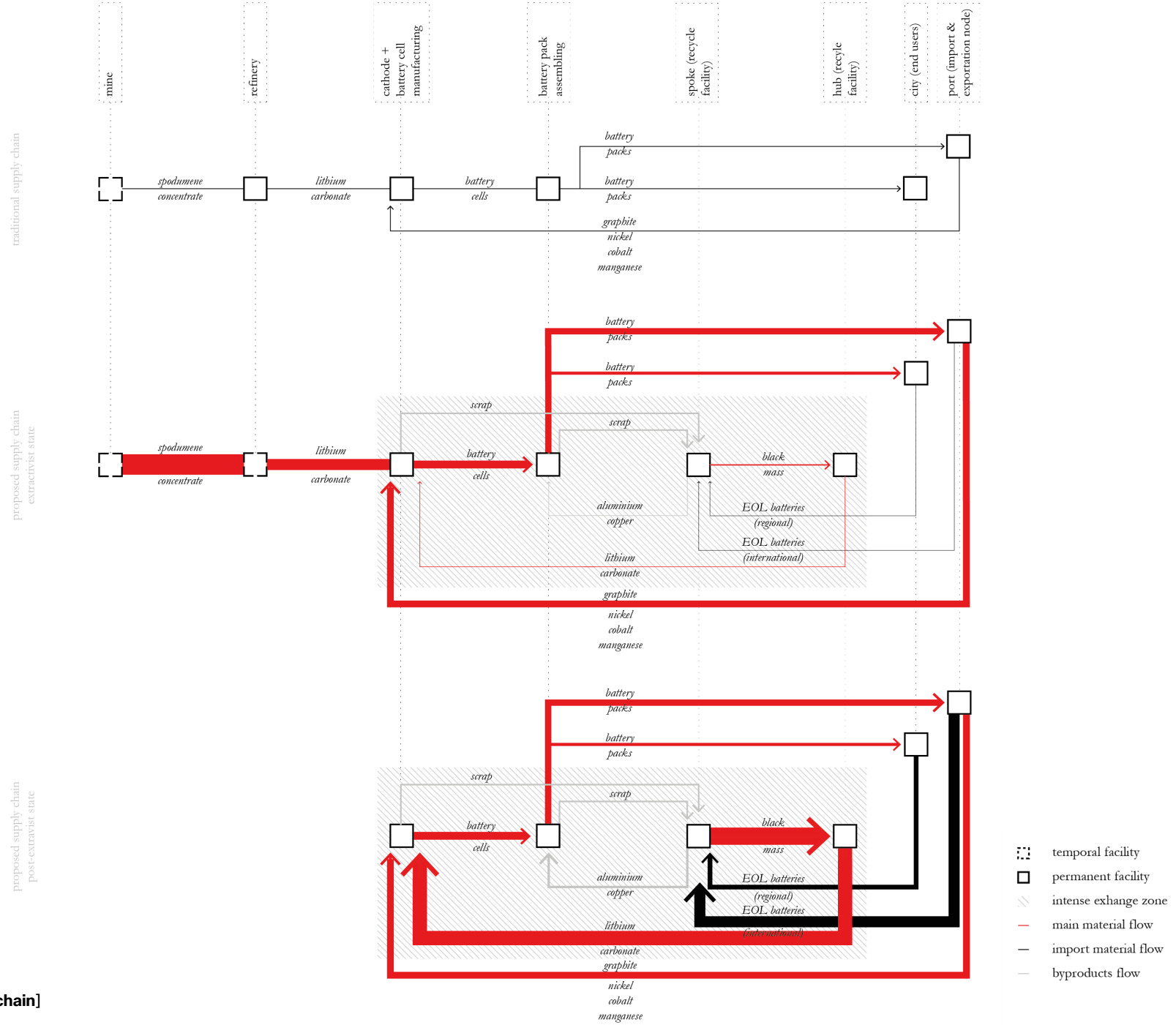
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Takeaways Analysis

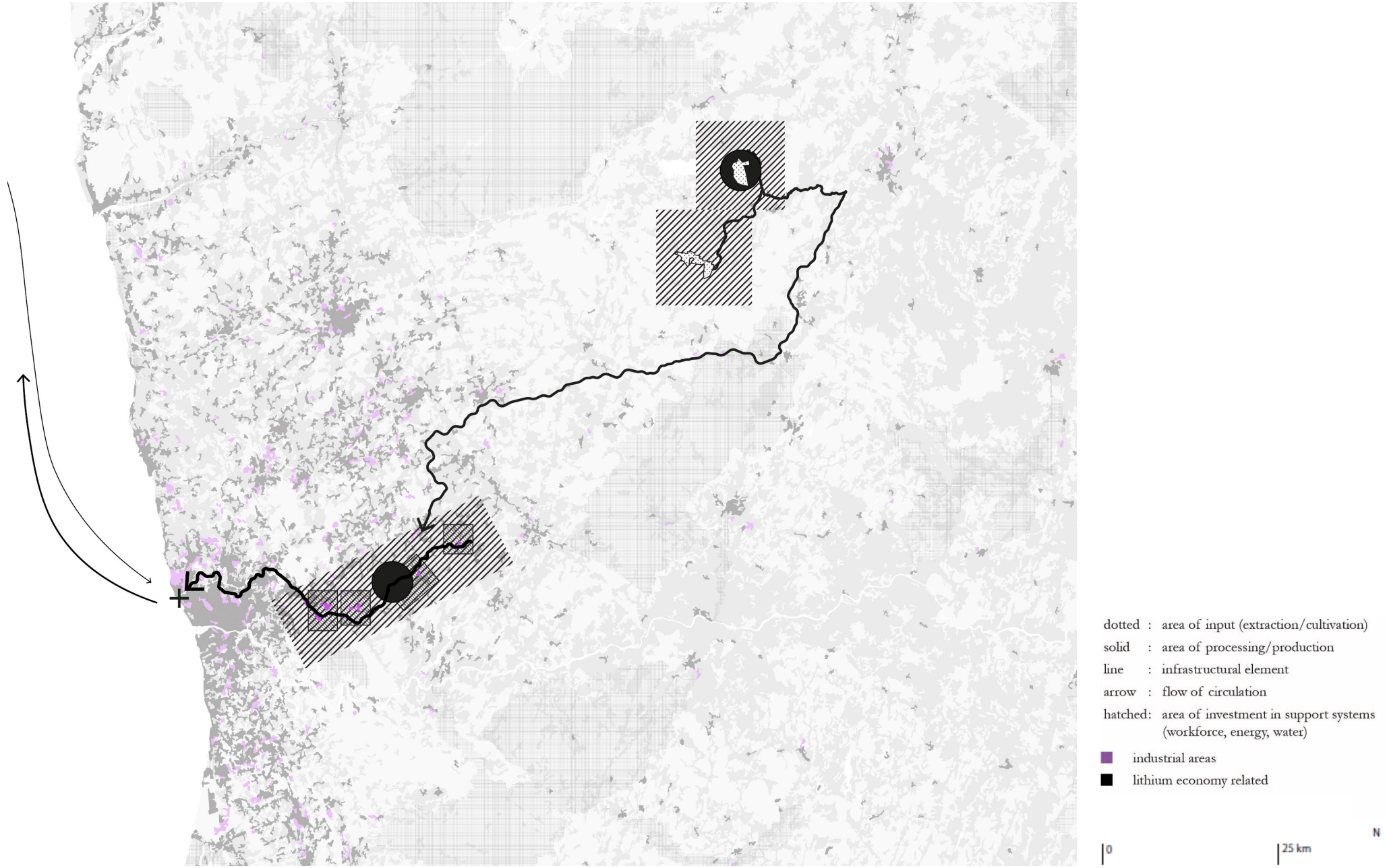
- Understanding the regional population patterns and trends can help **strategically locate** the industries and stimulate development.

- Recognizing the role of the agriculture sector in shaping the cultural and physical landscape of the Alto Tâmega region is crucial for envisioning a post extractive future that **respects and integrates in the local context and identity**, ensuring a strategy that is widely accepted.

- Understanding of the key features of each industry helps to **plan and facilitate for the requirements of each landscape**, mainly size workforce, energy and water demand.

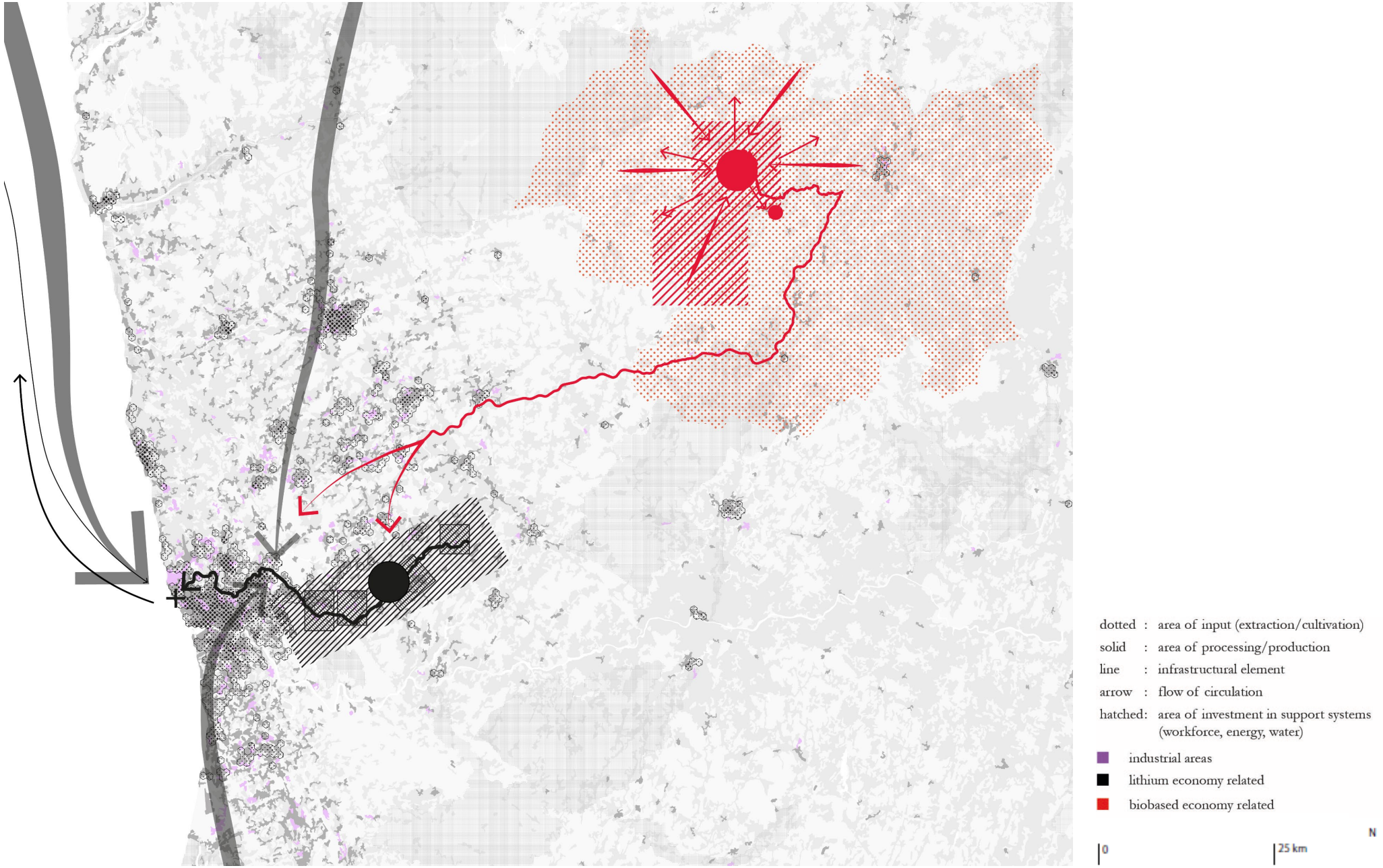
- **Strategically** situating and **clustering** the industries in the battery supply chain can significantly enhance operational efficiencies, exchange of materials and encourage collaboration with the quaternary sector to support innovation in the field.

Part 03 – Projecting *(form)*



[projecting / **vision / extractivist state**]

Vision map Portugal's Norte region extractivist state (by Author)



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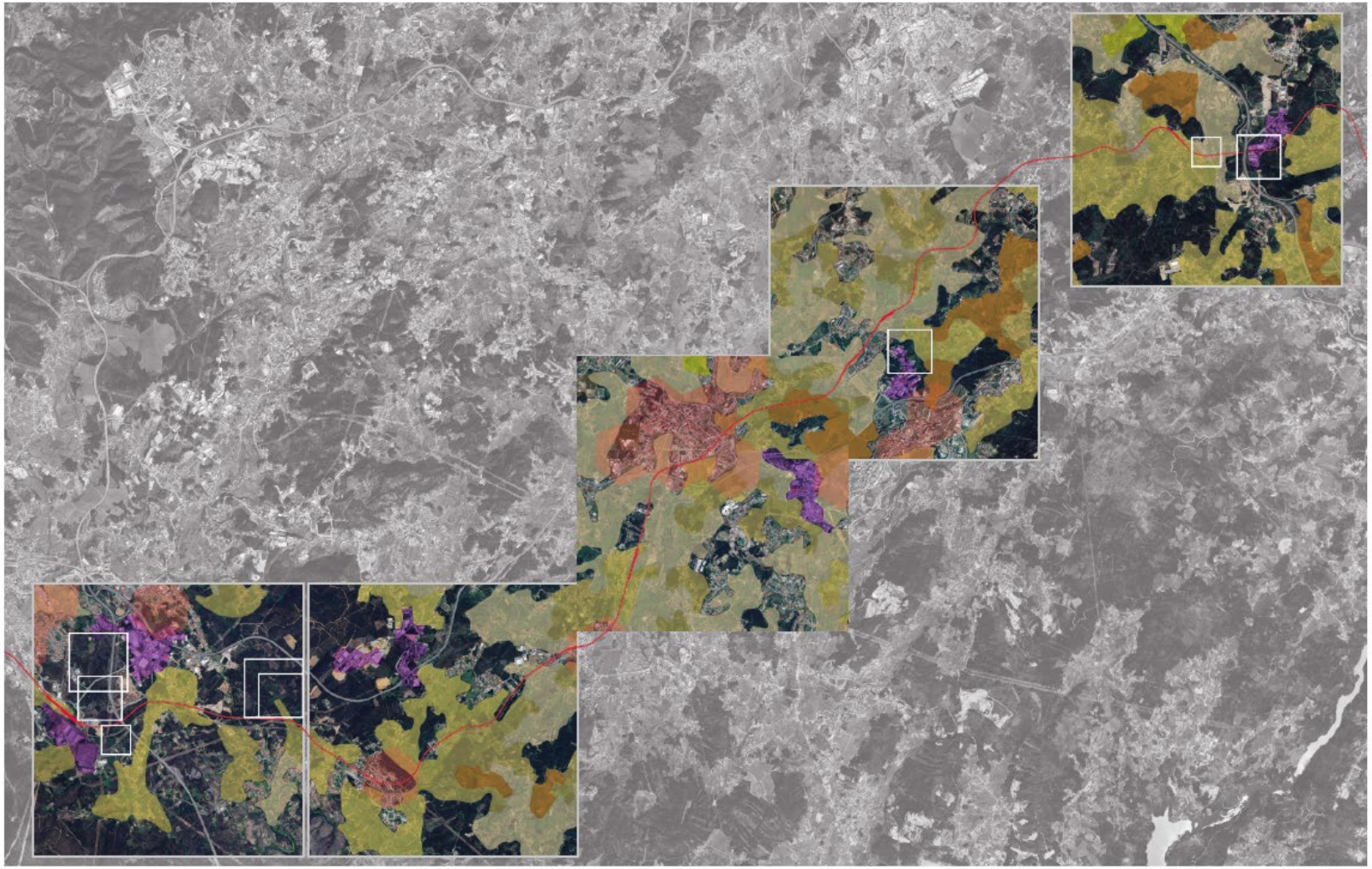
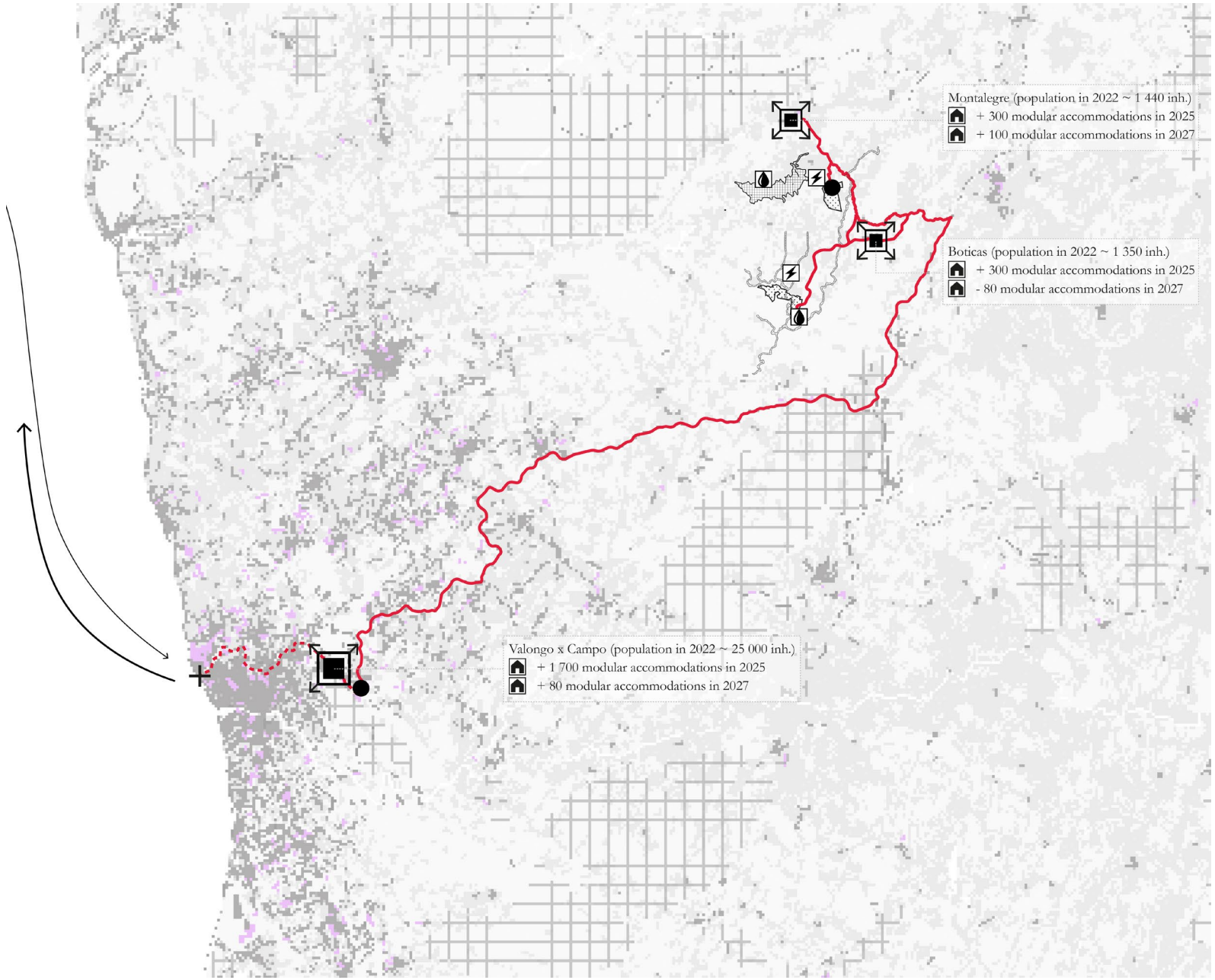


Acces to ... / Availability of ...	Space	Motorway	Railway	Labour	Energy	Typography
Area 01	++	++	++	+	+	+
Area 02	+	0	++	-	-	-
Area 03	-	+	0	0	0	0
Area 04	0	++	--	--	--	--

urban agglomeration >1 000 inh.
agriculture
industrial area
railway
25/50/100 ha

0 5 km



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

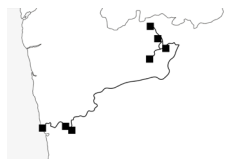
INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

ENERGY & WATER INFRASTRCURE DEVELOPMENT

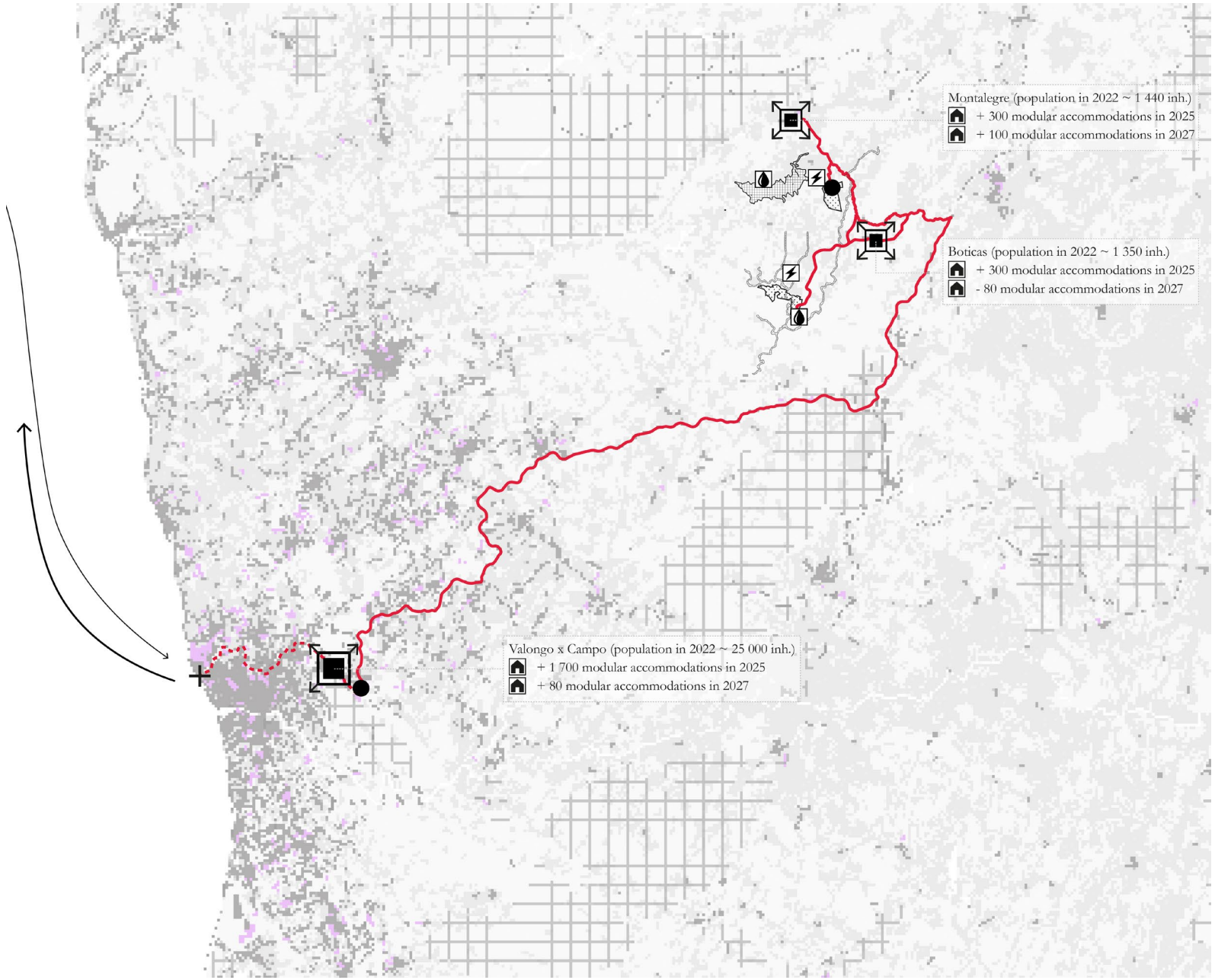
INDUSTRIAL DEVELOPMENT

- area of lithium extraction
- area of refinery
- industry district cluster
- city growth
- related waterbody & watershed
- international circulation flow
- road
- railway
- port



N

0 | 25 km



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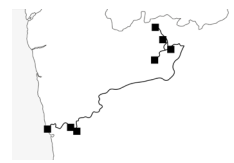

N

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URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

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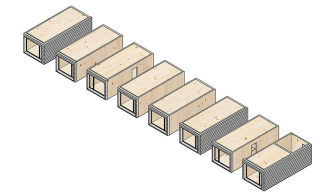
ENERGY & WATER INFRASTRCURE DEVELOPMENT

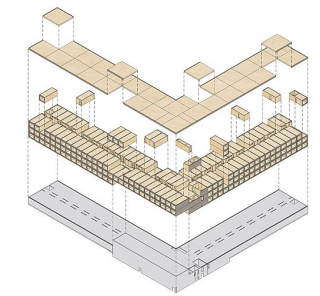
INDUSTRIAL DEVELOPMENT

Montalegre (population in 2022 ~ 1 450 inh.)
- 350 (-90%) modular accommodations in 2040

Boticas (population in 2022 ~ 1 350 inh.)
- 150 (-70%) modular accommodations in 2040

Valongo x Campo (population in 2022 ~ 25 000 inh.)
+ 500 modular accommodations in 2040 from Montalegre and Boticas





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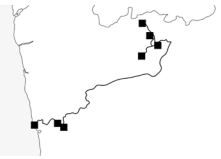

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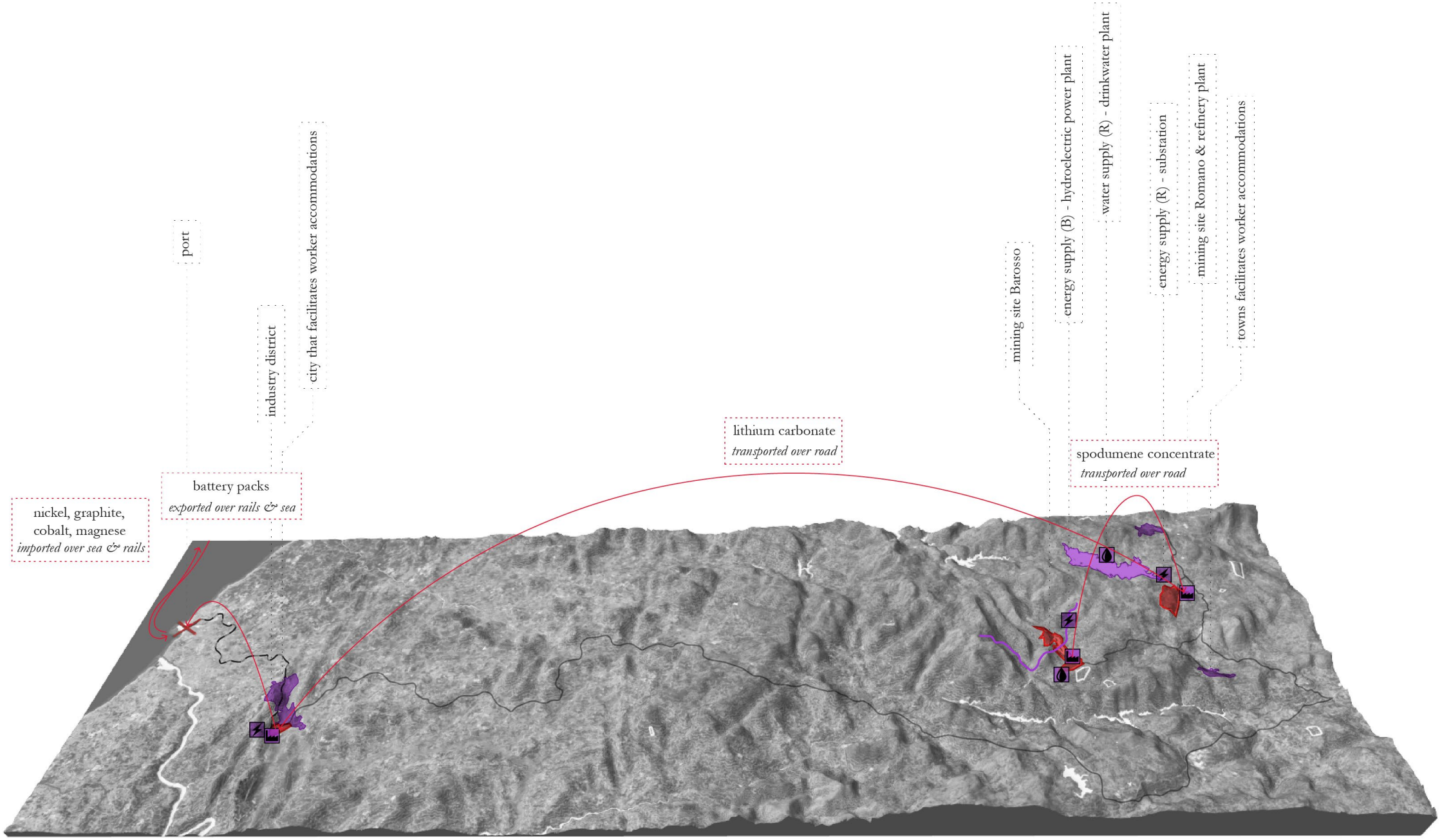
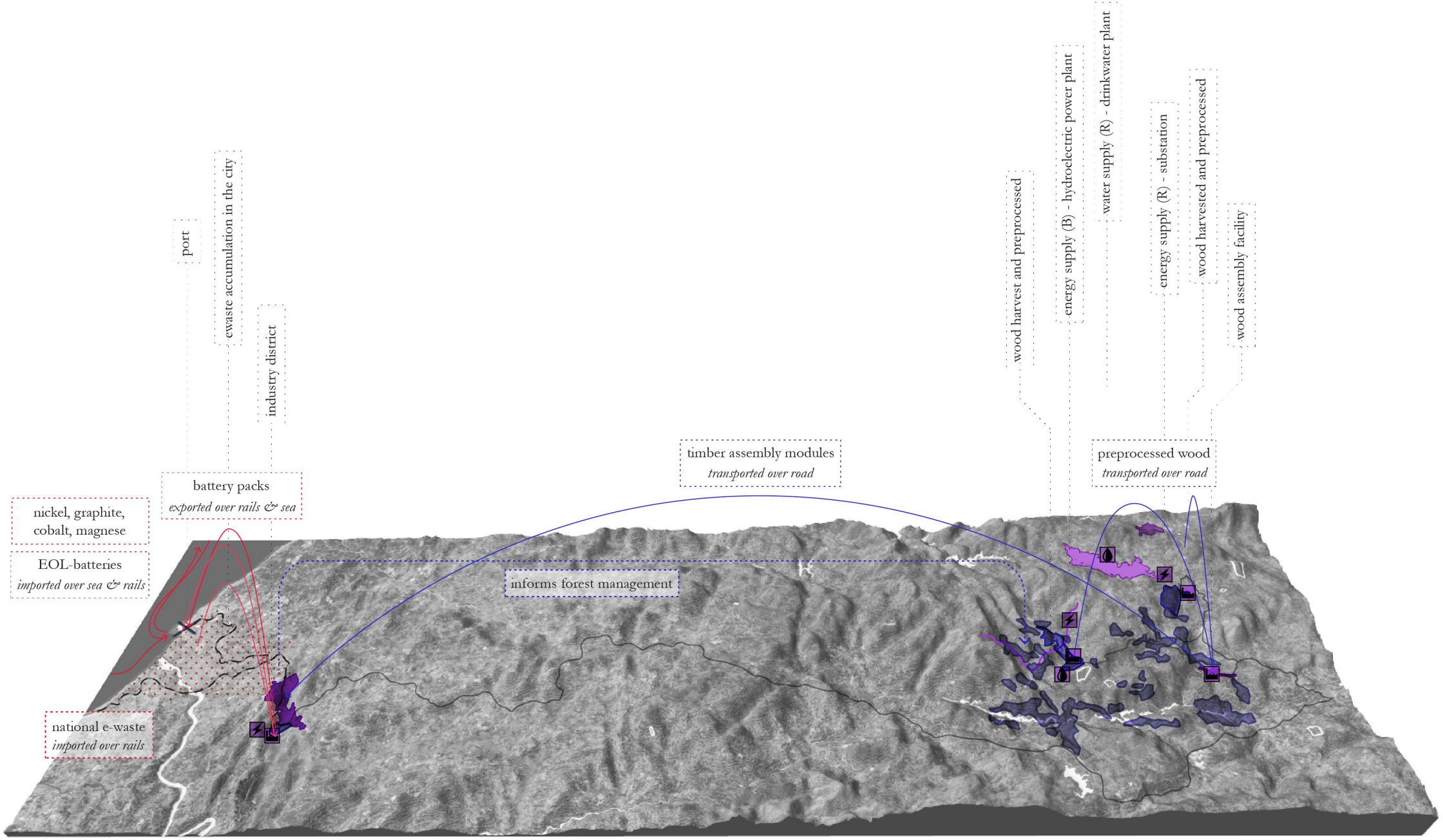
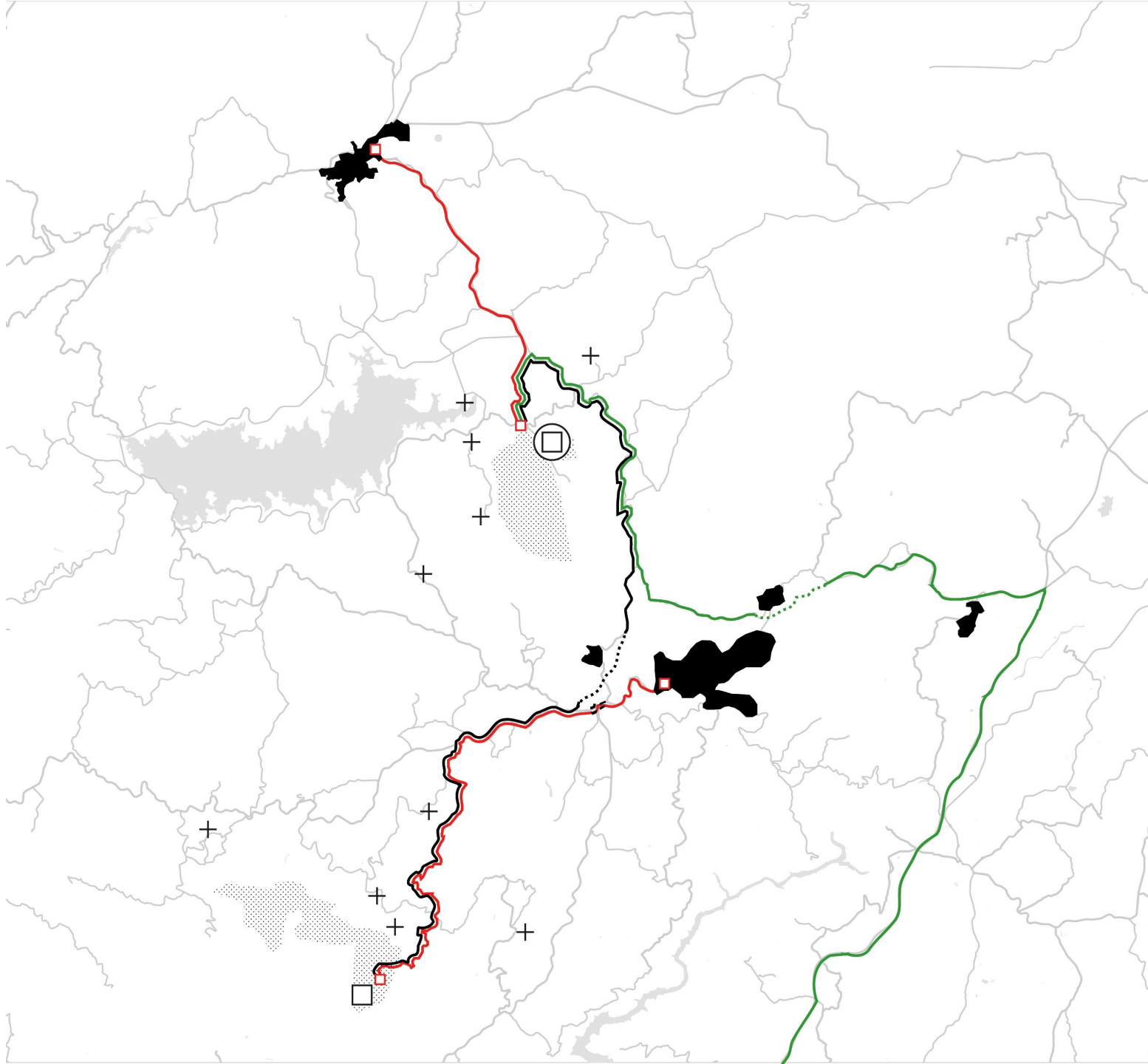
0 | 25 km


port
industry district
city that facilitates worker accommodations
mining site Barosso
energy supply (B) - hydroelectric power plant
water supply (R) - drinkwater plant
energy supply (R) - substation
mining site Romano & refinery plant
towns facilitates worker accommodations
nickel, graphite, cobalt, magnese
imported over sea & rails
battery packs
exported over rails & sea
lithium carbonate
transported over road
spodumene concentrate
transported over road

0 25 km N


port
ewaste accumulation in the city
industry district
wood harvest and preprocessed
energy supply (B) - hydroelectric power plant
water supply (R) - drinkwater plant
energy supply (R) - substation
wood harvested and preprocessed
wood assembly facility
timber assembly modules
transported over road
preprocessed wood
transported over road
battery packs
exported over rails & sea
nickel, graphite, cobalt, magnese
EOL-batteries
imported over sea & rails
informs forest management
national e-waste
imported over rails

0 25 km N



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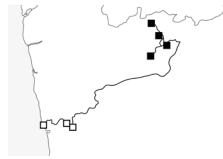
LAND USE CHANGE / CULTIVATION PATTERNS

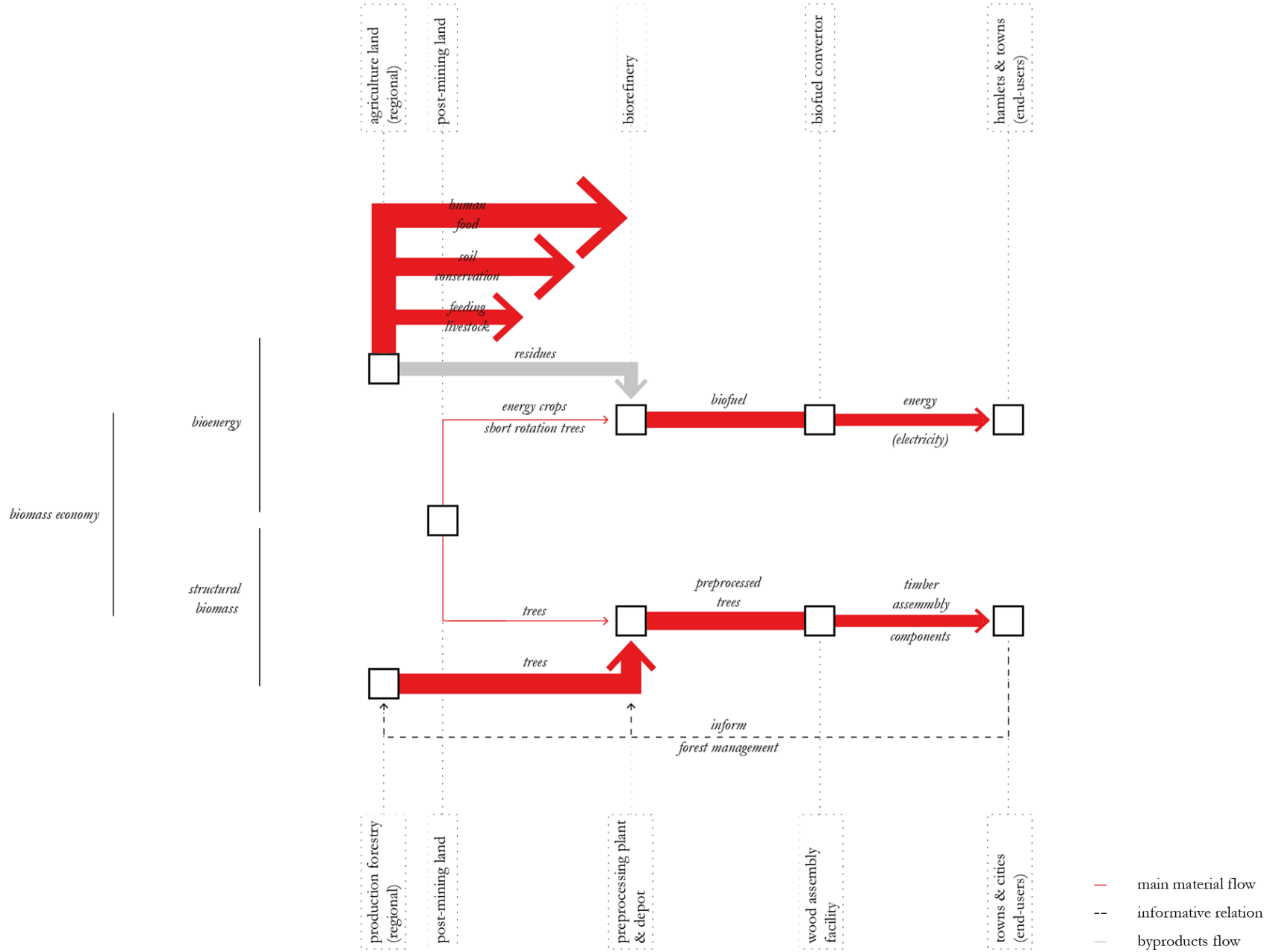
ENERGY & WATER INFRASTRCURE DEVELOPMENT

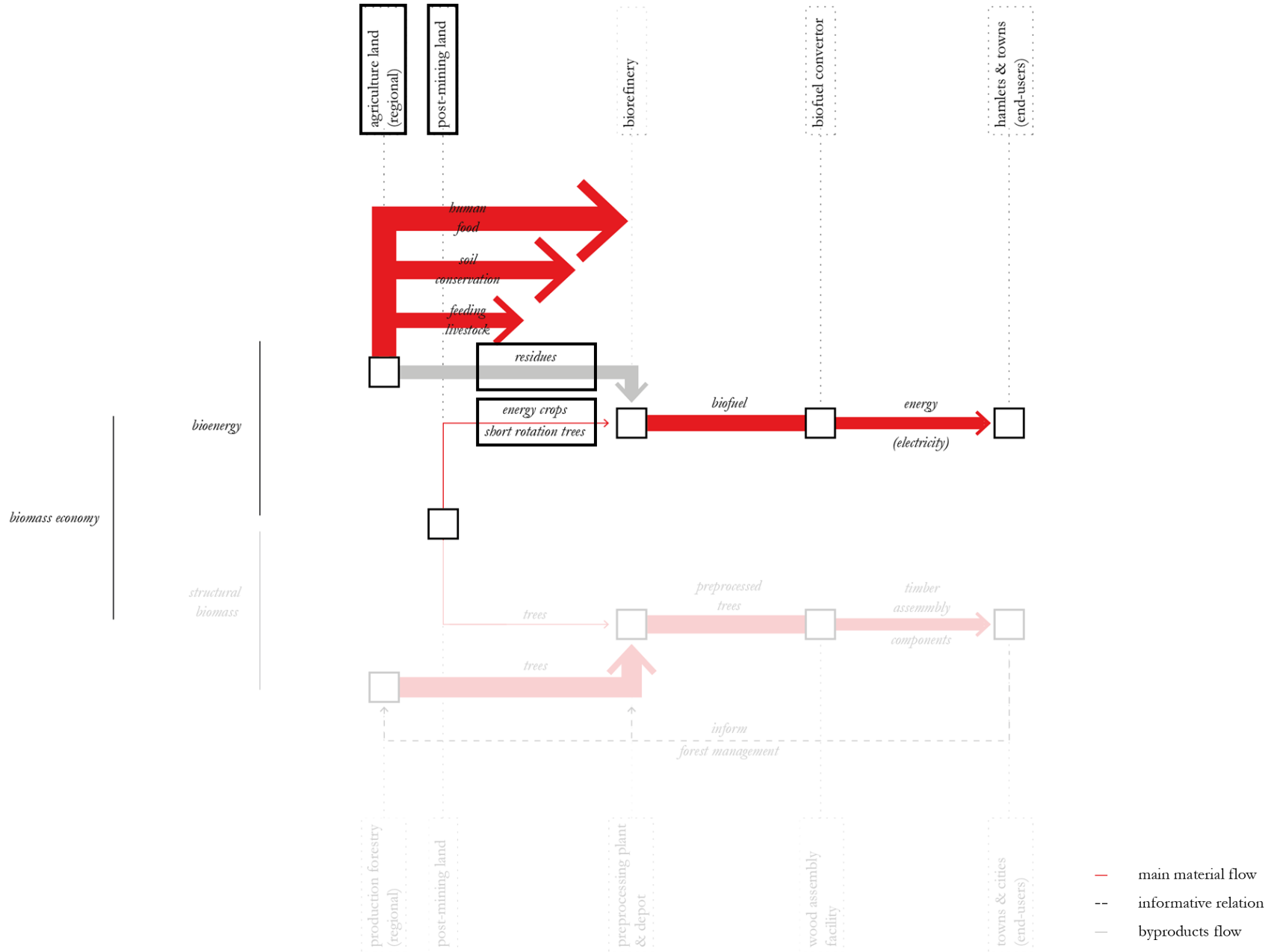
INDUSTRIAL DEVELOPMENT

- mine to mine connection
- mine to town bus connection
- mine to battery cell manufacturer connection
- bypass road
- bus stop
- hamlets
- benification facility (preprocessing)
- refinery plant
- mining concession
- settlements



0 | 10 km


agriculture land (regional)
post-mining land
biorefinery
biofuel convertor
hamlets & towns (end-users)
human food
soil conservation
feeding livestock
residues
energy crops
short rotation trees
biofuel
energy
(electricity)
bioenergy
biomass economy
structural biomass
trees
preprocessed trees
timber assemmbly
components
trees
inform
forest management
production forestry (regional)
post-mining land
preprocessing plant & depot
wood assembly facility
towns & cities (end-users)
main material flow
informative relation
byproducts flow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main material flow
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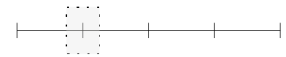
byproducts flow

biomass resources	associated landcover	asssociated facility	seasonallity	harvest frequency
			winter spring summer autumn	
short rotation trees	post-mining area	thermochemical		every 2-4 years
energy crops	post-mining area	thermochemical		
miscanthus				annually
switchgrass				annually
crop residues	non-irrigated land / annual crops associated permanent crops	thermochemical, biochemical		annually (depends on crop type)
orchard prunnings / vineyard prunnings	vineyards / land coverd by agriculture and significant areas of natural vegetation	thermochemical		1-2 times per year
forestry residues / logging residues	forestry	thermochemical		every 1-2 years (depends on forestry management plans)
livestock manure	pastures	anaerobic		year-round
food waste	residential areas	anaerobic		year-round

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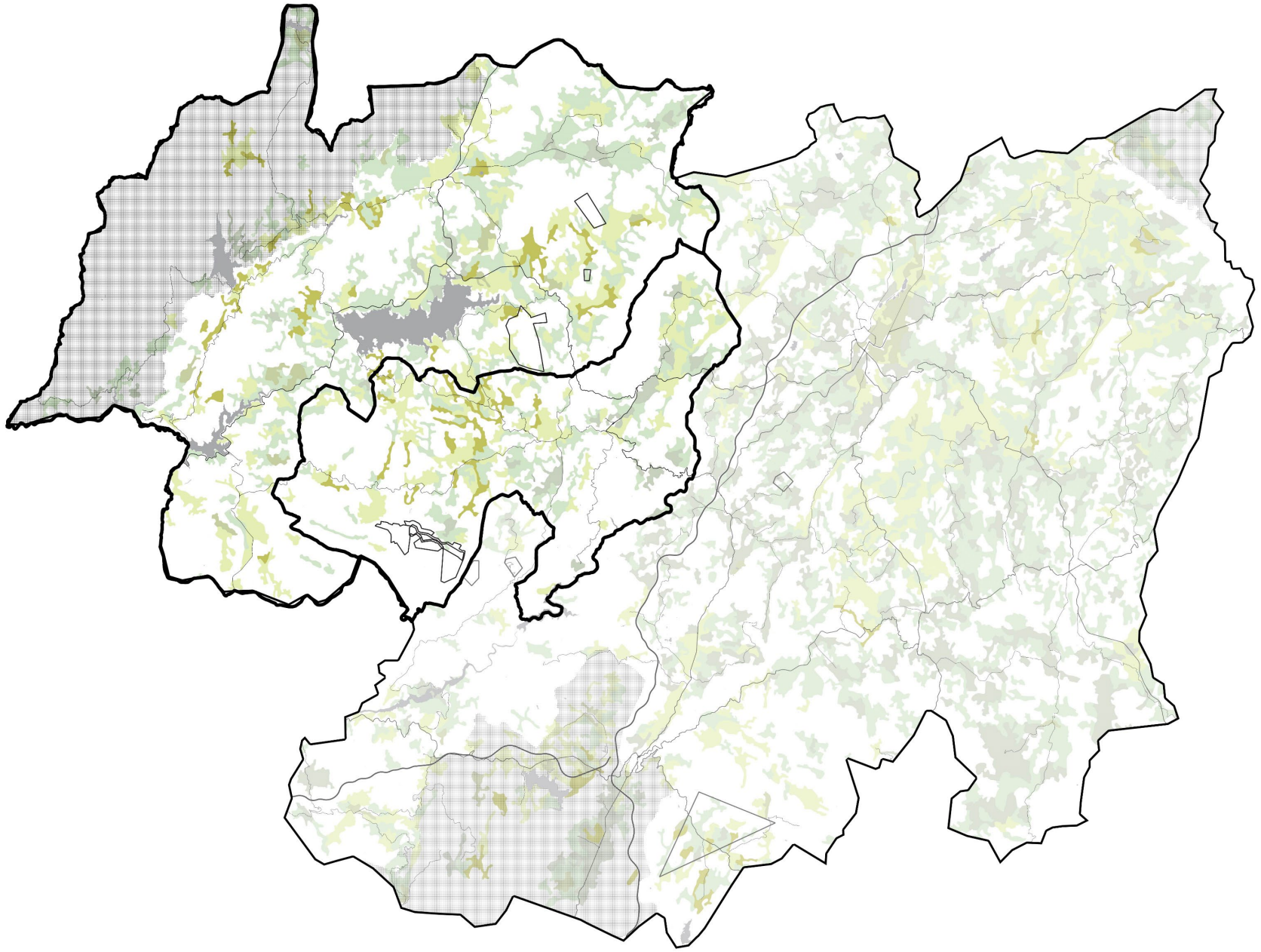
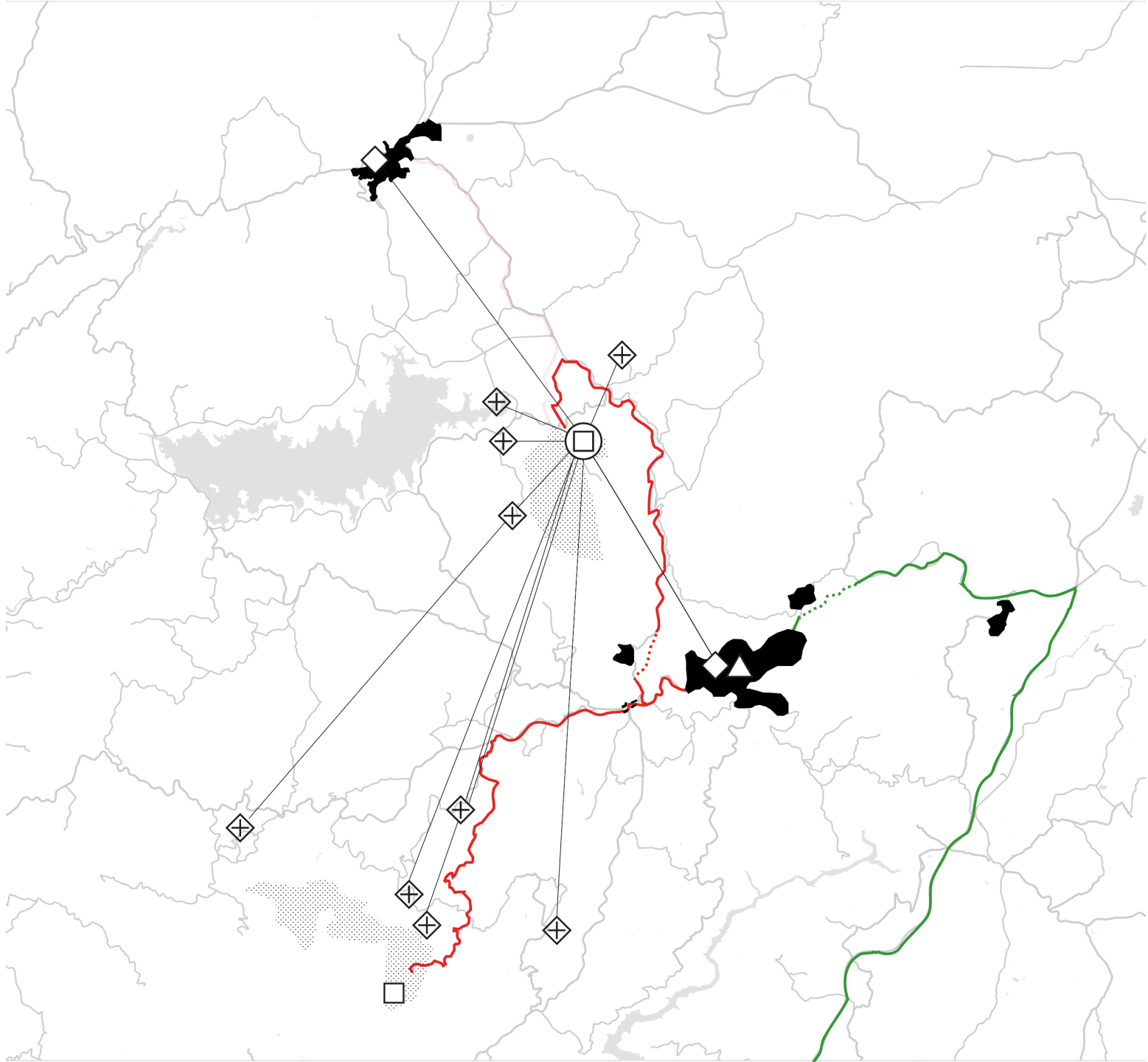
ENERGY & WATER INFRASTRCURE DEVELOPMENT

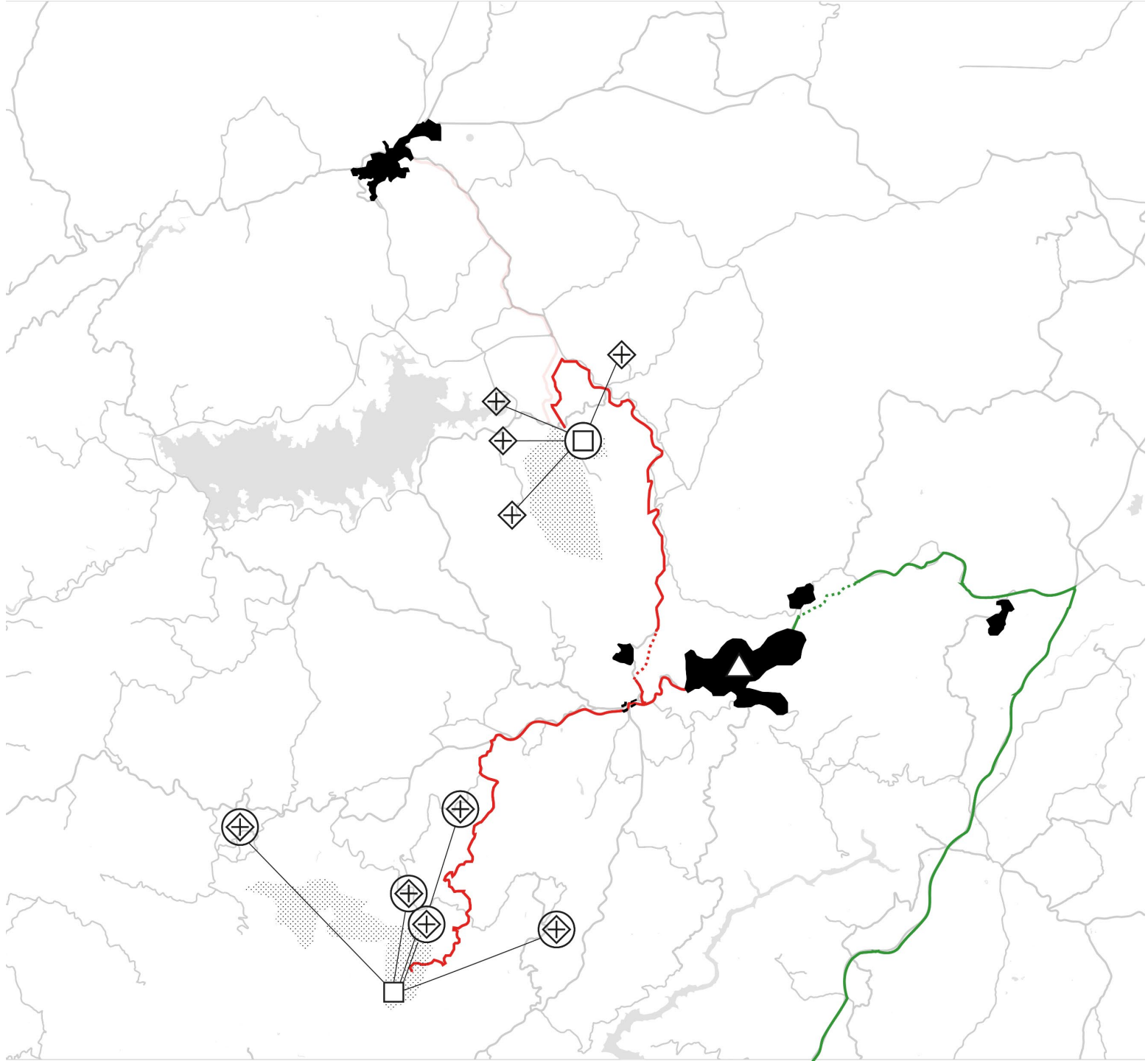
INDUSTRIAL DEVELOPMENT



- mine concession area
- vineyards/orchard prunings
- live stock manure
- crop residues (from irrgated land)
- crop residues from (non irrigated land)
- nature 2000 areas



[projecting / **strategy / post-extractivist state**]


post-mining area to timber assembly facility
timber assembly facility to Grande Porto
bypass road
biofuel converter
hamlets
preprocessing and depot facility
biorefinery plant
energy crops cultivation / forestry
settlements
timber assembly facility
0
10 km

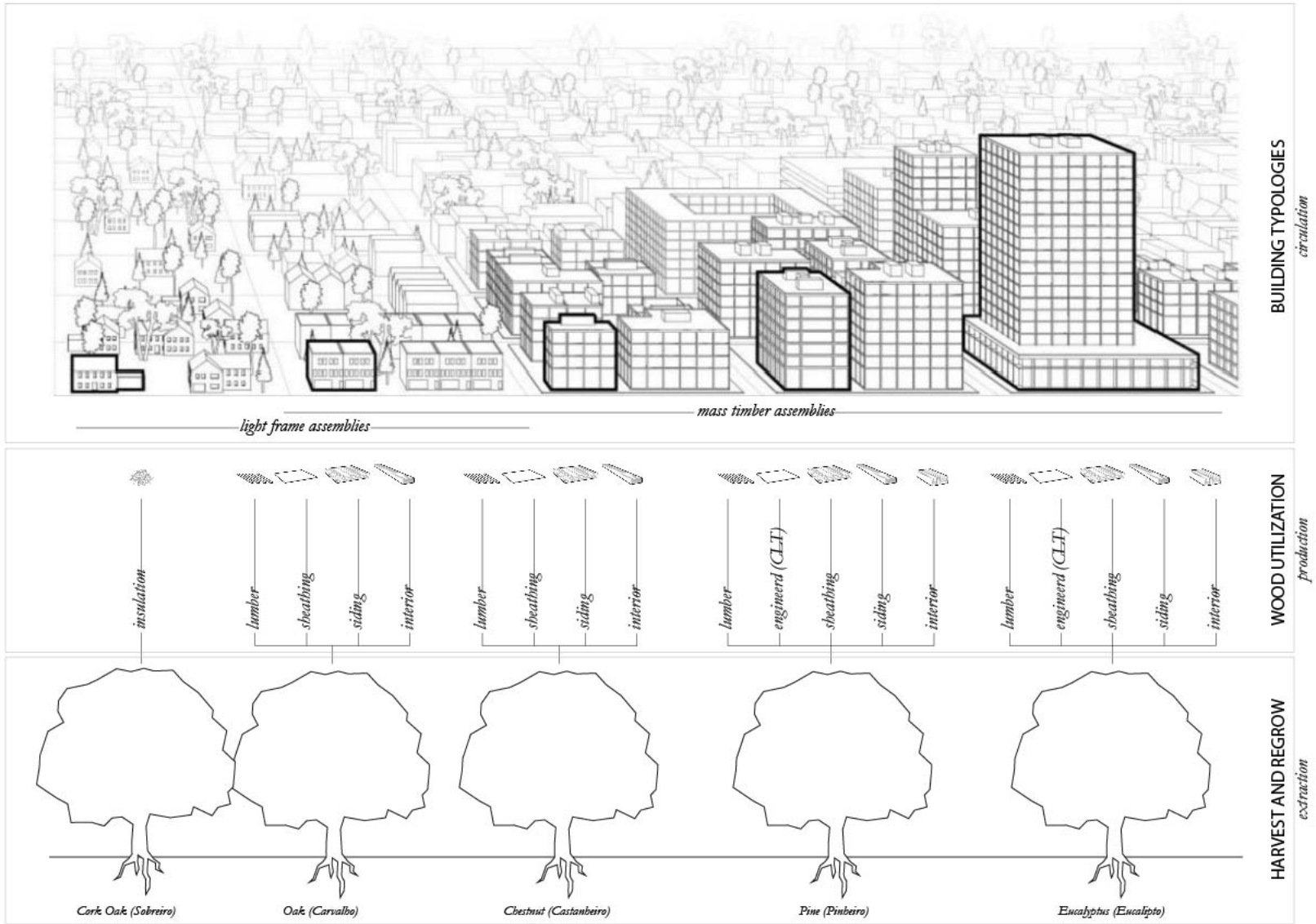
URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

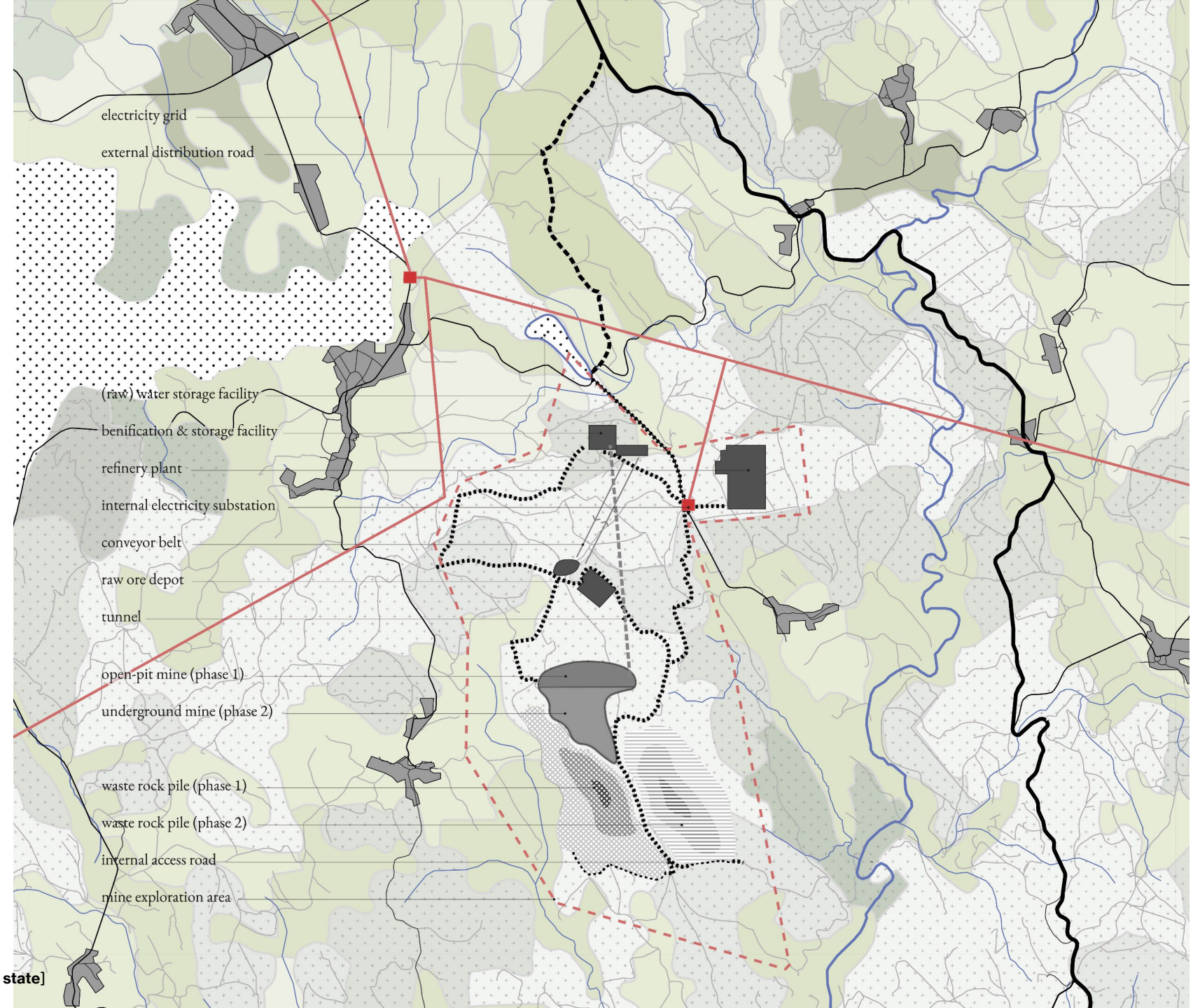
INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

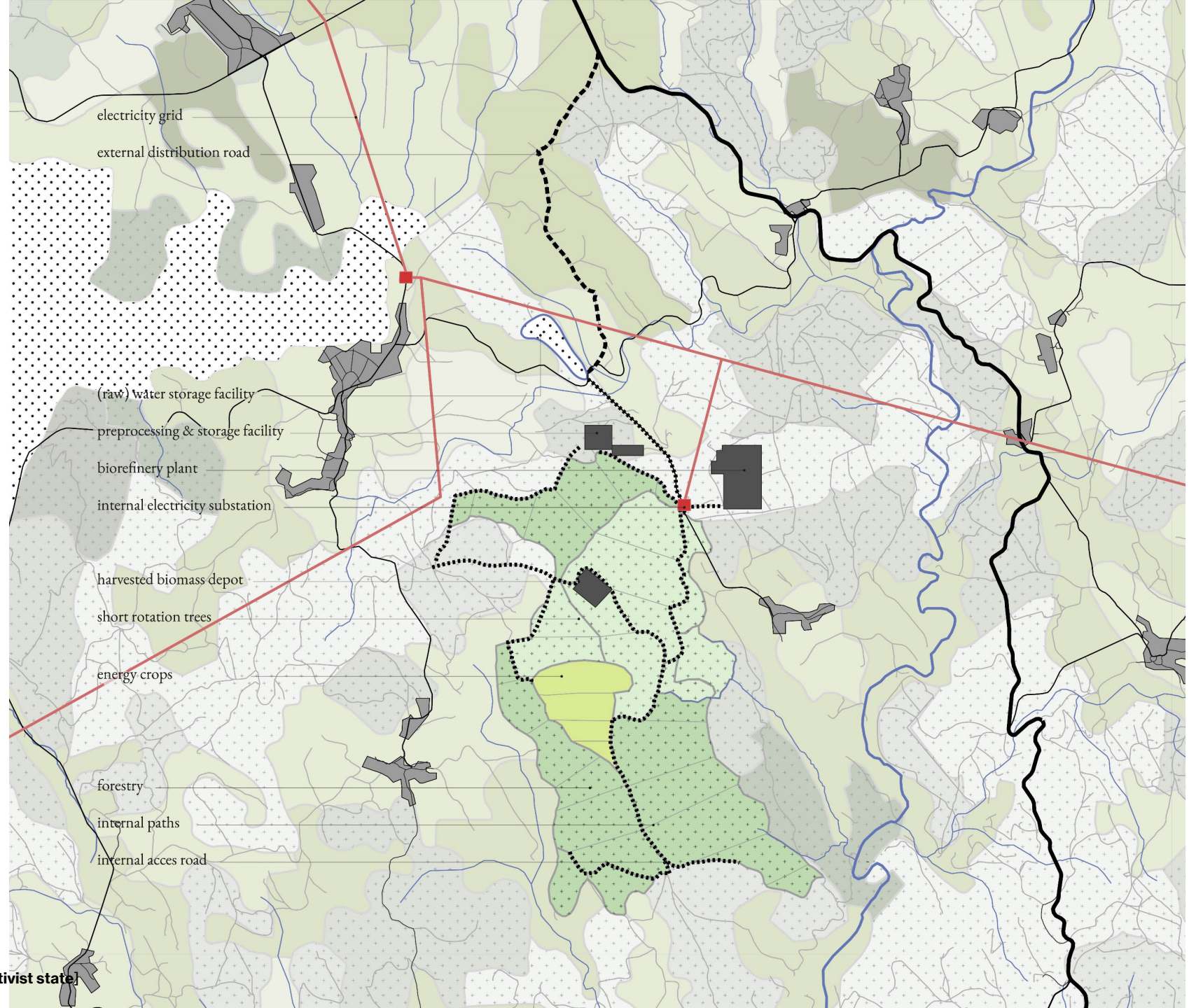
ENERGY & WATER INFRASTRCURE DEVELOPMENT

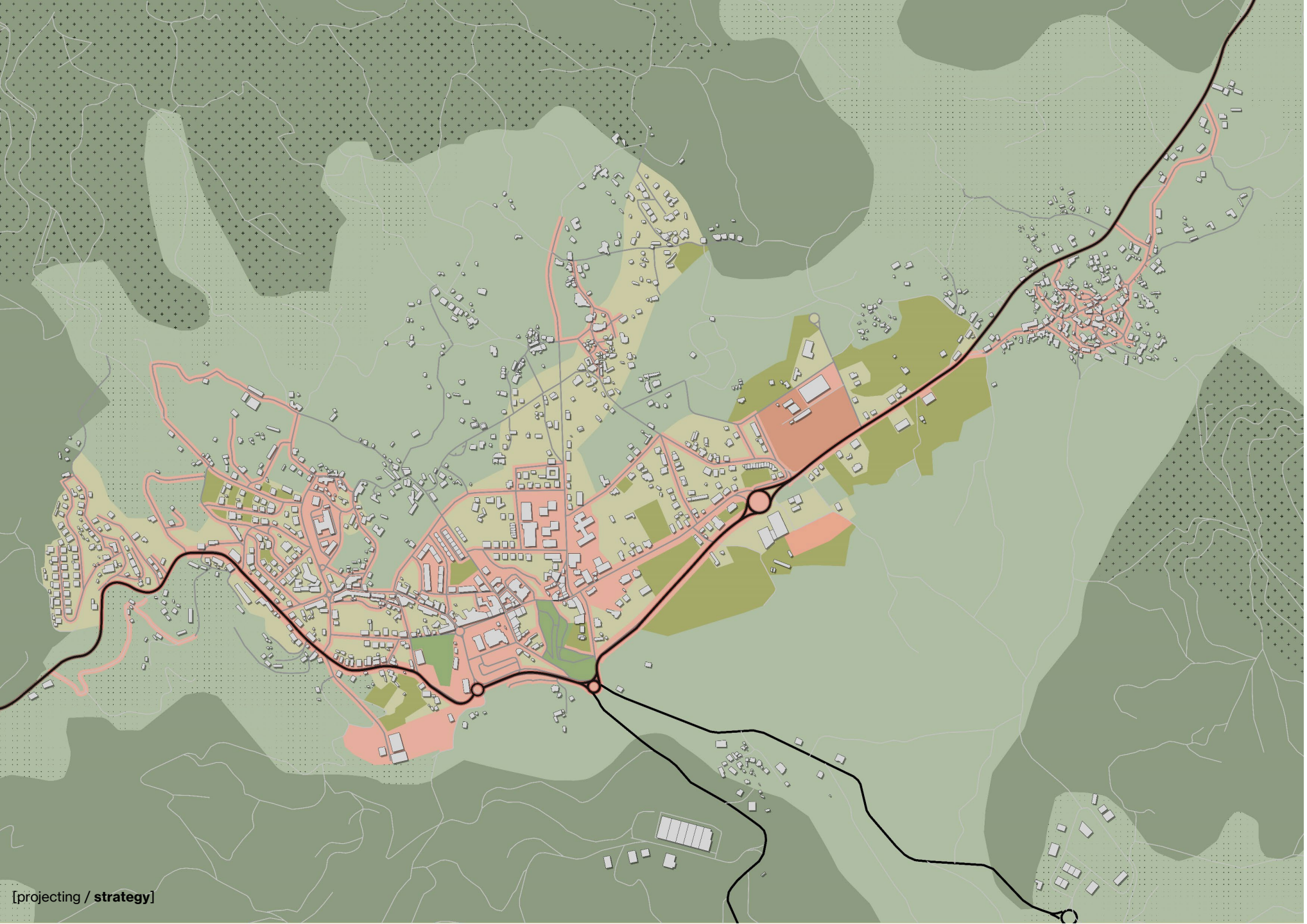
INDUSTRIAL DEVELOPMENT





[projecting / **strategy / extractivist state**]


electricity grid
external distribution road
(raw) water storage facility
preprocessing & storage facility
biorefinery plant
internal electricity substation
harvested biomass depot
short rotation trees
energy crops
forestry
internal paths
internal acces road
hamlets
waterbody
waterstream
paths (fragmentation of land patches)
roads
natural grasslands
sparsely vegetated land
moors and heathland
confirous forest
transitional woodland scrub
complex cultivated land (crops)
permanent irrigated land
orchards
non-irrigated land
pastures
0
2 km



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

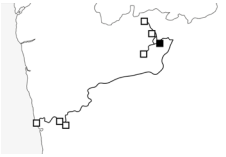
INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

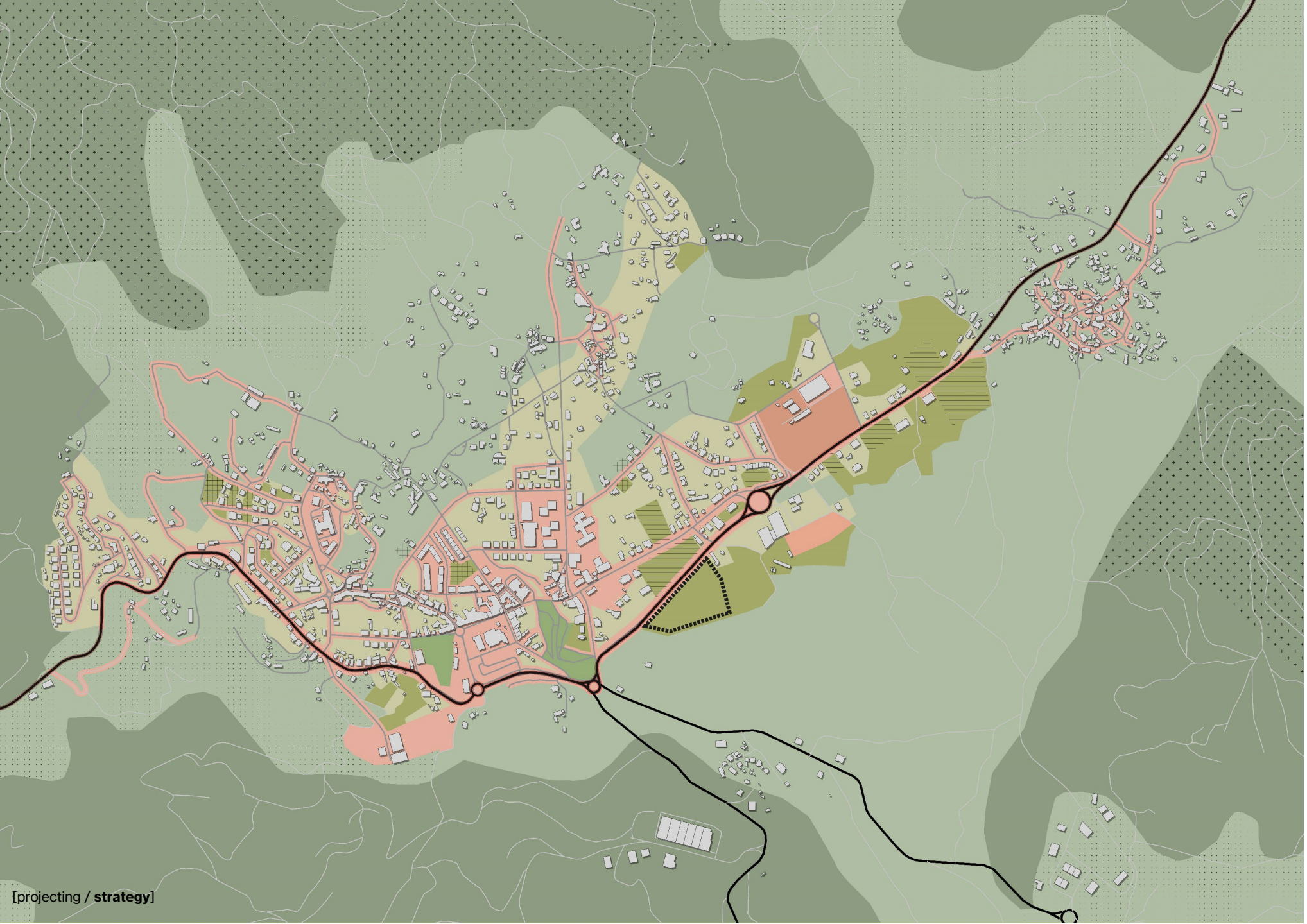
ENERGY & WATER INFRASTRCURE DEVELOPMENT

INDUSTRIAL DEVELOPMENT

- existing buildings
- additional modular timber buildings
- additional timber assembly & storage facility
- residential roads
- major transportation road / development axes
- public open space
- cemetery
- sports
- small/community scale agri-cultivation
- vegetated/developble land
- park
- coniferous forest
- crop residues
- complex cultivation patterns
- vineyards
- transitional woodland scrub
- coniferous forest



0 500 m



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LAND USE CHANGE / CULTIVATION PATTERNS

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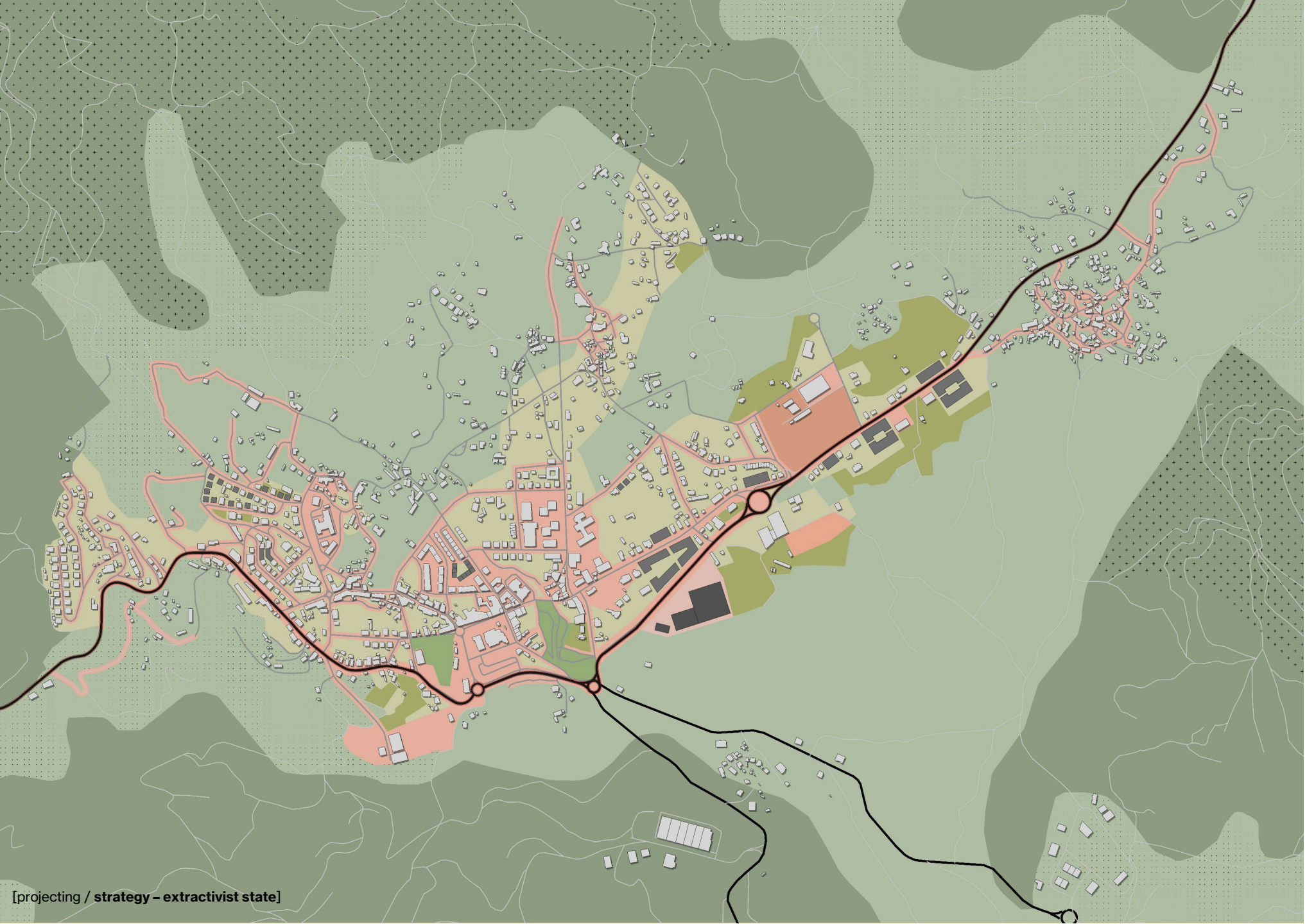
0 500 m



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

ENERGY & WATER INFRASTRCURE DEVELOPMENT

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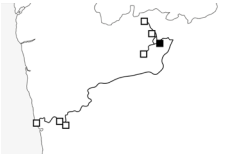
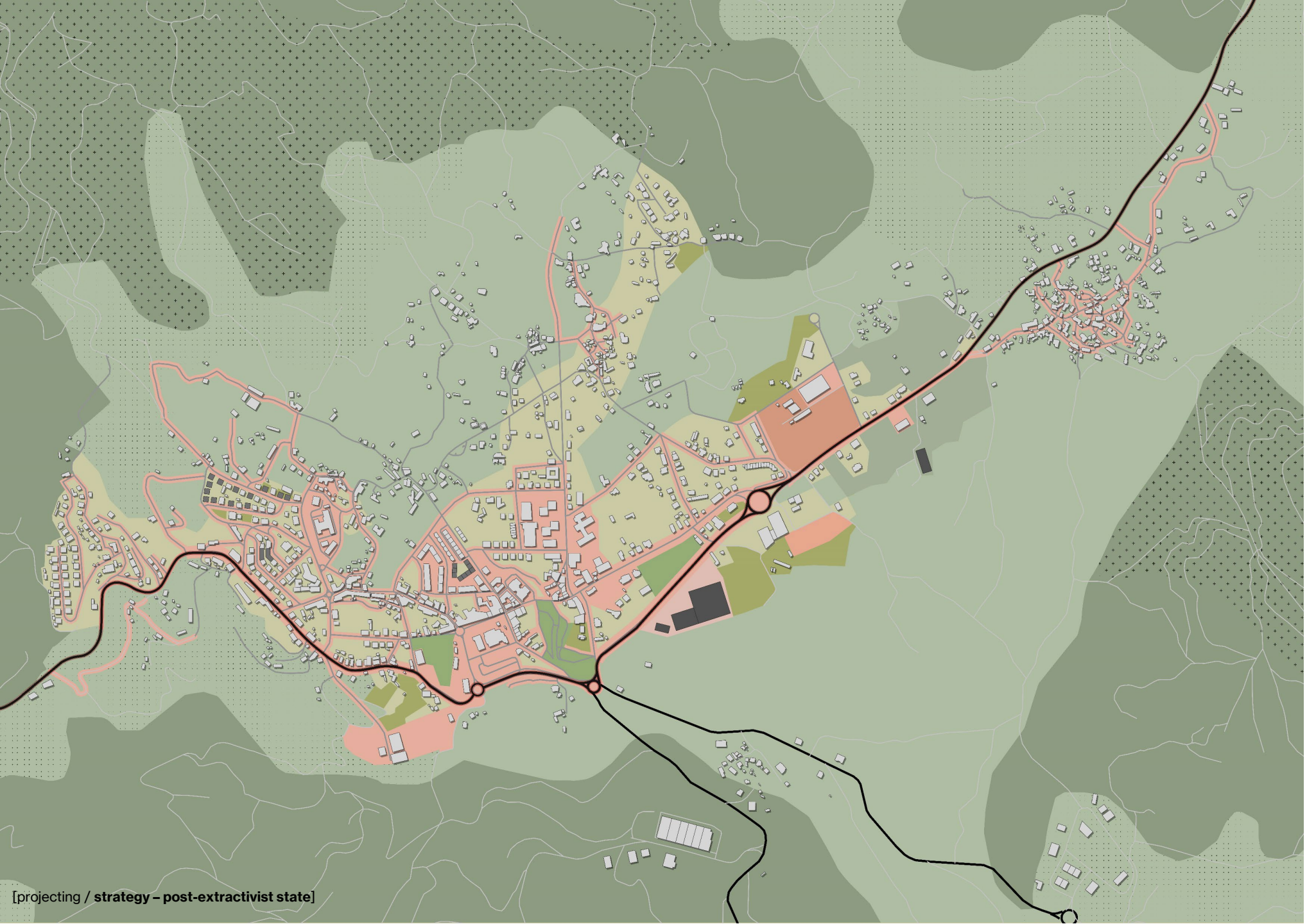


0 500 m



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

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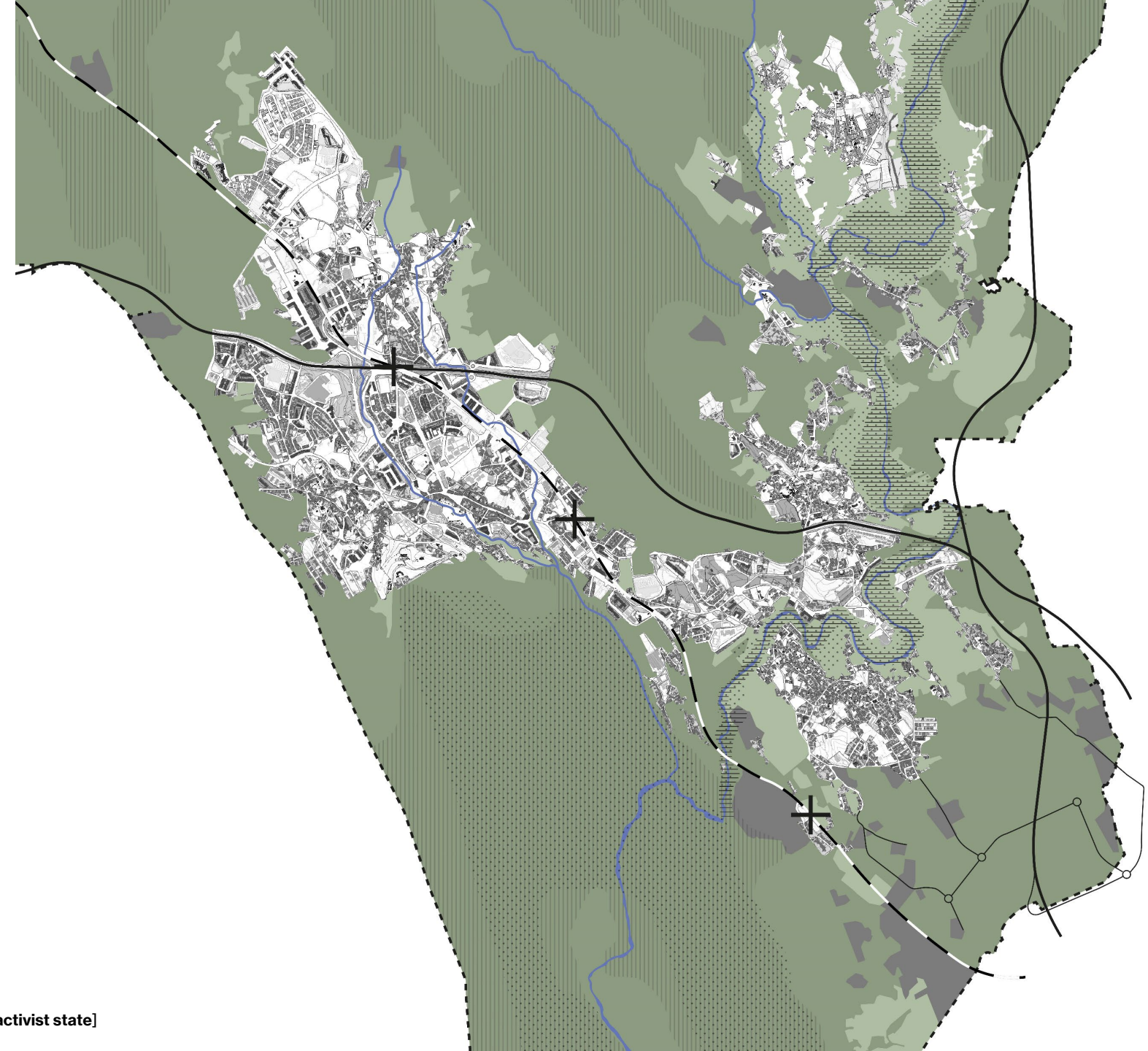
0 500 m



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

ENERGY & WATER INFRASTRCURE DEVELOPMENT

INDUSTRIAL DEVELOPMENT

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- (heavy) industry park district
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- railway
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- new trainstation
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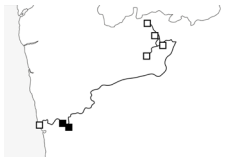
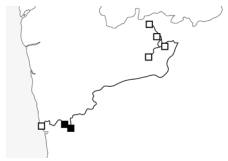
- administrative boundary municipality
- forestry
- agriculture
- urban fabric
- industrial fabric
- water course
- areas of maximum infiltration
- areas of risk erosion
- flood threatened areas
- motorway

0 2 km



[projecting / **strategy – post-extractivist state**]



[projecting / **strategy – post-extractivist state**]

URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

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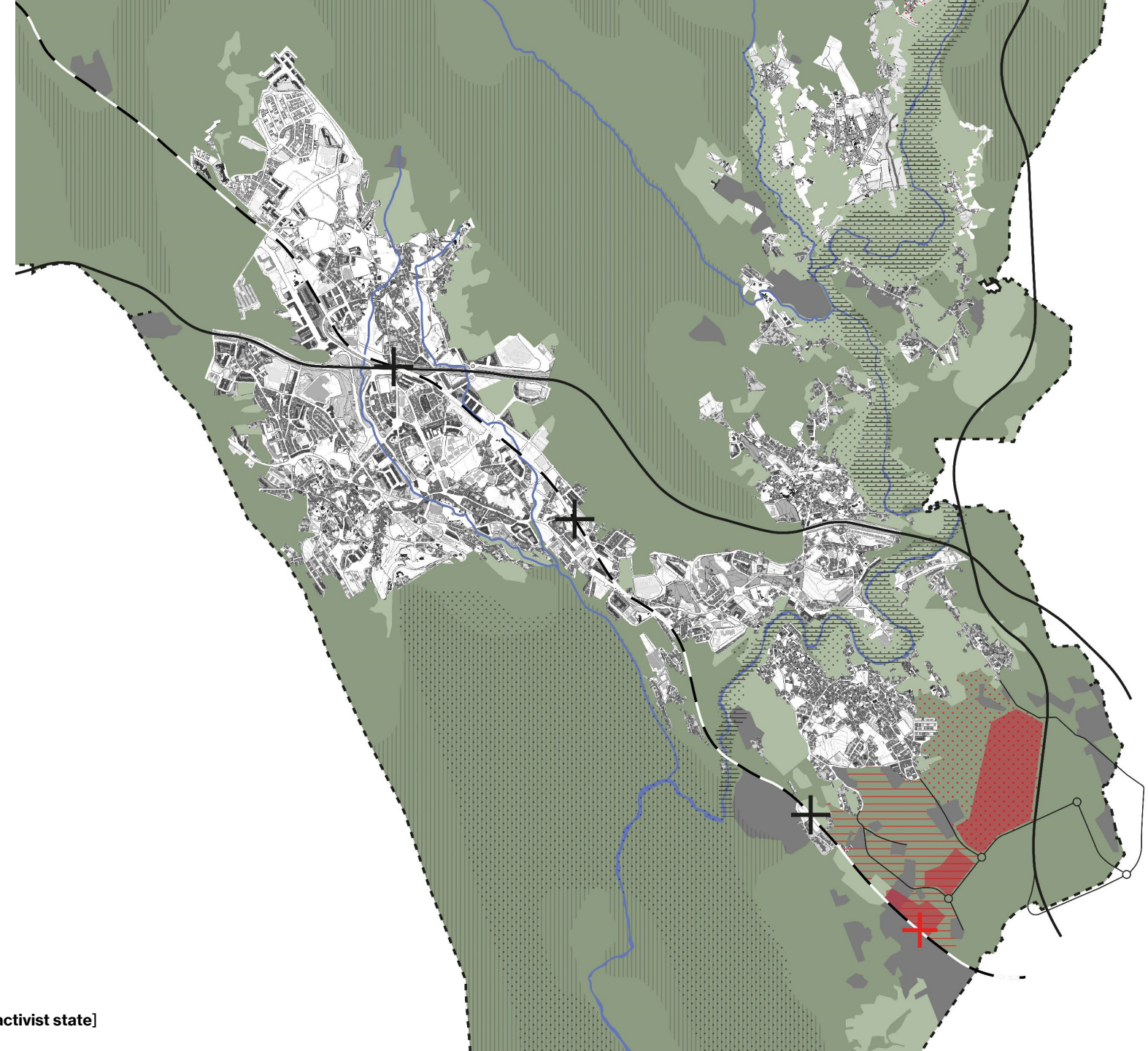

URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

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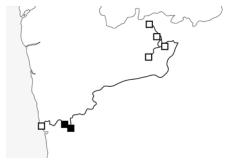
[projecting / **strategy – post-extractivist state**]



[projecting / **strategy – post-extractivist state**]

URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

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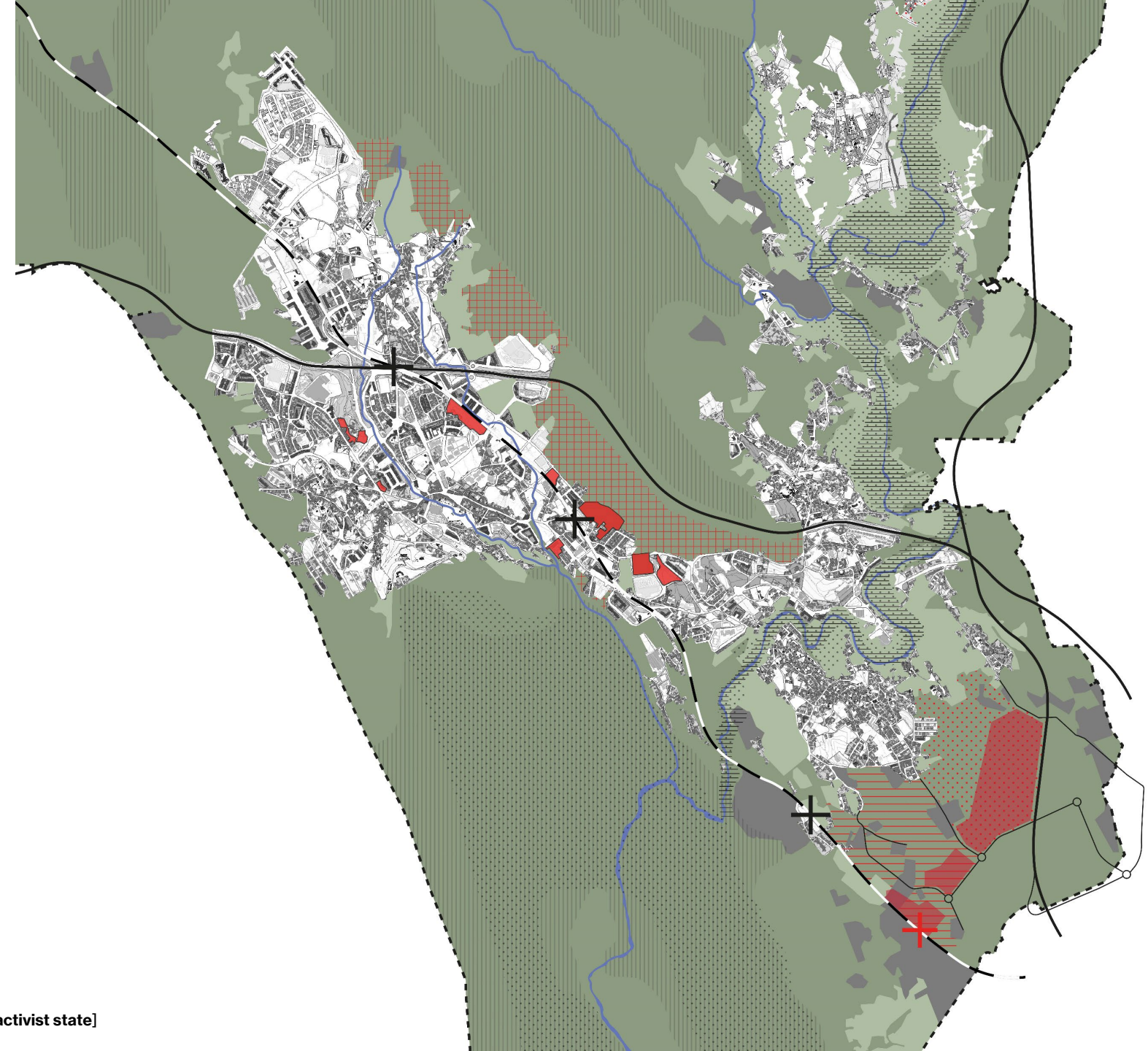
0 2 km



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

ENERGY & WATER INFRASTRCURE DEVELOPMENT

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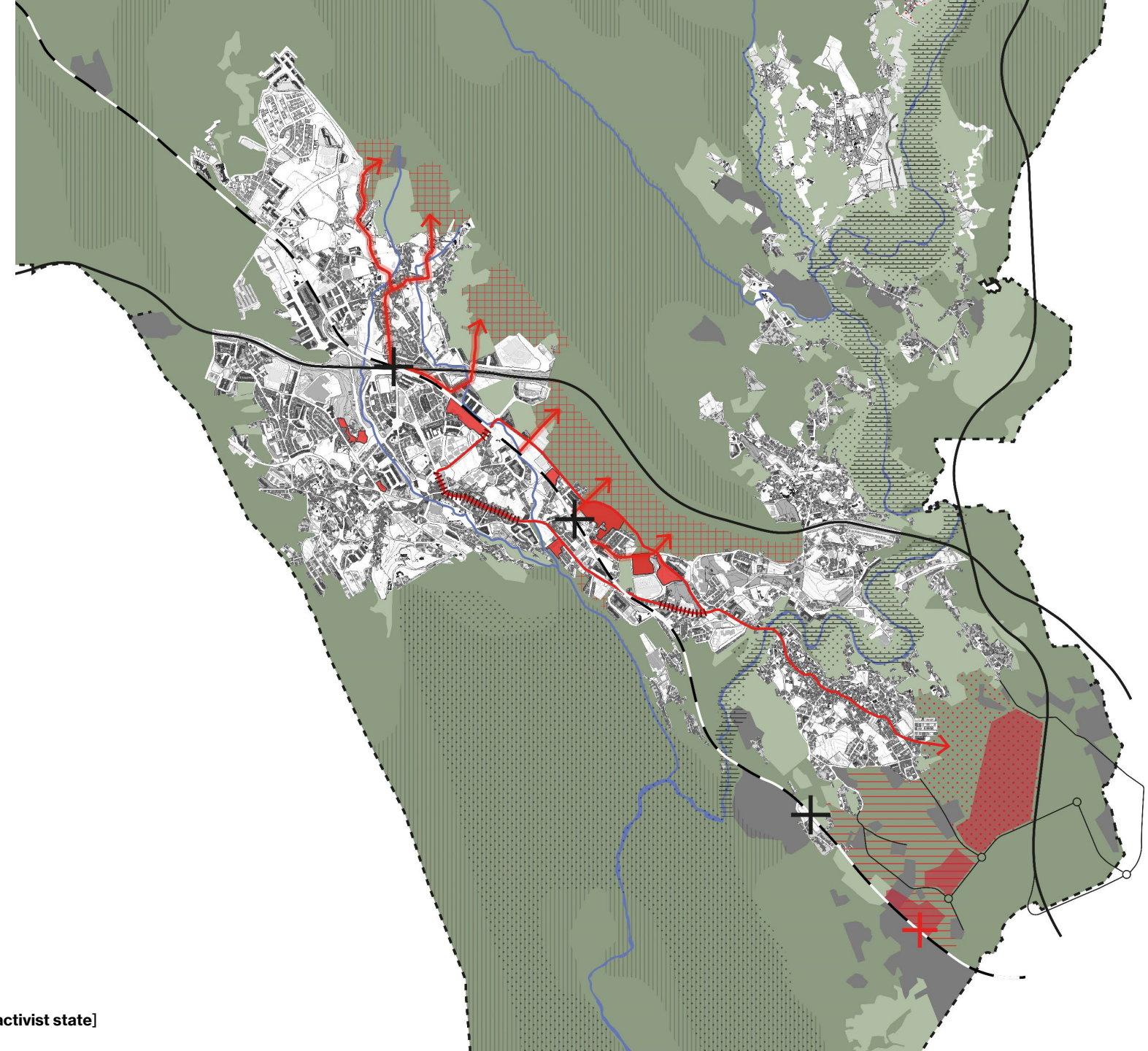
0 2 km

[projecting / **strategy – post-extractivist state**]



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

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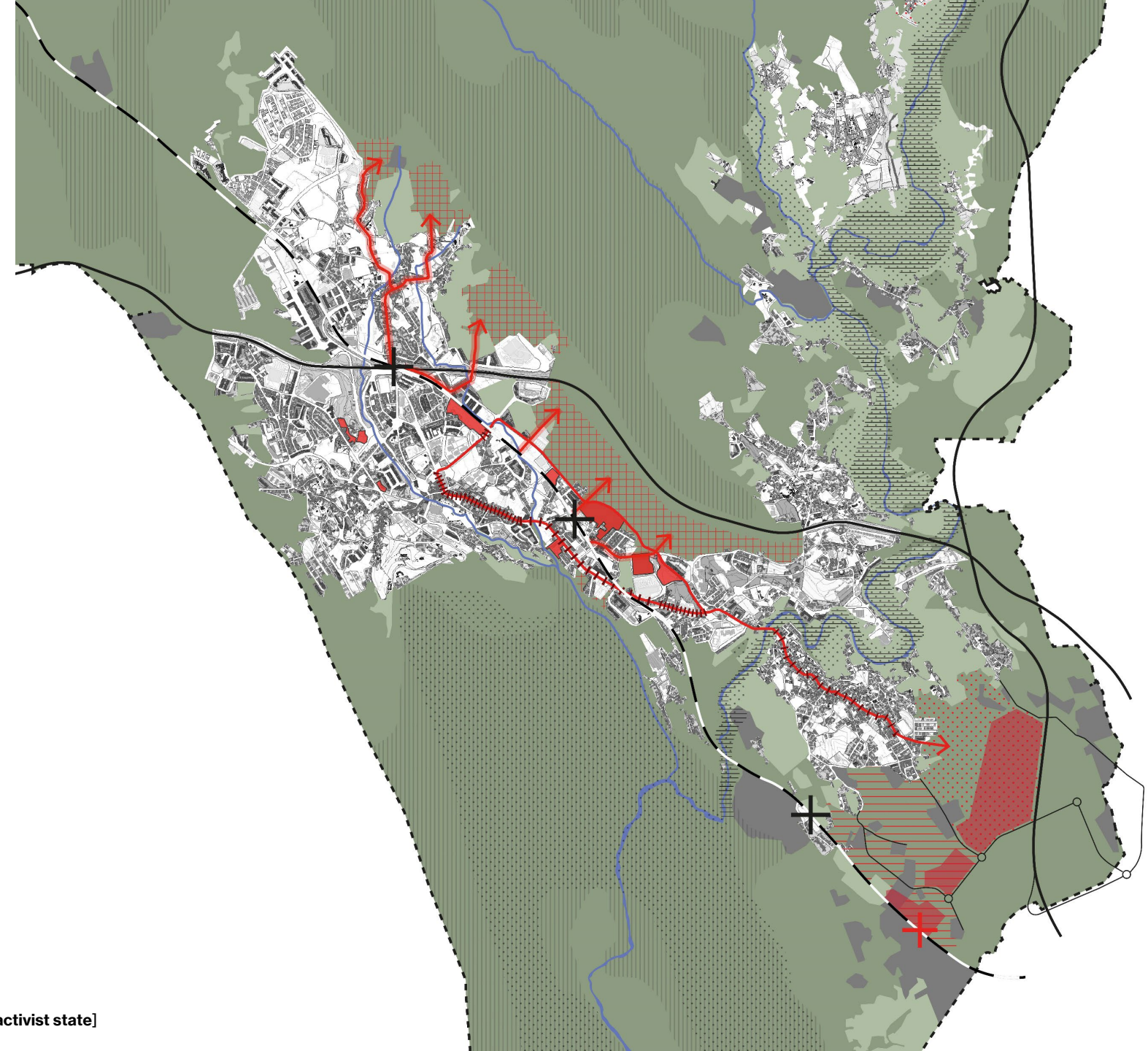
0 2 km

[projecting / **strategy – post-extractivist state**]



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

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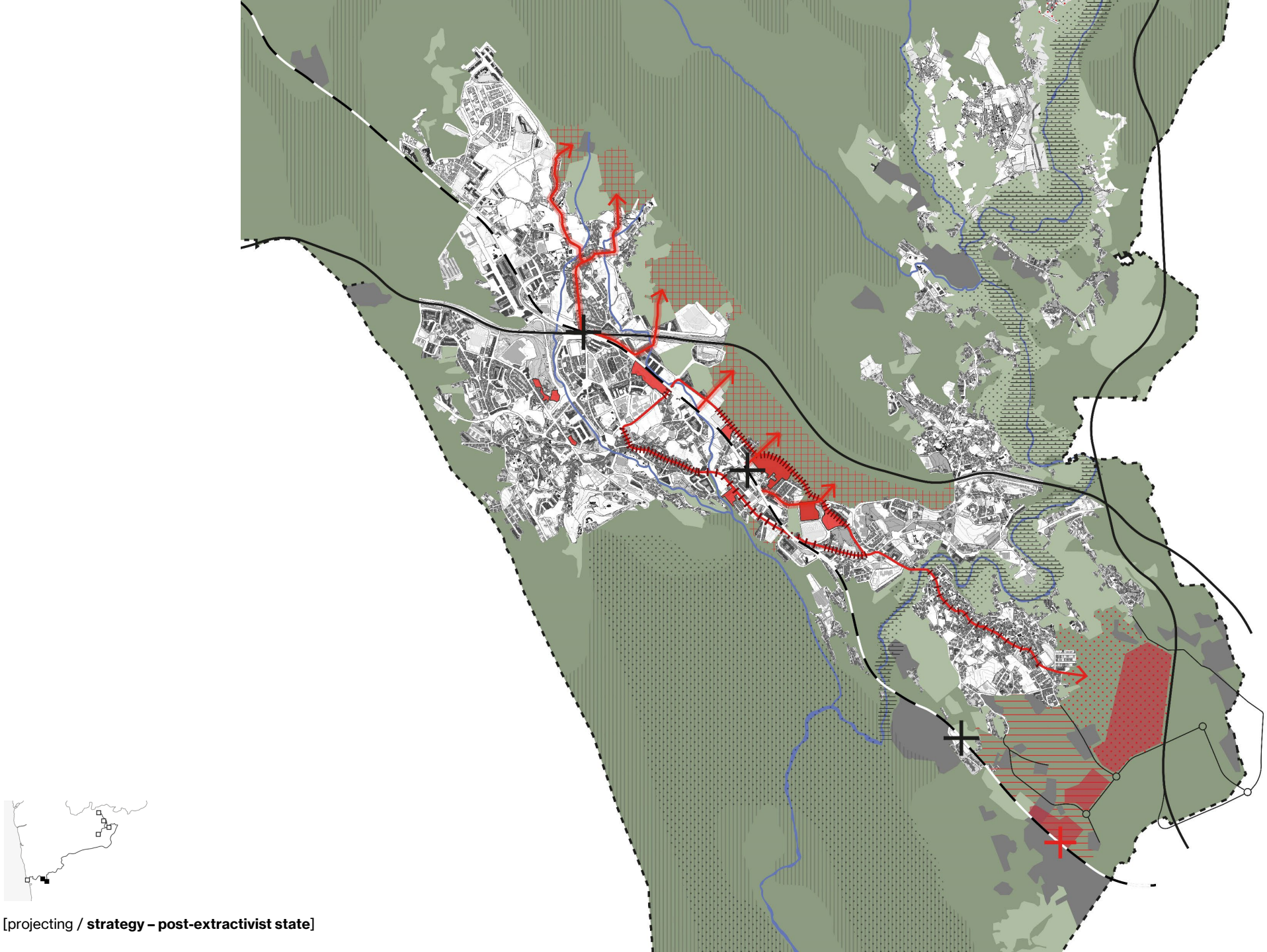
0 2 km

[projecting / **strategy – post-extractivist state**]



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

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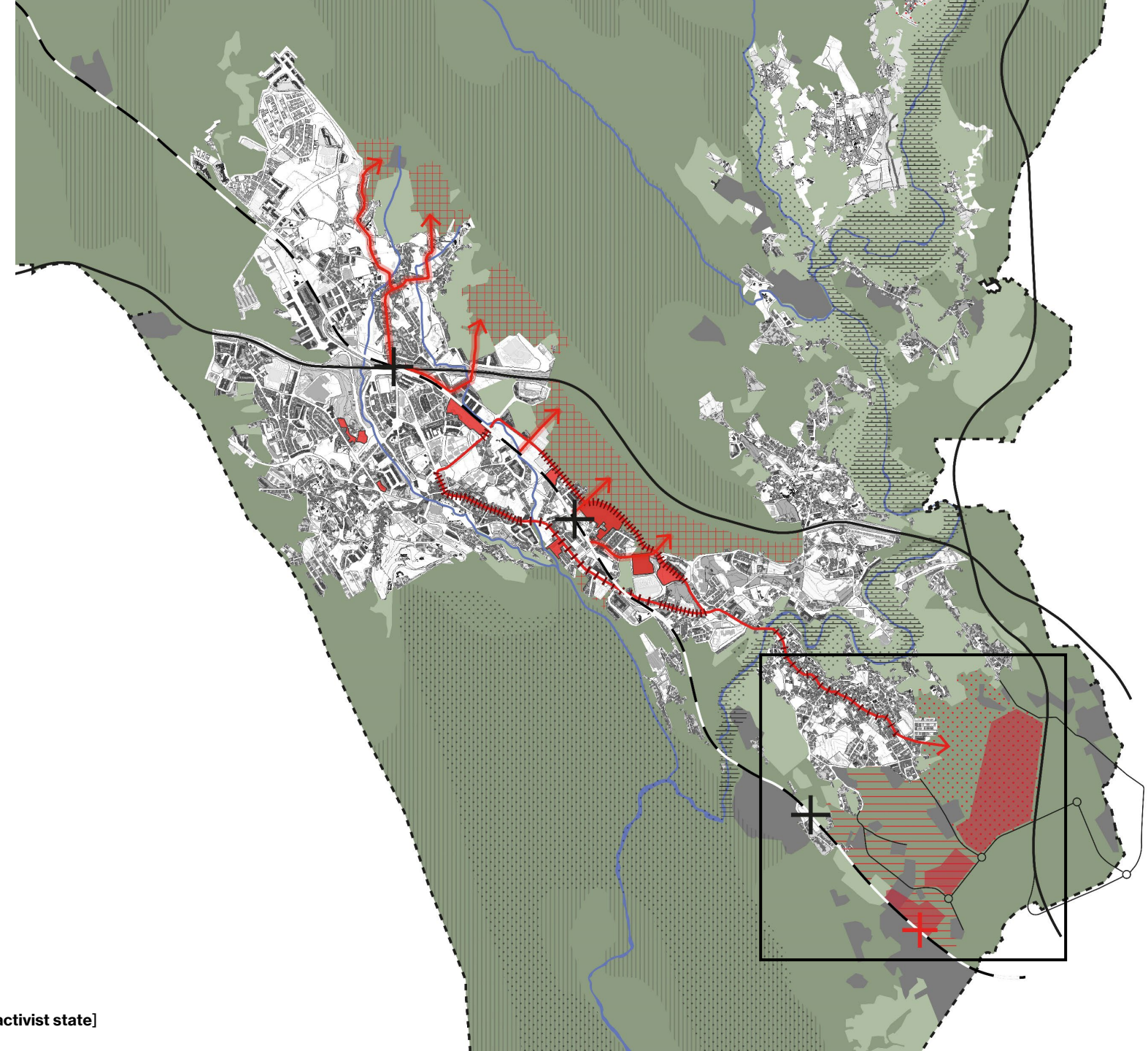
0 2 km

[projecting / **strategy – post-extractivist state**]



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

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0 2 km

[projecting / **strategy – post-extractivist state**]

URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

ENERGY & WATER INFRASTRCURE DEVELOPMENT

INDUSTRIAL DEVELOPMENT

- introduced trainstation
- innovation square (R&D/education)
- logistic hub
- additional light industries/services
- additional heavy industries
- administrative boundary municipality
- forestry
- agriculture
- existing buildings/fabric
- additional residential buildings
- wadi/water collection pond
- development axes/connection to park
- pedestrian/bicycle path
- building part under landscape
- additional building/fabric

0 500 m

recycle facility (spoke)

R&D / education center

battery pack manufacturer

logistic hub

trainstation

URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

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0 500 m

cathode & battery cell manufacturer

recycle facility (hub)

recycle facility (spoke)

R&D / education center

battery pack manufacturer

logistic hub

trainstation

URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

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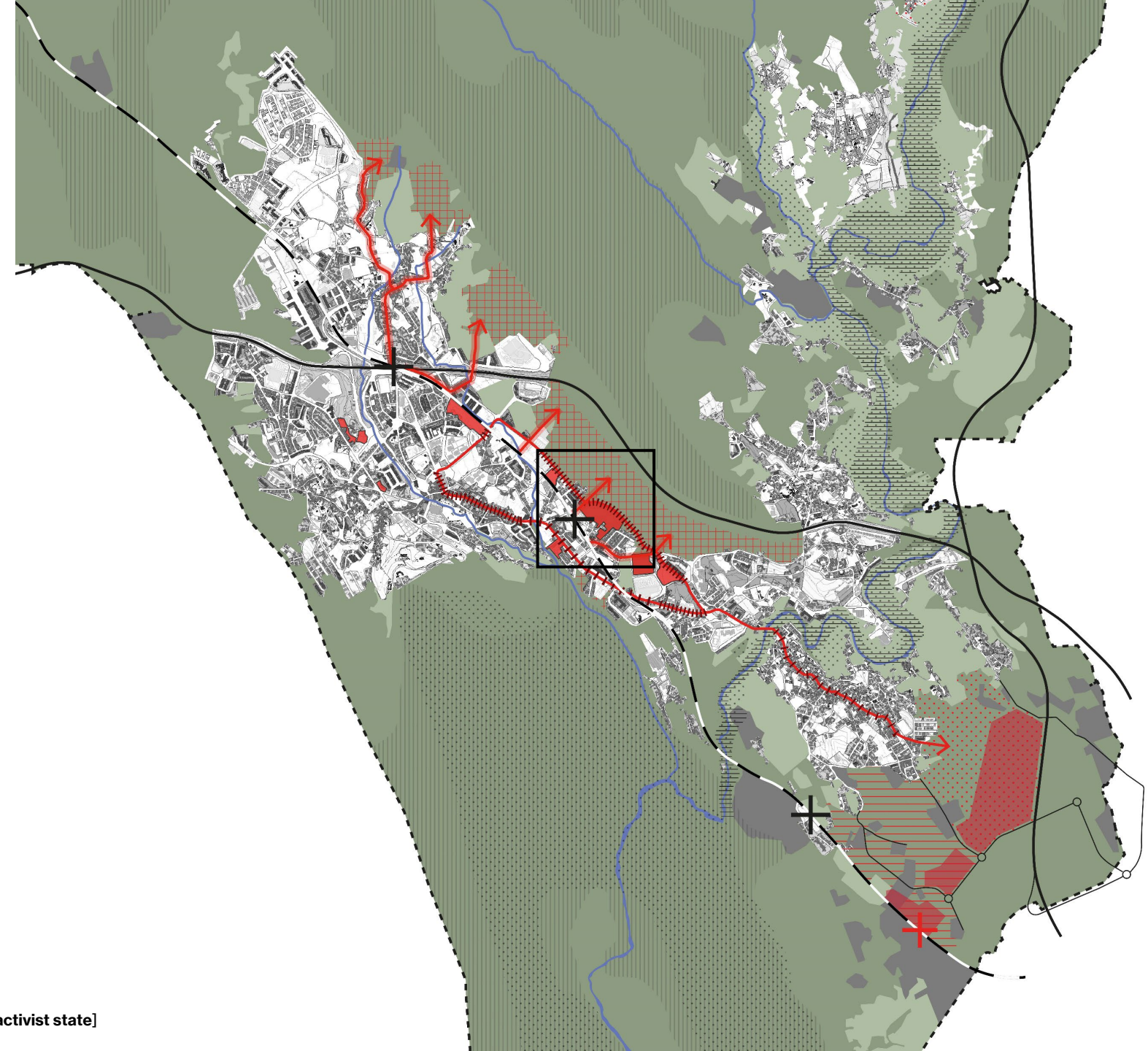
0 500 m

Reference Project, Indu Zero Landscape (by Buro de Haan, 2021)



URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

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- administrative boundary municipality
- forestry
- agriculture
- urban fabric
- industrial fabric
- water course
- areas of maximum infiltration
- areas of risk erosion
- flood threatened areas
- motorway

0 2 km

[projecting / **strategy – post-extractivist state**]

URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

ENERGY & WATER INFRASTRCURE DEVELOPMENT

INDUSTRIAL DEVELOPMENT

- train station
- railway
- existing roads
- additional roads
- development axes
- vegetated/developable land
- small/community scale agri-cultivation
- public space around public functions
- existing buildings
- additional modular timber buildings
- park

0 300 m

school

library & cinema

park

public square

URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

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0 300 m

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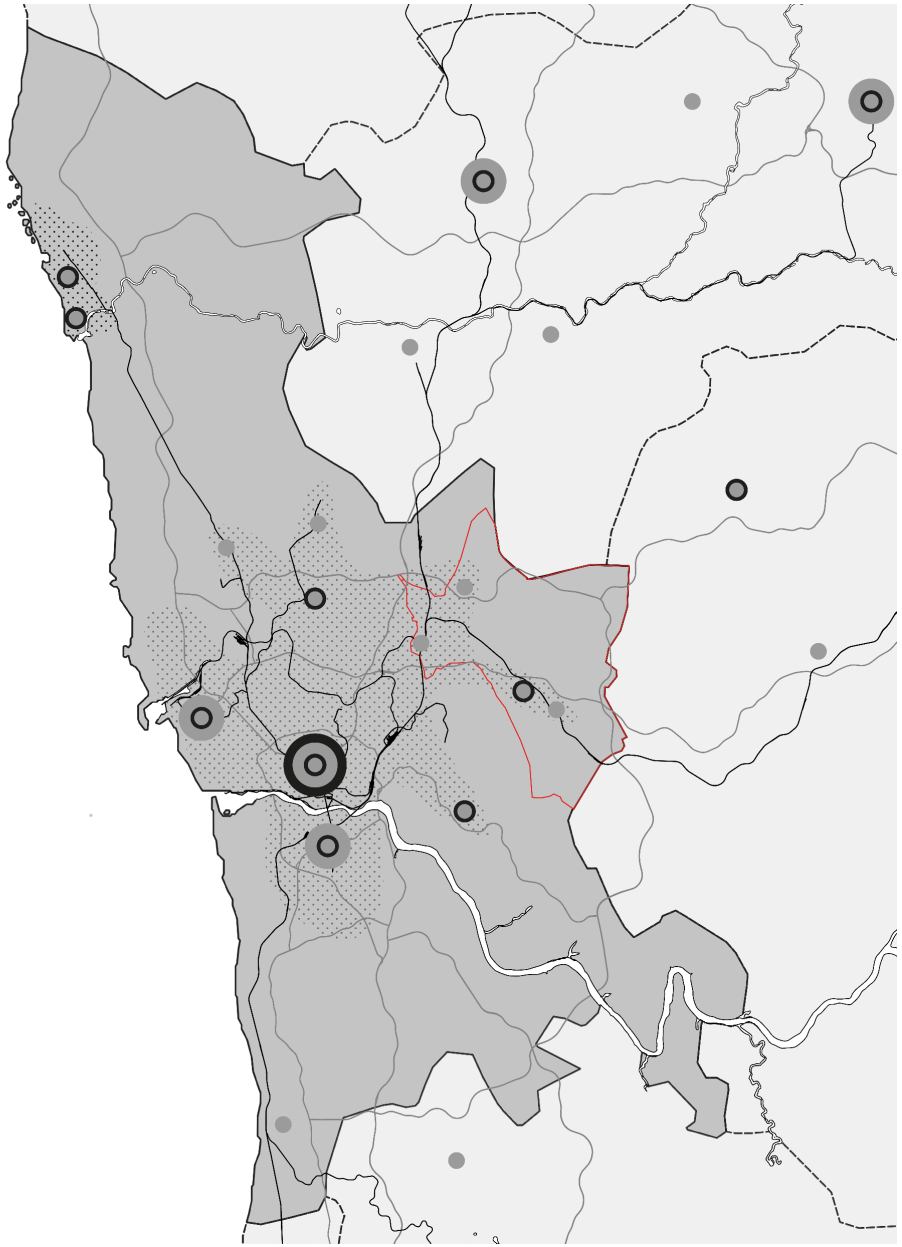
ENERGY & WATER INFRASTRCURE DEVELOPMENT

INDUSTRIAL DEVELOPMENT



- national urban center of international significance
- urban center of national significance
- urban center of regional significance
- urban center of municipal significance
- wider urban area
- infrastructural road network
- infrastructural railway network
- administrative boundary municipality Valongo
- metropolitan area Grande Porto (NUTS3)
- regional/national significance
- national/international significance
- international significance

0 20 km

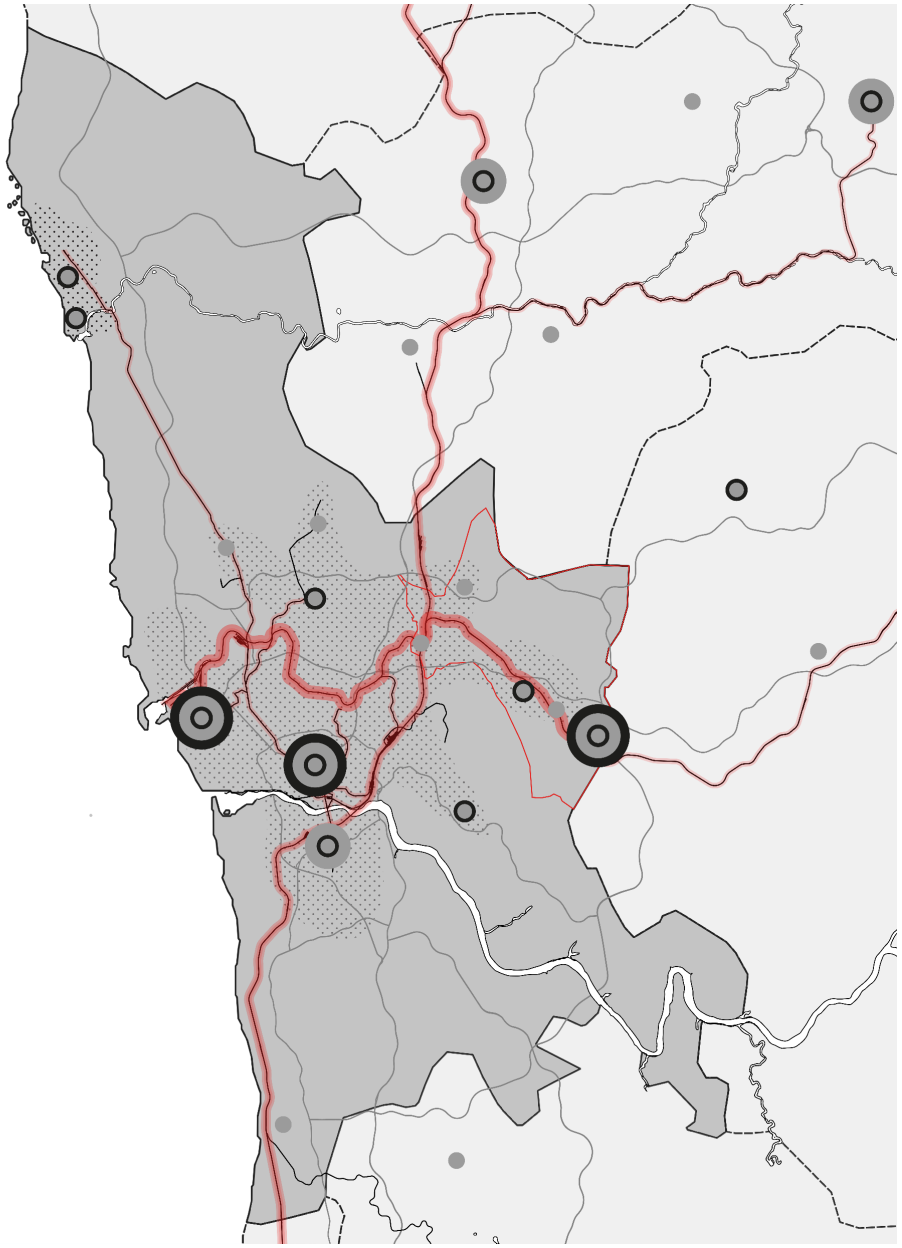
URBAN DEVELOPMENT (TEMPORARY) ACCOMMODATIONS

INFRASTRUCTURAL REINFORCEMENT & DEVELOPMENT

LAND USE CHANGE / CULTIVATION PATTERNS

ENERGY & WATER INFRASTRCURE DEVELOPMENT

INDUSTRIAL DEVELOPMENT



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Chapter 04 – Evaluating *(reflect)*

Conclusion

The thesis showcases the set of spatial interventions accompanied by establishing extractivist landscapes in a non-traditional manner, by planning for the post-extractivist state, ensuring circular long-term development

- At the European level, the proposed strategy fosters **greater independence** in lithium supply

- Nationally, it enhances Portugal's **position as a key contributor** to achieving European green transition goals

- Regionally, the strategy **promotes long-term circular development** by using extractivist facilities to establish a circular battery economy and stimulate the **integration of circular practices**

- Locally, the strategy **minimizes the nuisances** of extractive operations while enabling ongoing activities in the Alto Tamega region while

shaping the **conditions for a circular bio-based economy** that helps **remediate the mining landscape**, while **connecting to the local economy and cultural identity**, as well as creating **additional income** for these rural areas.

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Project Limitations

- This thesis is based on the **idea that Europe is committed to electrification and battery storage** as key technologies of the clean energy transition to combat climate change. The demand for lithium (landscapes) is highly dependent on the deployment of certain types of clean energy technologies

- Ultimately, **policymakers will determine** whether lithium remains an essential factor in the clean energy transition. Additionally, the demand of lithium is depending on the product design industry

- **Alternative battery designs** could reduce or eliminate the demand for lithium

Avenues for Future Research

- A potential directions of the project could be opening up the project and **co-design** the post-extractivist economy in collaboration with the local stakeholders and examinate the proposal for biomass economy on the two levels – biofuel and structural biomass.

- Moreover, investigate further on how the proposed **co-operative of farmers** in the subregion Alto Tamenga could be established and function This could be enhanced **by the creating of policy and regulatory frameworks** for better stakeholder involvement and emphasize more on making the strategy more socially just.

- Furthermore, the design could elaborate deeper on the aspects of **repair of the mining landscape**.

Results in Relation to Theoretical Body

- The thesis shows that there is no such thing as just or green mining. Extractivist practices will always results in **local ecological disruption**

- Nevertheless, the thesis still advocates for the need for critical minerals for the production of green energy technologies following an alternative form of extractivism based on **economies that not heavily rely on extraction of natural resources** but rather prioritize extraction out of waste streams based on circular principles

- In addition, the thesis suggest an alternative economic model, that suggest that **clean energy technologies should not be the only mean to reduce greenhouse gas emissions**, but also reducing the demand for critical minerals like lithium

Thanks for listening

Any Questions?