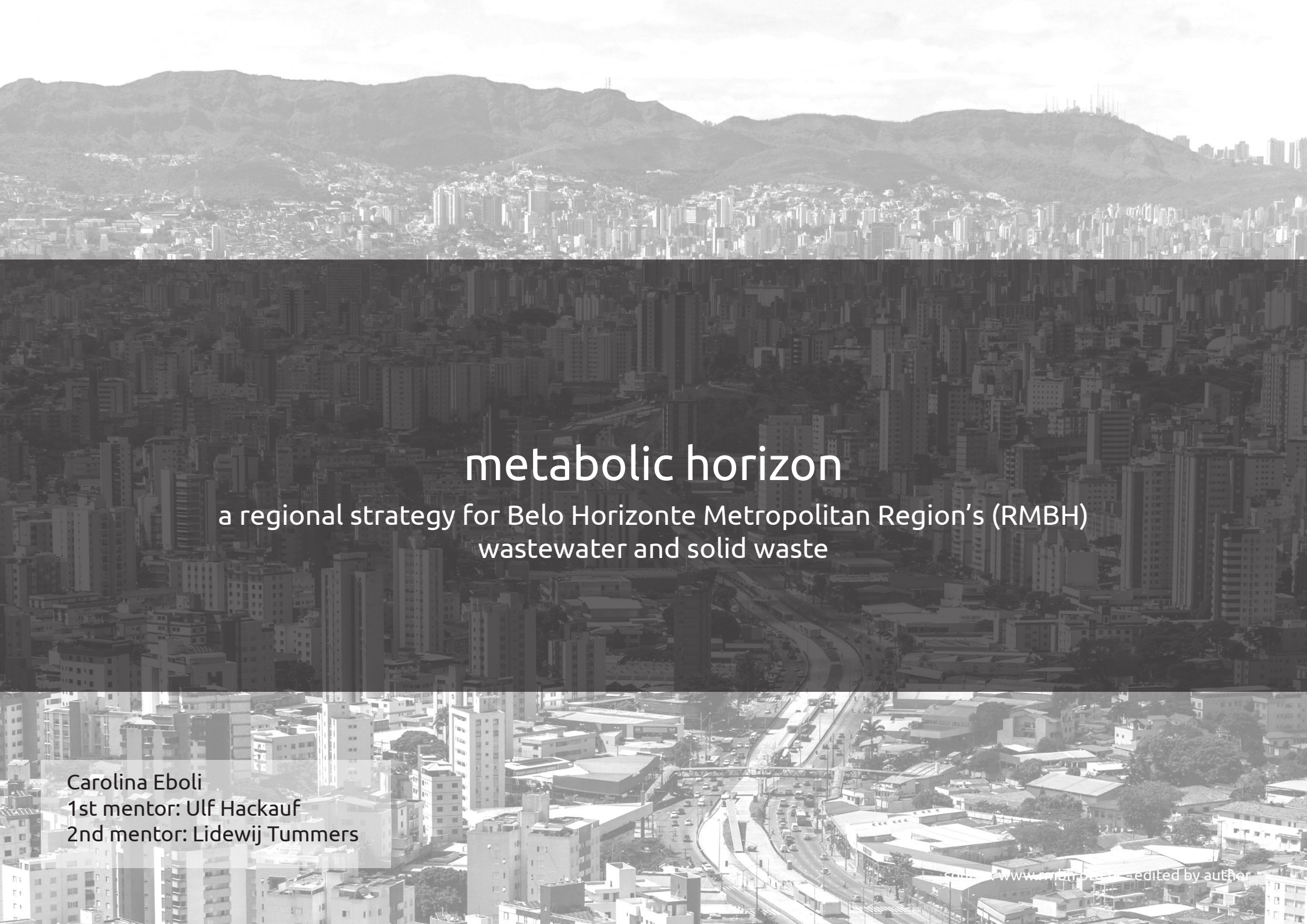


metabolic horizon

a regional strategy for Belo Horizonte Metropolitan Region's (RMBH) wastewater and solid waste

Carolina Eboli
1st mentor: Ulf Hackauf
2nd mentor: Lidewij Tummers

source: www.[illegible] - edited by author

1-presenting Belo Horizonte Metropolitan Region (RMBH) and its environmental pressures

2-research question + methodology

4-metabolic analysis: wastewater + solid waste

5-decentralization + combined systems

6-testing Ribeirão das Neves

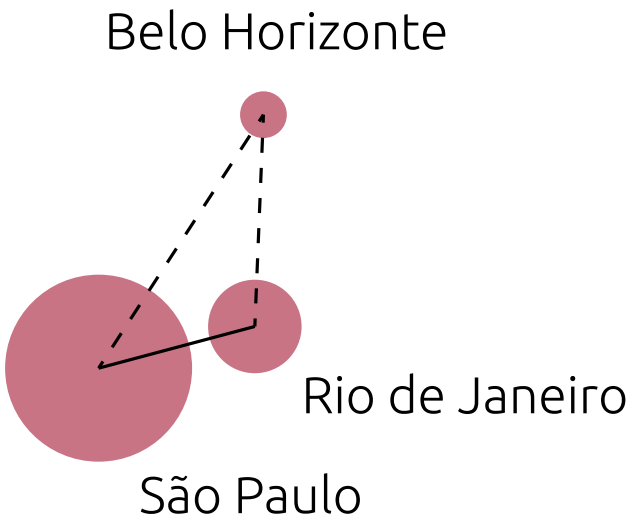
7-testing Belo Horizonte

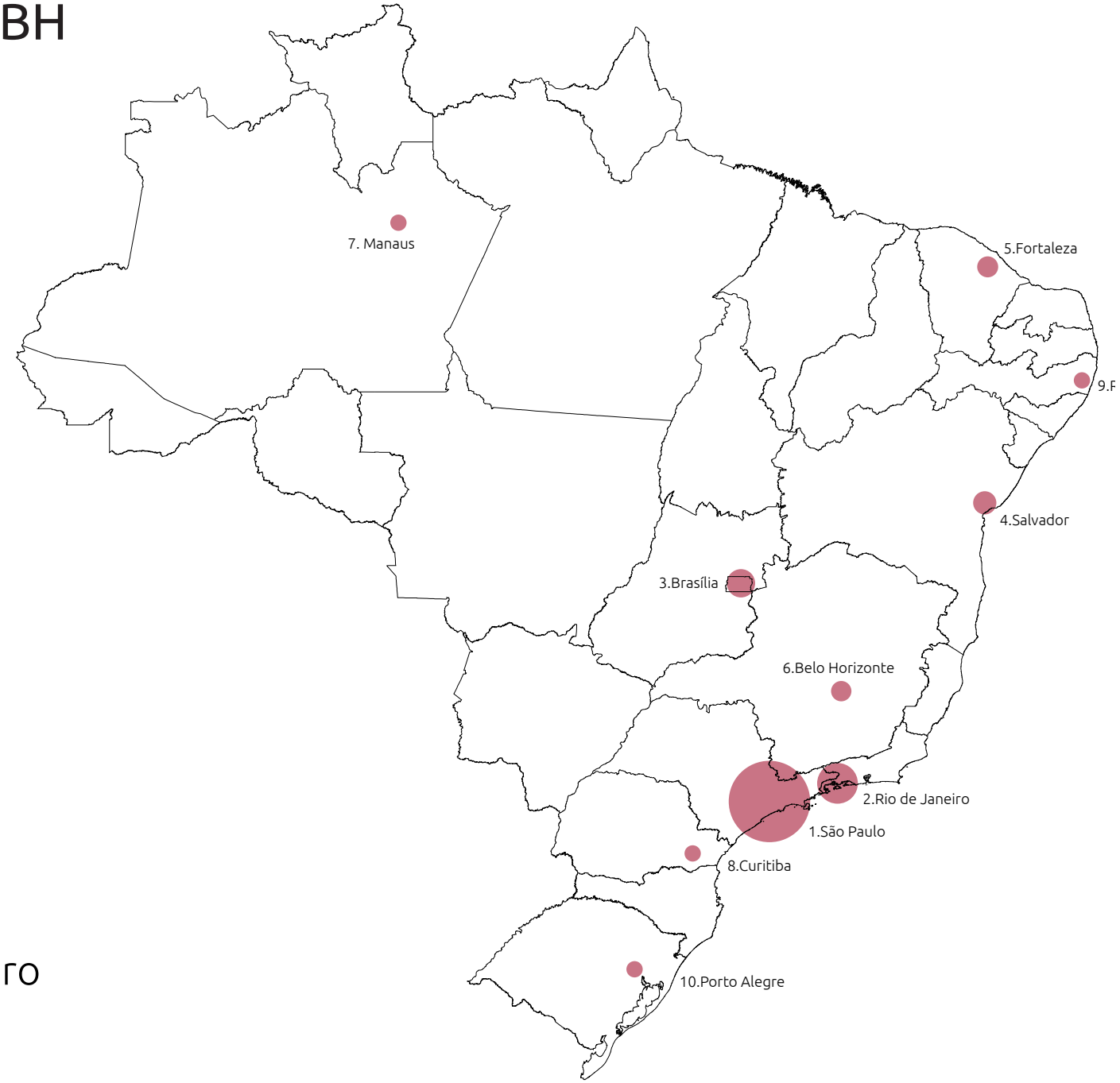
8-up-scale and spin-off

9-conclusions + reflection

RMBH

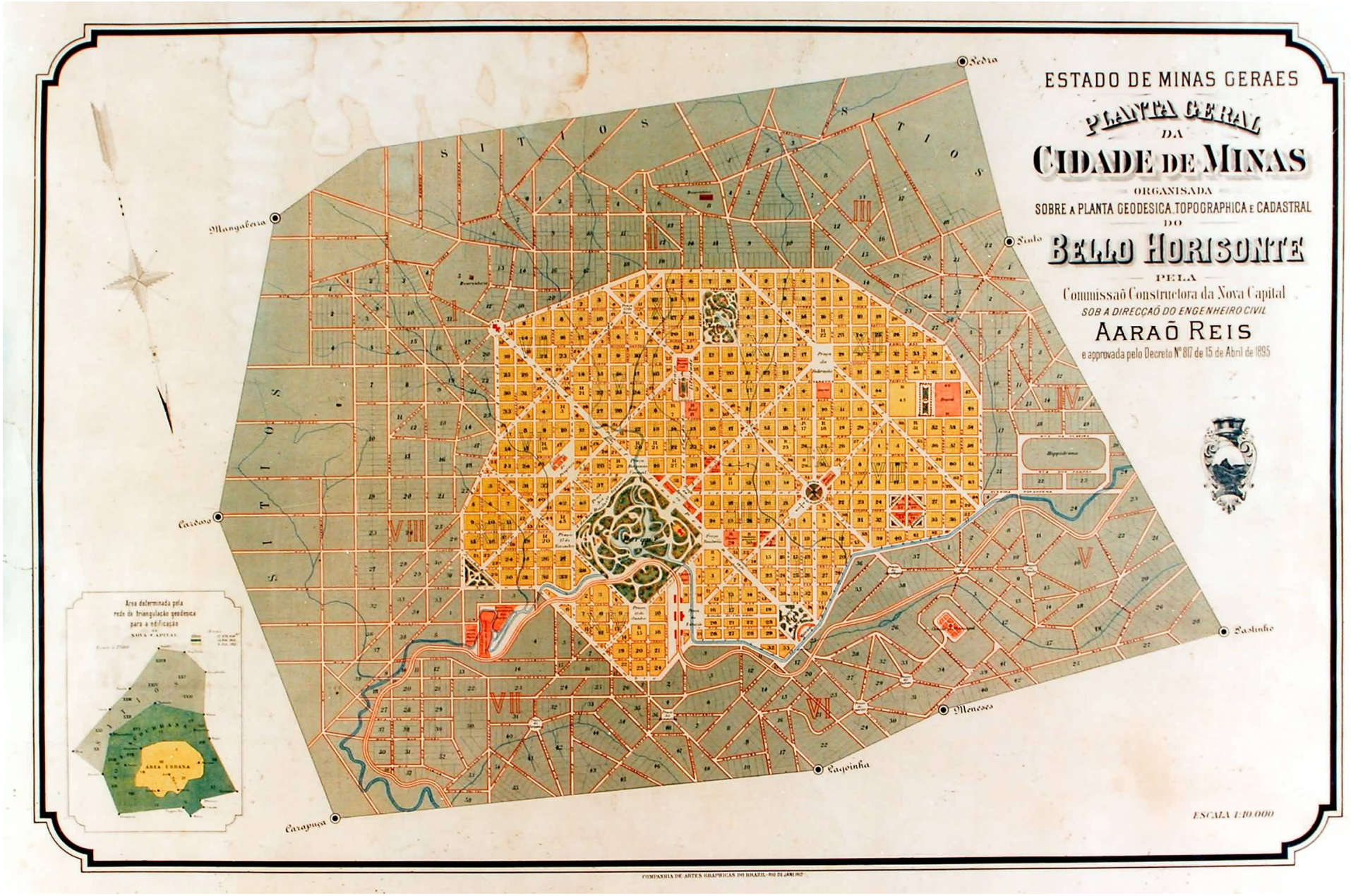
Belo Horizonte or just BH





source: www.copa2014.gov.brr

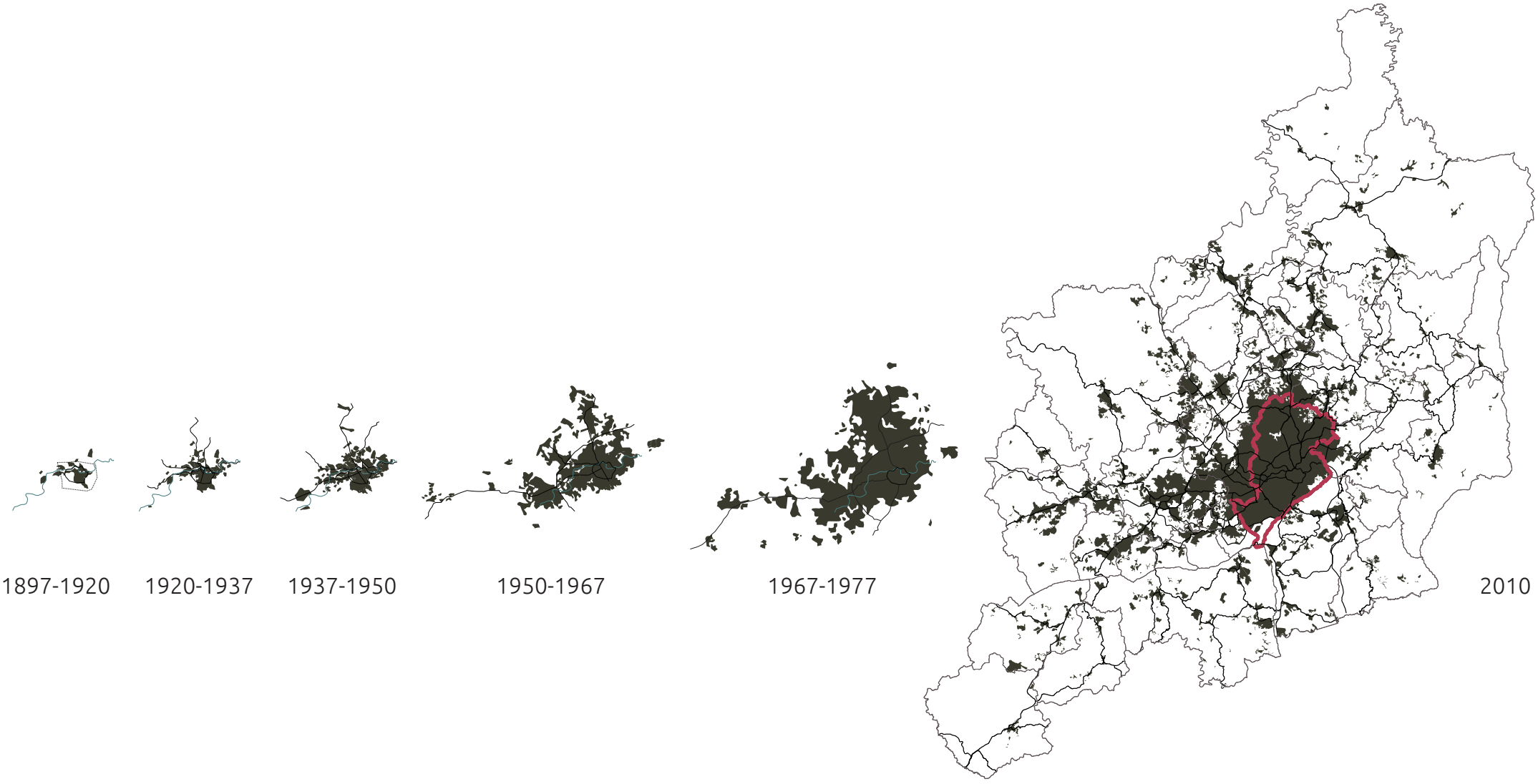
planned city




source: Google Earth


belo horizonte
source: Google Earth

rapid urbanization heritage

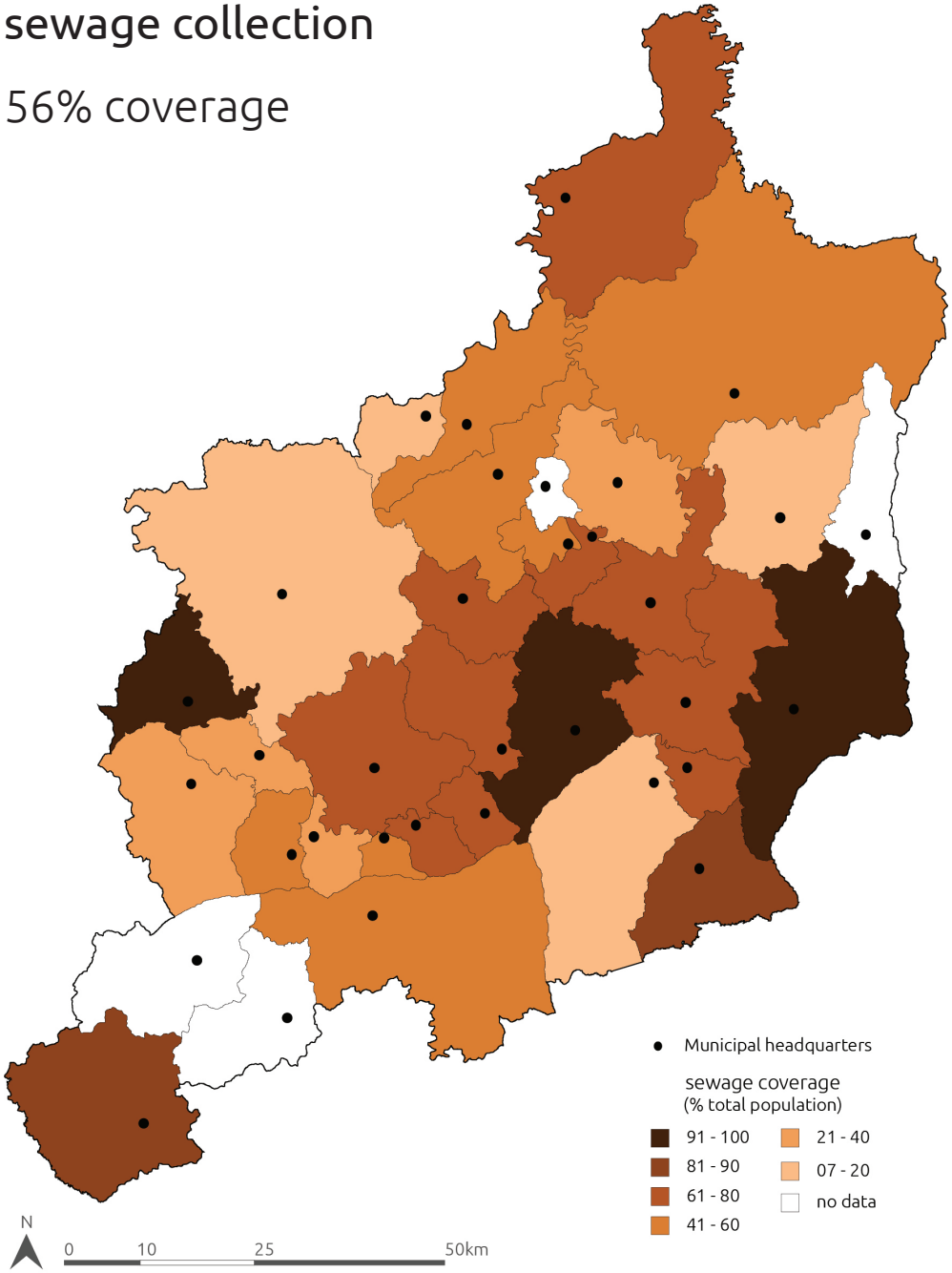


Pollution in Onça Watershed, in Belo Horizonte
Picture: Michelle Parron & Bianca Aun

Waste along Das Velhas River in Santa Luzia (2017).
Picture: Leandro Durães

sewage collection

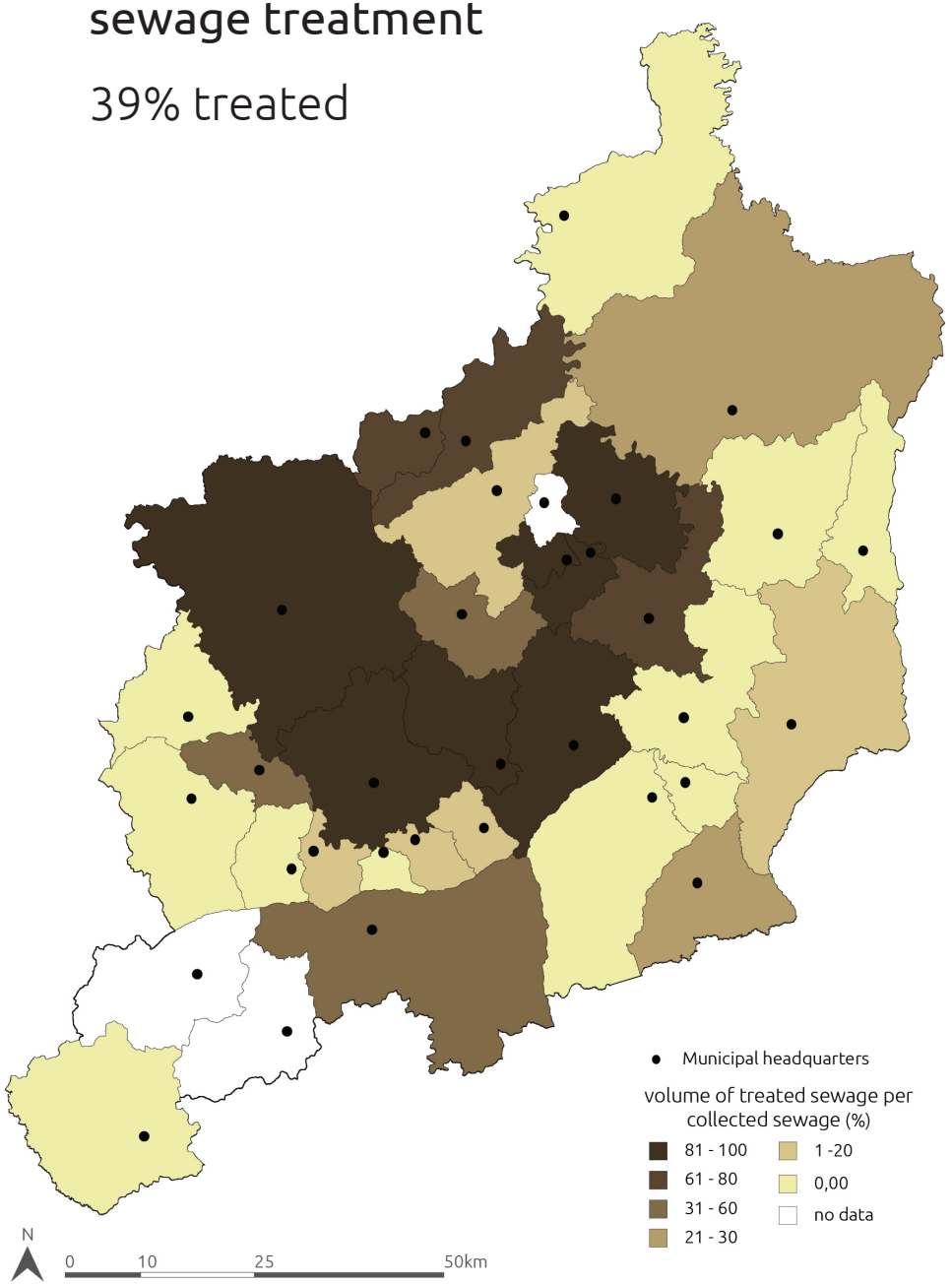
56% coverage



Notes:
Map based on the National System of Sanitary Information (SNIS) 2015.

sewage treatment

39% treated

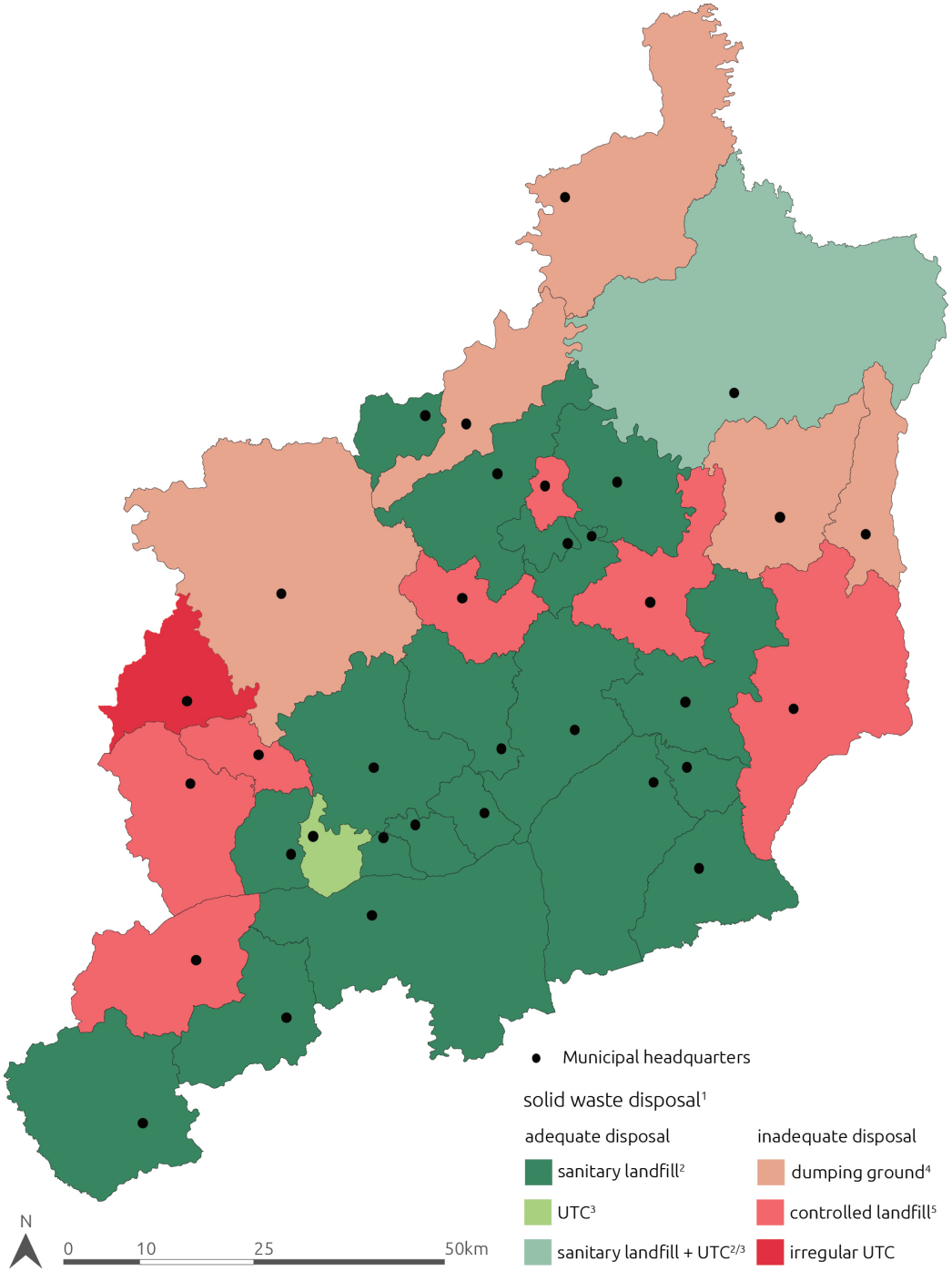


Notes:
Map based on the National System of Sanitary Information (SNIS) 2015.

Dumping ground city Vespasiano
Picture: Municipal Director Plan Revision Team

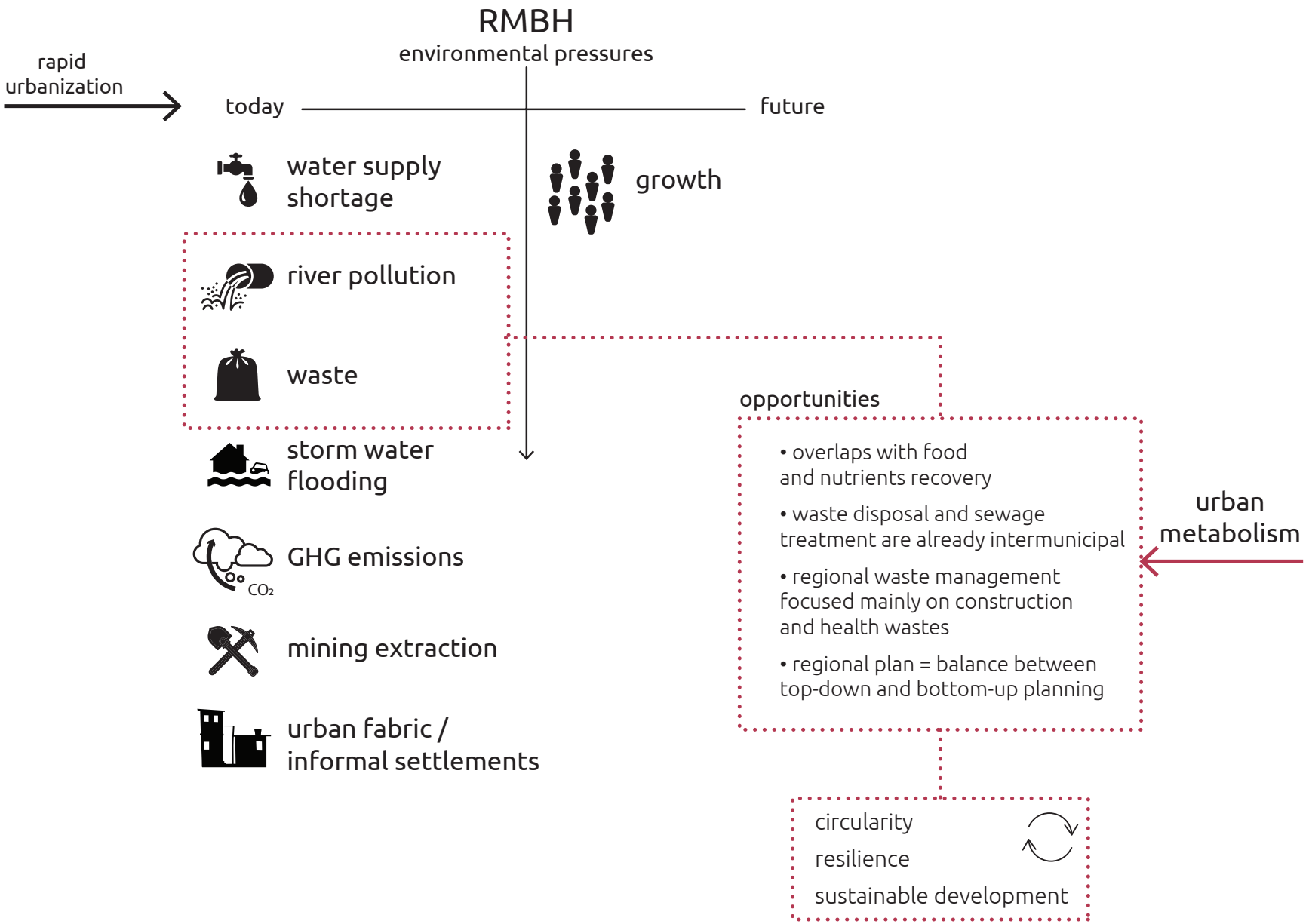
Controlled landfill in the city Itatiaiuçu
Picture: Municipal Director Plan Revision Team

waste disposal



around 13% of the population,
or almost 780.000 people
do not have adequate waste
disposal

environmental pressures and key flows



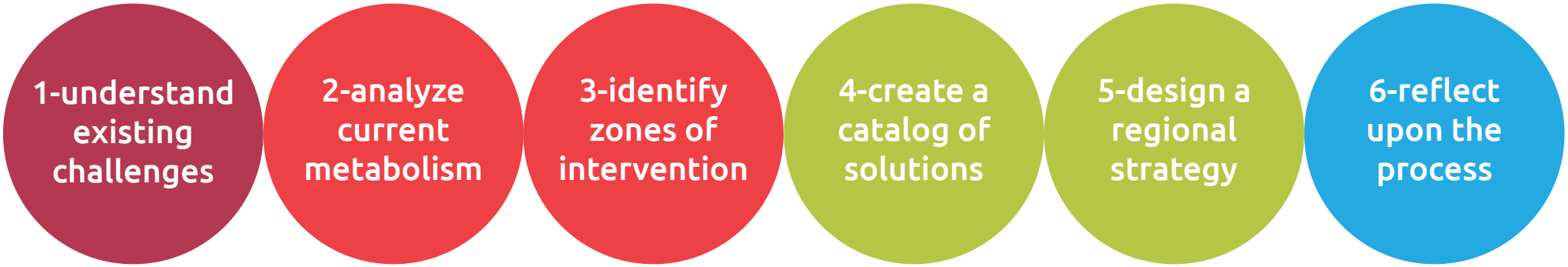
!

Studying RMBH through **Urban Metabolism** perspective can give insights on how to deal with its current and future environmental challenges by managing better its resources related to wastewater and waste.

?

How to develop a feasible **regional strategy** for RMBH's wastewater and solid waste flows?

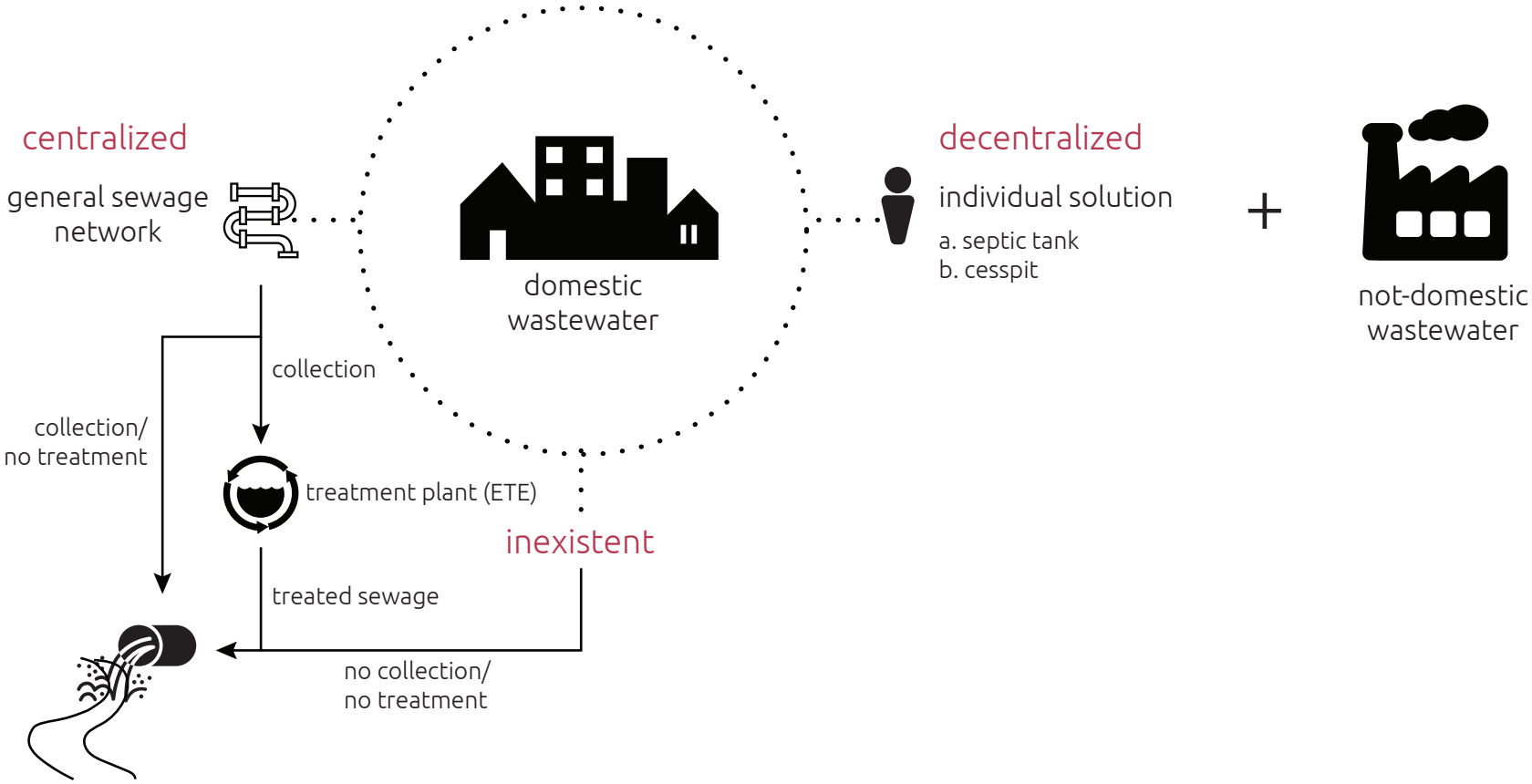
methodology

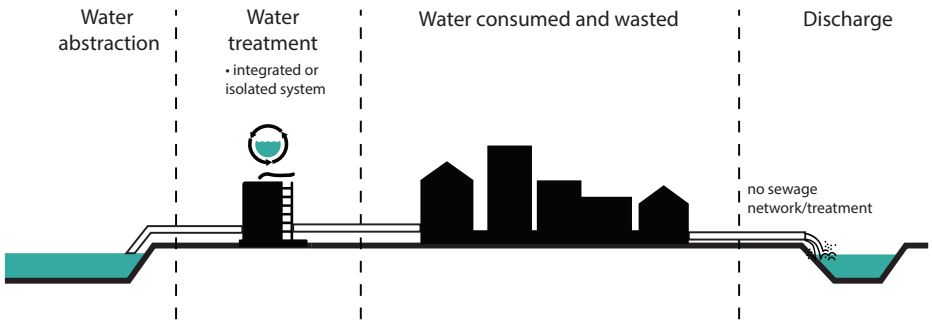


metabolic analysis

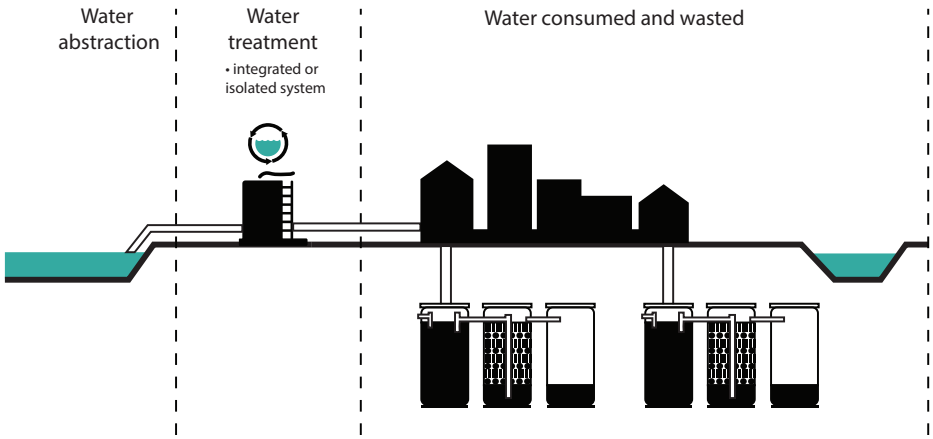
wastewater

wastewater

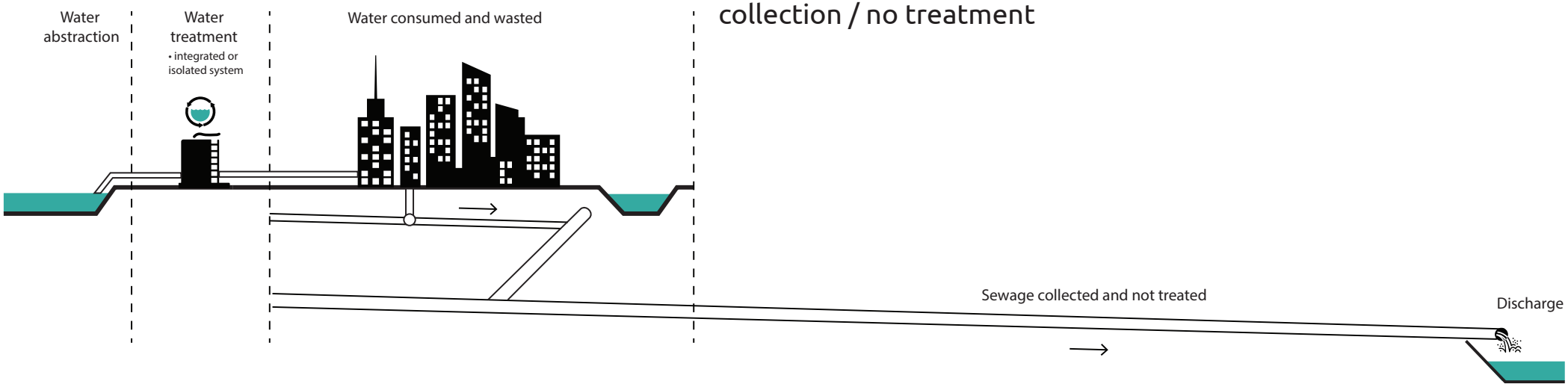

centralized
general sewage network
domestic wastewater
decentralized
individual solution
a. septic tank
b. cesspit
+
not-domestic wastewater
collection
collection/ no treatment
treatment plant (ETE)
inexistent
treated sewage
no collection/ no treatment



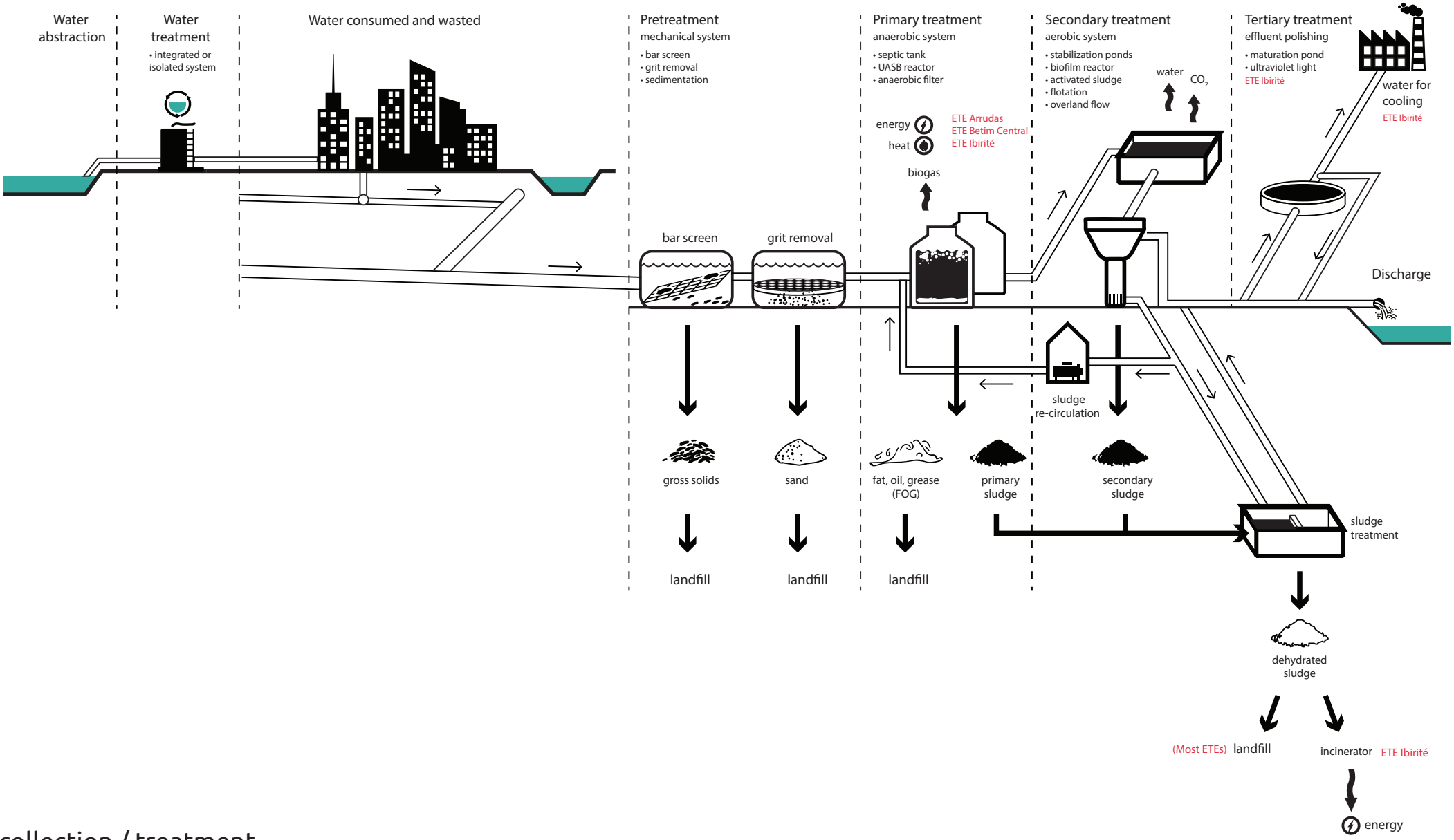
inexistent



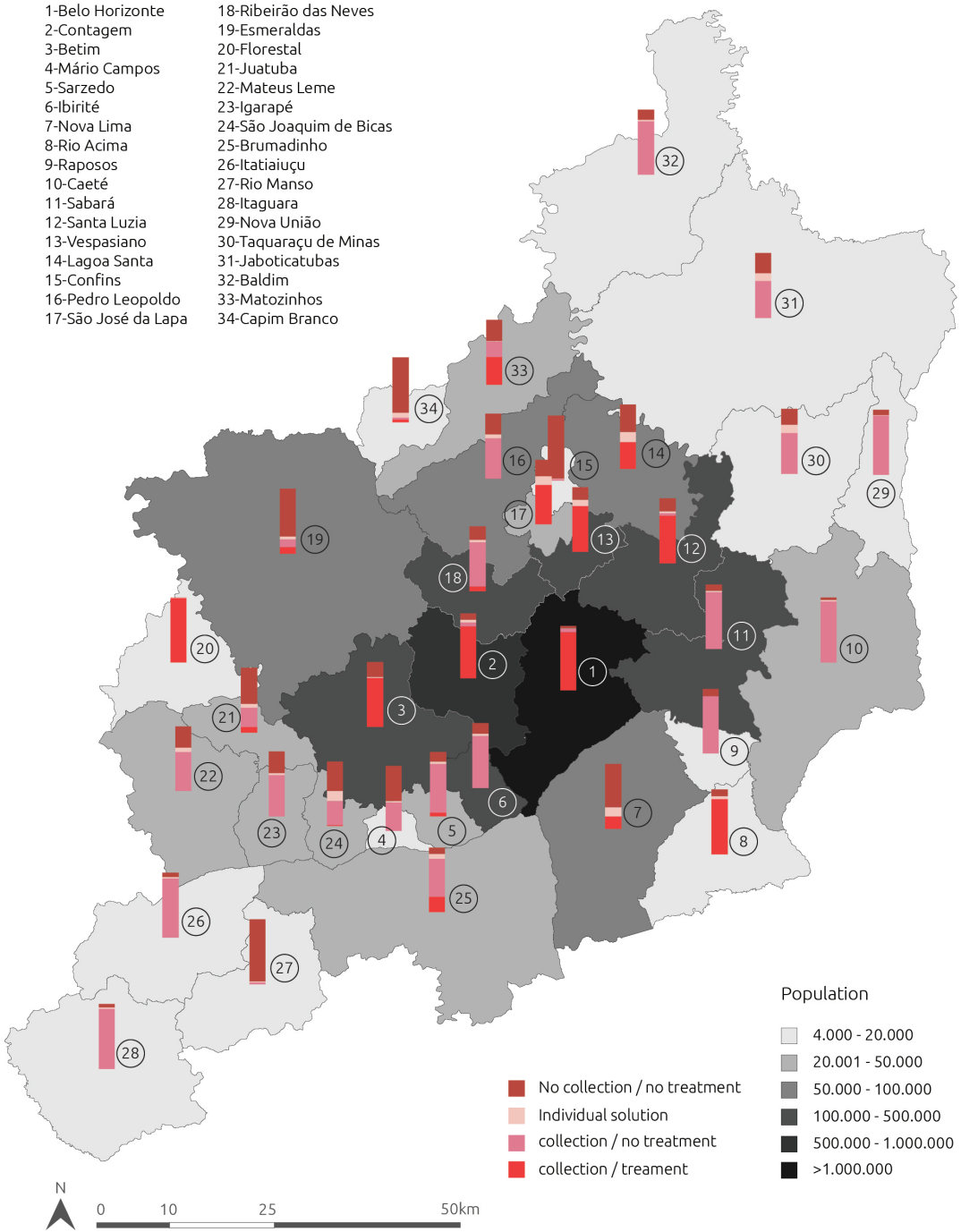
individual solution



collection / no treatment

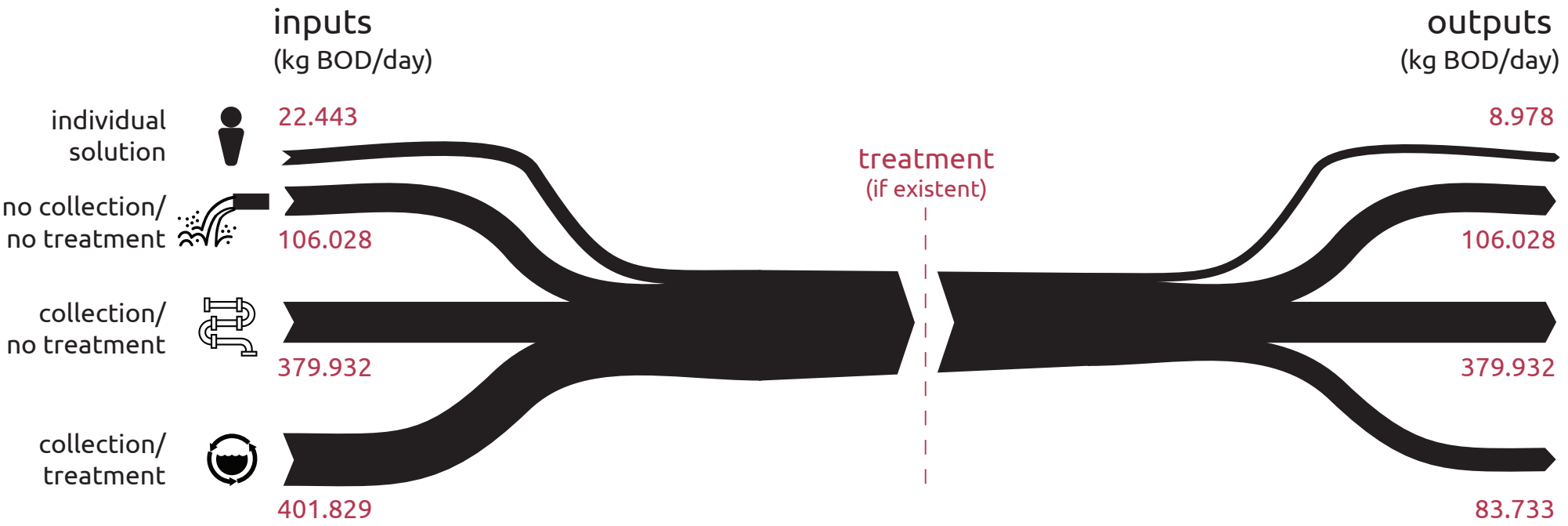


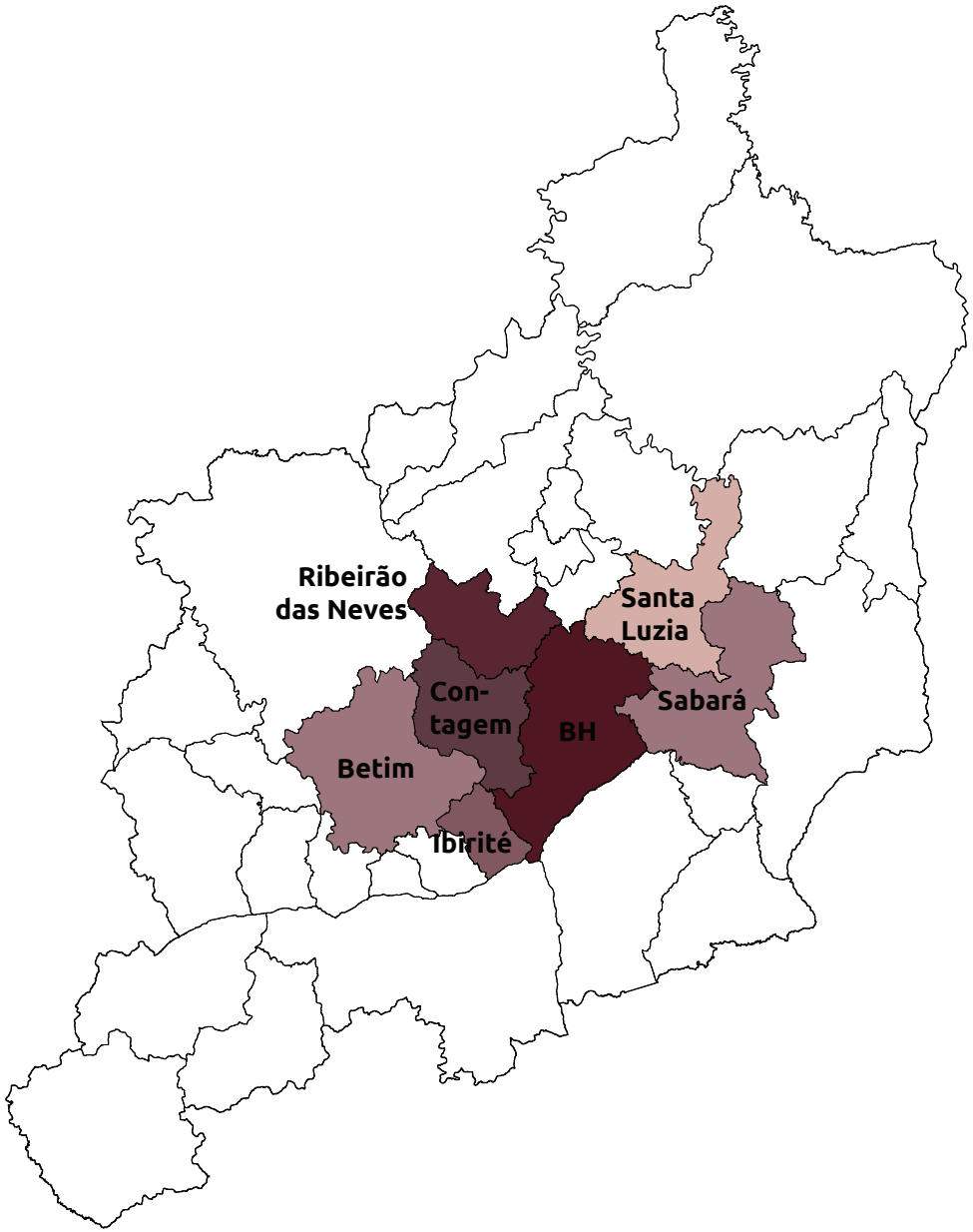
collection / treatment



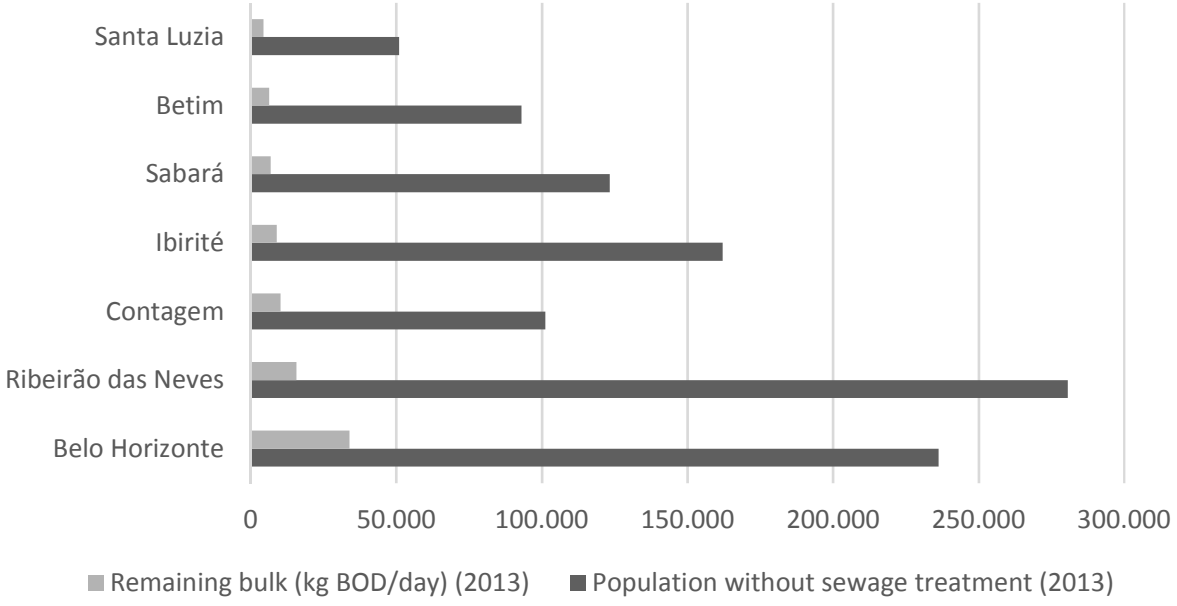
majority:

collection / no treatment
collection / treatment

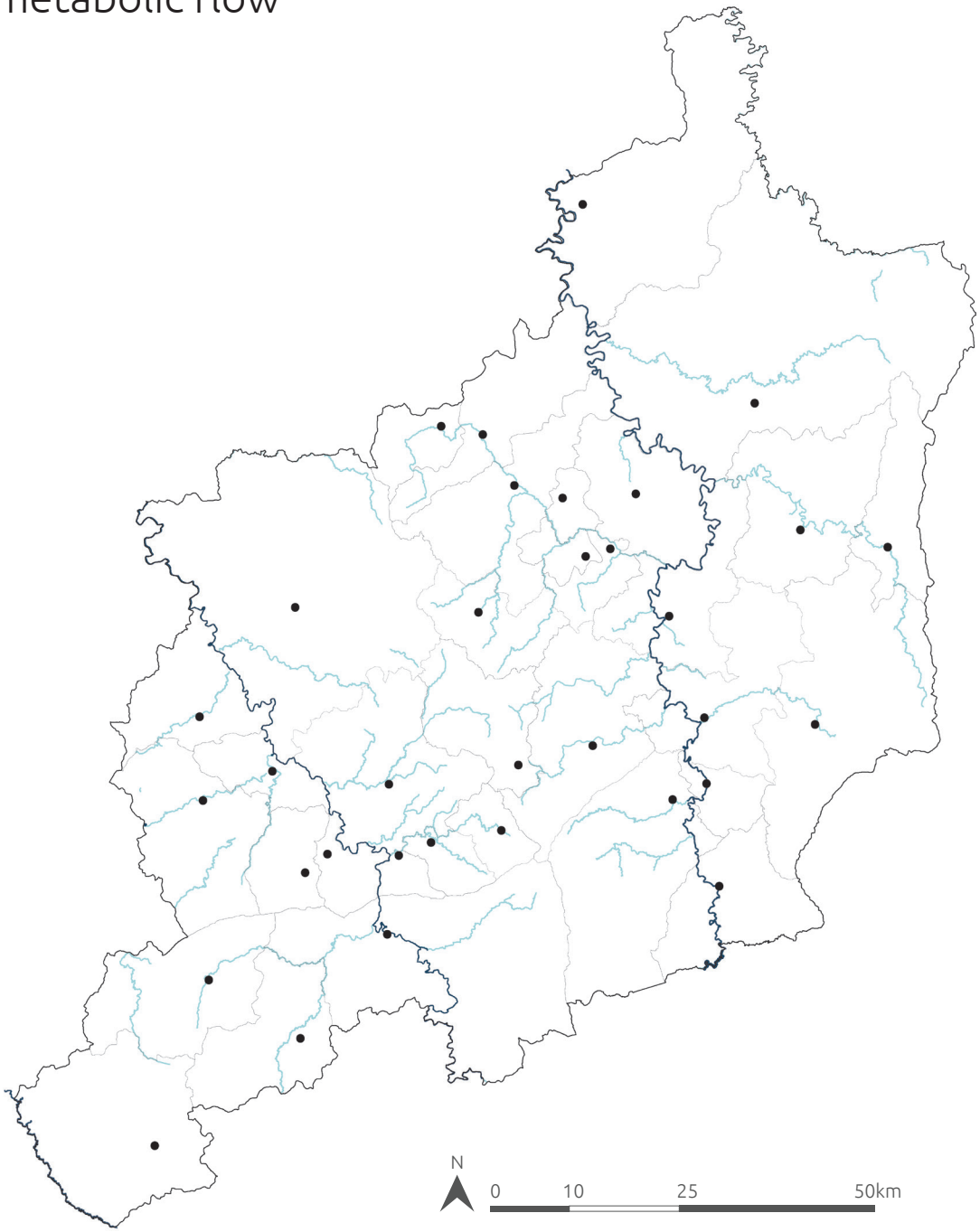

inputs
(kg BOD/day)
outputs
(kg BOD/day)
individual solution
22.443
no collection/ no treatment
106.028
collection/ no treatment
379.932
collection/ treatment
401.829
treatment
(if existent)
8.978
106.028
379.932
83.733



City	Population without sewage treatment (2013)	Remaining Bulk (kg BOD/day - 2013)
Belo Horizonte	236.264	33.930
Ribeirão das Neves	280.594	15.740
Contagem	101.156	10.299
Ibirité	162.840	8.938
Sabará	123.303	6.885
Betim	93.049	6.310
Santa Luzia	50.993	4.365

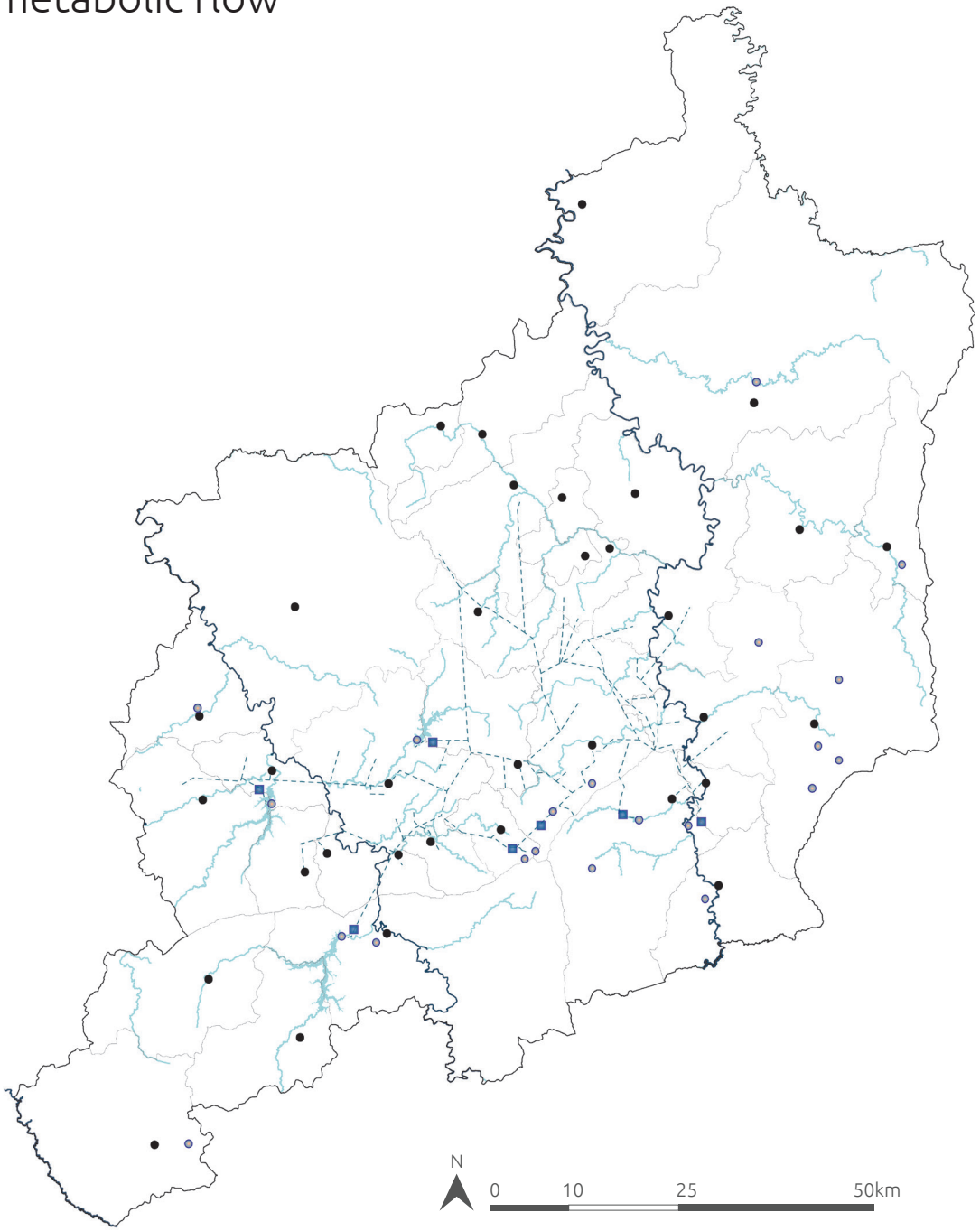


metabolic flow



rivers and watersheds

metabolic flow

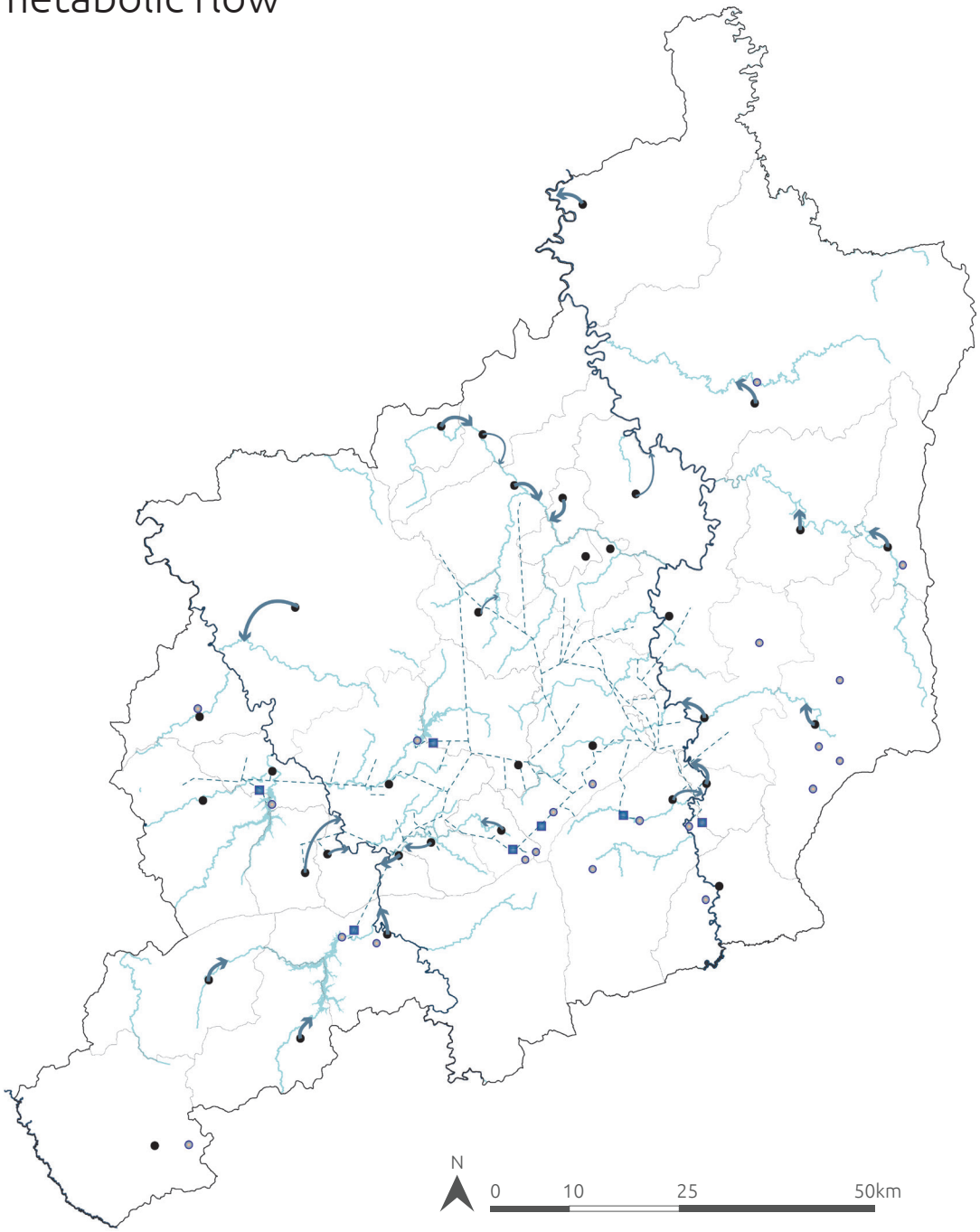


drinking water network

Drinking water

- reservoir
- watershed
- water mains
- water treatment plant (ETA)
- water abstraction

metabolic flow



untreated sewage discharge

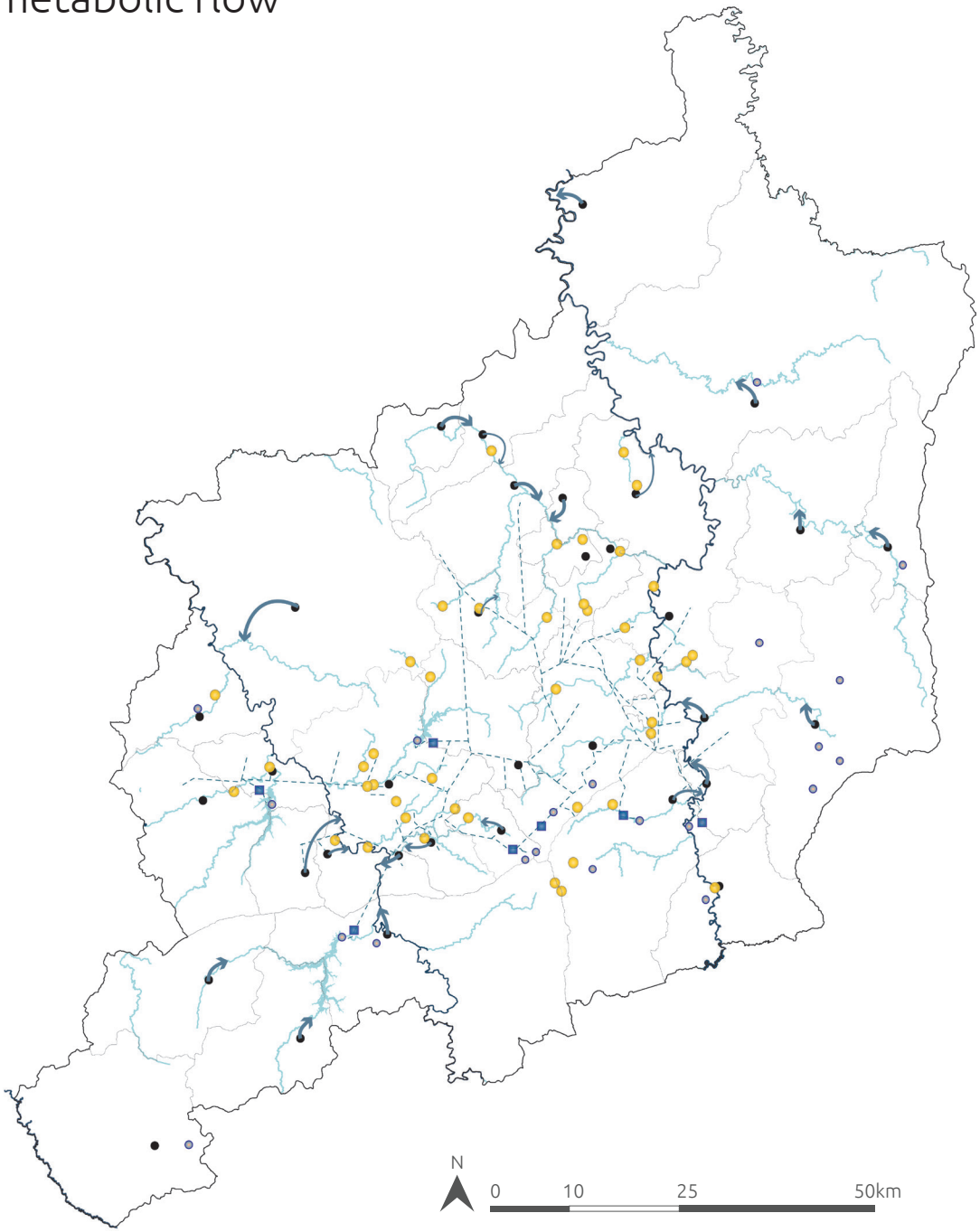
Drinking water

- reservoir
- watershed
- water mains
- water treatment plant (ETA)
- water abstraction

Wastewater

- untreated sewage discharge

metabolic flow



treatment plants

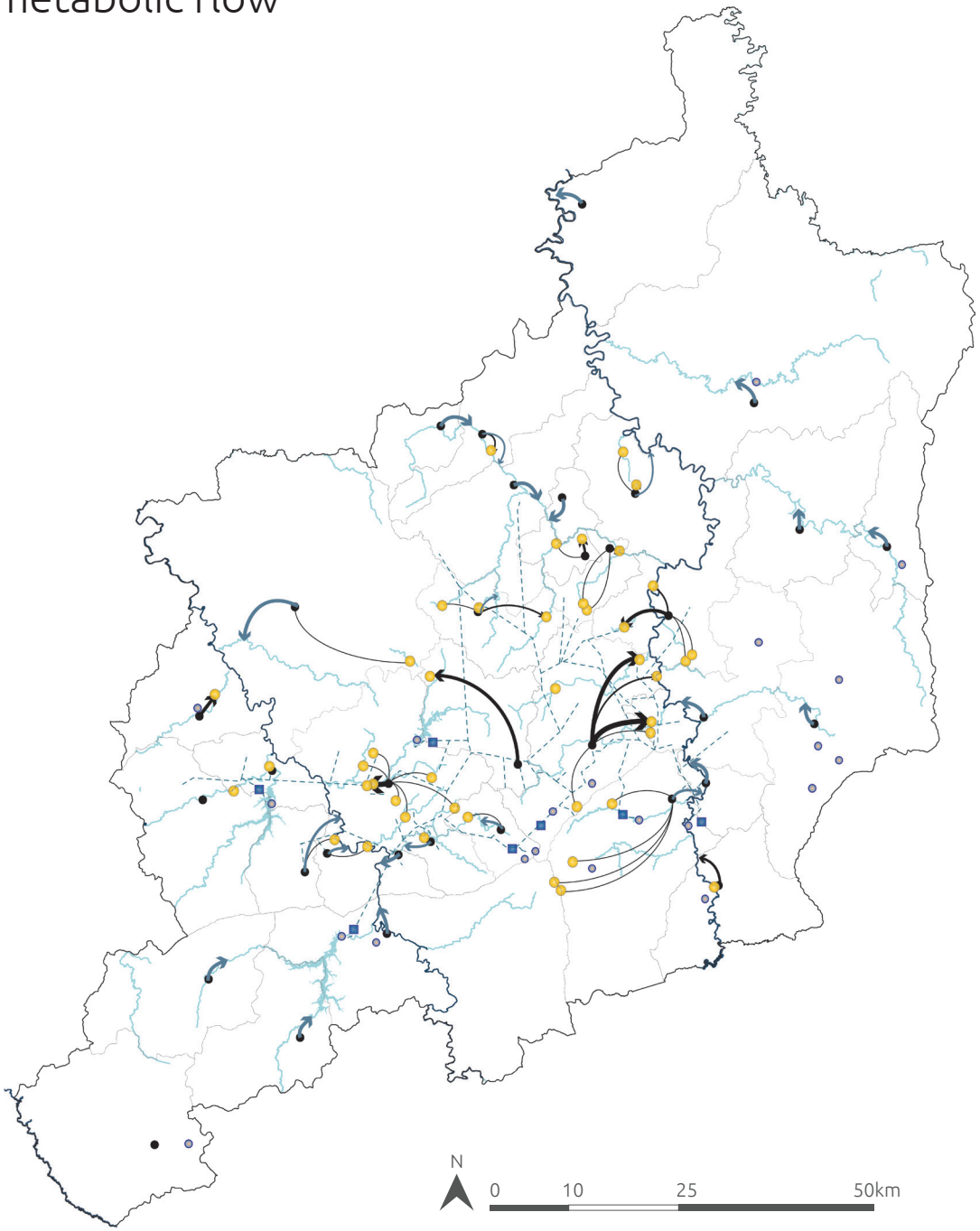
Drinking water

- reservoir
- watershed
- water mains
- water treatment plant (ETA)
- water abstraction

Wastewater

- untreated sewage discharge
- sewage treatment plant (ETE)

metabolic flow



treated sewage discharge

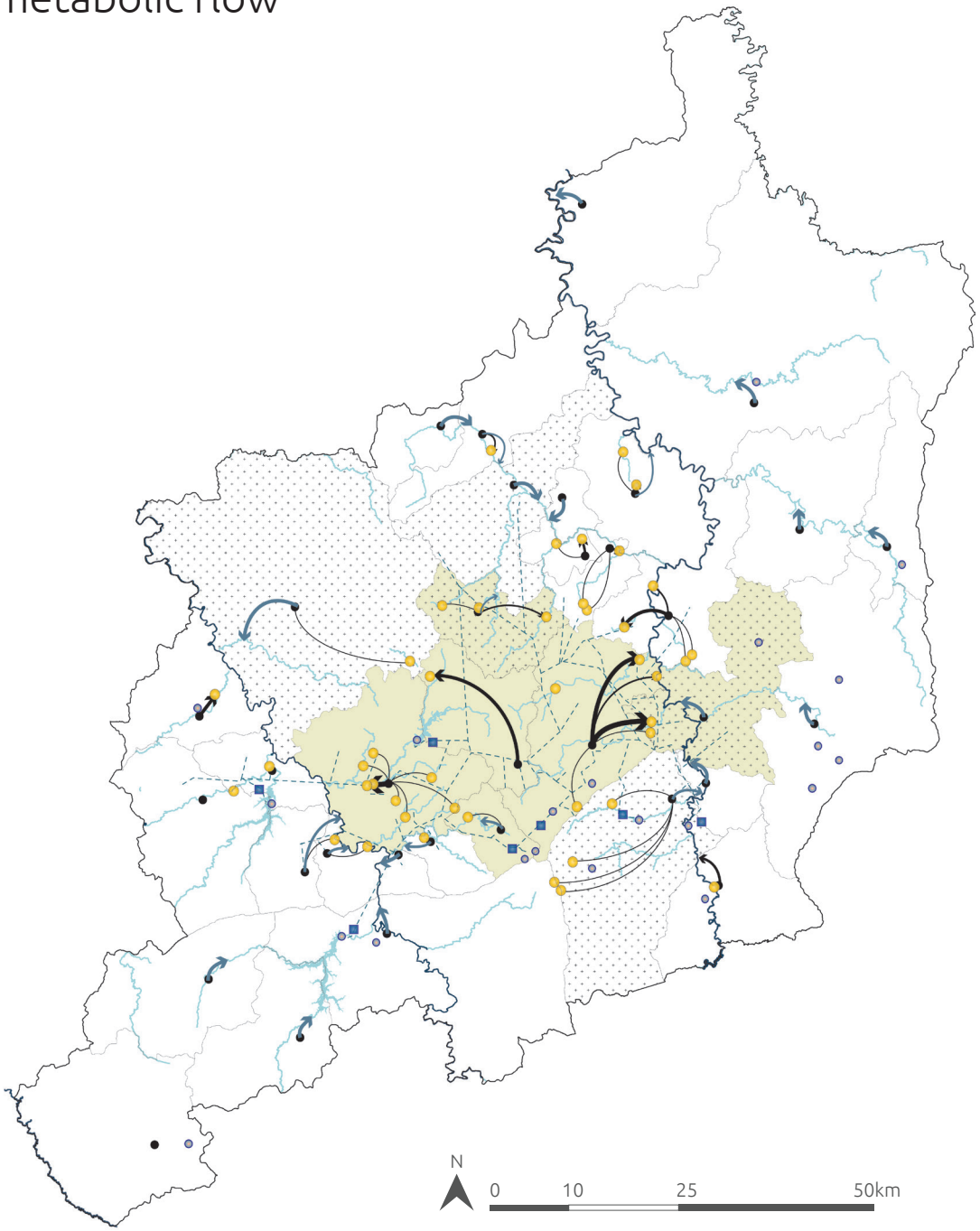
Drinking water

- reservoir
- watershed
- water mains
- water treatment plant (ETA)
- water abstraction

Wastewater

- untreated sewage discharge
- sewage treatment plant (ETE)
- sewage treatment plant discharge

metabolic flow



main cities without treatment and largest contributors for river pollution

Drinking water

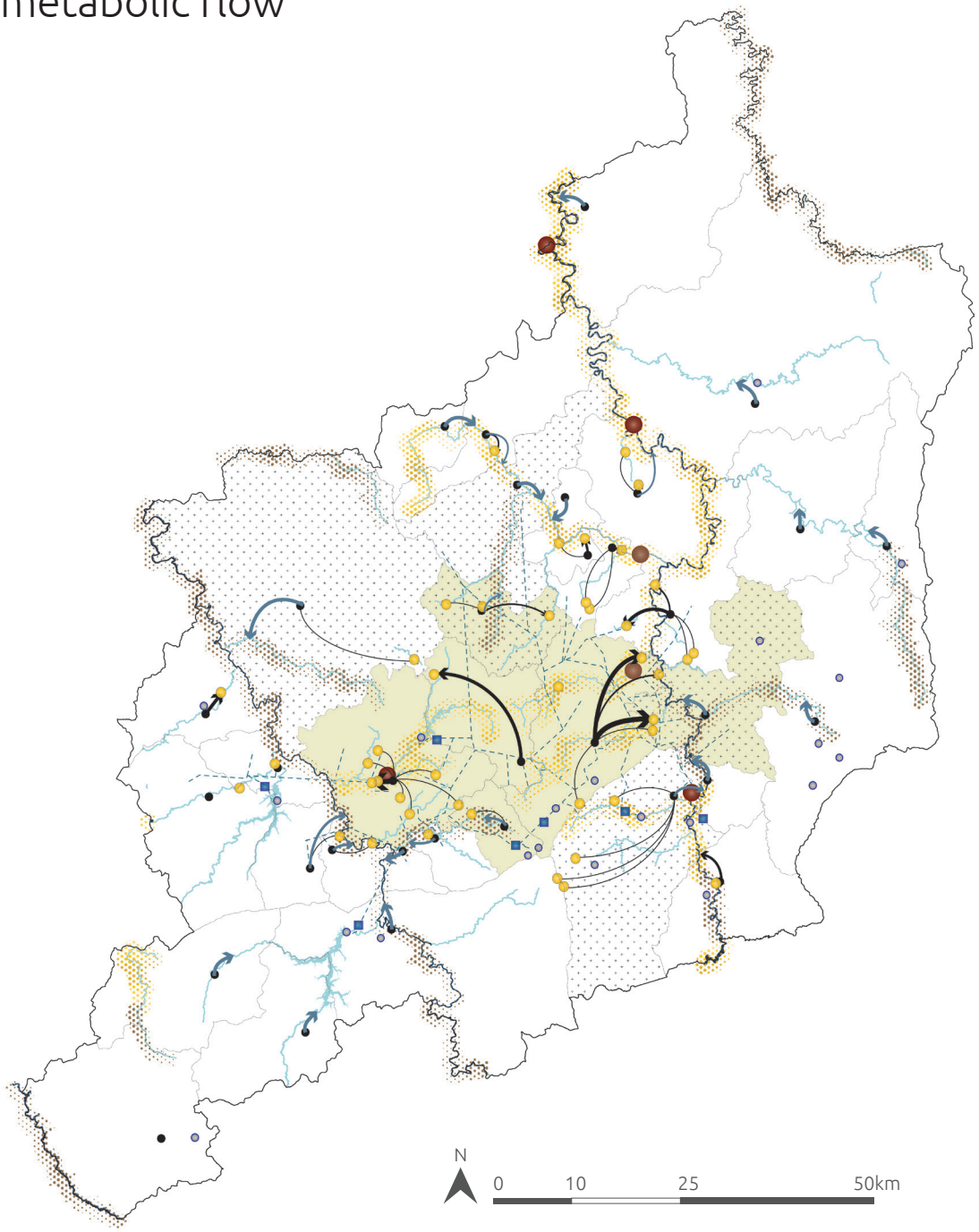
- reservoir
- watershed
- water mains
- water treatment plant (ETA)
- water abstraction

Wastewater

- untreated sewage discharge
- sewage treatment plant (ETE)
- sewage treatment plant discharge

- no treatment majority (population> 50.000)
- largest BOD contribution

metabolic flow



river pollution and water quality

Drinking water

- reservoir
- watershed
- water mains
- water treatment plant (ETA)
- water abstraction

Wastewater

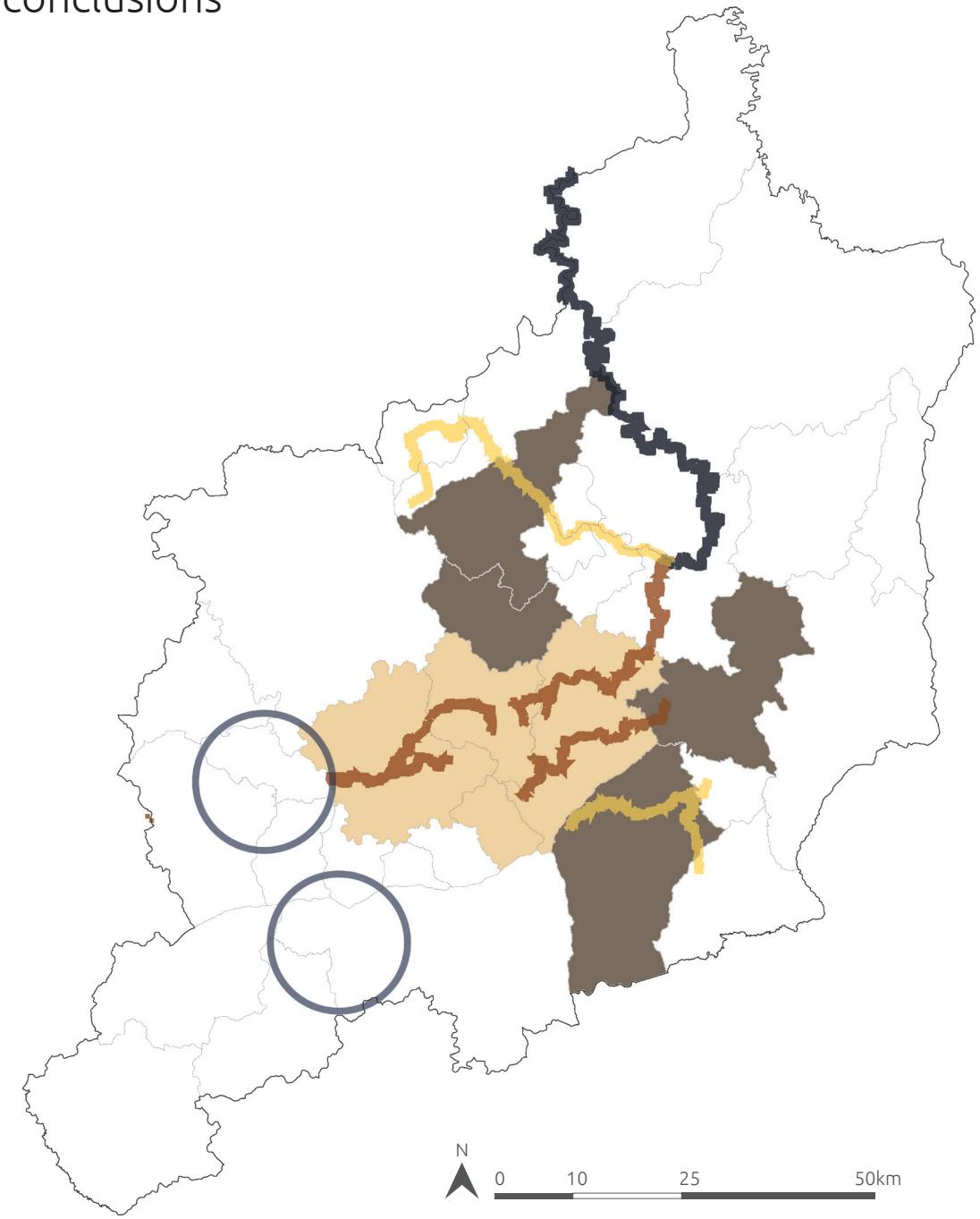
- untreated sewage discharge
- sewage treatment plant (ETE)
- sewage treatment plant discharge

- no treatment majority (population> 50.000)
- largest BOD contribution

Water quality

- moderate pollution
- high pollution
- moderate toxic contamination
- high toxic contamination

conclusions

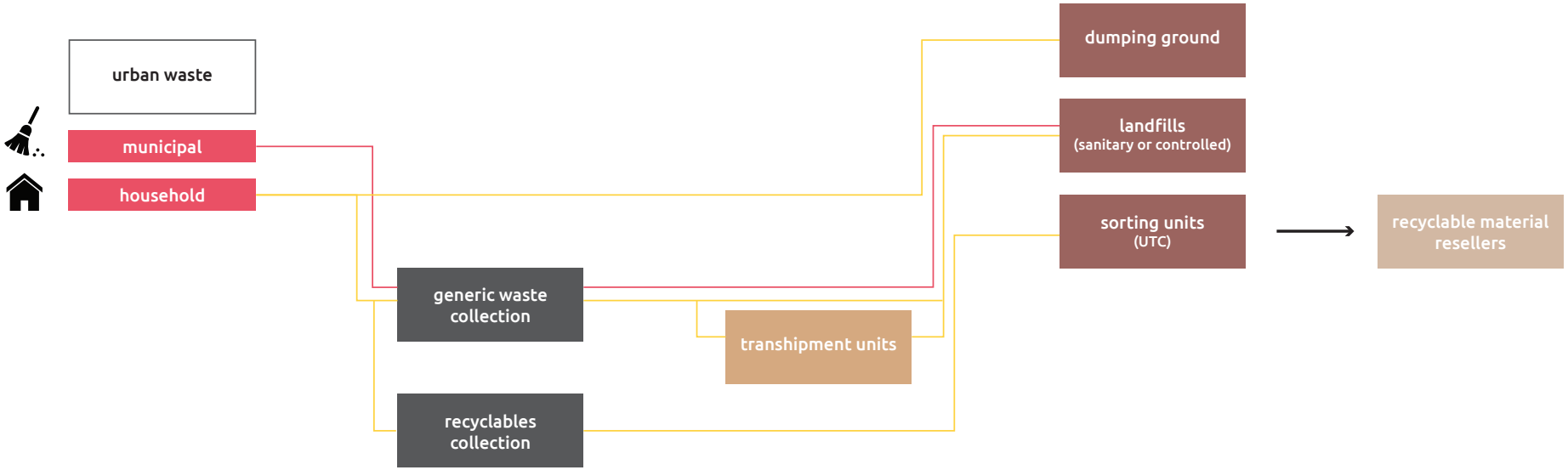


- pollution due to upstream contamination
- pollution due to expressive minority without treatment (high density)
- pollution due to majority without treatment
- critical areas A (population x minority without sewage treatment x pollution)
- critical areas B (population x majority without sewage treatment x pollution)
- critical areas for expansion (drinking water x no sewage treatment)

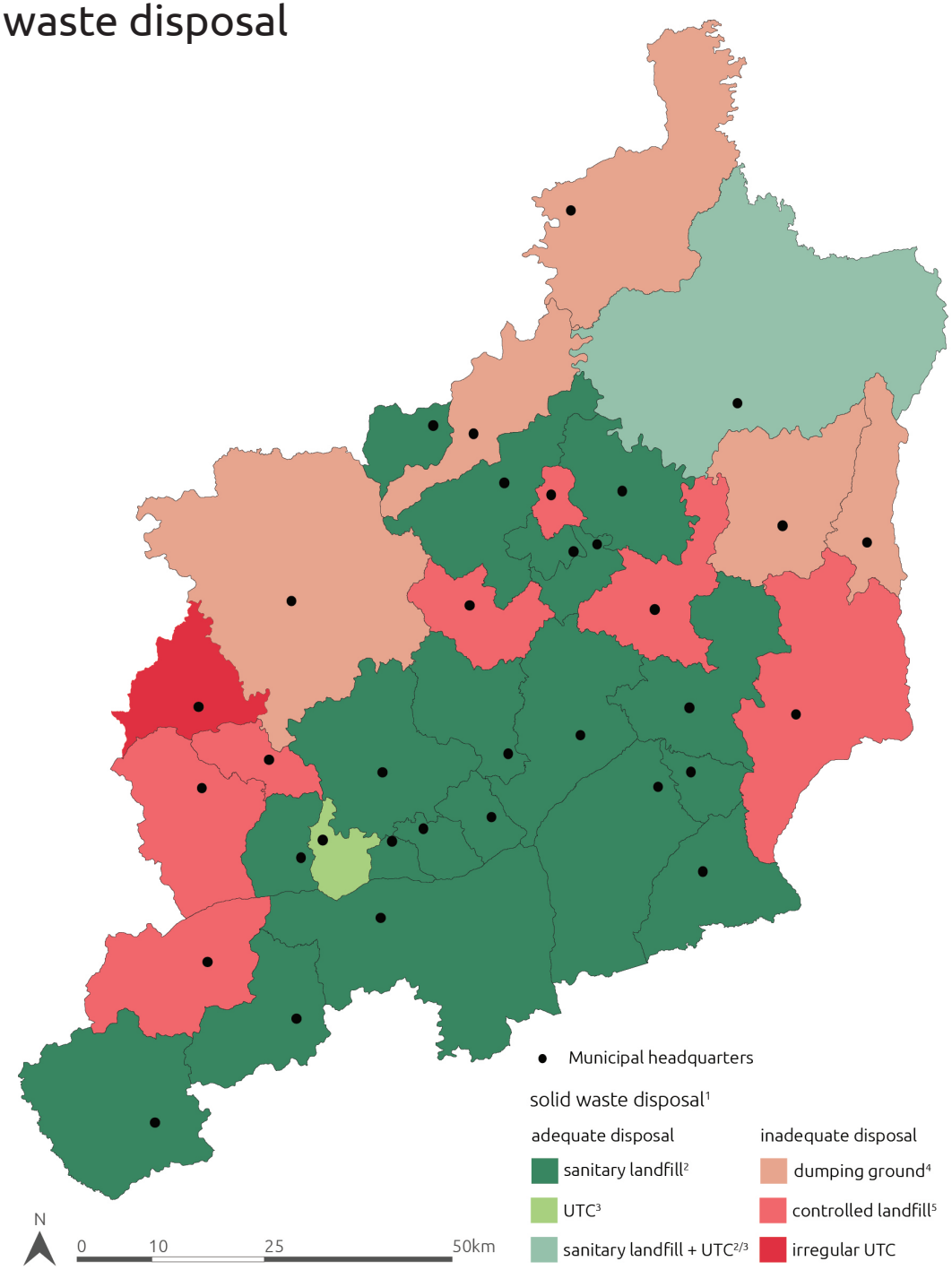
metabolic analysis

solid waste

domestic waste focus



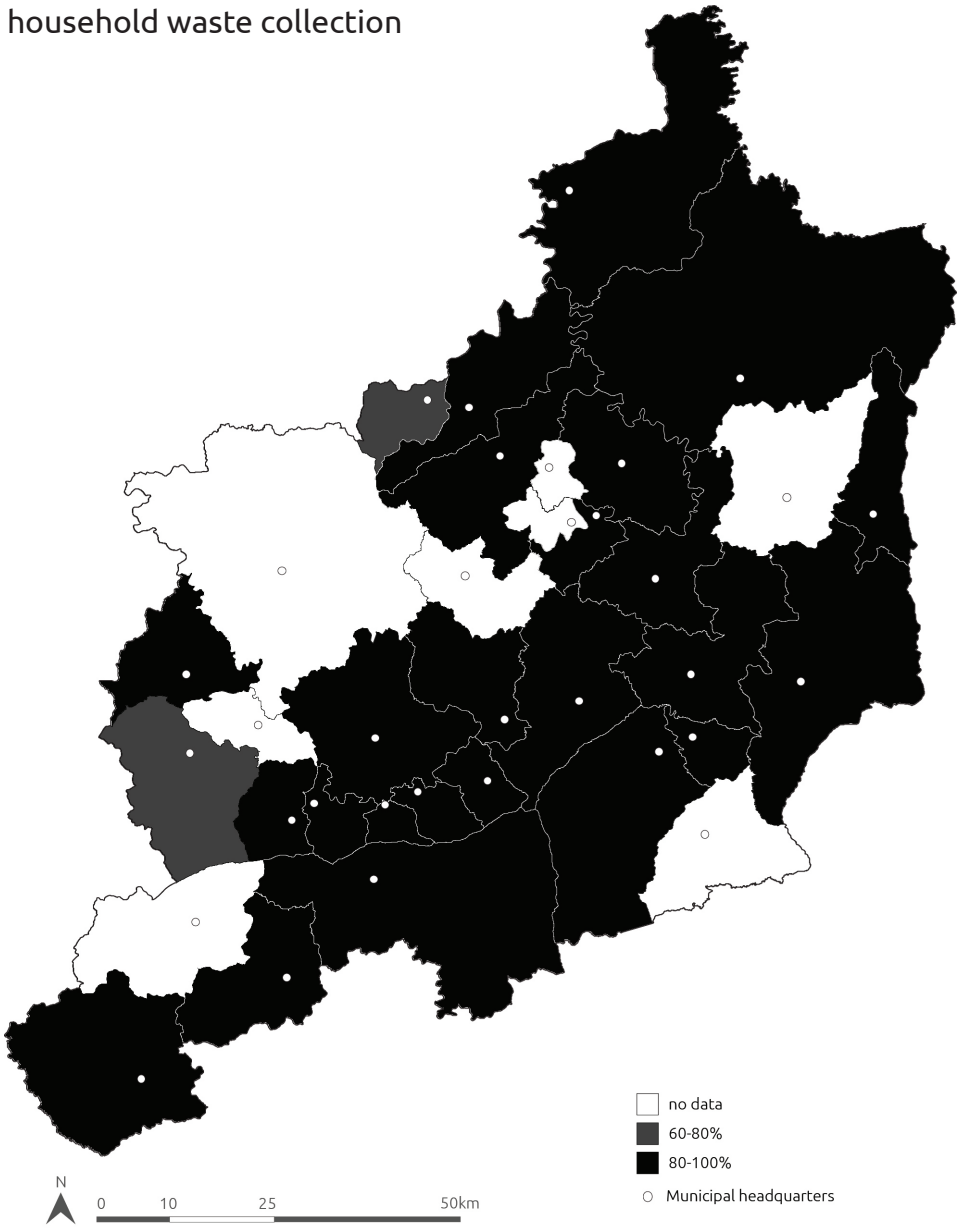
waste disposal



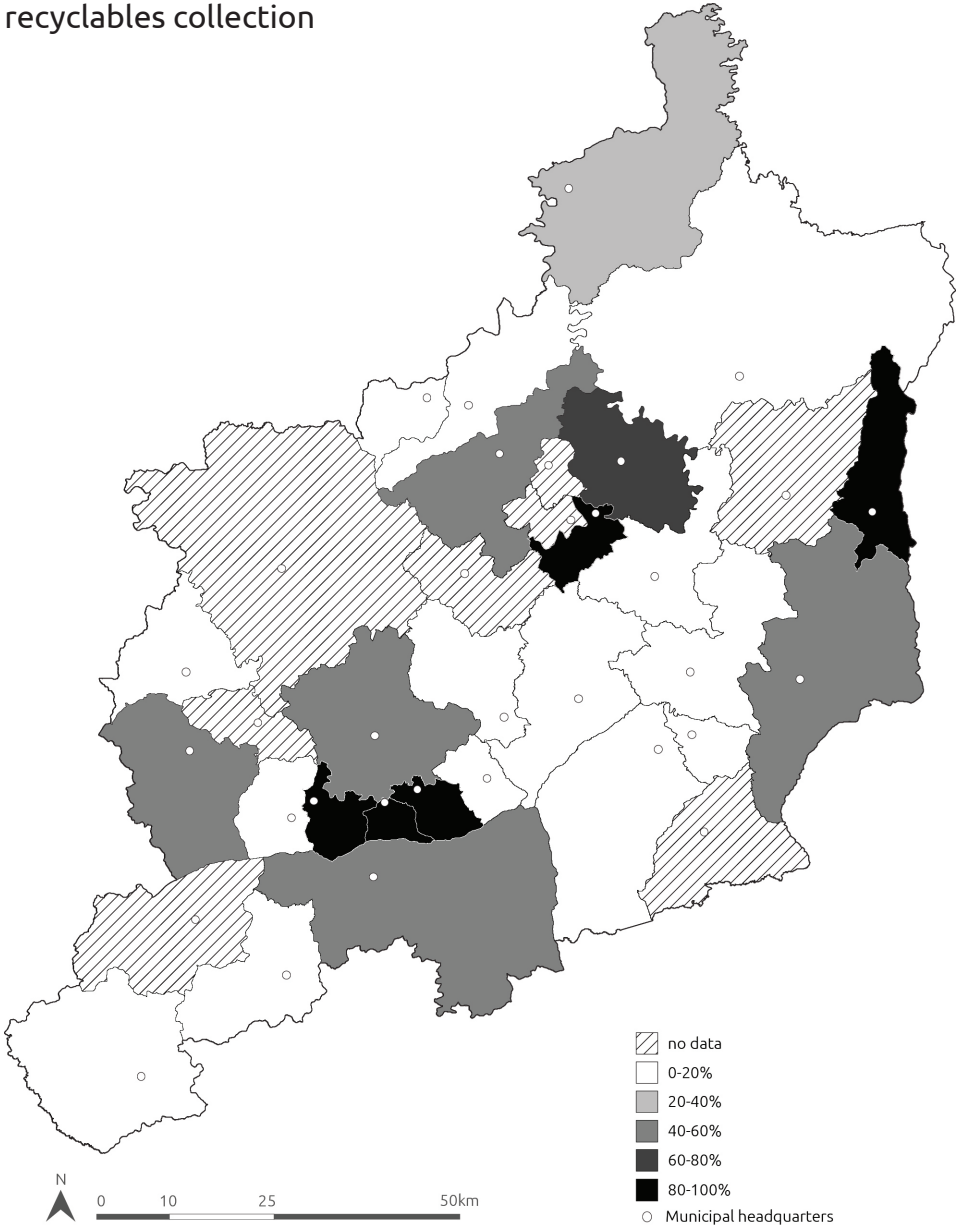
around 13% of the population,
or almost 780.000 people
do not have adequate waste
disposal

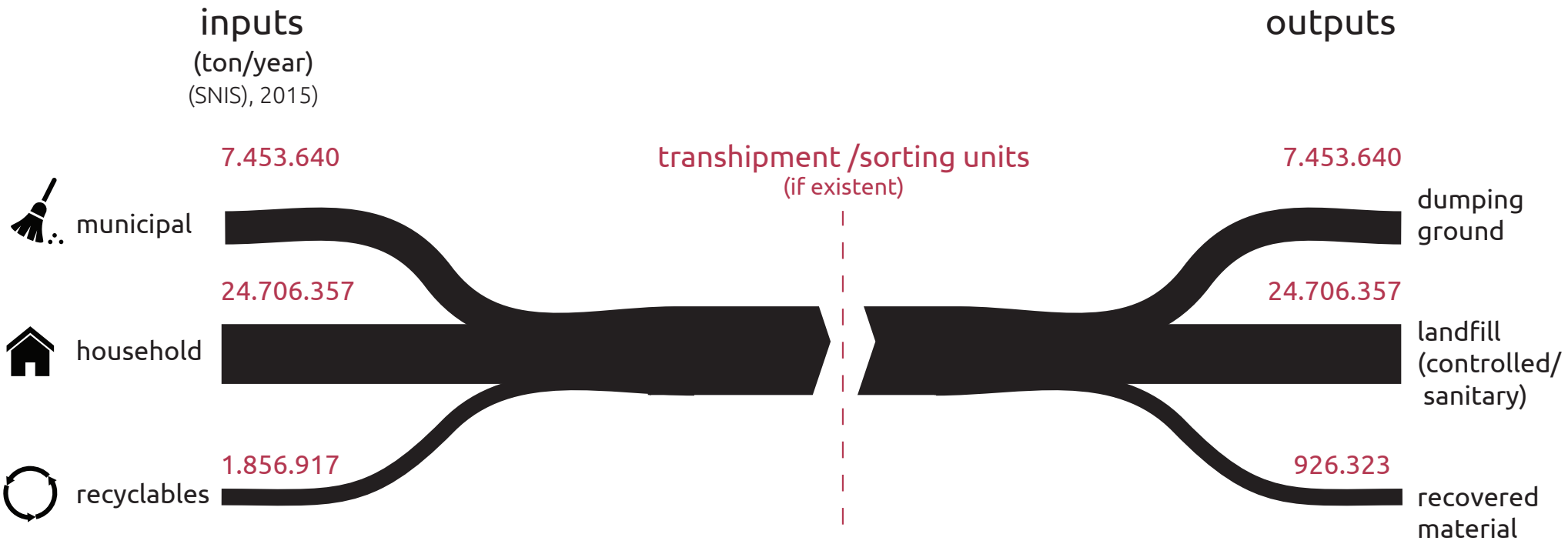
household waste x recyclable waste

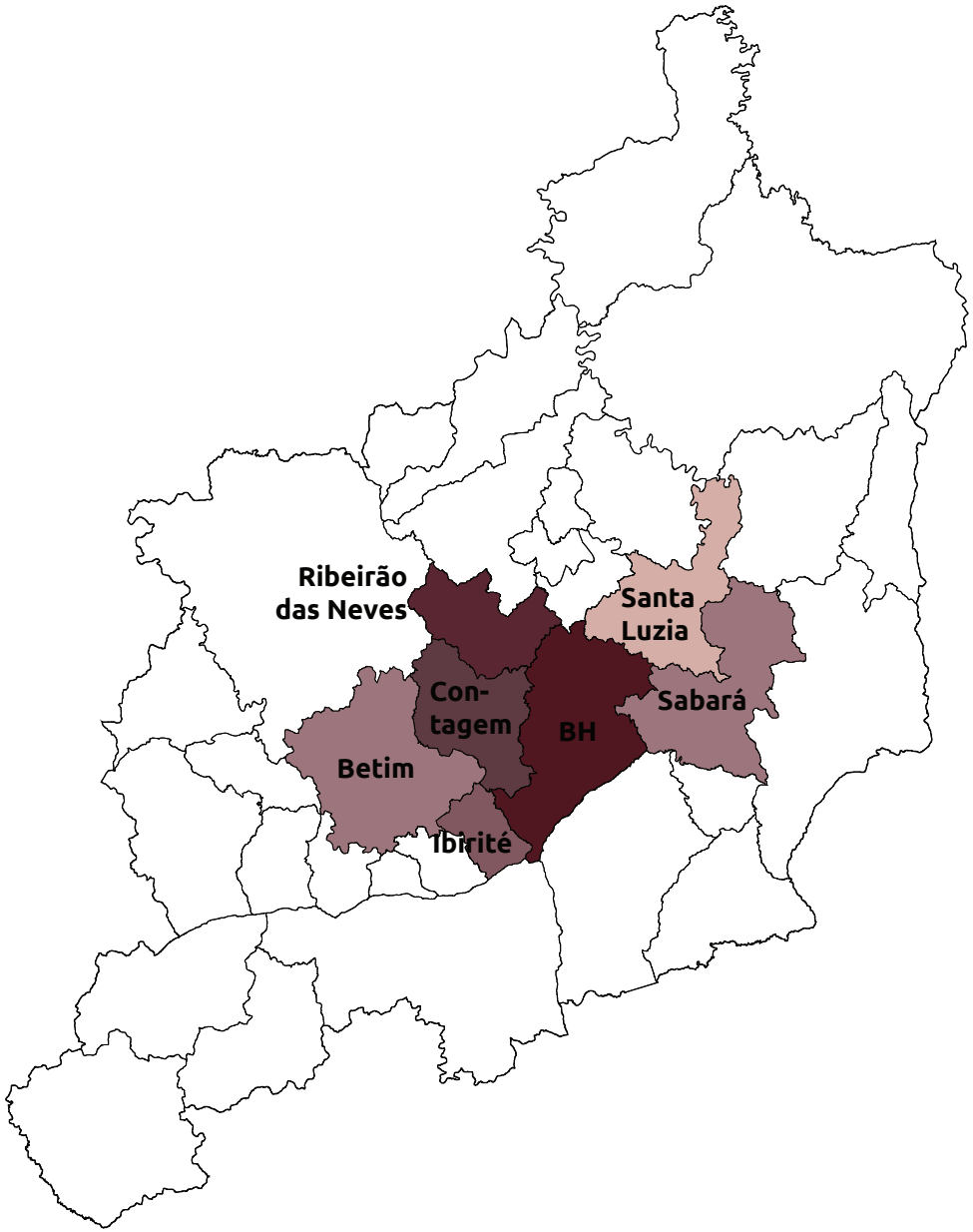
household waste collection



recyclables collection

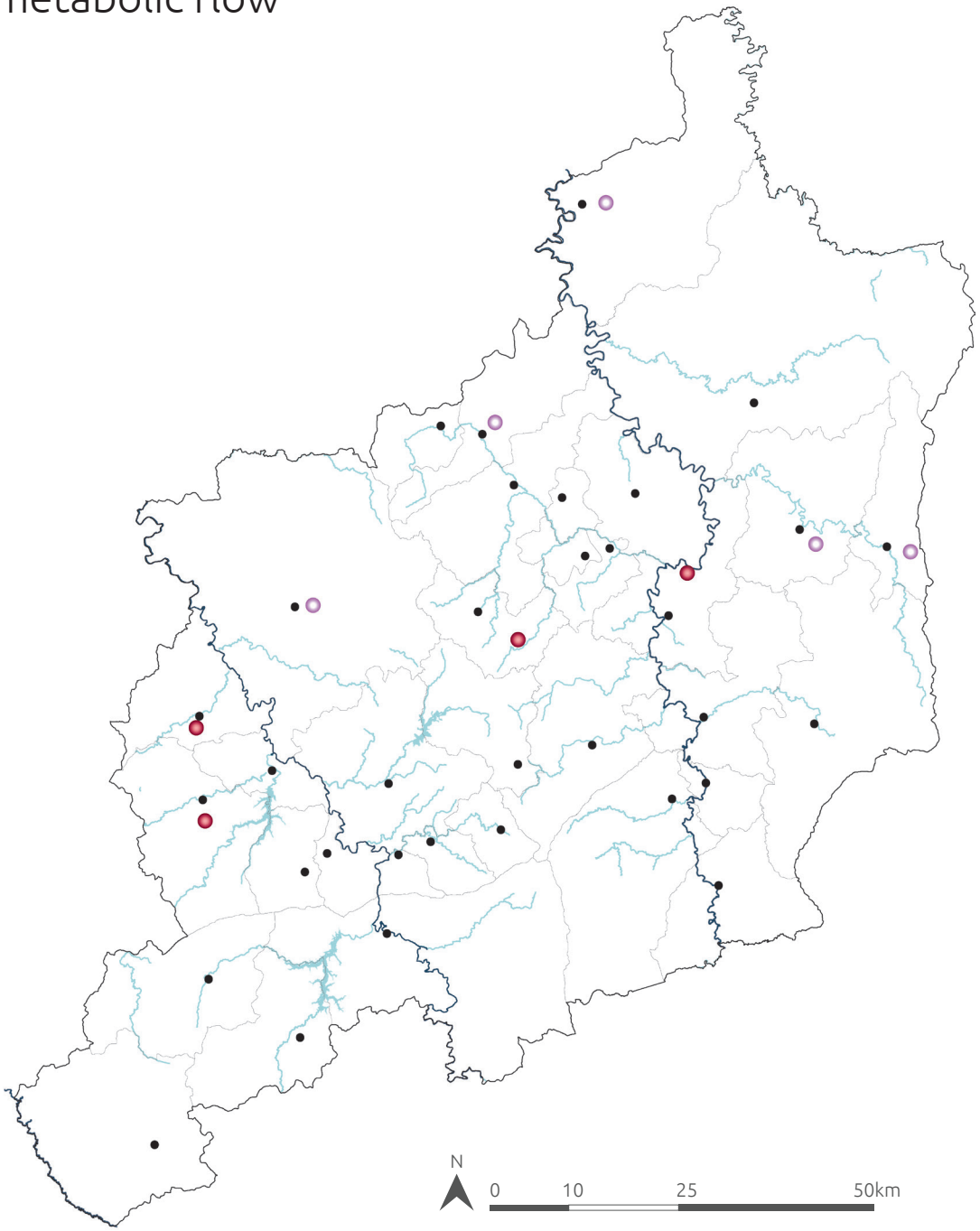



inputs
(ton/year)
(SNIS), 2015
7.453.640
municipal
24.706.357
household
1.856.917
recyclables
transhipment /sorting units
(if existent)
outputs
7.453.640
dumping ground
24.706.357
landfill (controlled/ sanitary)
926.323
recovered material



City	Population with recyclables collection <20% (2015)	Population (>50.000) (2015)
Nova Lima	0%	89.900
Sabará	0%	134.382
Santa Luzia	0%	216.254
Ibirité	2,88%	173.873
Belo Horizonte	15%	2.302.557
Contagem	20%	648.766

metabolic flow

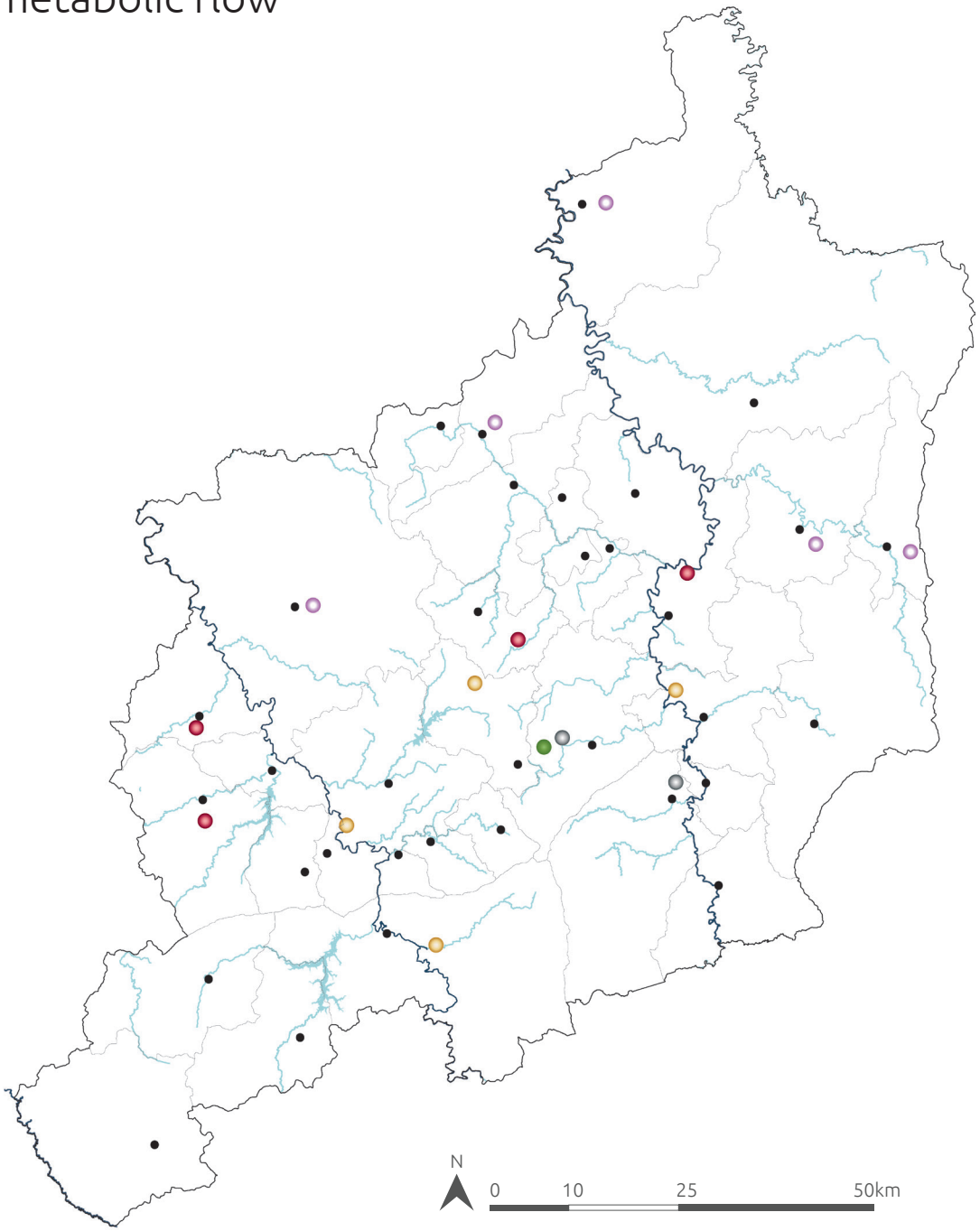


indequate waste disposal facilities

Solid Waste

- controlled landfill
- dumping ground

metabolic flow

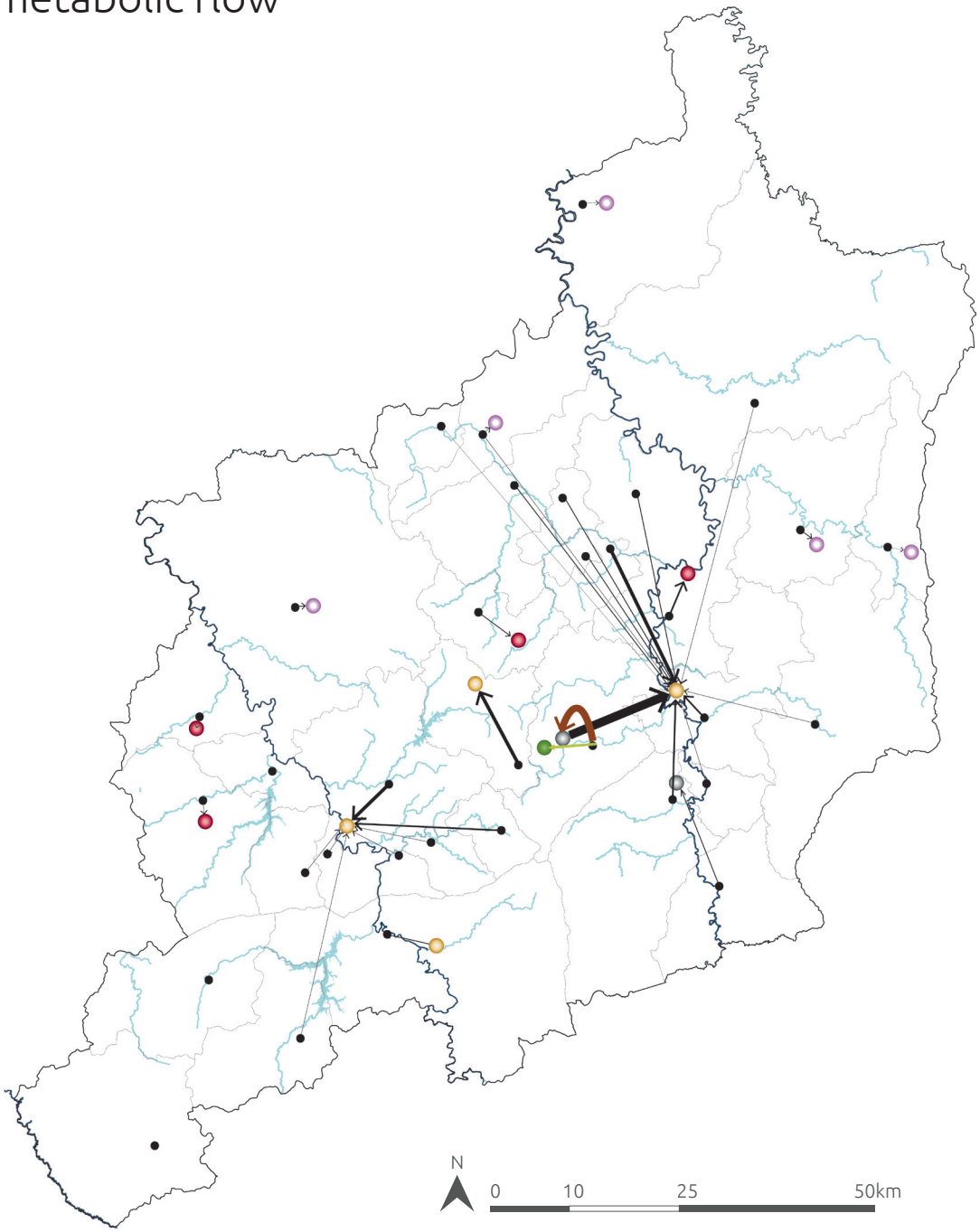


adequate waste disposal facilities

Solid Waste

- controlled landfill
- dumping ground
- sanitary landfill
- composting unit
- transhipment unit

metabolic flow

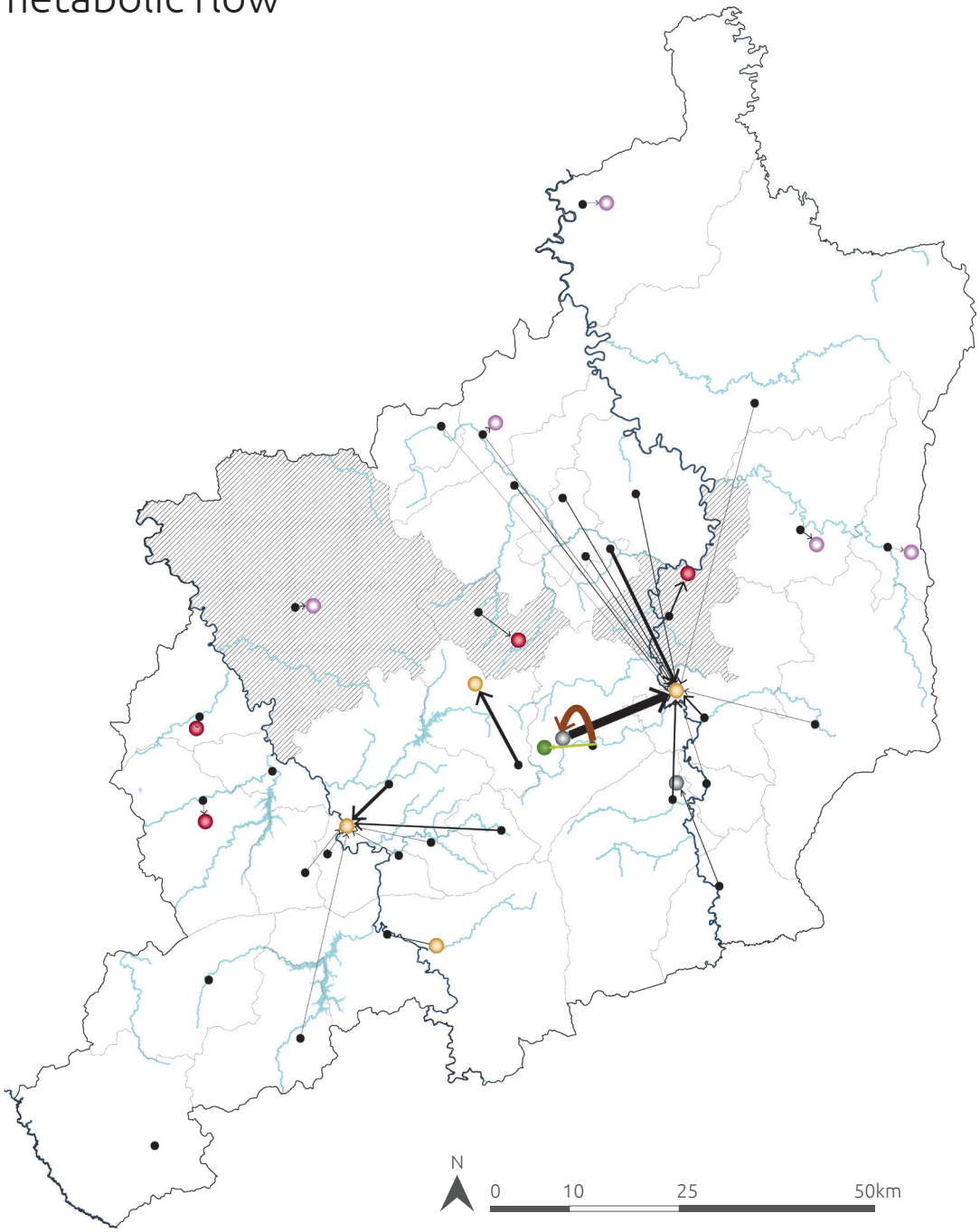


waste flows

Solid Waste

- controlled landfill
- dumping ground
- sanitary landfill
- composting unit
- transhipment unit
- urban waste disposal
- organic waste disposal
- to transhipment unit

metabolic flow



main cities with inadequate waste disposal

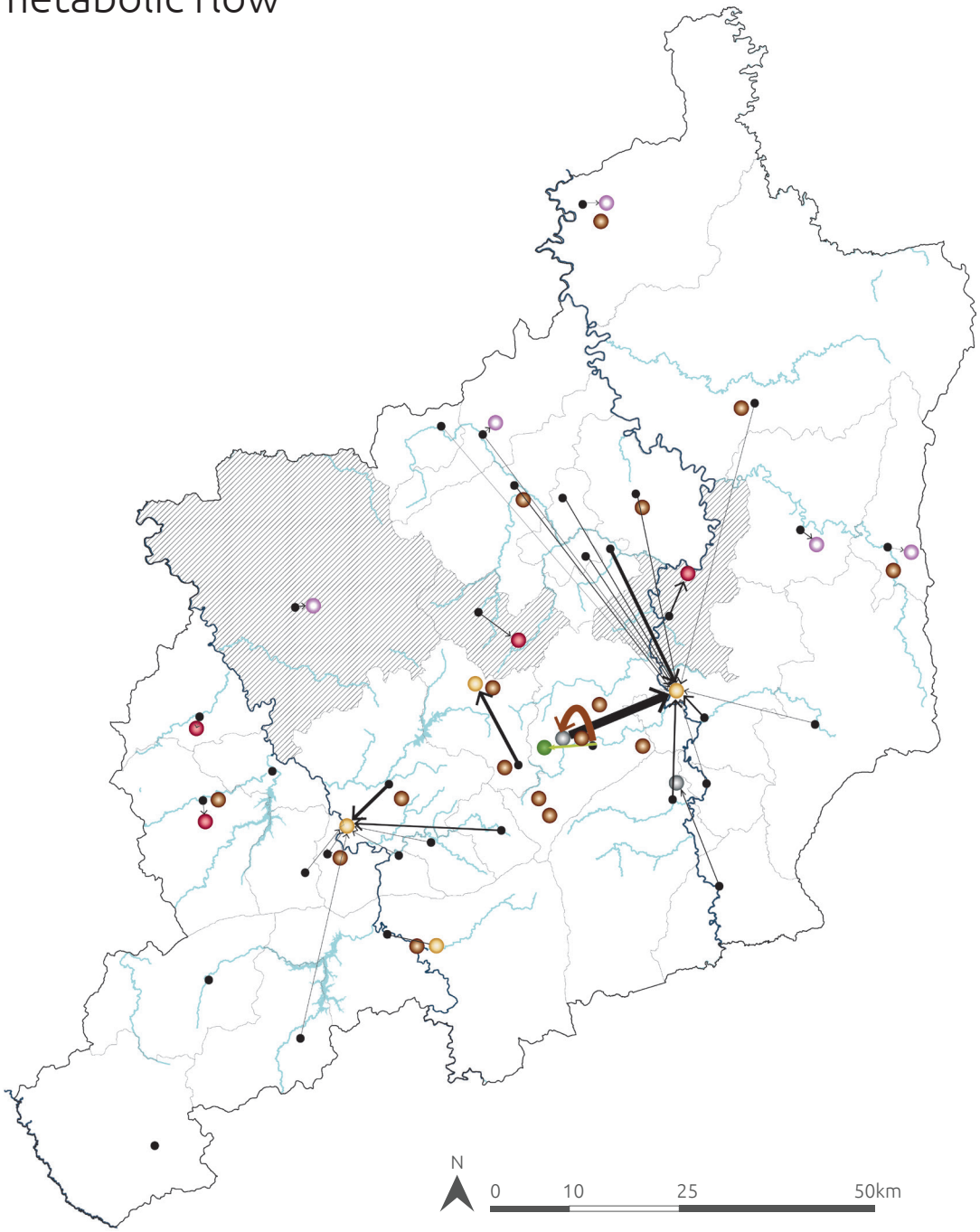
Solid Waste

- controlled landfill
- dumping ground
- sanitary landfill
- composting unit
- transhipment unit
- urban waste disposal
- organic waste disposal
- to transhipment unit

population >50.000:

- without adequate waste diposal

metabolic flow



recyclables facilities

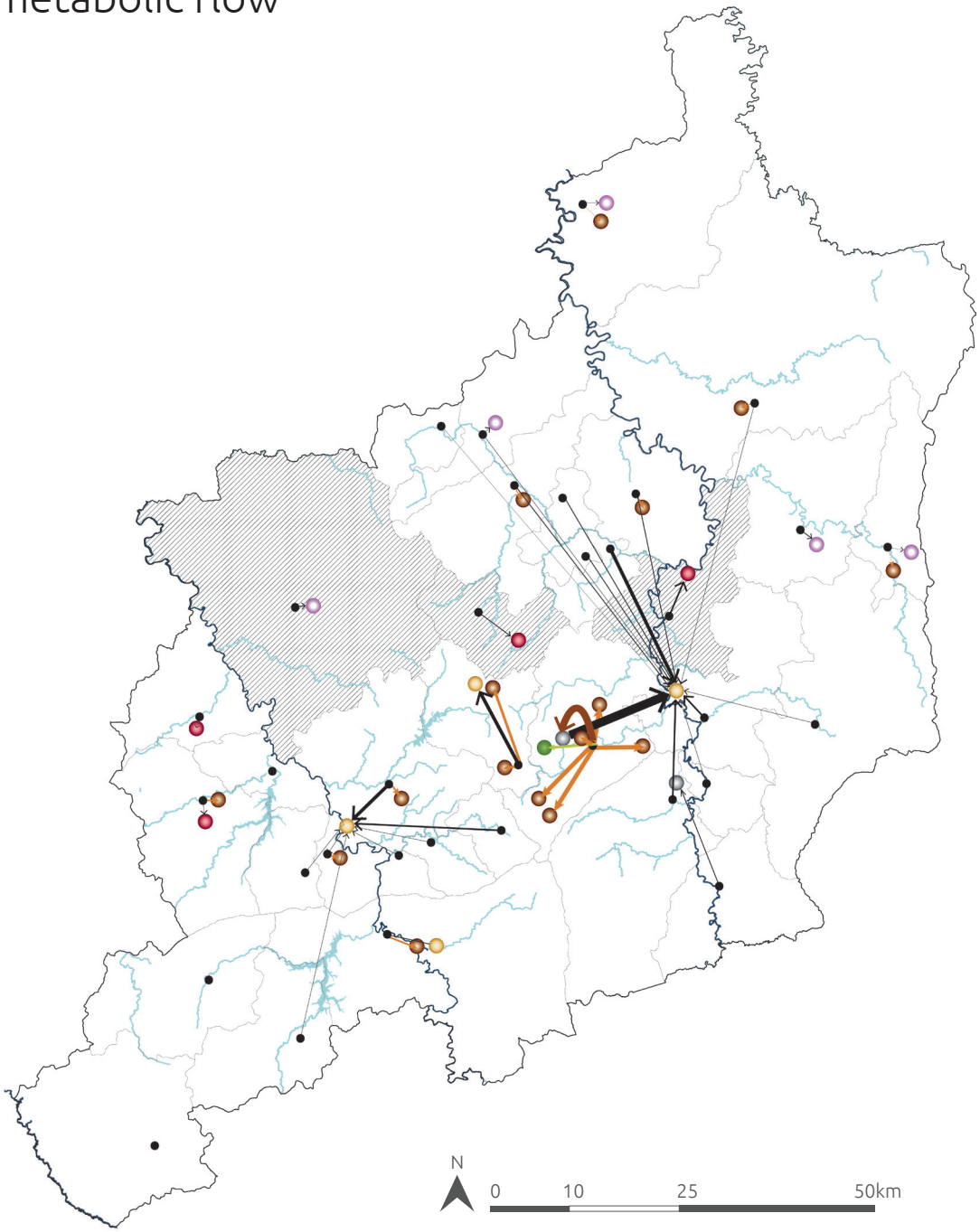
Solid Waste

- controlled landfill
- dumping ground
- sanitary landfill
- composting unit
- transhipment unit
- sorting unit
- urban waste disposal
- organic waste disposal
- to transhipment unit

population >50.000:

- without adequate waste diposal

metabolic flow



recycling flows

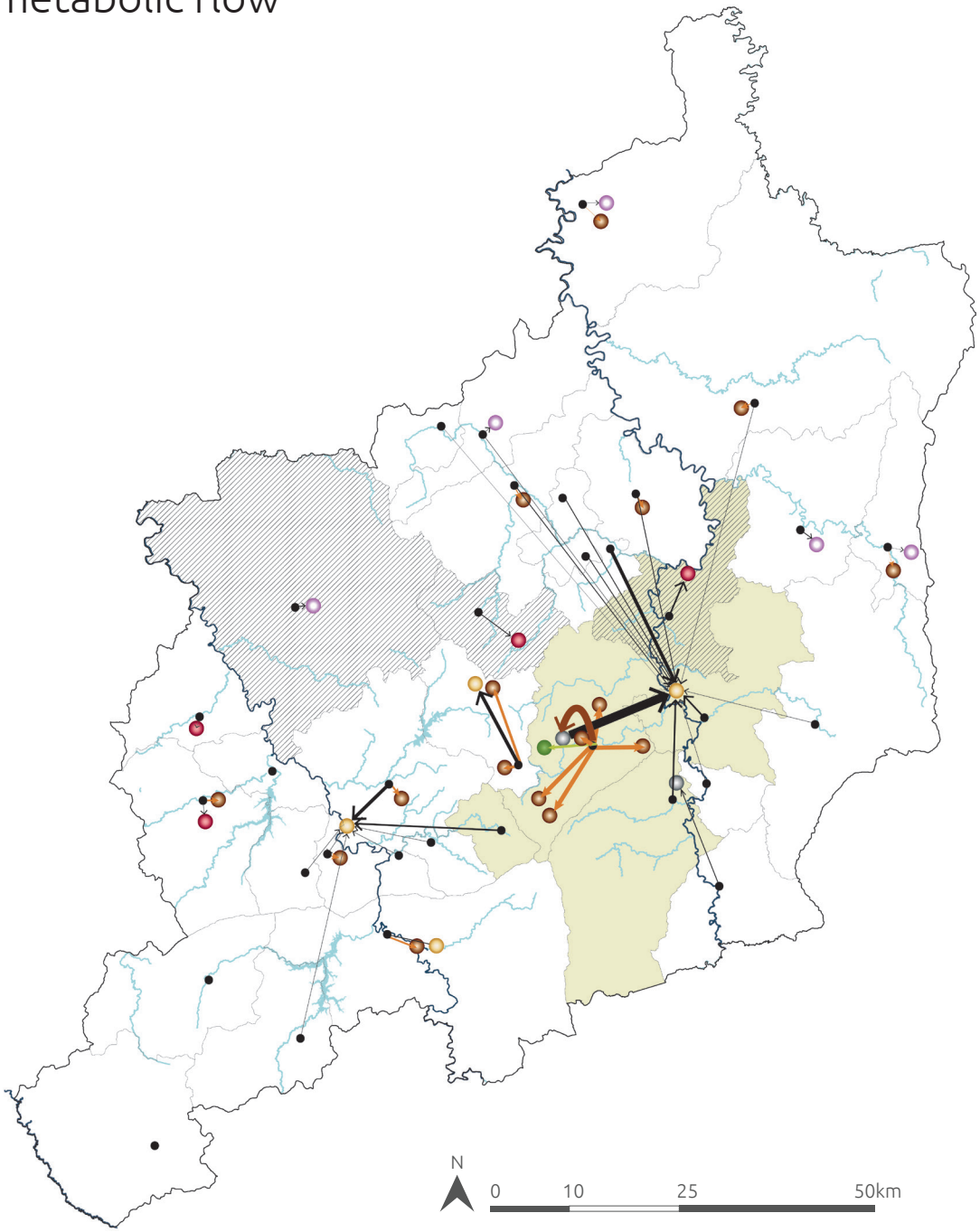
Solid Waste

- controlled landfill
- dumping ground
- sanitary landfill
- composting unit
- transhipment unit
- sorting unit
- urban waste disposal
- organic waste disposal
- to transhipment unit
- recyclable waste disposal

population >50.000:

- without adequate waste diposal

metabolic flow



cities with lowest recycling collection (<20%)

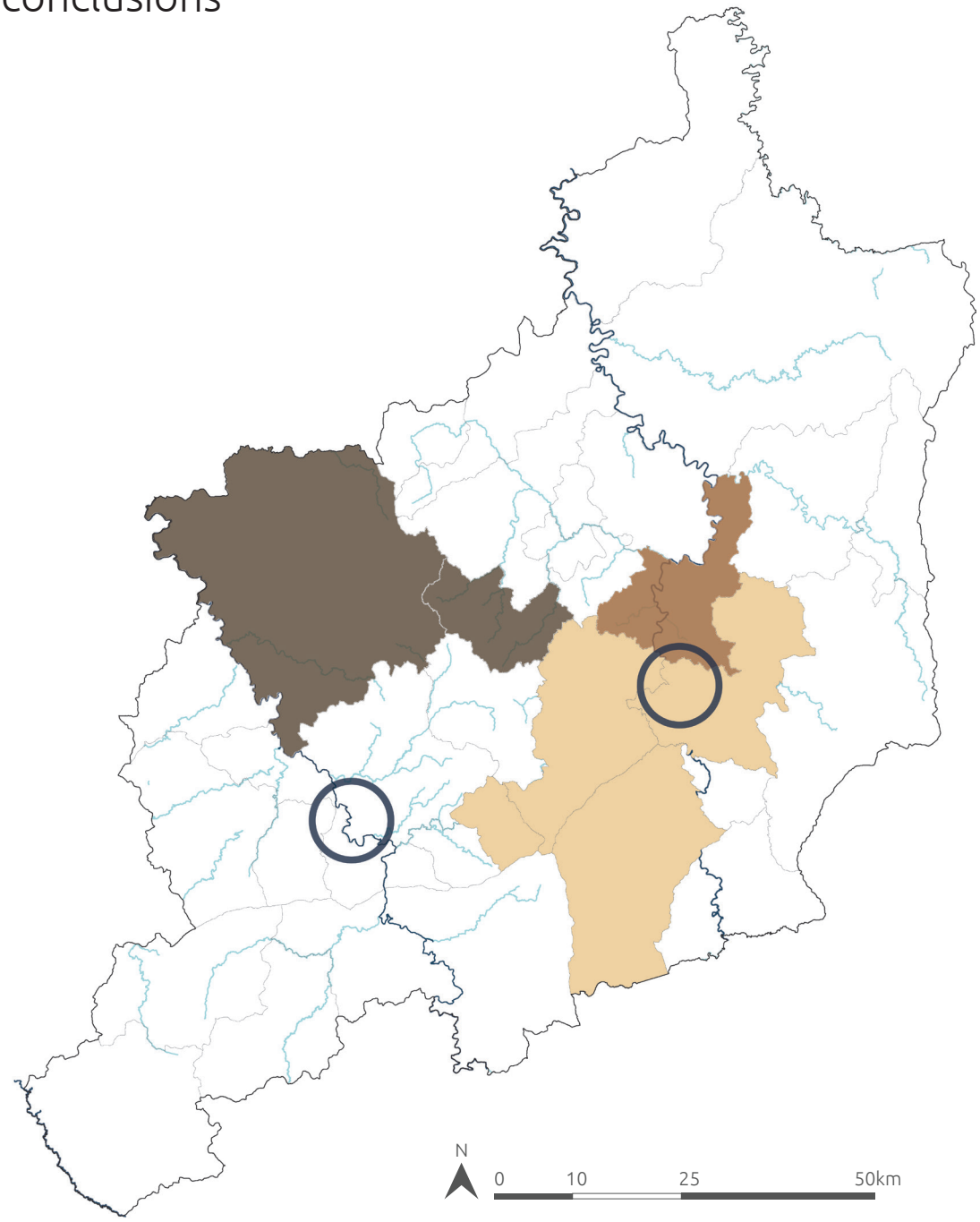
Solid Waste

- controlled landfill
- dumping ground
- sanitary landfill
- composting unit
- transhipment unit
- sorting unit
- urban waste disposal
- organic waste disposal
- to transhipment unit
- recyclable waste disposal

population >50.000:

- without adequate waste diposal
- with lowest recyclable collection (<20%)

conclusions



critical areas A
(population x inadequate waste disposal facility)

critical areas B
(population x recycling deficiency)

critical areas C
(waste disposal and recycling deficiency)

concentration of waste disposal facilities

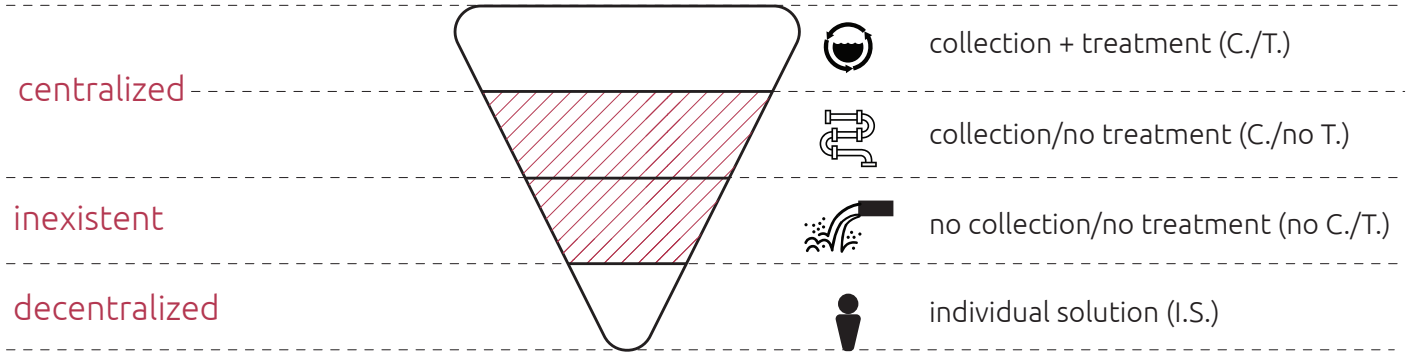
?

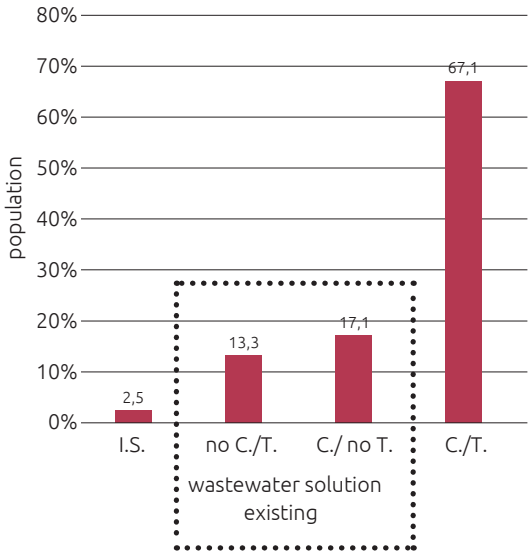
what if instead of aiming to connect 100%
of the population to a centralized system,
decentralized solutions could be applied?

decentralization

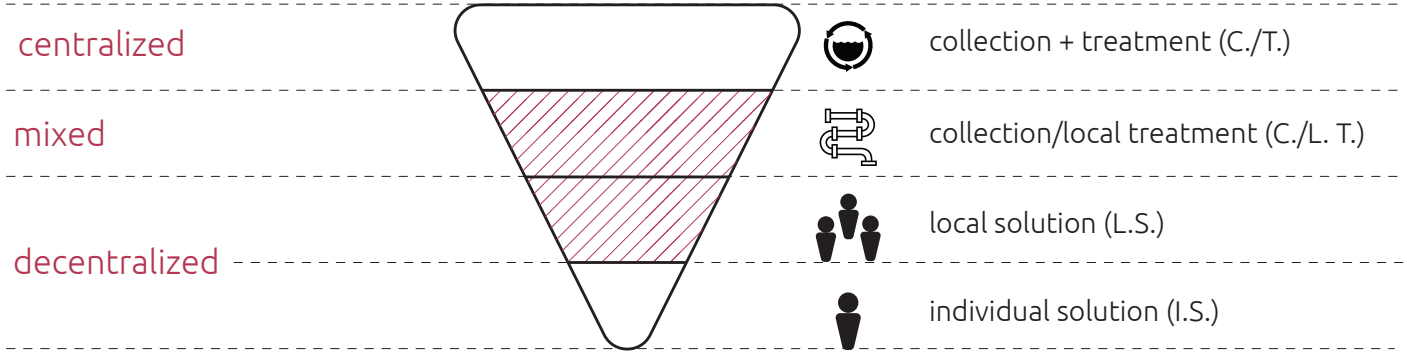
wastewater

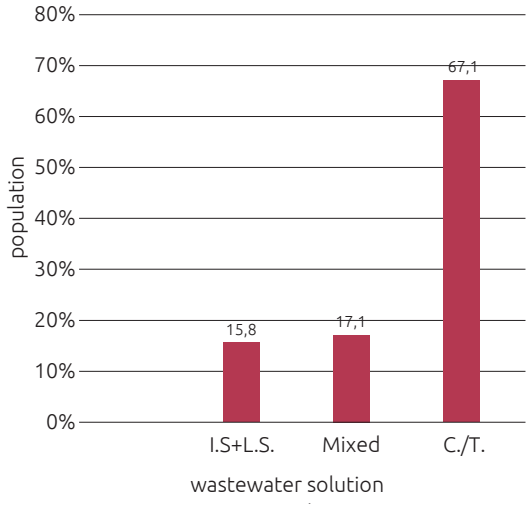
existing



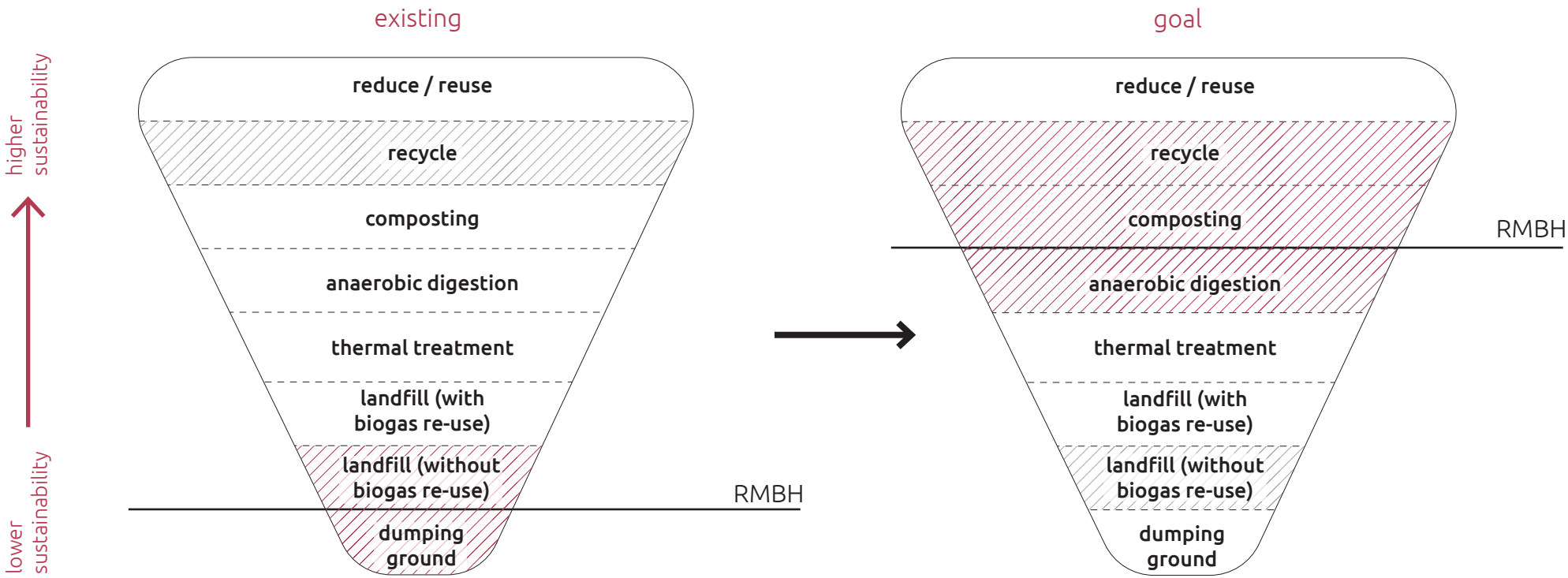


goal

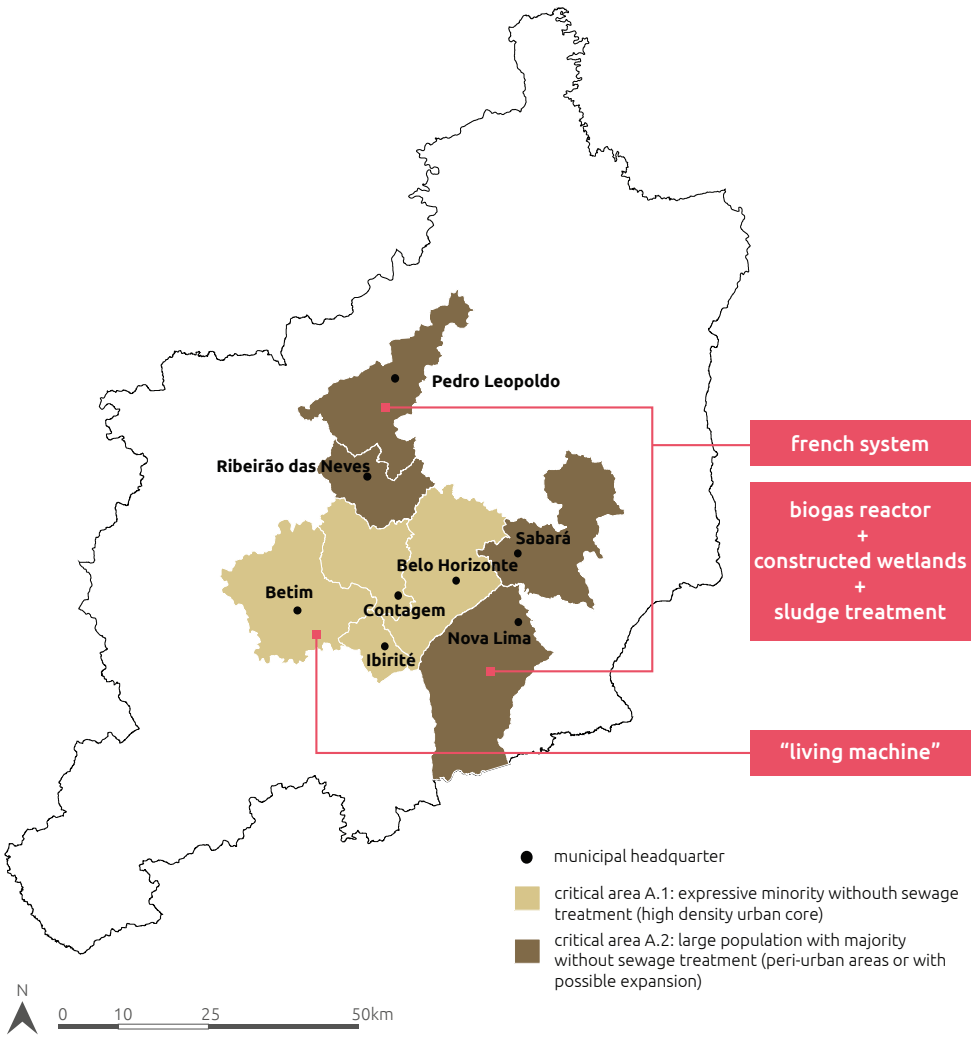




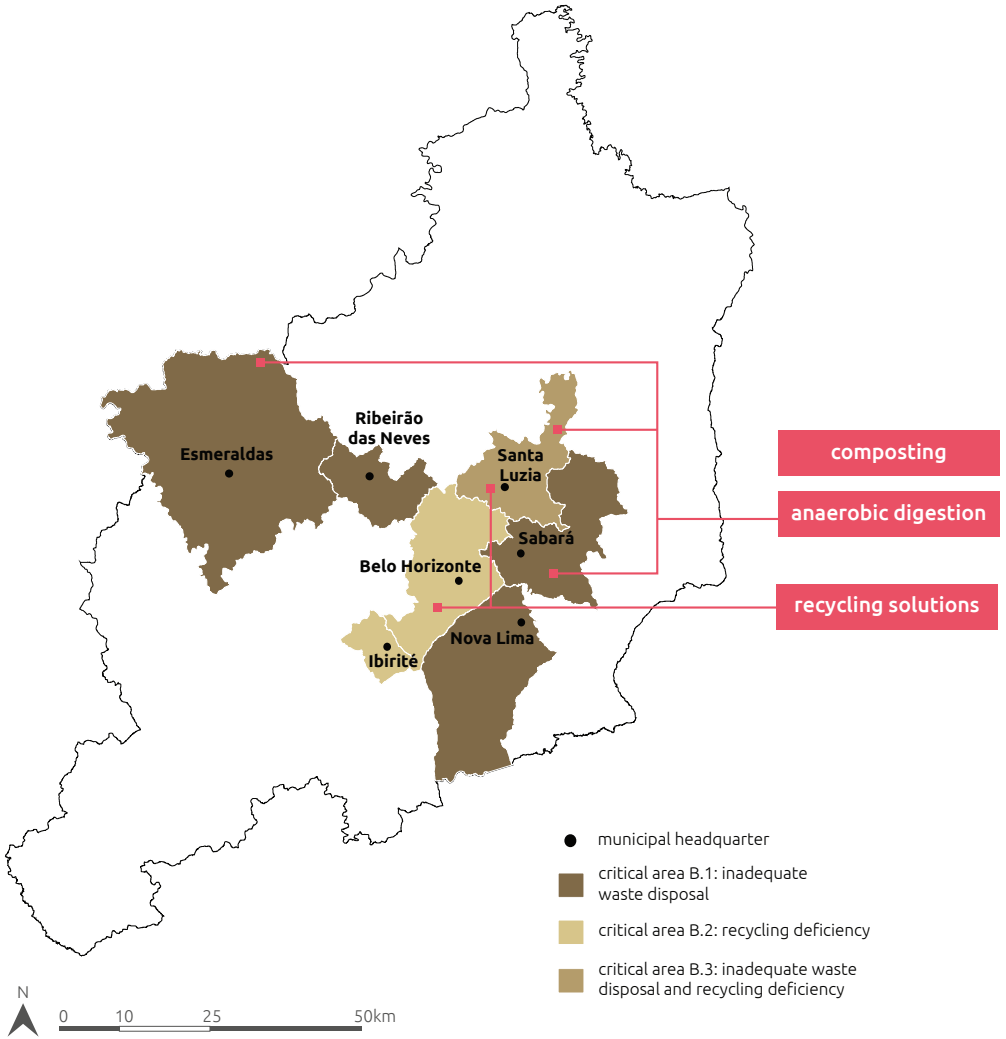
solid waste


existing
goal
higher sustainability
lower sustainability
reduce / reuse
recycle
composting
anaerobic digestion
thermal treatment
landfill (with biogas re-use)
landfill (without biogas re-use)
dumping ground
RMBH
reduce / reuse
recycle
composting
anaerobic digestion
thermal treatment
landfill (with biogas re-use)
landfill (without biogas re-use)
dumping ground
RMBH

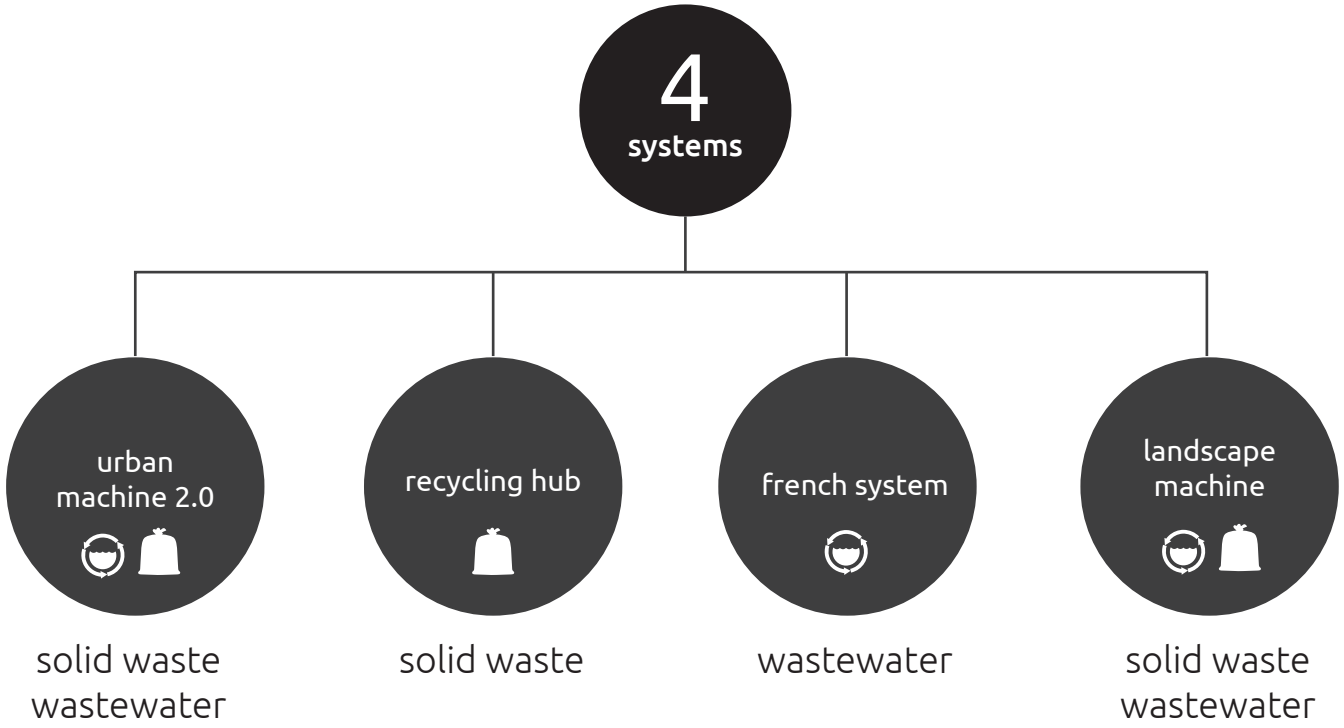
wastewater



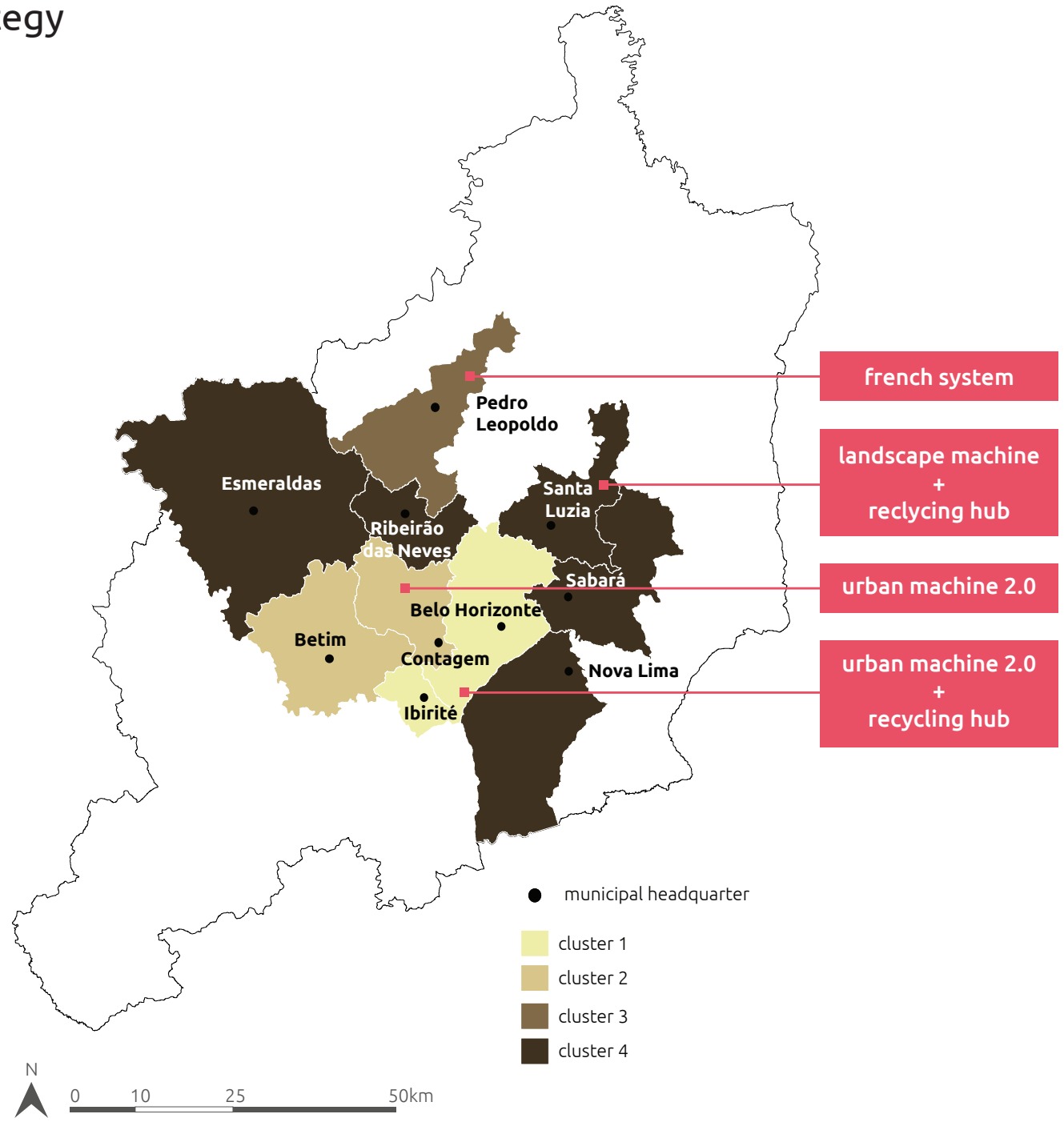
solid waste



wastewater + solid waste = combined strategy


4
systems
urban
machine 2.0
recycling hub
french system
landscape
machine
solid waste
wastewater
solid waste
wastewater
solid waste
wastewater

combined strategy



french system

landscape machine + reclycing hub

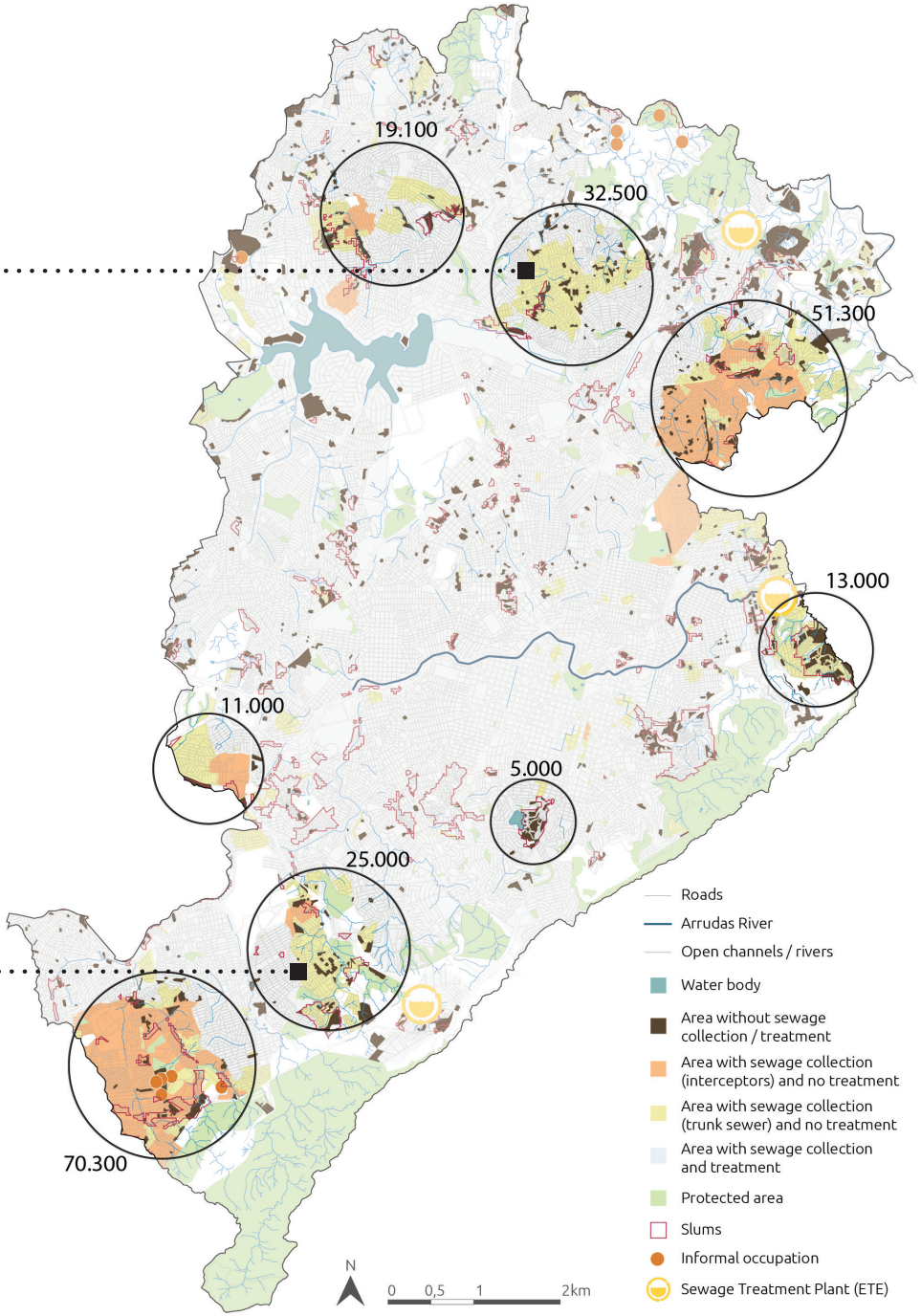
urban machine 2.0

urban machine 2.0 + recycling hub

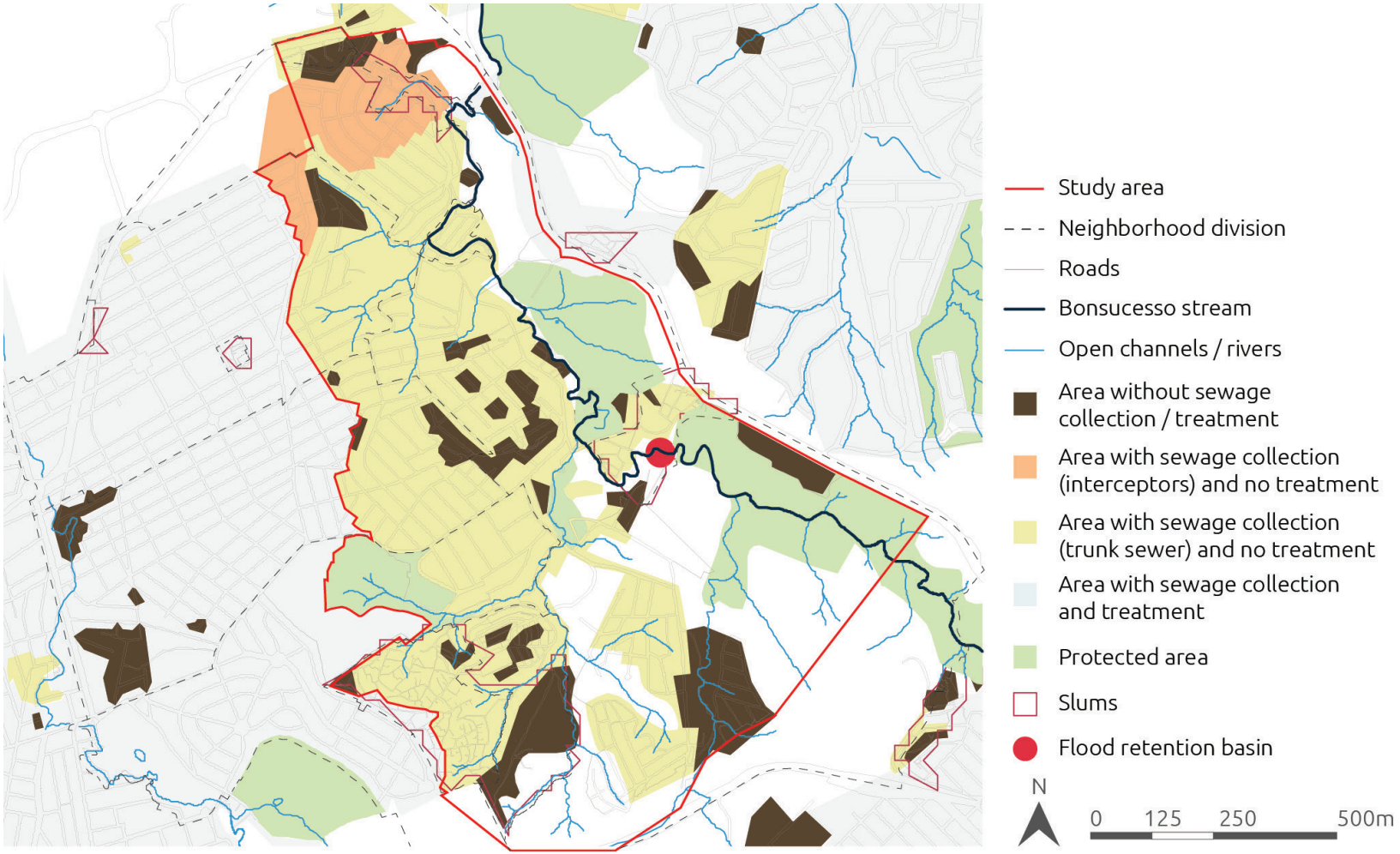
belo horizonte

Urban Machine 2.0

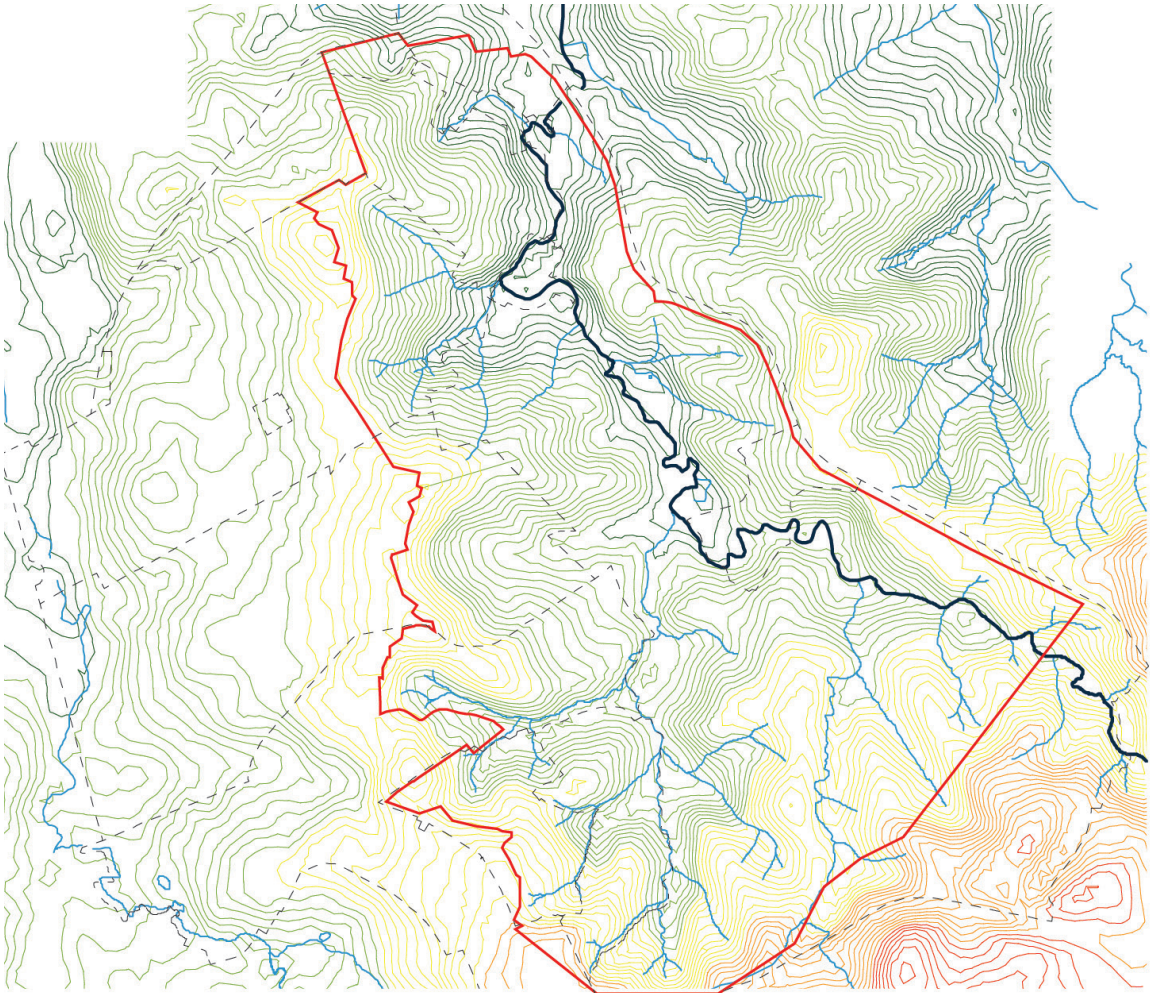
Belo Horizonte



3-step analysis: current situation



3-step analysis: topography

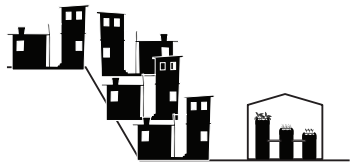


Study area
Neighborhood division
Bonsucesso stream
Open channels / rivers
>1139m
1081-1139m
1023-1081m
965-1023m
907-965m

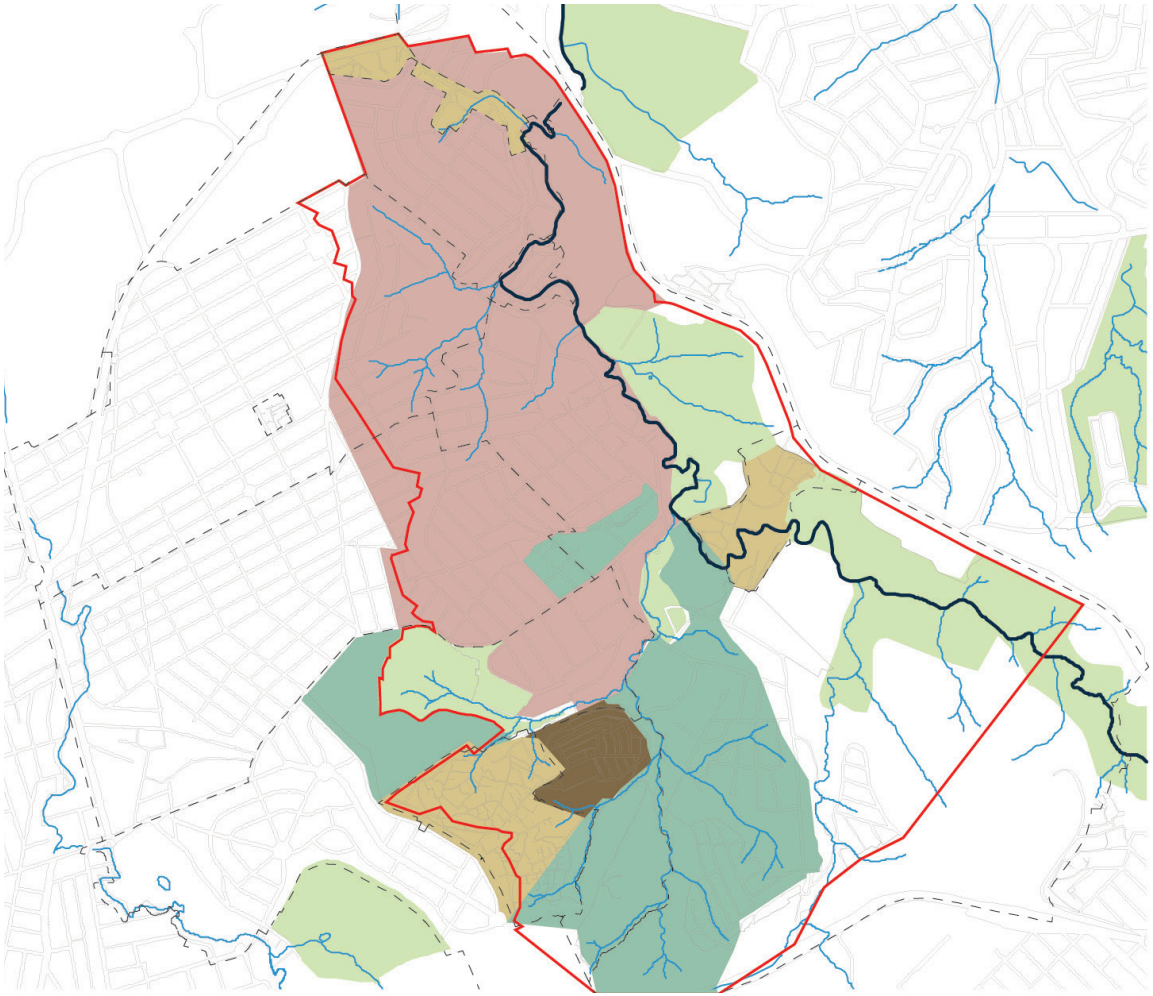
N

0 125 250 500m

T lower than urban core when possible, but necessarily in informal settlement



3-step analysis: existing zoning

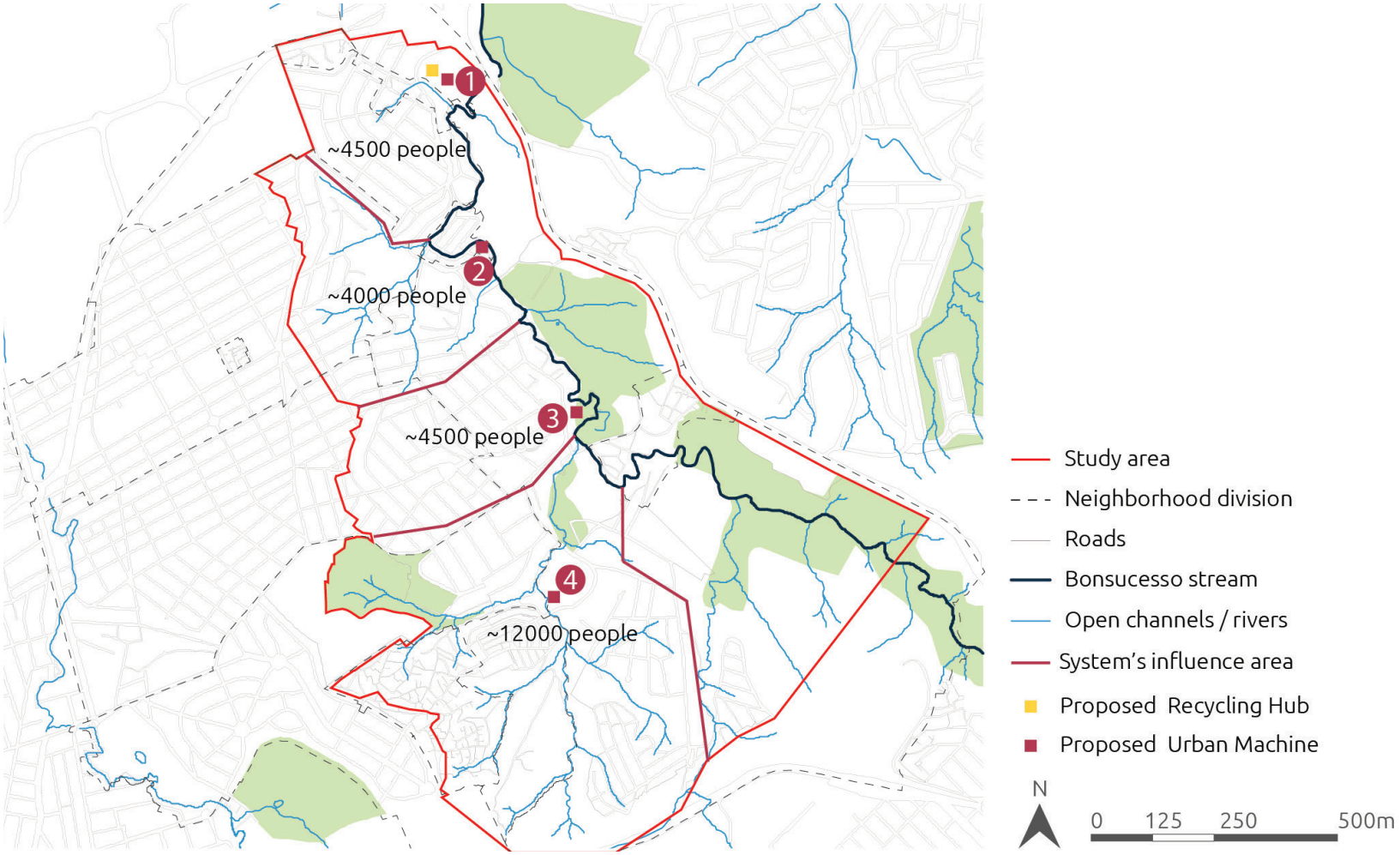


Study area
Neighborhood division
Roads
Bonsucesso stream
Open channels / rivers
Areas where public housing programs were implemented
Area occupied without planning by low income population and with public interest for housing programs for improvement
Restricted densification
Protected area with occupation permited under special conditions
Protected area

N
0 125 250 500m

Lu **greenhouse construction: preferably in derelict areas or unused buildings**

conclusion: election of areas




1
N
100 m


2
N
60 m

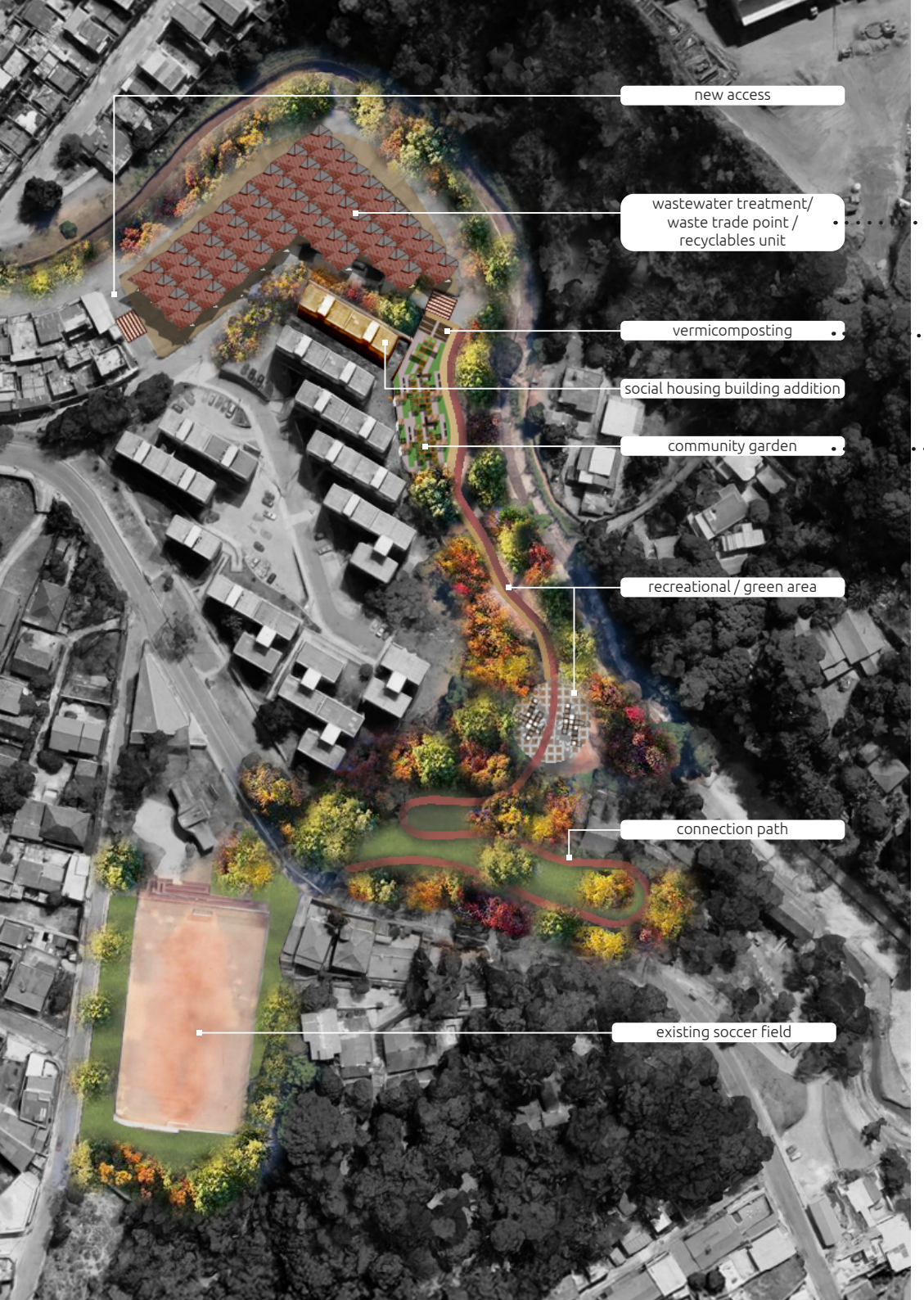

3
N
40 m


4
Earth
Copernicus
DigitalGlobe
30 m


Dr. Cristiano
Rezende St.
proposed demolition:
12 houses
#1
social housing complex
#2
derelict area:
proposed housing
proposed demolition:
18 houses
derelict area:
proposed public space
#3

Source: Google Street View, 2014

Source: Google Street View, 2014



wastewater treatment: eco-cells

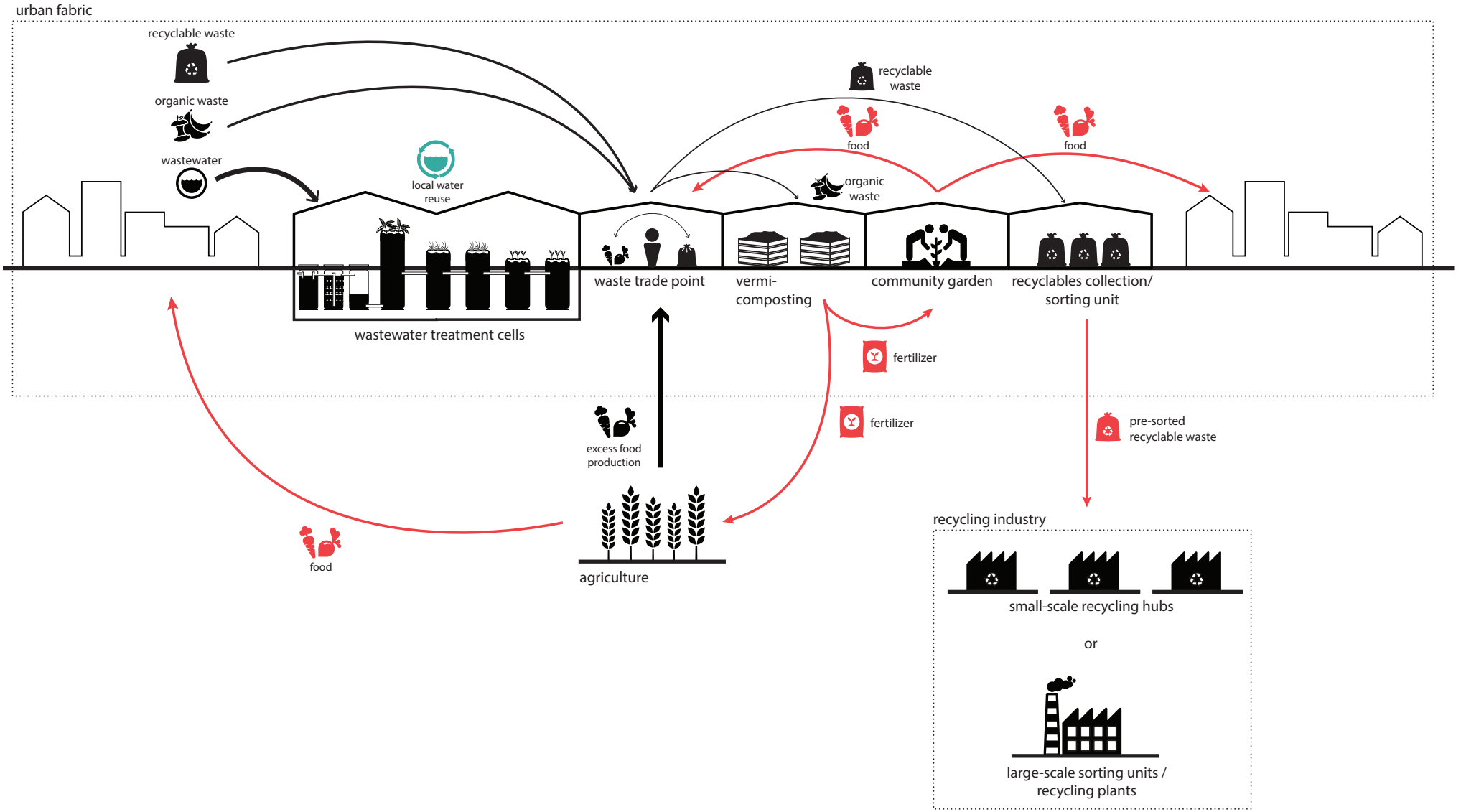
waste trade point

vermicomposting

community garden

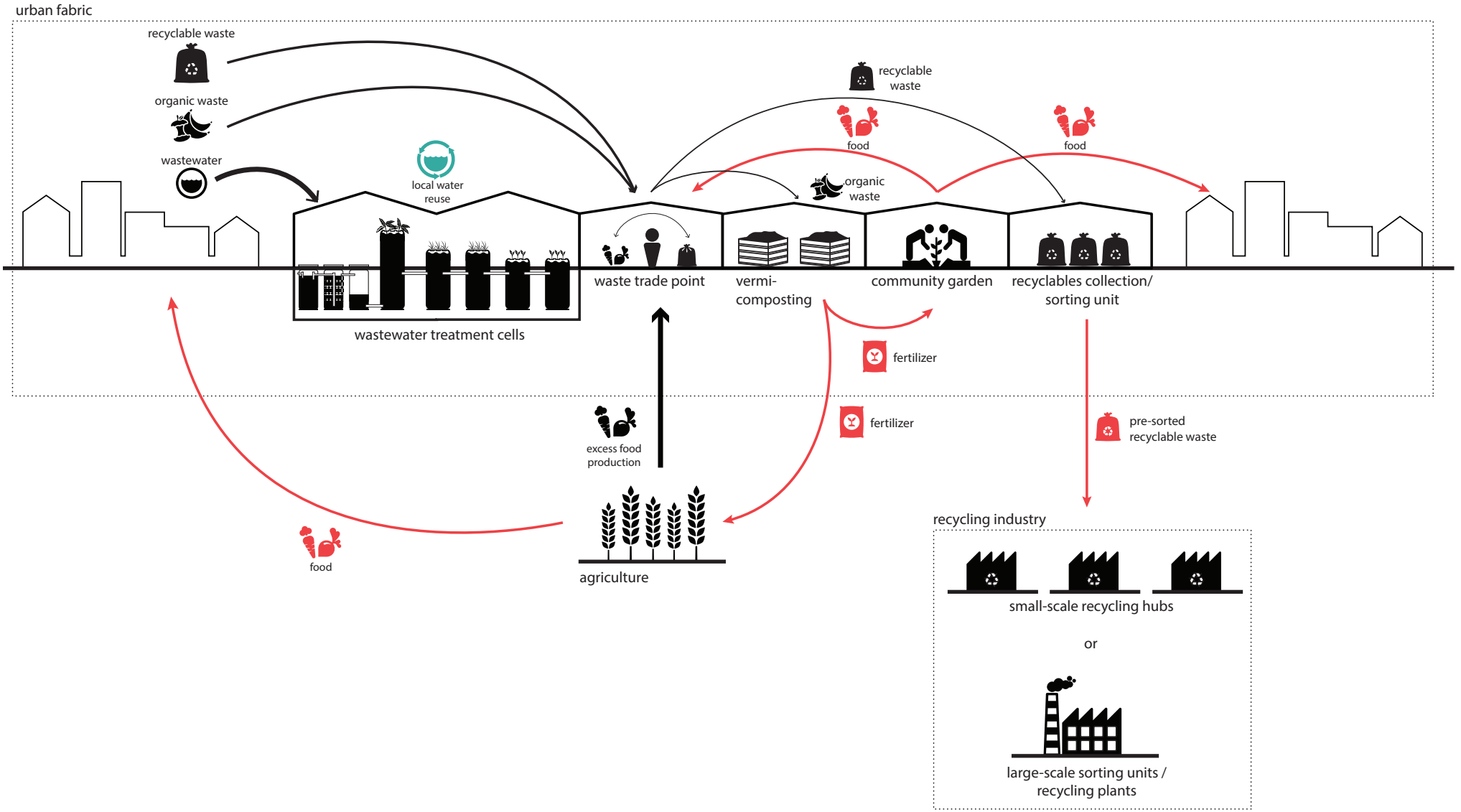
Picture: Findhorn Foundation
Source: mindnetworks.blogspot.nl
Picture: Jaelson Lucas

urban machine 2.0

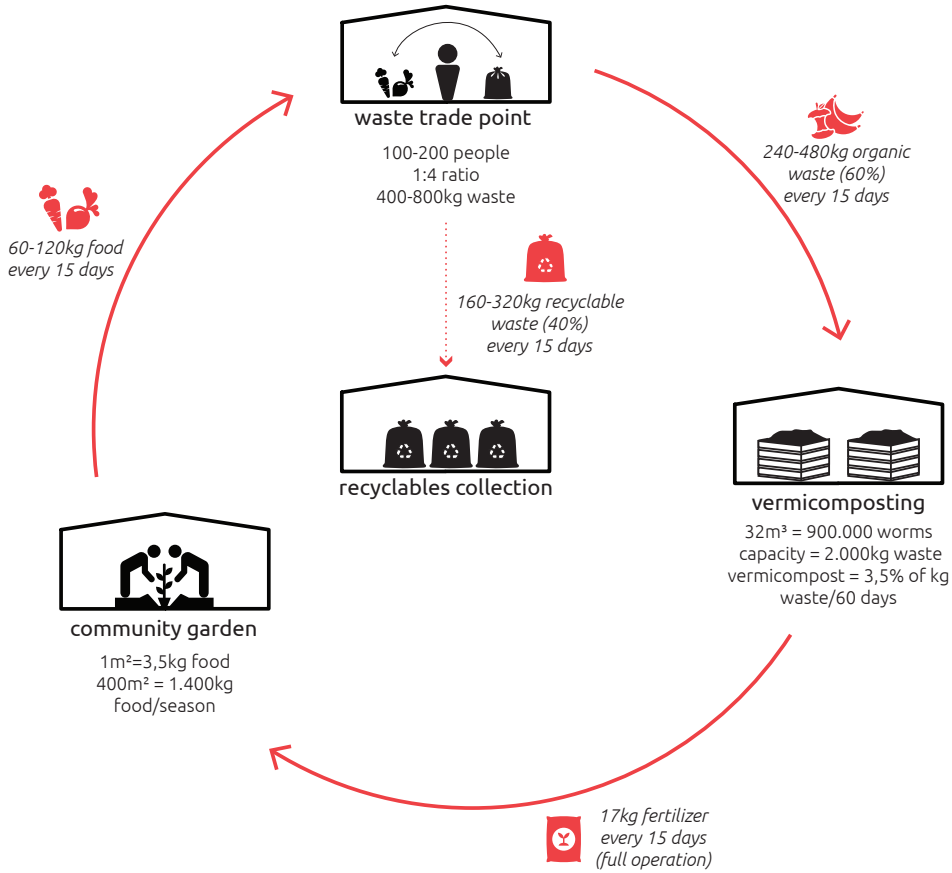


Source: John Todd Ecological Design

urban machine 2.0




new access
wastewater treatment/
waste trade point /
recyclables unit
vermicomposting
social housing building addition
community garden
recreational / green area
connection path
existing soccer field

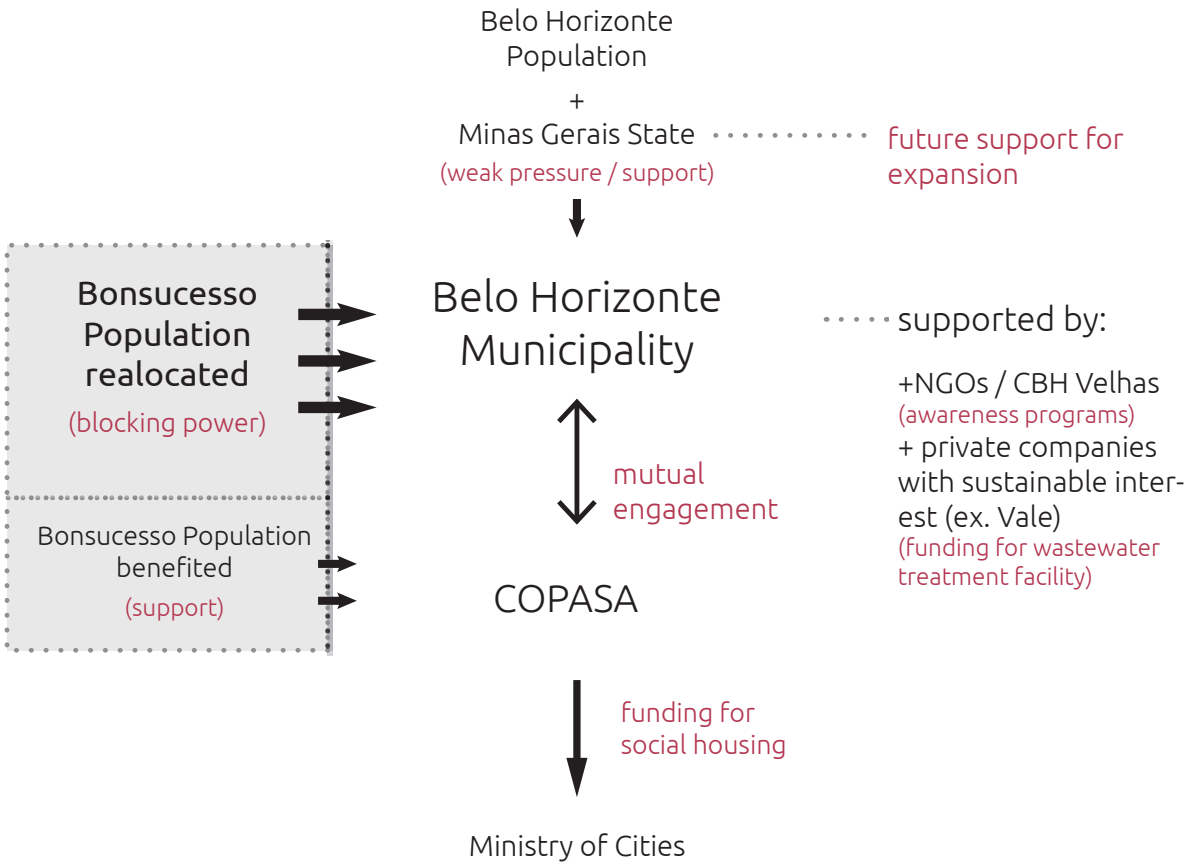

waste trade point
100-200 people
1:4 ratio
400-800kg waste
240-480kg organic
waste (60%)
every 15 days
160-320kg recyclable
waste (40%)
every 15 days
recyclables collection
vermicomposting
32m³ = 900.000 worms
capacity = 2.000kg waste
vermicompost = 3,5% of kg
waste/60 days
community garden
1m²=3,5kg food
400m² = 1.400kg
food/season
60-120kg food
every 15 days
17kg fertilizer
every 15 days
(full operation)

community garden
social housing additional building
wastewater treatment facility

community
garden
social housing
additional building
with sustainable
features
wastewater
treatment facility

community garden
vermicom-posting
social housing additional building with sustainable features
wastewater treatment facility

stakeholders



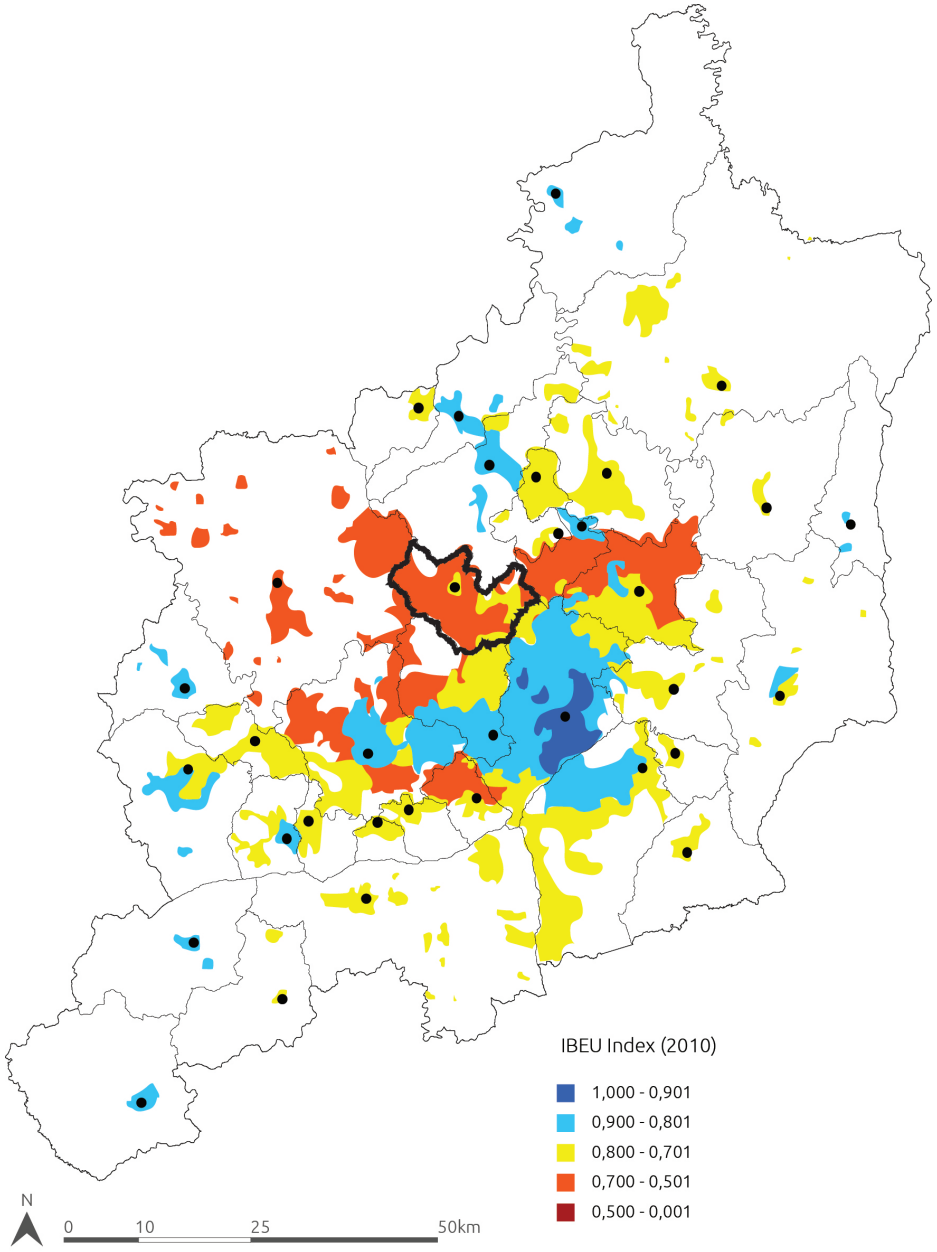
ribeirão das neves

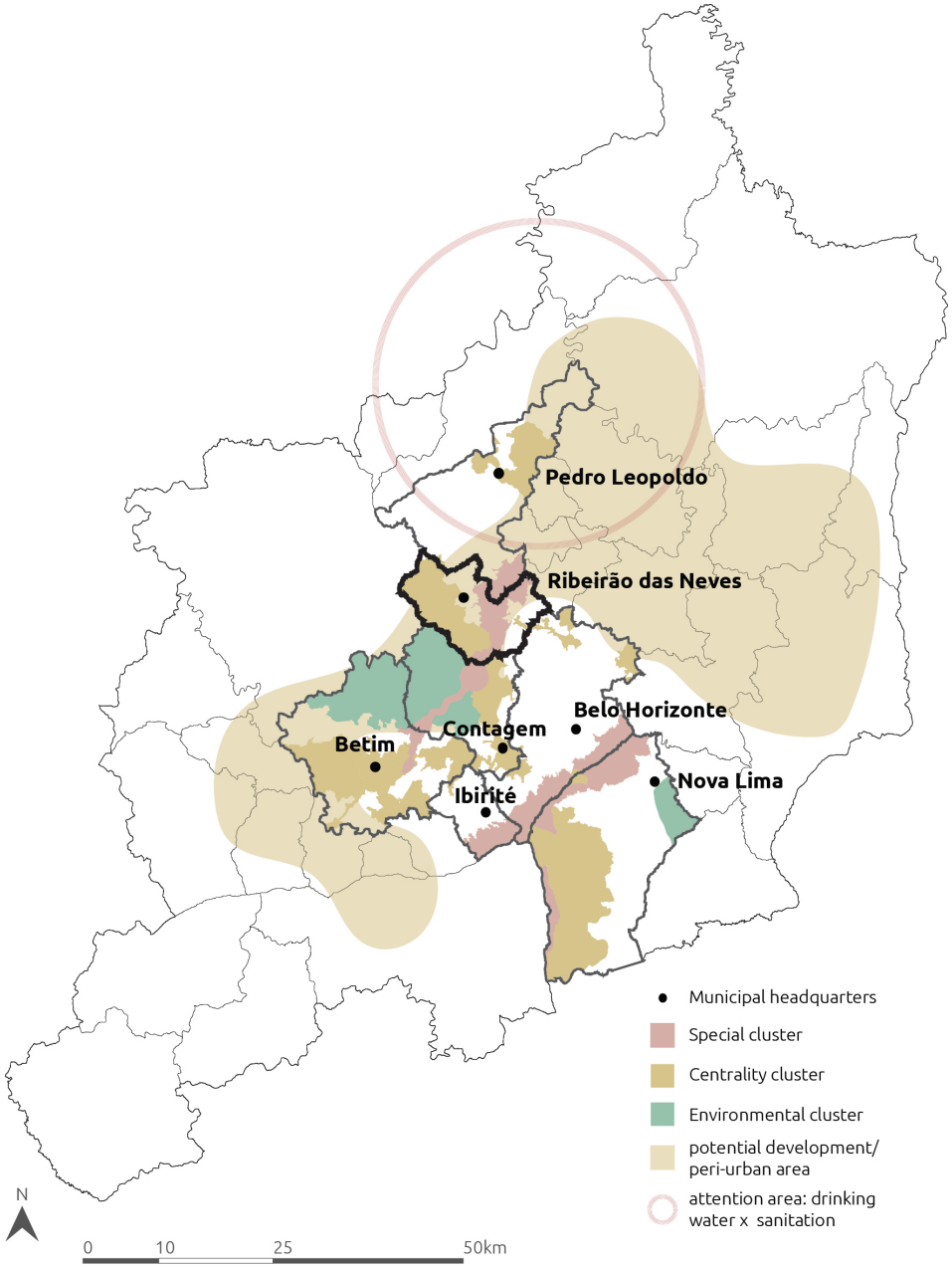
Landscape Machine

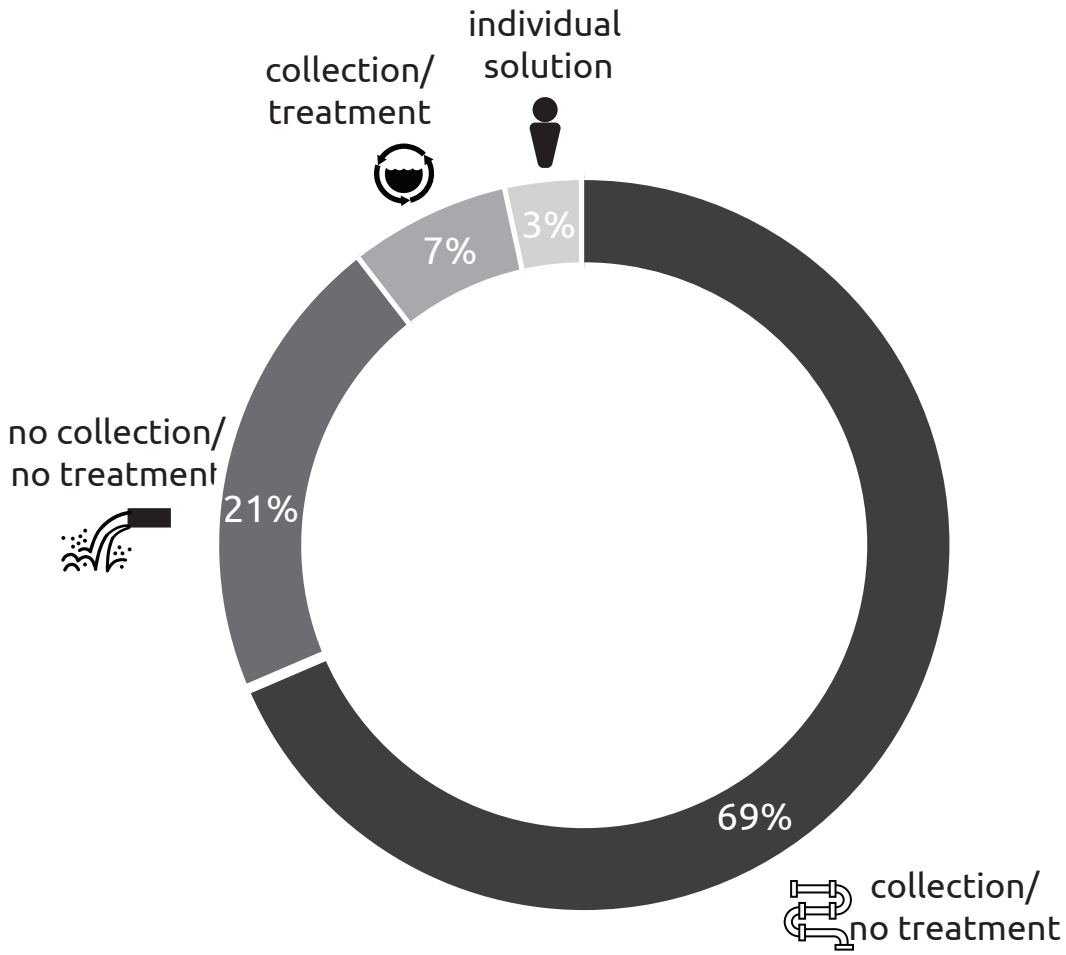
+

Recycling Hub

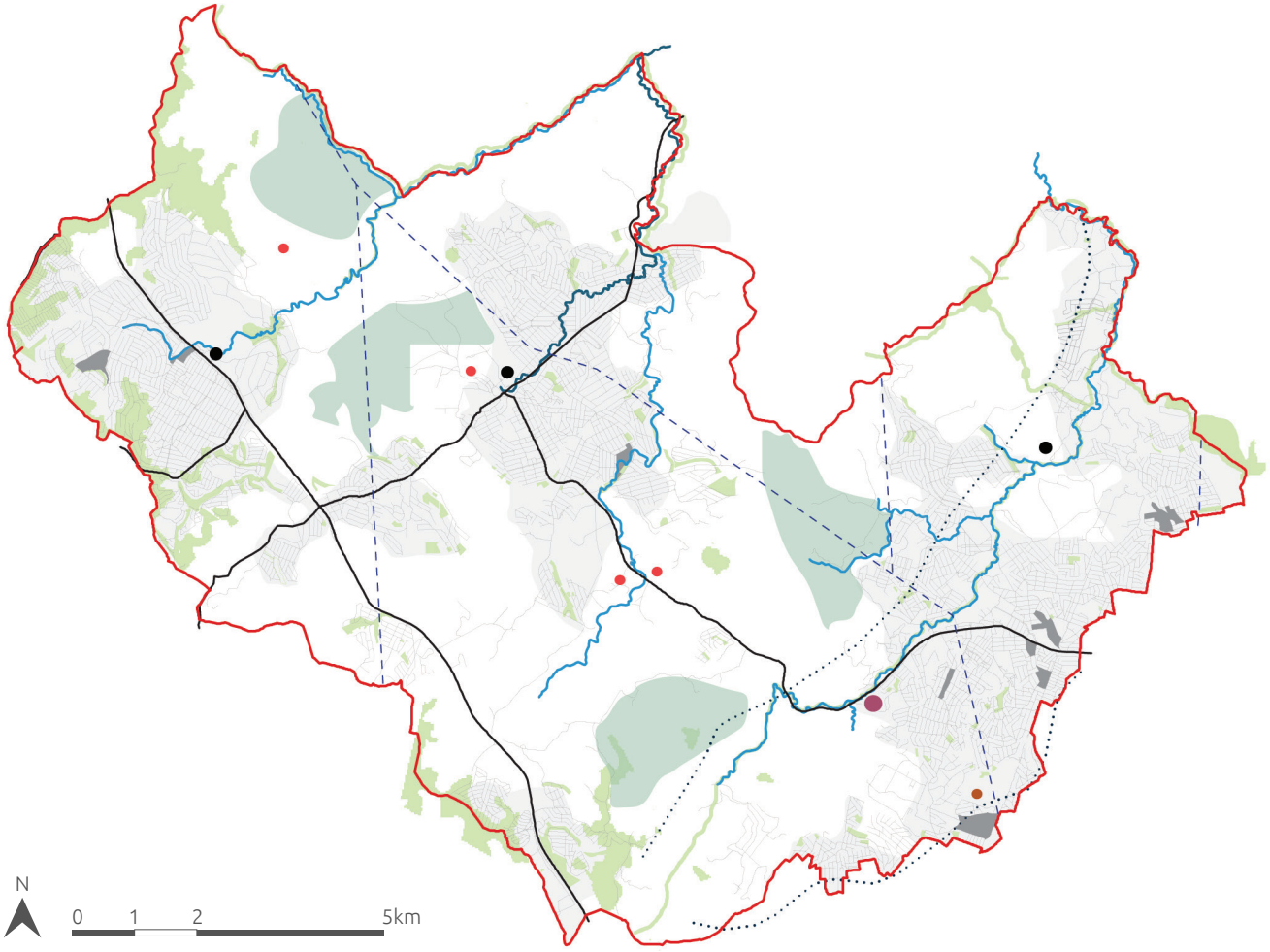
why Ribeirão das Neves





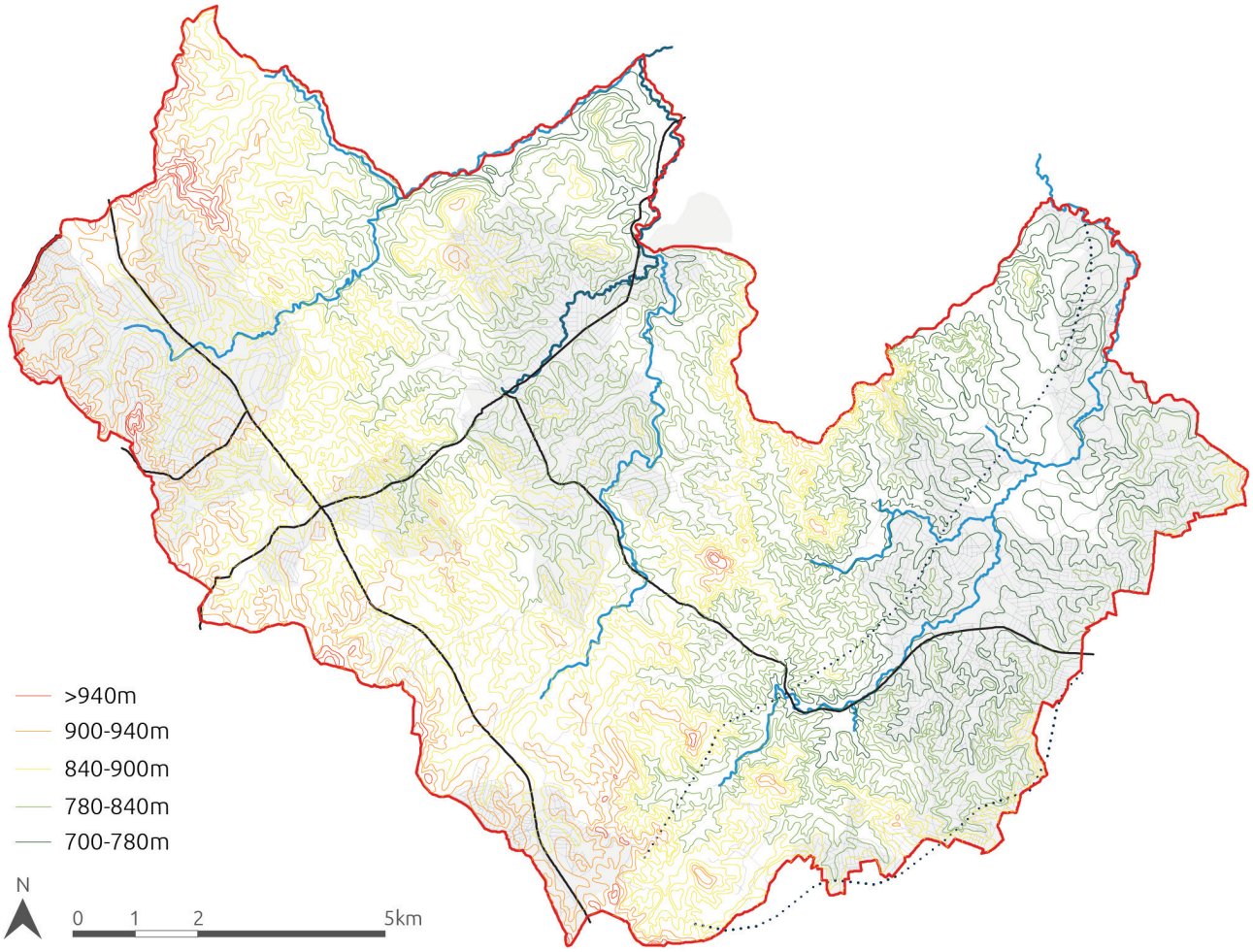

individual solution
collection/ treatment
3%
7%
no collection/ no treatment
21%
69%
collection/ no treatment

3-step analysis: current situation

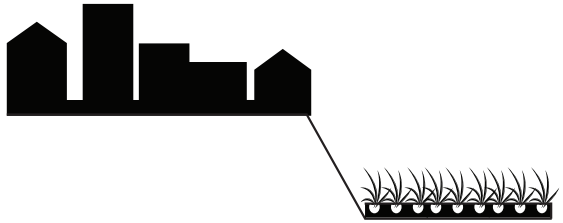


- Prisons
- Controlled landfill
- Sewage Treatment Plant (ETE)
- Degrated area due to mining activity
- Main roads
- Neves stream
- Rivers
- High flodding risk
- Water mains
- Protected area
- Preservation area with possible sustainable use
- Slums
- Urban fabric

3-step analysis: topography

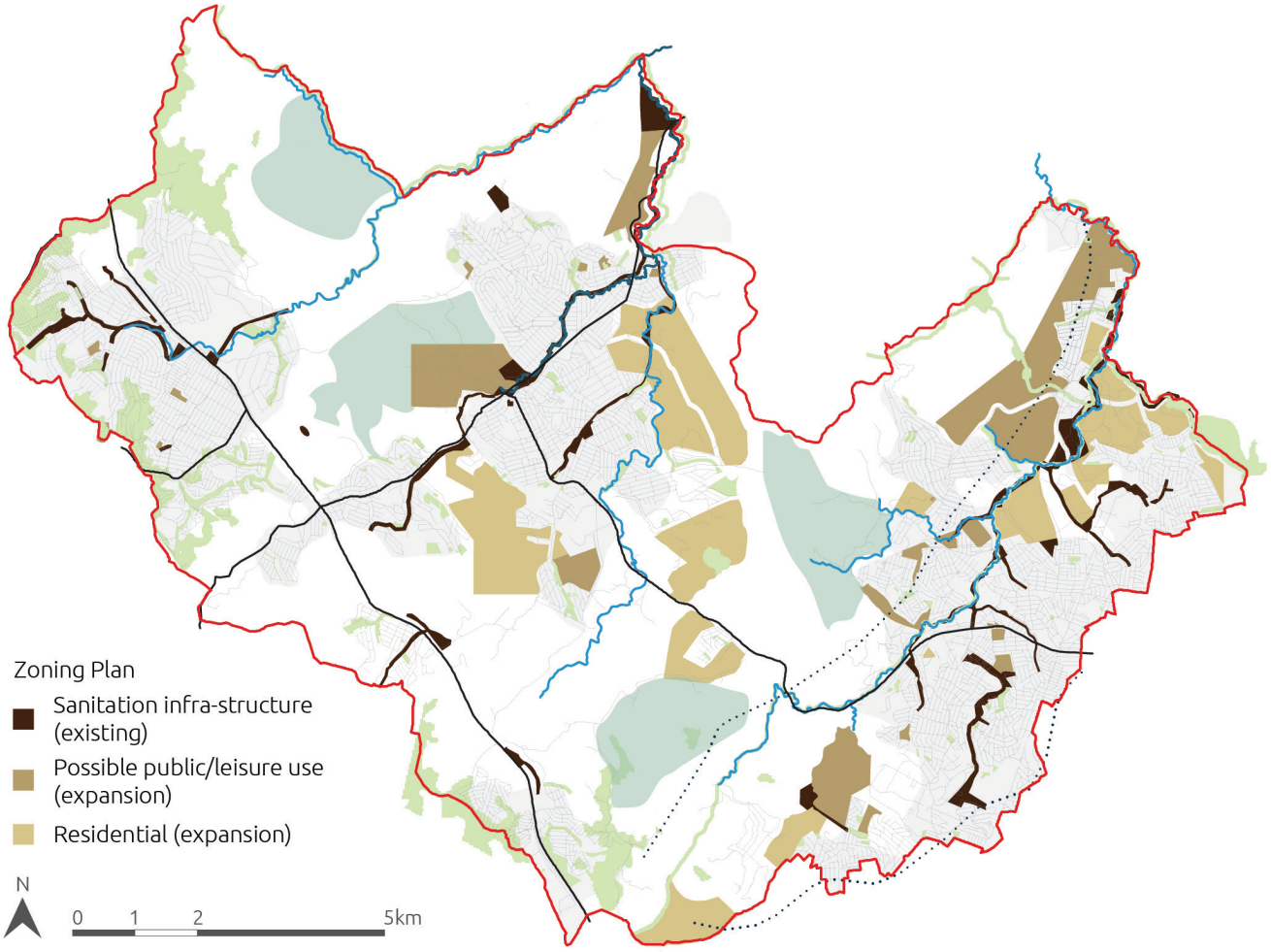


T lower than the urban core

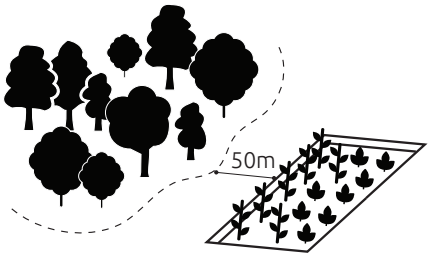


T preferably implement on slopes with 10-20% inclination

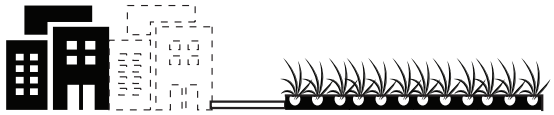
3-step analysis: existing zoning



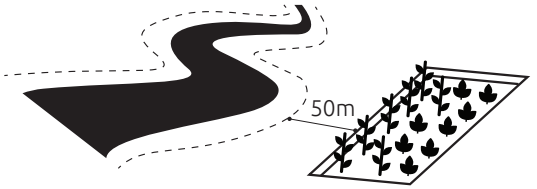
Lu **not in protected areas**



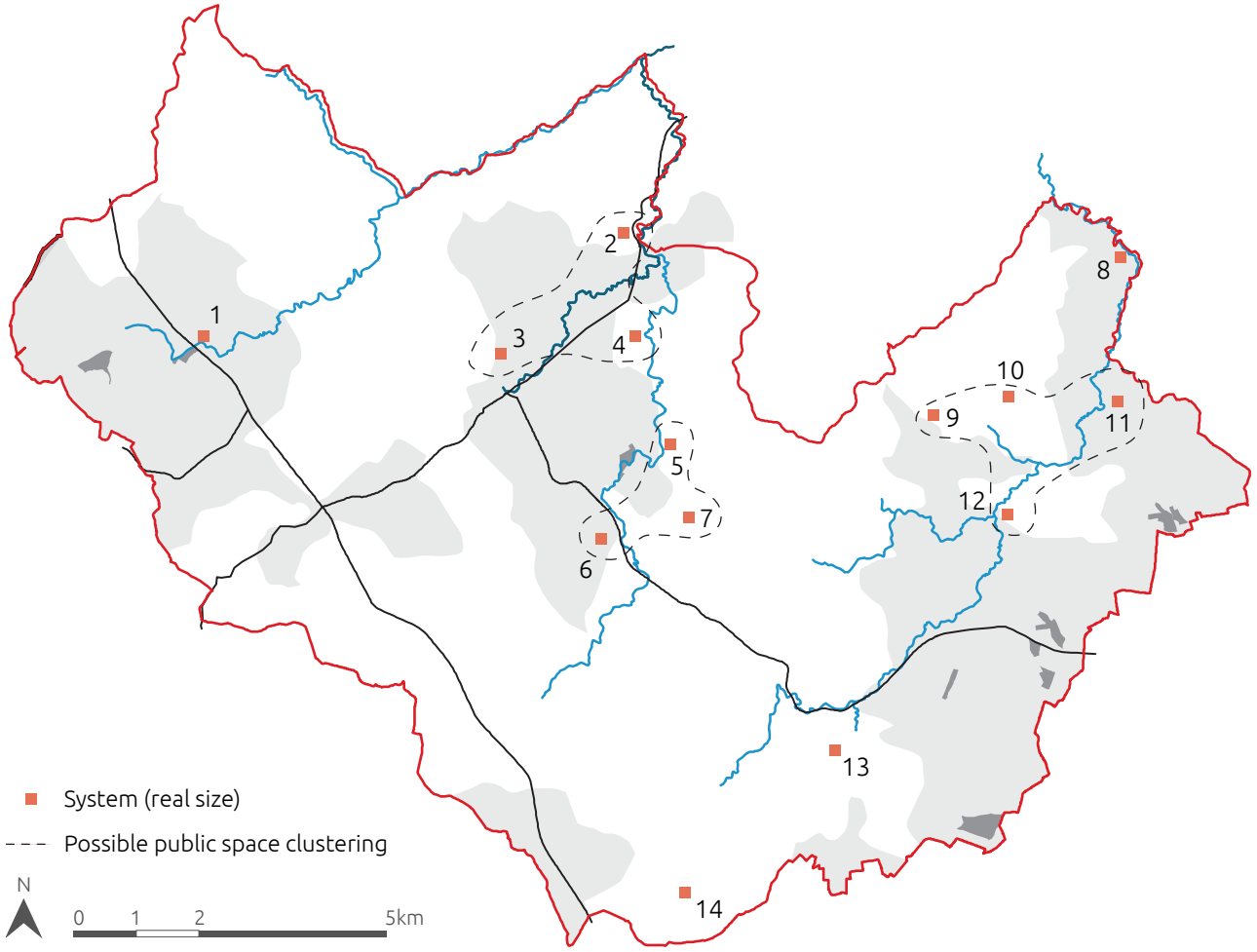
Lu **close to expansion areas**



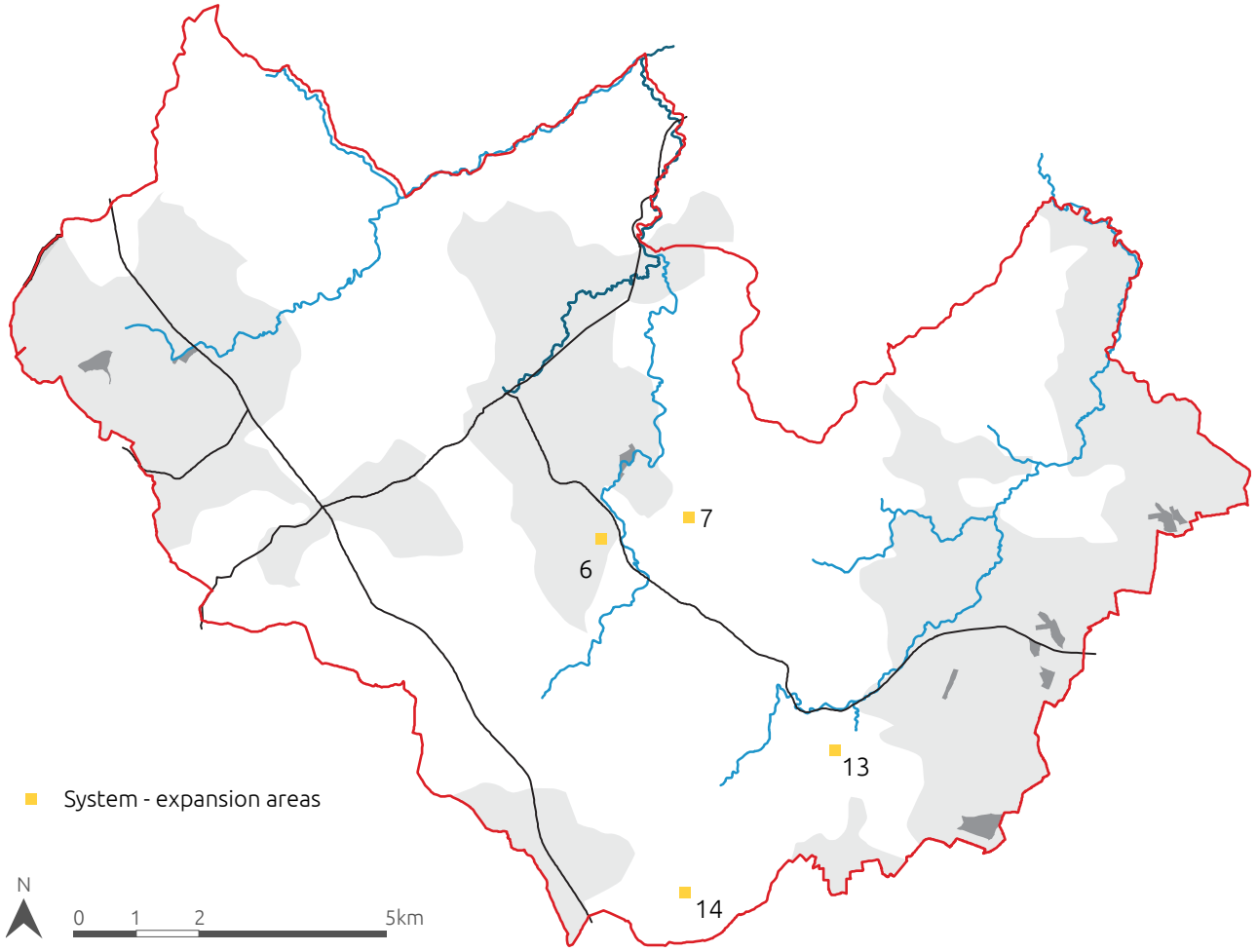
Lu **not in flooding areas**



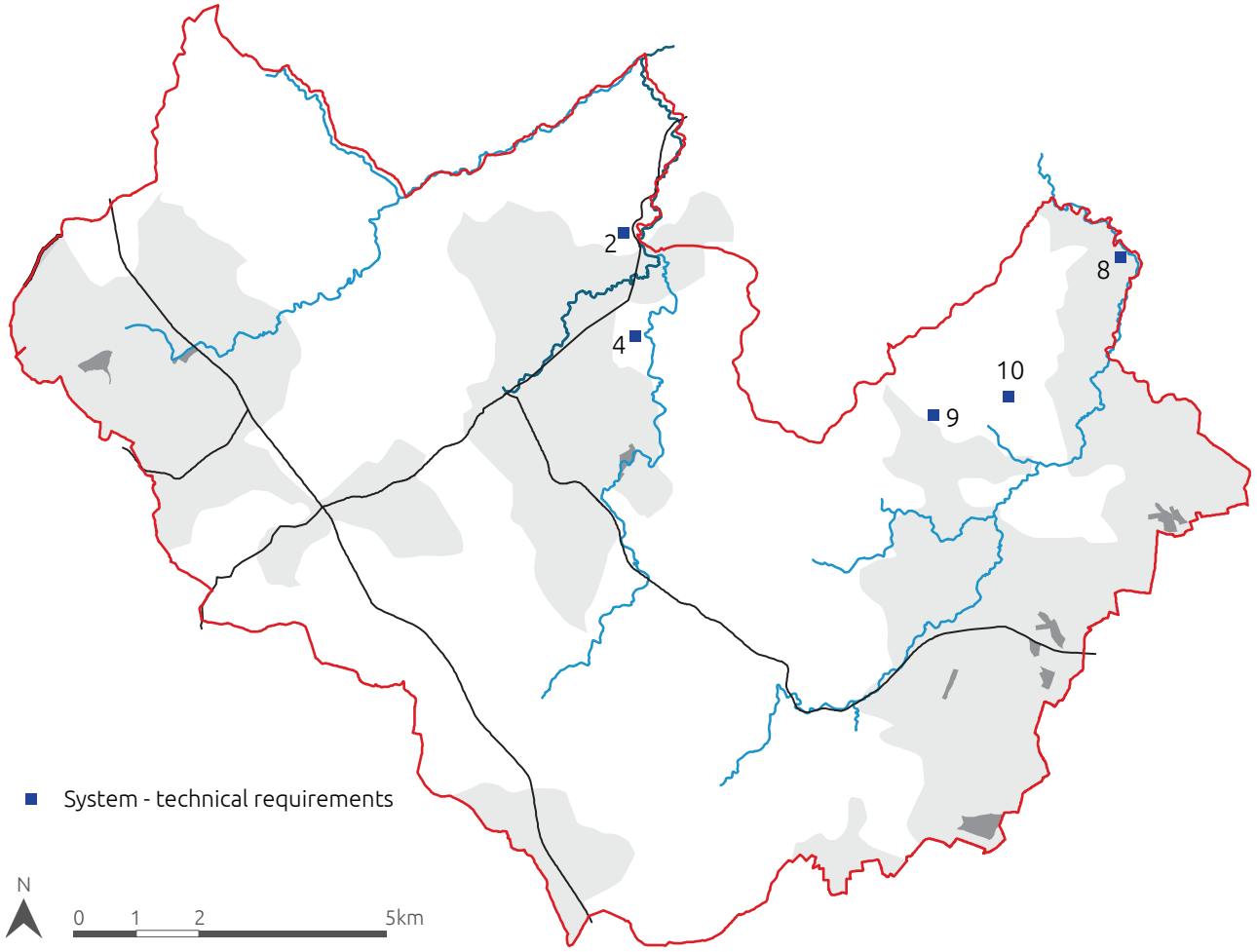
conclusion: election of areas



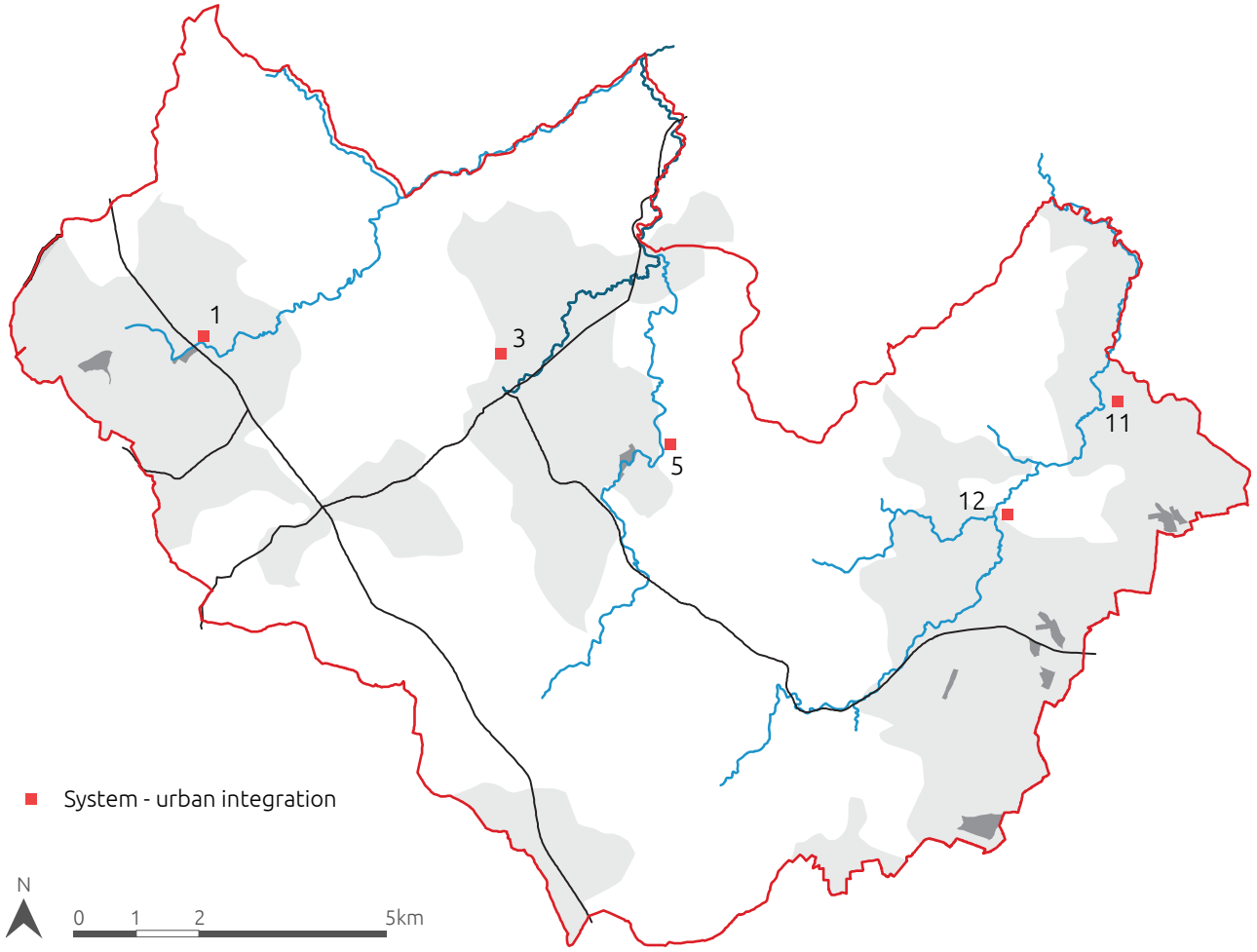
conclusion: election of areas



conclusion: election of areas



conclusion: election of areas



1. Penitentiary José Maria Alkmin
2. Federal Institute of Minas Gerais - IFMG Ribeirão das Neves
3. Forum of the District of Ribeirão das Neves Judge Assis Santiago
4. Stabilization pond (wastewater treatment - COPASA)
5. City Council of Ribeirão das Neves

city center

main accesses

Neves stream

proposed access (vehicles)

proposed access (pedestrians)

secondary access

main accesses

demolition required

city center

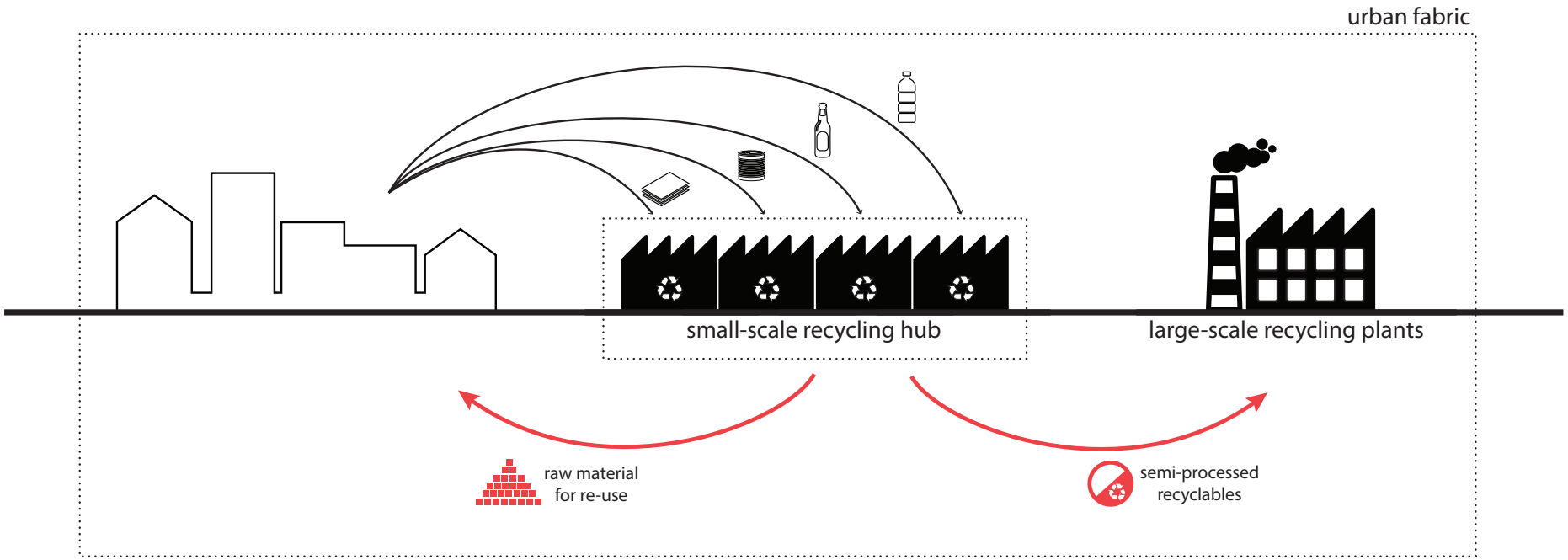
Neves stream

Source: Google Street View, 2017

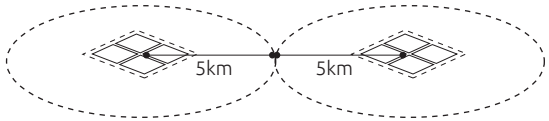

N
0
50
100m

Source: Sinobaler
Source: Untha
Source: KRS Recycling Systems GmbH
Picture: Russ Willcutt

recycling hub



Lu **implement in a maximum 5km radius**



So **processing yields**

glass = 2,4ton/day

plastic = 2,4ton/day

metal = 3,2ton/day

paper = 4ton/day

(Van Leer, 2016)

recycling hub

N

0 50 100m

Source: NiT
Source: BySam

Co-composting

Constructed wetlands

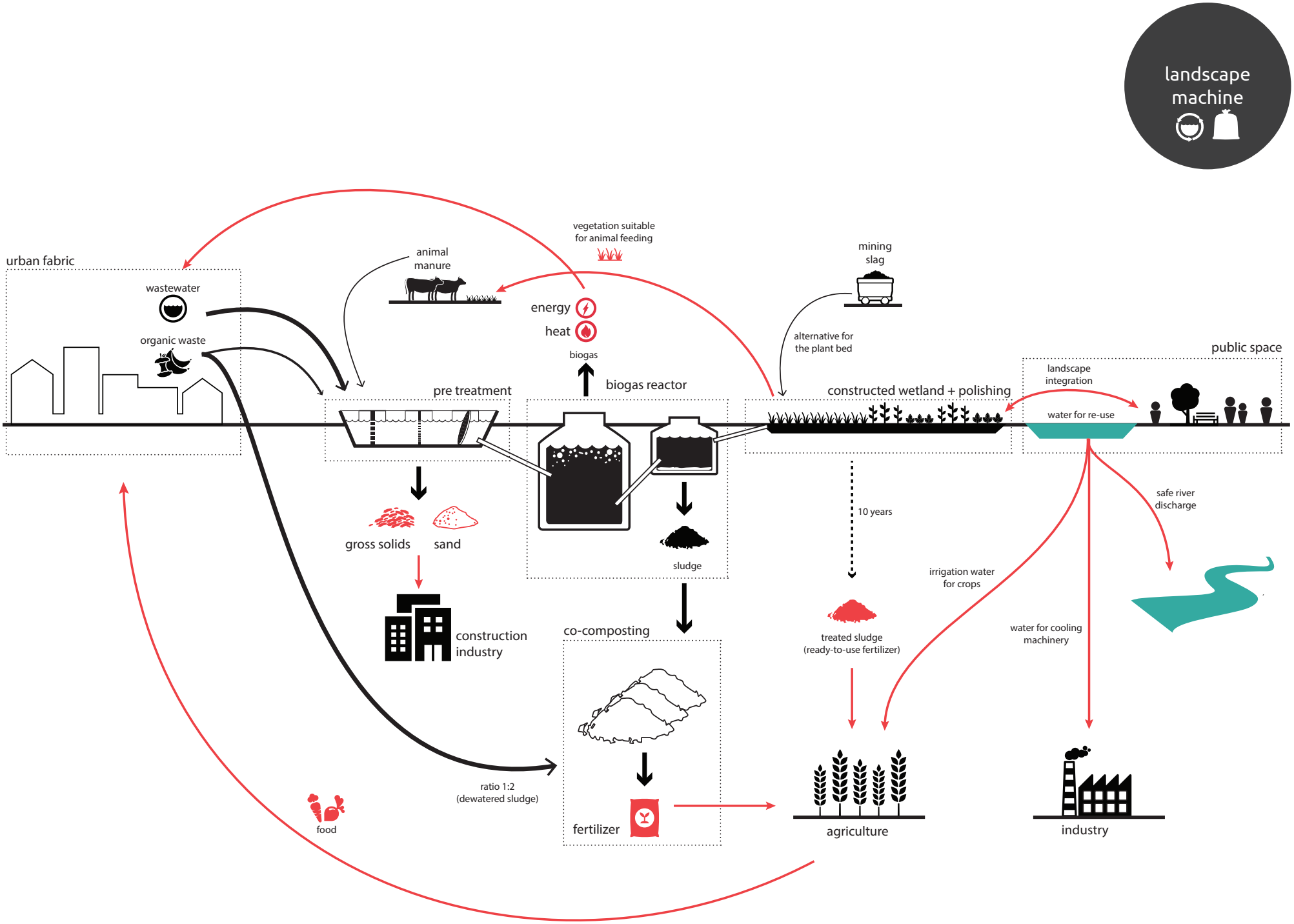
Biogas reactor

landscape machine

N

0 50 100m

Picture: Crystalclear CC BY-SA 3.0
Picture: M. Blumberg
Source: Veolia


landscape machine
urban fabric
wastewater
organic waste
animal manure
vegetation suitable for animal feeding
energy
heat
biogas
biogas reactor
pre treatment
mining slag
alternative for the plant bed
constructed wetland + polishing
public space
landscape integration
water for re-use
gross solids
sand
sludge
10 years
safe river discharge
irrigation water for crops
water for cooling machinery
construction industry
co-composting
treated sludge (ready-to-use fertilizer)
ratio 1:2 (dewatered sludge)
food
fertilizer
agriculture
industry

Typha latifolia

Chrysopogon zizanioides

landscape machine

N

0 50 100m

Source: Wetlands Construídos

Strelitzia nicolai

Capa x generalis

landscape machine

N

0 50 100m

Source: Wetlands Construídos

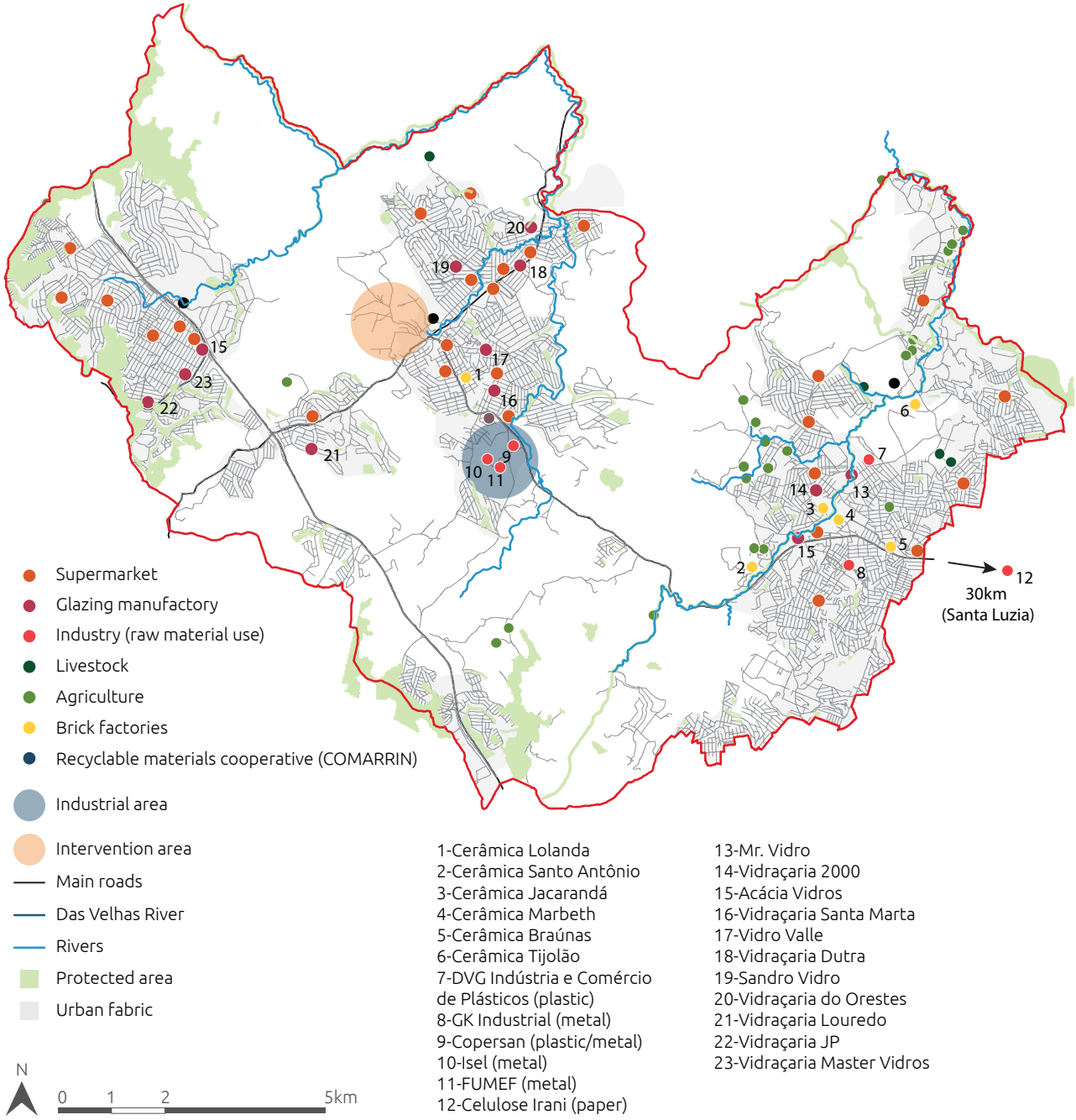
N

0 50 100m

Picture: Federico Cairoli
Source: Municipality of Madrid

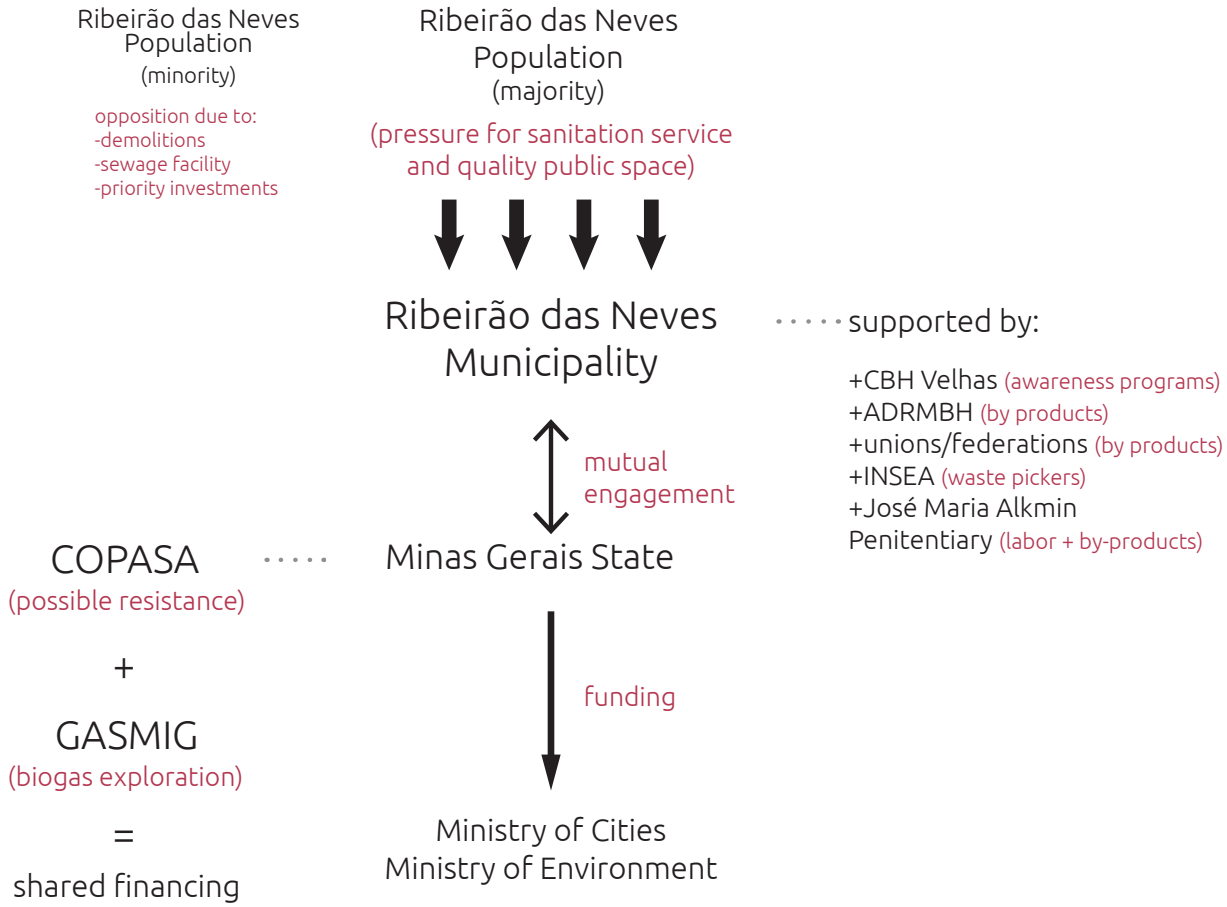
park
lake from re-use water
pre-treatment + biogas reactors
recreational area
constructed wetland

by-products

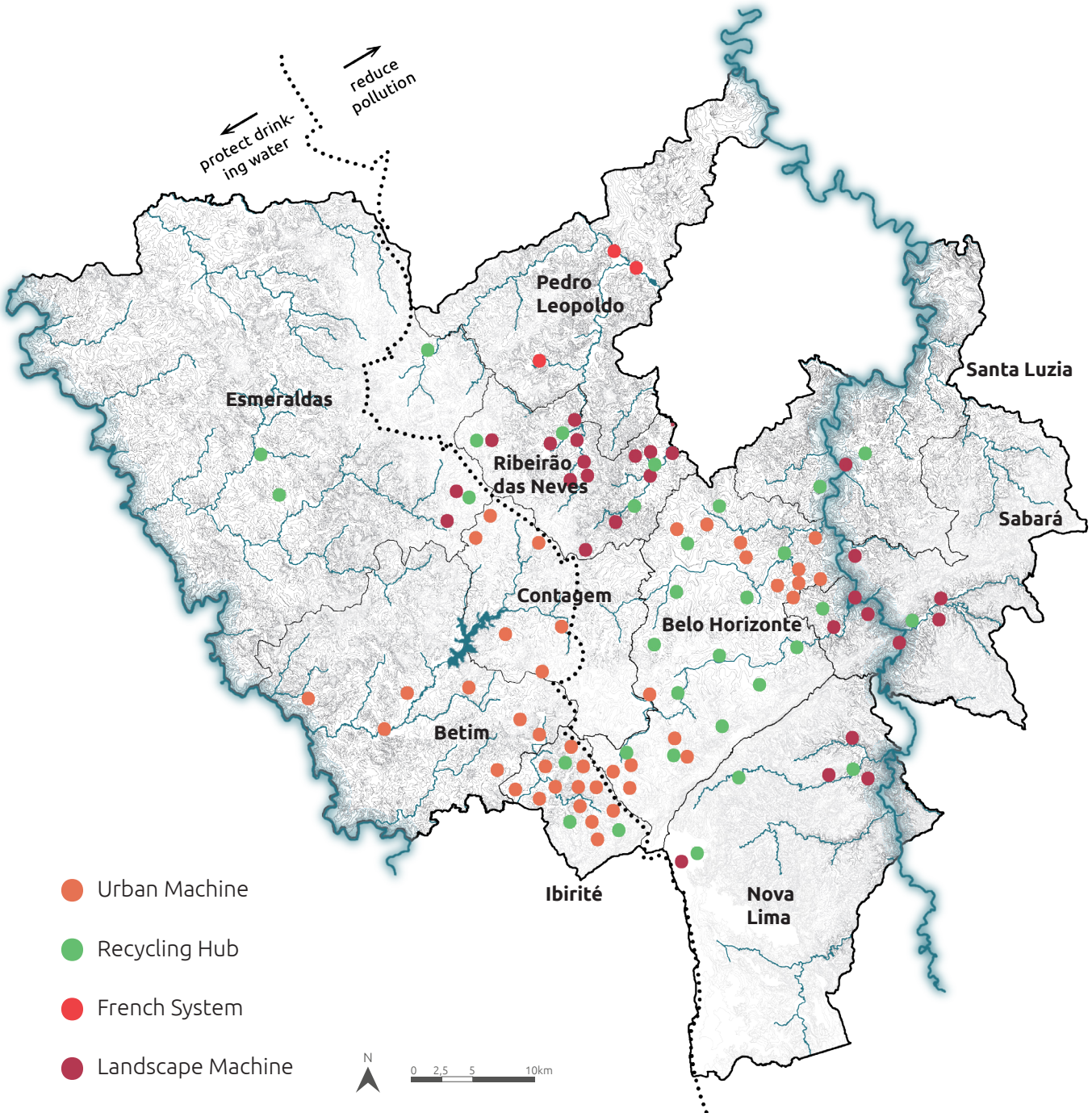

Supermarket
Glazing manufactory
Industry (raw material use)
Livestock
Agriculture
Brick factories
Recyclable materials cooperative (COMARRIN)
Industrial area
Intervention area
Main roads
Das Velhas River
Rivers
Protected area
Urban fabric
N
0 1 2 5km
30km
(Santa Luzia)
1-Cerâmica Lolanda
2-Cerâmica Santo Antônio
3-Cerâmica Jacarandá
4-Cerâmica Marbeth
5-Cerâmica Braúnas
6-Cerâmica Tijolão
7-DVG Indústria e Comércio de Plásticos (plastic)
8-GK Industrial (metal)
9-Copersan (plastic/metal)
10-Isel (metal)
11-FUMEF (metal)
12-Celulose Irani (paper)
13-Mr. Vidro
14-Vidraçaria 2000
15-Acácia Vidros
16-Vidraçaria Santa Marta
17-Vidro Valle
18-Vidraçaria Dutra
19-Sandro Vidro
20-Vidraçaria do Orestes
21-Vidraçaria Louredo
22-Vidraçaria JP
23-Vidraçaria Master Vidros

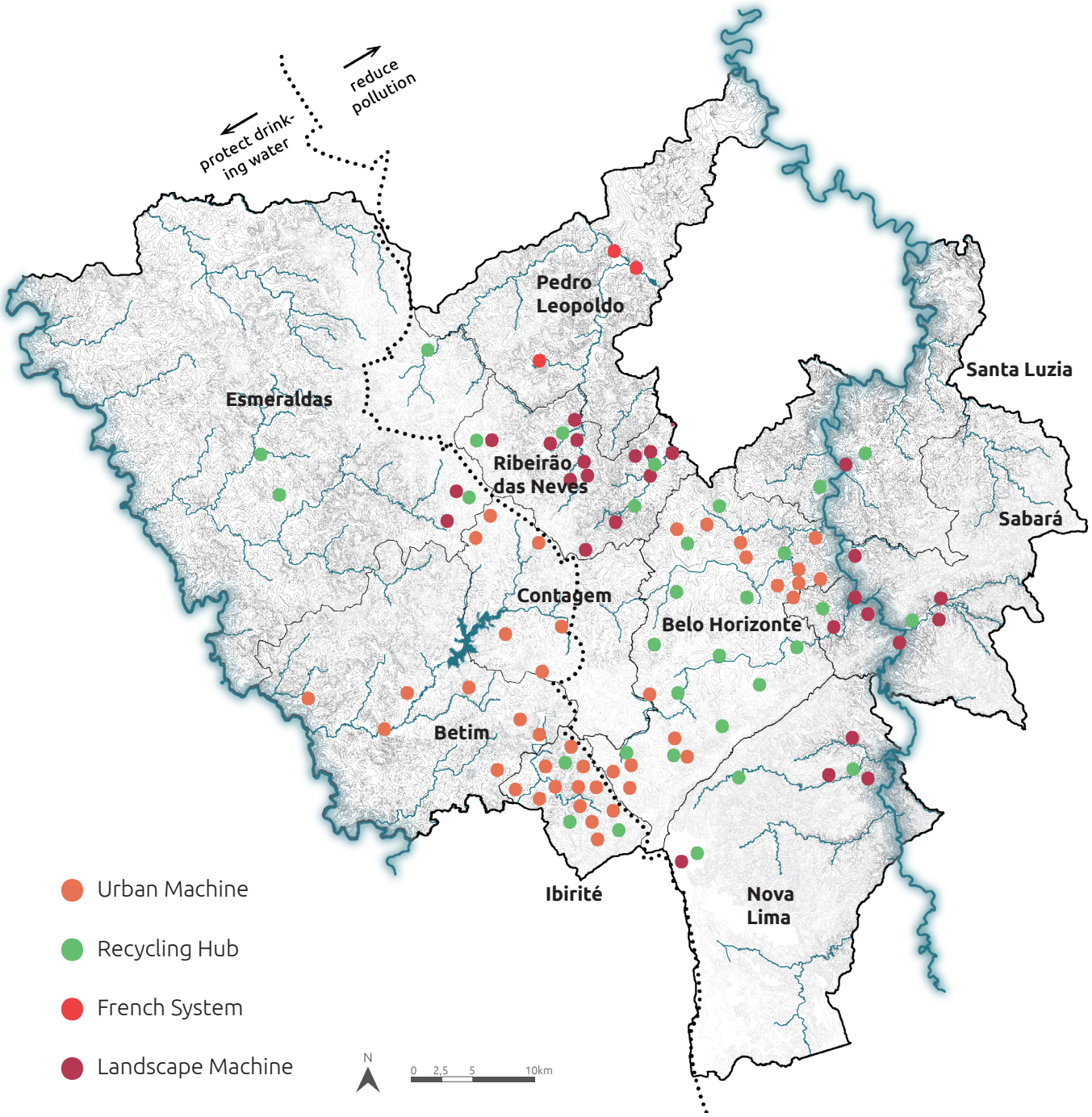
by-products: José Maria Alkmin Penitentiary

stakeholders



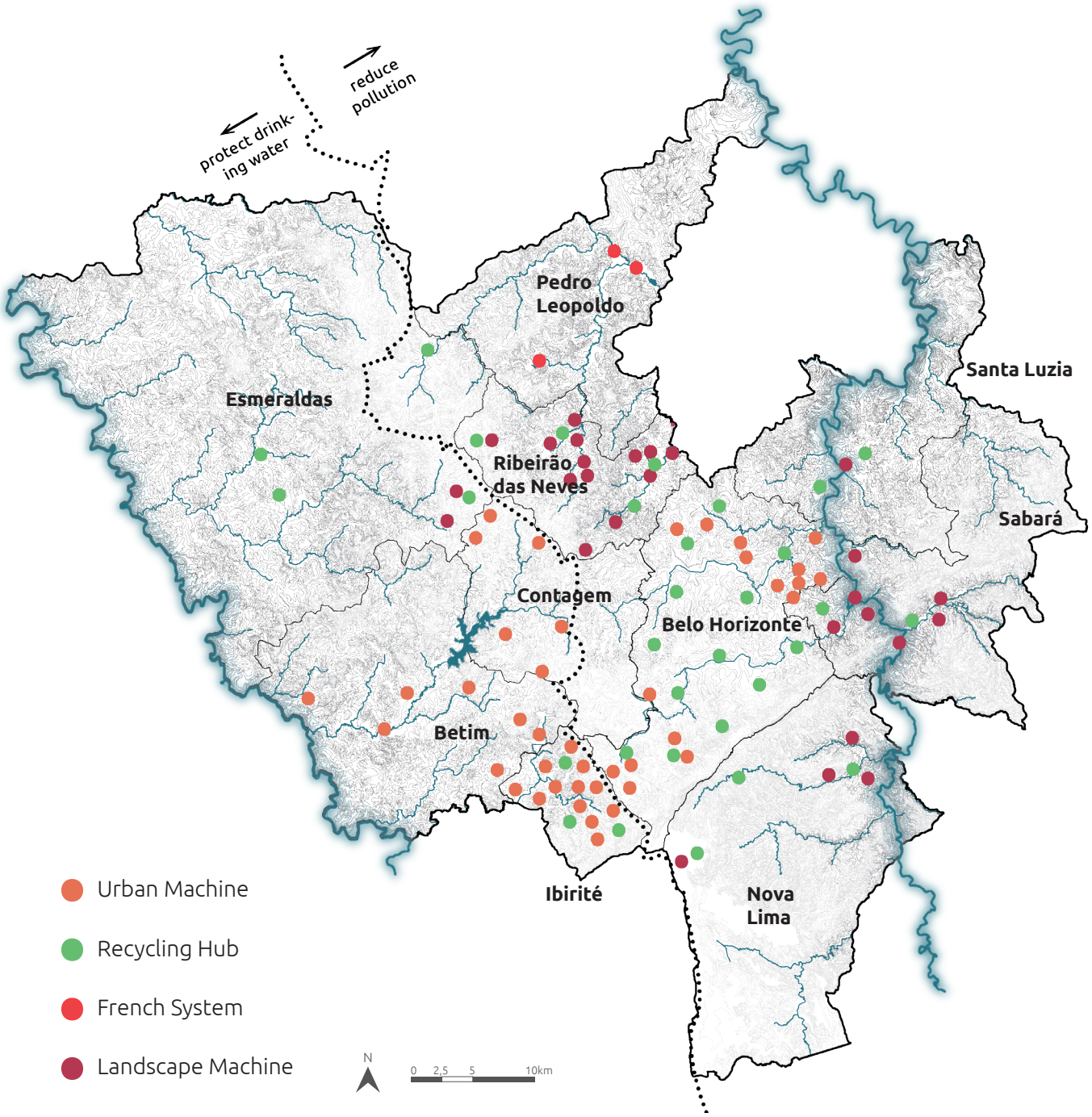
up-scale and spin-off


protect drink-
ing water
reduce
pollution
Pedro
Leopoldo
Santa Luzia
Esmeraldas
Ribeirão
das Neves
Sabará
Contagem
Belo Horizonte
Betim
Ibirité
Nova
Lima
Urban Machine
Recycling Hub
French System
Landscape Machine
N
0 2,5 5 10km



2
purposes

- drinking water protection
- pollution reduction

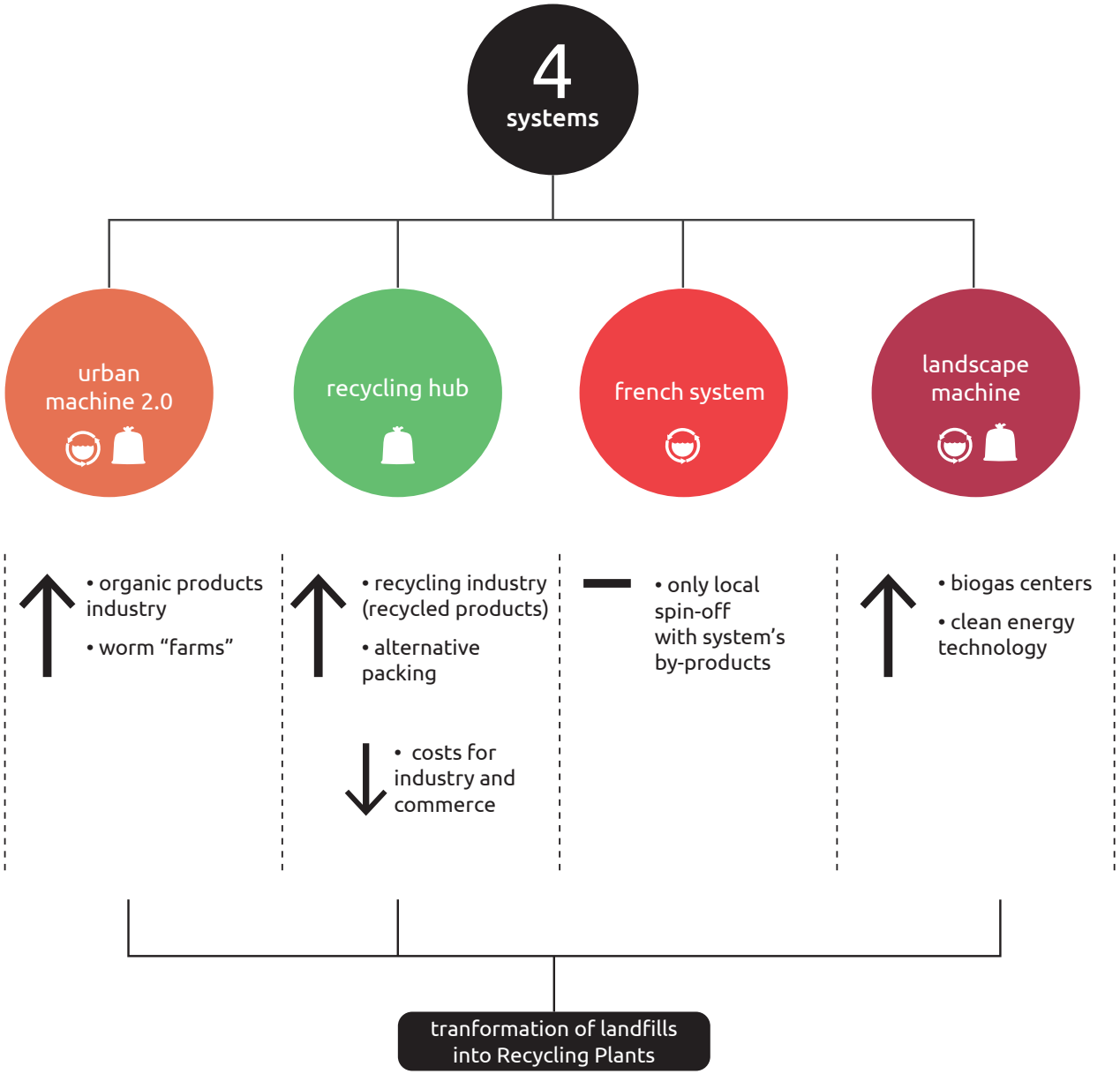


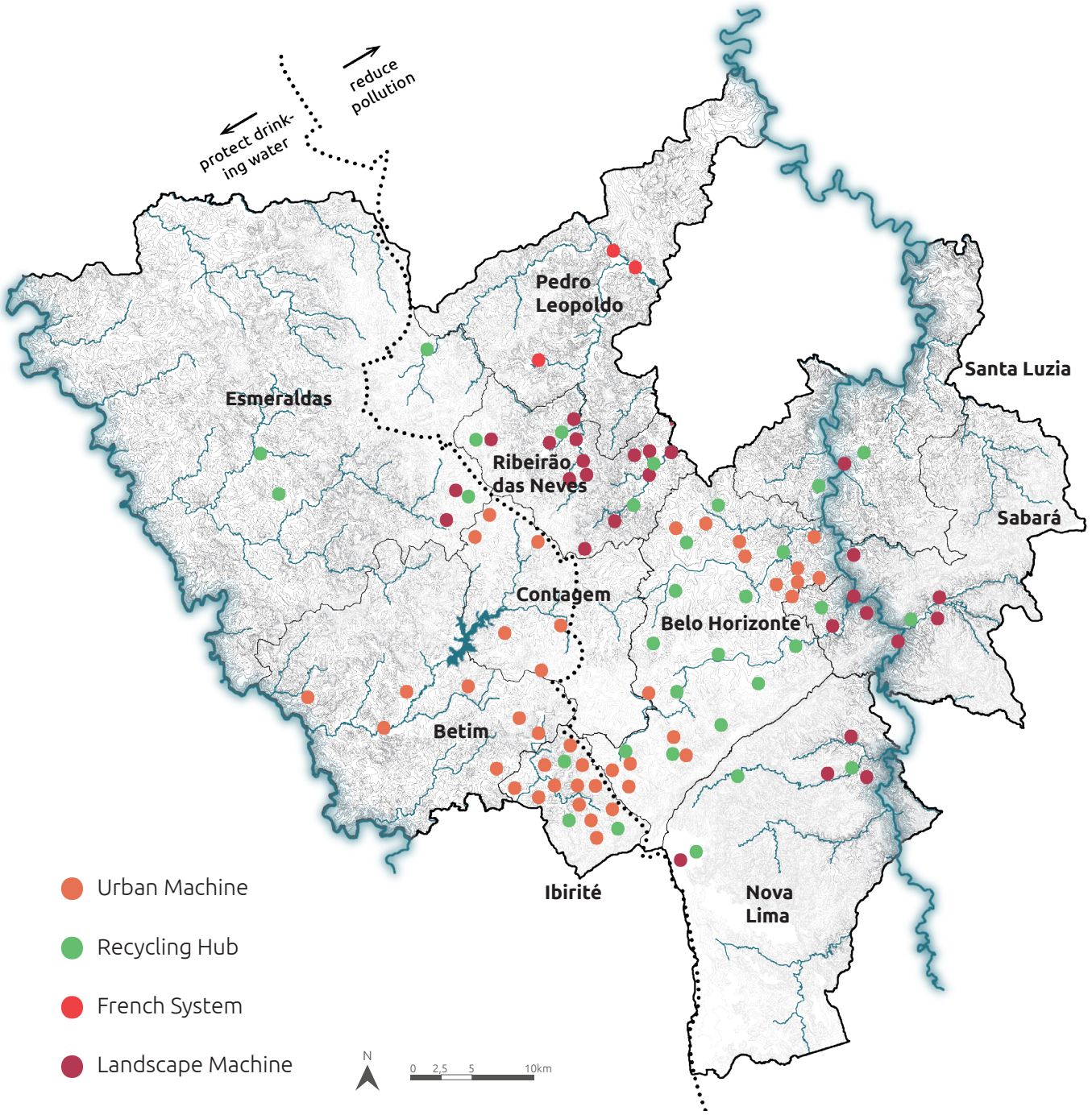
2 purposes

implemen-tation strategies

landscape relations

- number of systems x area
- technical support
- political will
- maintenance (PPP)


4
systems
urban
machine 2.0
recycling hub
french system
landscape
machine
• organic products industry
• worm “farms”
• recycling industry (recycled products)
• alternative packing
• costs for industry and commerce
• only local spin-off with system’s by-products
• biogas centers
• clean energy technology
tranformation of landfills into Recycling Plants


protect drinking water
reduce pollution
Pedro Leopoldo
Santa Luzia
Esmeraldas
Ribeirão das Neves
Sabará
Contagem
Belo Horizonte
Betim
Ibirité
Nova Lima
Urban Machine
Recycling Hub
French System
Landscape Machine
N
0 2,5 5 10km


4
systems
urban machine 2.0
recycling hub
french system
landscape machine
• organic products industry
• worm "farms"
• recycling industry (recycled products)
• alternative packing
• costs for industry and commerce
• only local spin-off with system's by-products
• biogas centers
• clean energy technology
tranformation of landfills into Recycling Plants

conclusions + reflection

!

Studying RMBH through **Urban Metabolism** perspective can give insights on how to deal with its current and future environmental challenges by managing better its resources related to wastewater and waste.

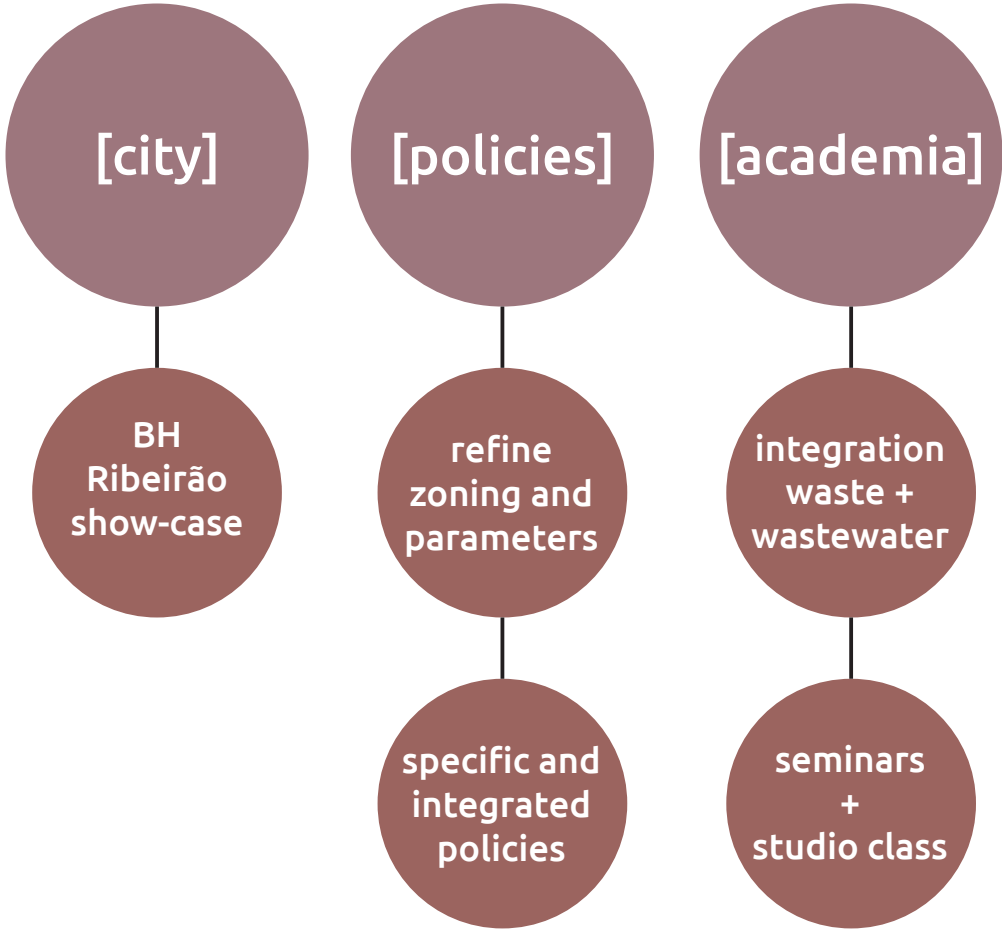
Urban Metabolism:

- do not point to synergies in particular;

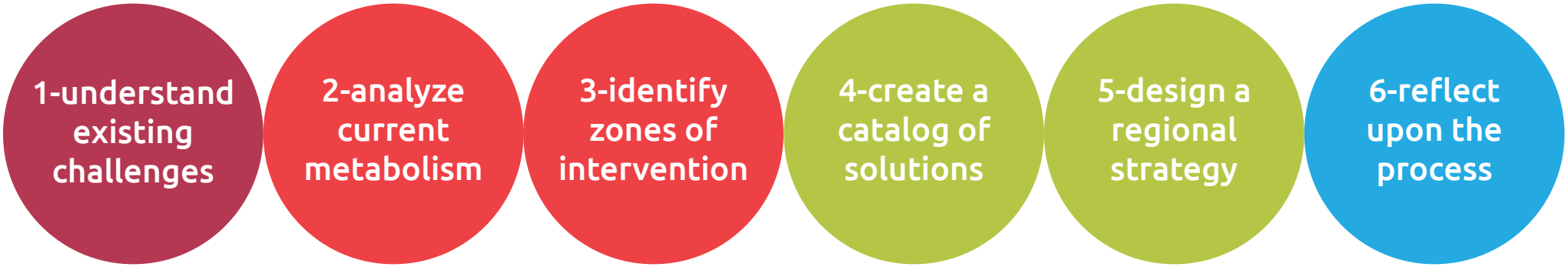
- it can only unravel what is already part of a metabolism;

- yet, when searching for solutions to improve the metabolism, possible synergies become evident, given the holistic understanding of urban processes;

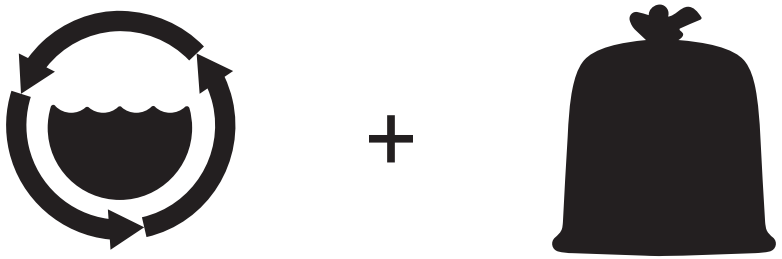
contributions



contributions



contributions



combined systems to treat wastewater and solid waste are more interesting from both metabolic and urban perspectives

>by-products = >synergies = > social and landscape integration

thank you.