

Living with drought prone Landscapes

Spatial design interventions for a rain and dry seasons mitigation system
in Ryabega, Eastern Rwanda

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P5 Presentation

Circular Water Stories Lab

Landscape Architecture Master Track

TU Delft

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Contents

1

Introduction

Problem statement

- National scale

- Plateau scale

Methodology

- Arid water system Case study

Research question

2

Learnings from the case study

3

Savannah scale

Catchement potentials

4

Town scale

Historical analysis

Spatial analysis

Analysis <> Design interventions

5

Living with droughts

Design concept

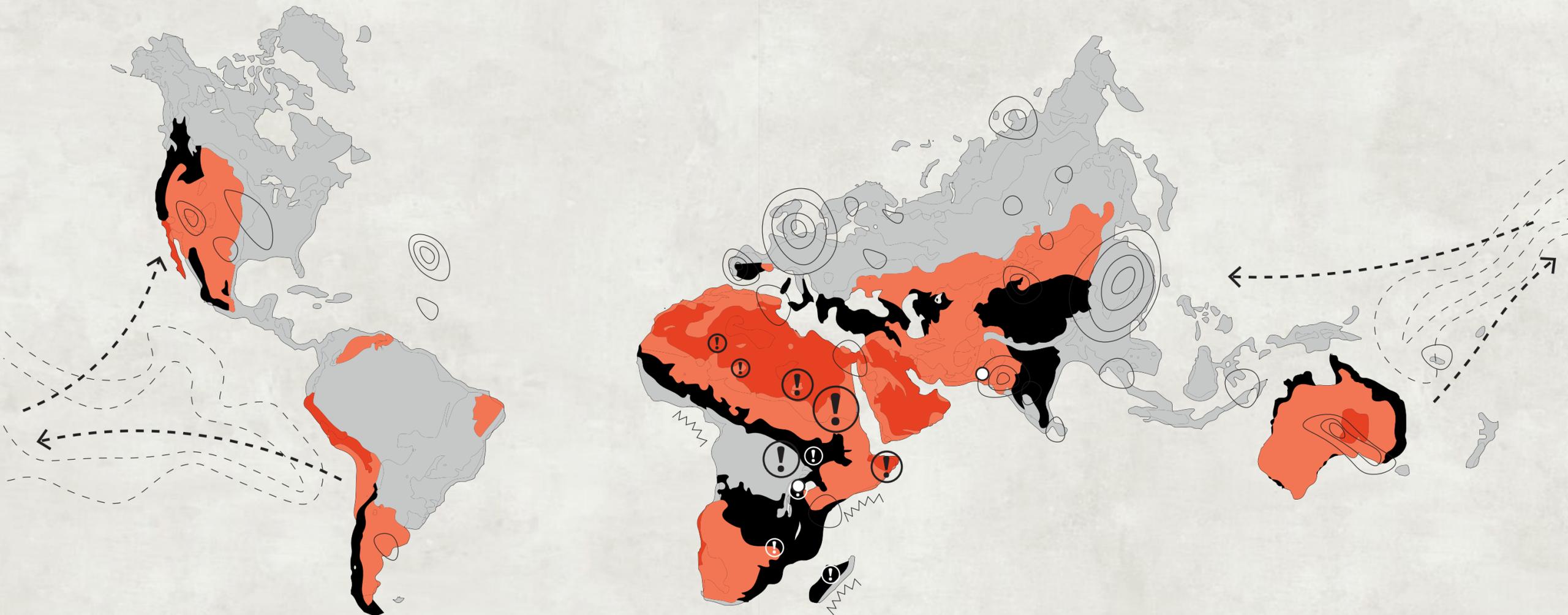
Master plan

Zoom-in: Rural landscape design

6

Conclusion/Reflection

Introduction



- Rwanda
- Khadin, India
- Deserts
- Arid areas
- Severe drought prone areas - process of aridification
- ▣ El Nino
- La Nina
- ⊙ Human influenced heat events
- ⚡ Rising water levels
- ⚠ Lack of climate resiliency

Fascinations



Jaisalmer (Inditales, n.d.)



Sandy and rocky soil (Gyaan, n.d.)



Khadin landscape (Narain & Kar, 2005)



Akagera National Park (WorldAtlas, n.d.)



Orange soil (Kawinda, n.d.)



Drought landscape (East Africa Monitor, n.d.)

Khadin, India

Case study - Hypothesis

Eastern Rwanda

Design location

Soil stories

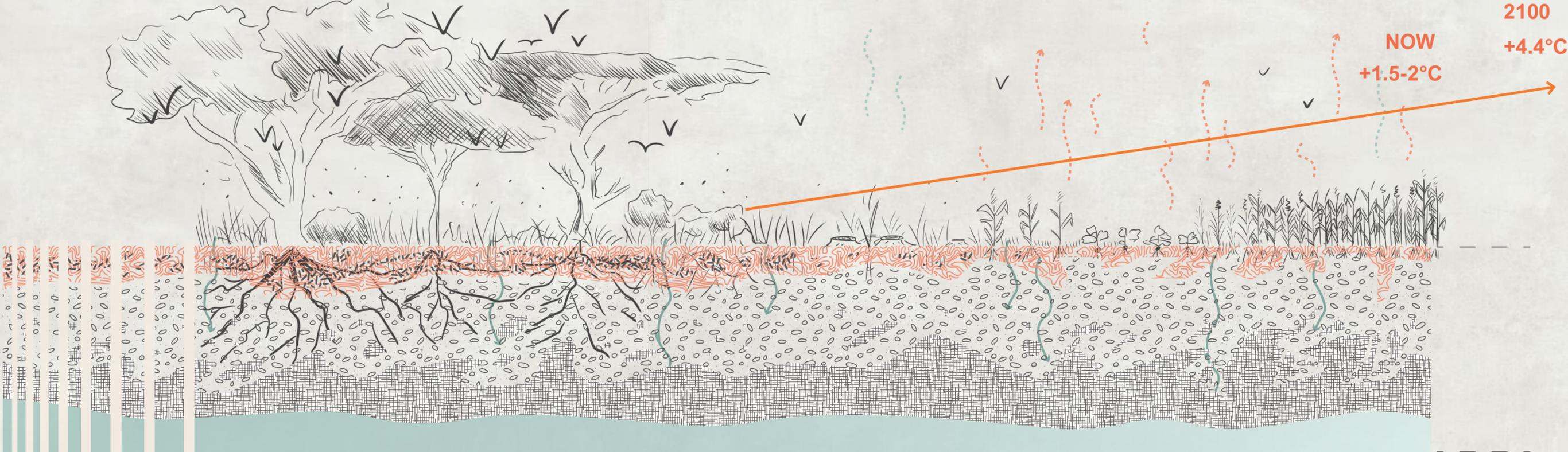
Khadin, India

Case study - Hypothesis



Eastern Rwanda

Design location



Design location



African ethnicities before colonization (Deutinger, 2018)



Colonized boundaries



Scale analysis

Problem statement

Shaping the landscape

90 % of the population works directly or indirectly in agriculture



Hills agriculture (Logar, n.d.)

80 % of Rwanda's surface area



Hills bocage (The Economist, 2019)

25 % of the country's GDP



Hills benching (Ntirengaya, n.d.)



River edge agriculture (FAO, n.d.)

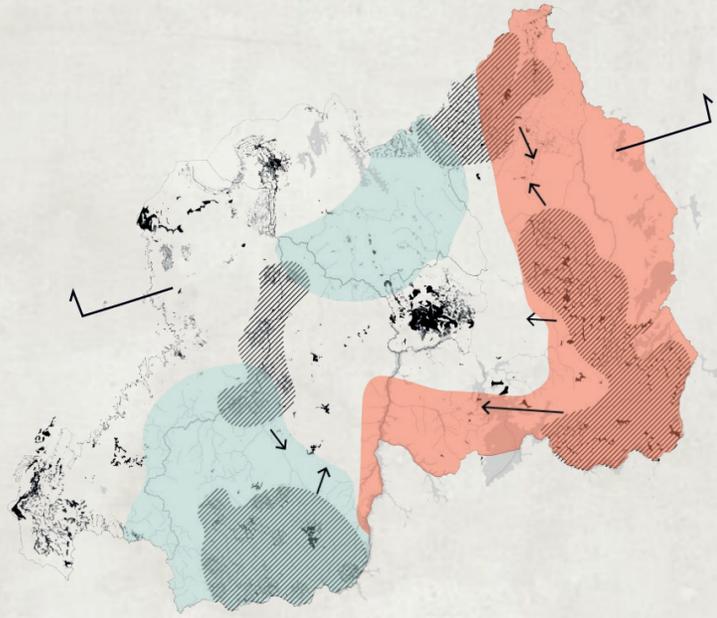


Wetlands rice fields (L.M. Spencer, n.d.)



Pivot irrigation (RwandaAgri, n.d.)

National scale challenges



Landslides, droughts and cities

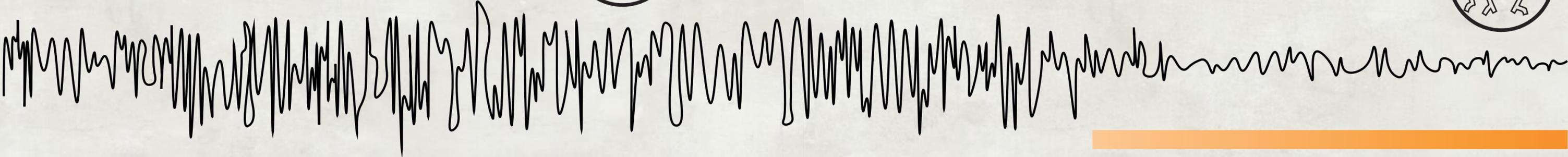
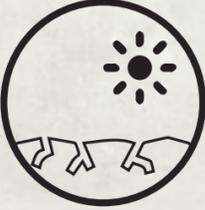
Kivu Lakeside

Congo-Nile watersheds

Central Plateau

Ridges and Plateaux

Eastern Plateau

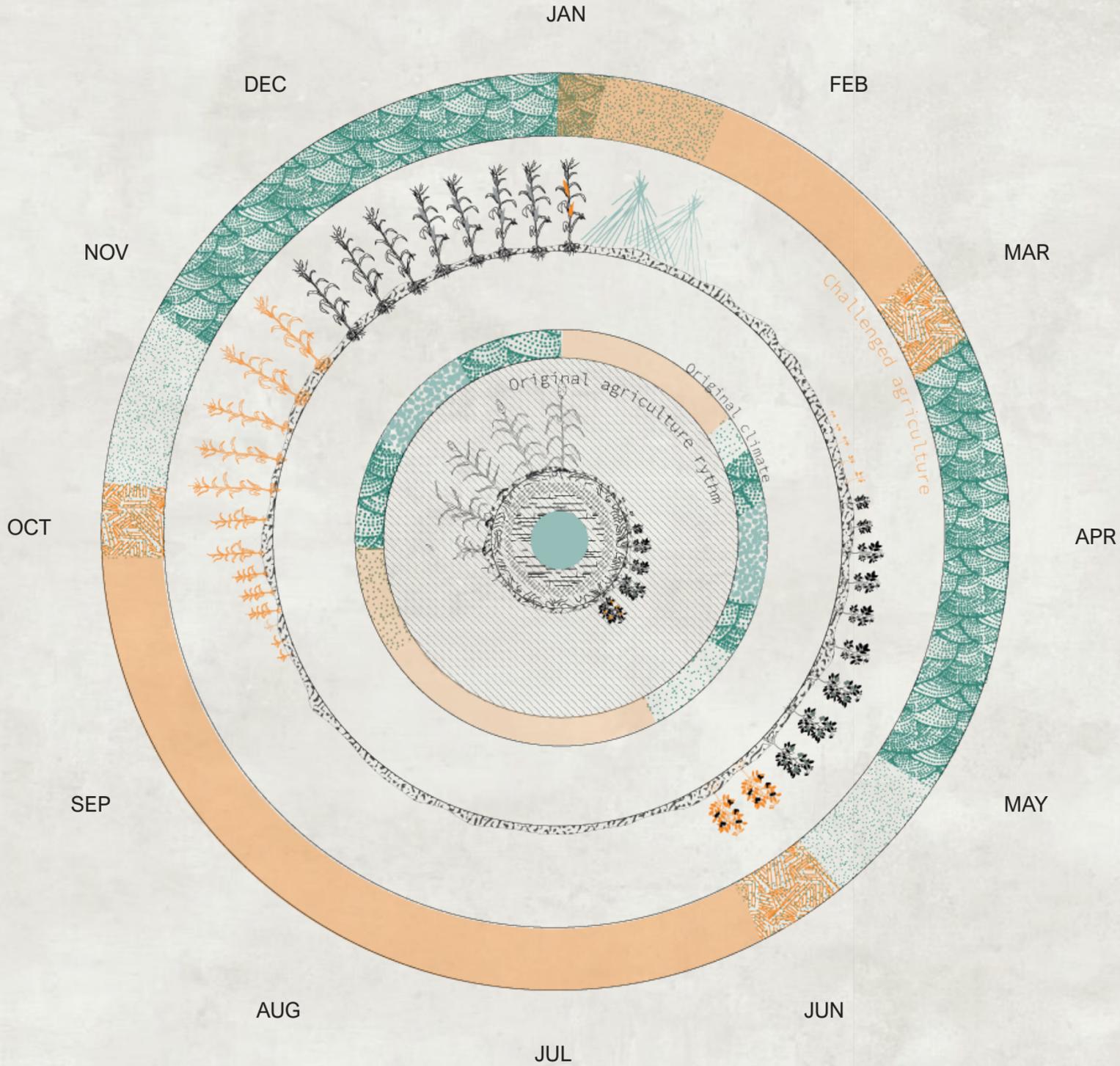
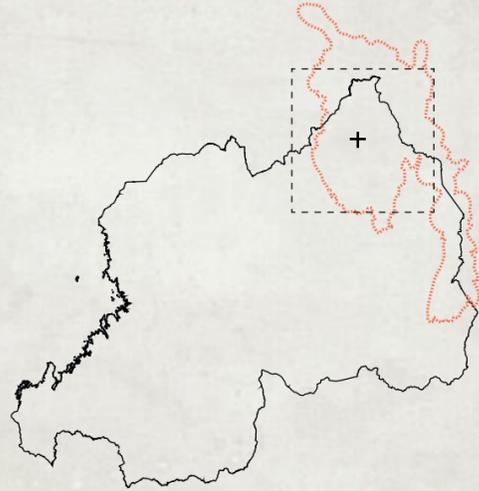


+



Intara y'Iburasirazuba Plateau scale

Irregular and changing seasonal patterns



People's stories



Unknown farmer



«We had a drought and we were starving.»

«When a disease strikes one area, all the animals would be infected because they drink from the same river.»



Martin Ntambara

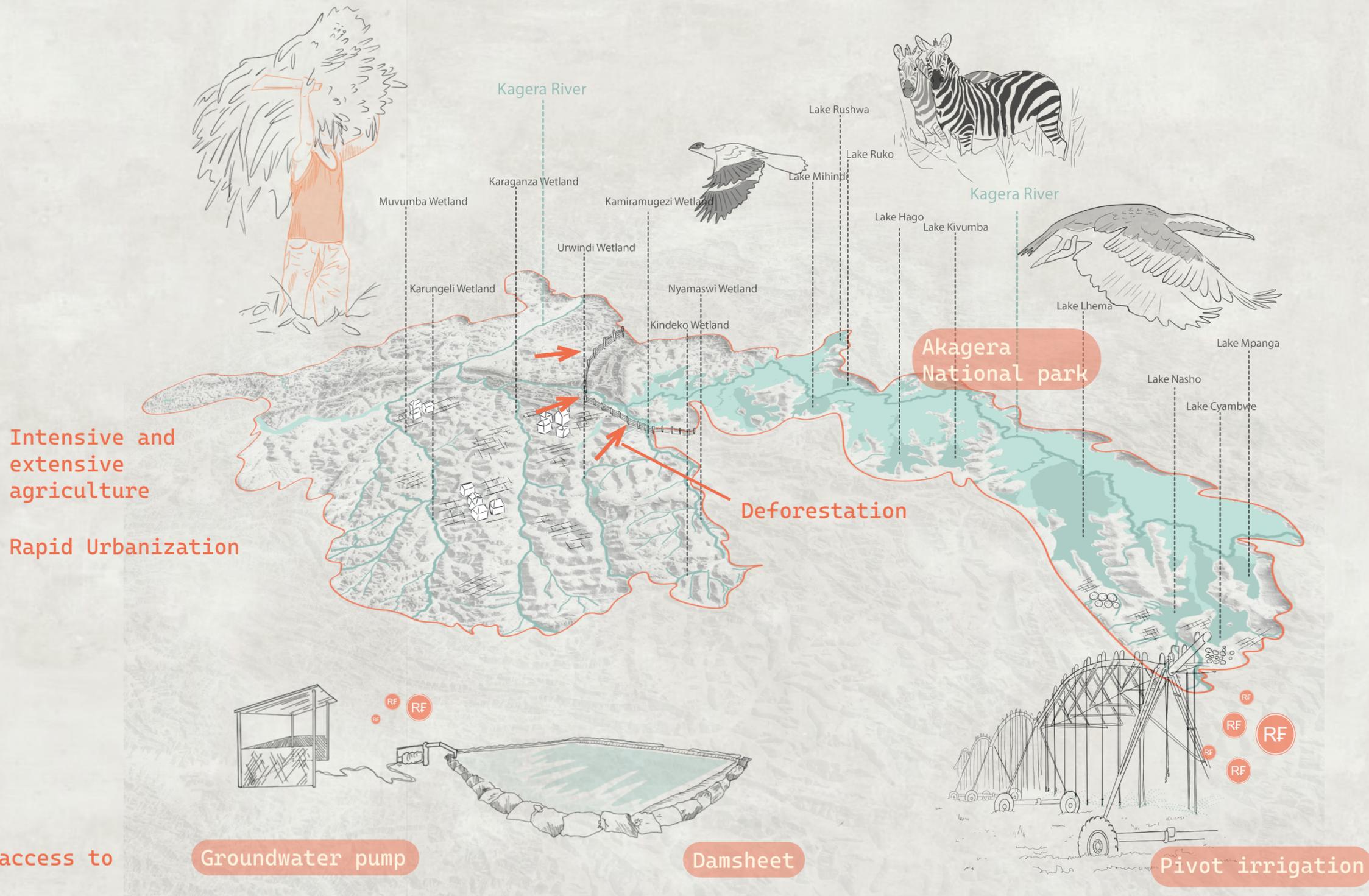
«2021 has been bad with no rainfall. I do not plant the seeds because I wait for enough rain. That is a loss for farmers.»

«There will be a shortage of money for those who rely on agriculture.»

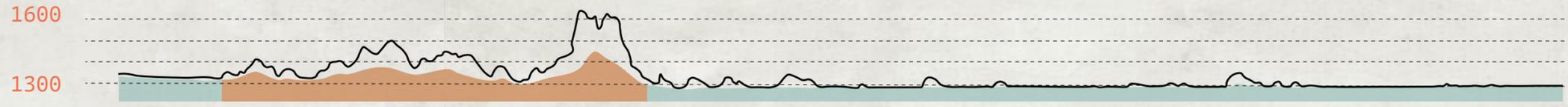


Jean Marie Vanny Ndikumukiza

Plateau stories



- Pressure of agriculture expansion
- Lack of groundwater potential
- Groundwater



Research question

Considering the impacts of global warming and the intensification of droughts, in what ways can the Khadin water system be a **resilient design tool** for tropical landscapes, the agriculture and communities?

How can the design project enable communities towards town autonomy, resilient economy and water circularity ?

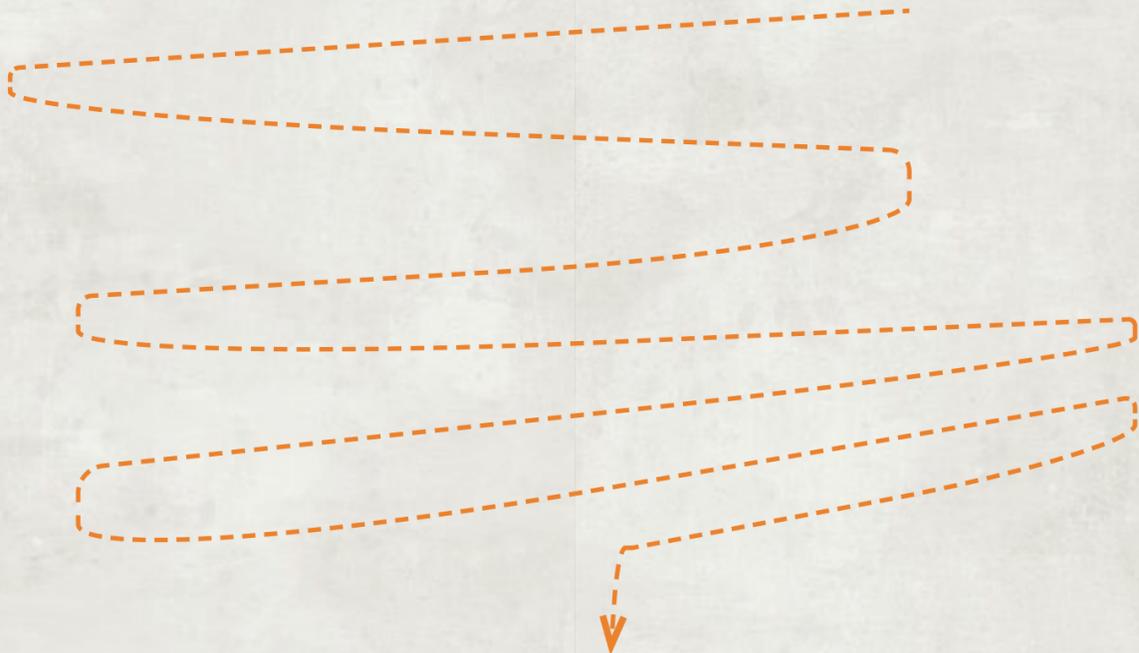
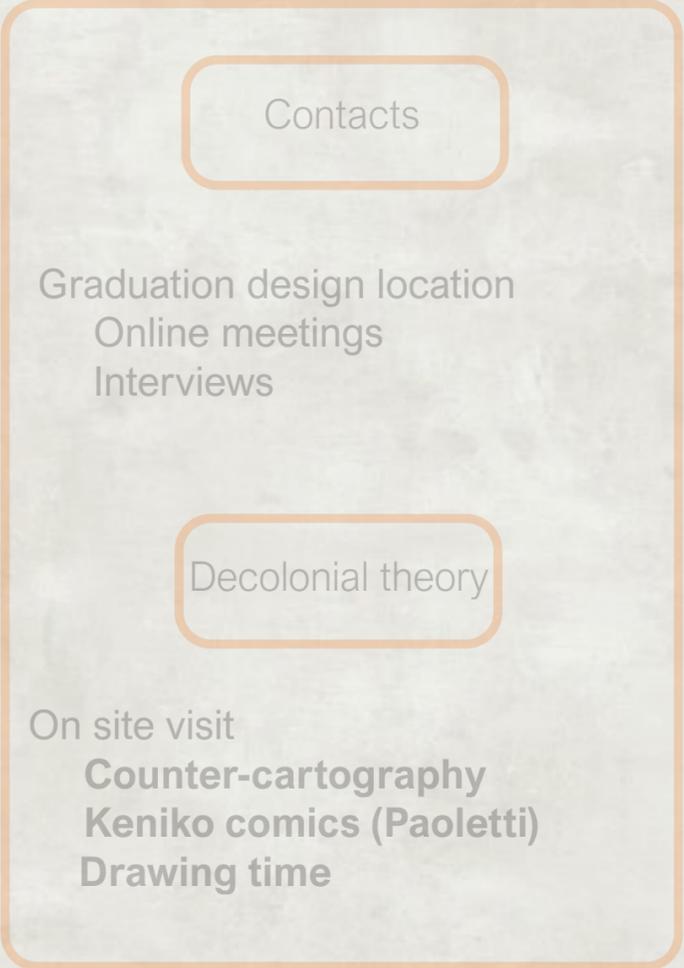
As the design assignment is located in a different culture, which methods can be employed in order to learn and understand how people use public spaces?

How can the design intervention evolve through seasons, years and time ?

Methodology

Case study and theories

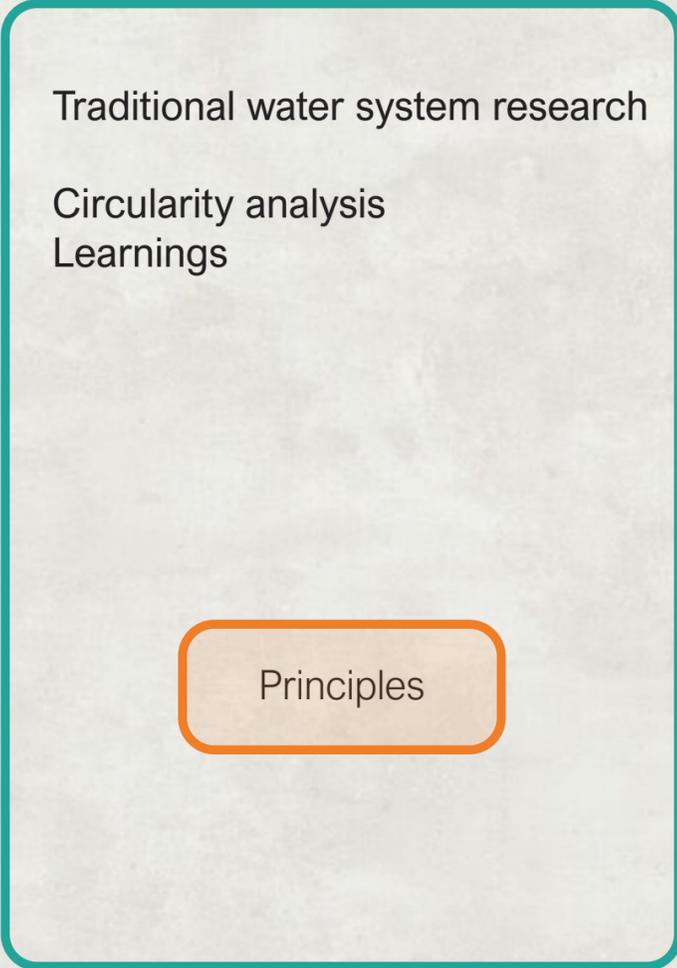
Rwanda



Design interventions

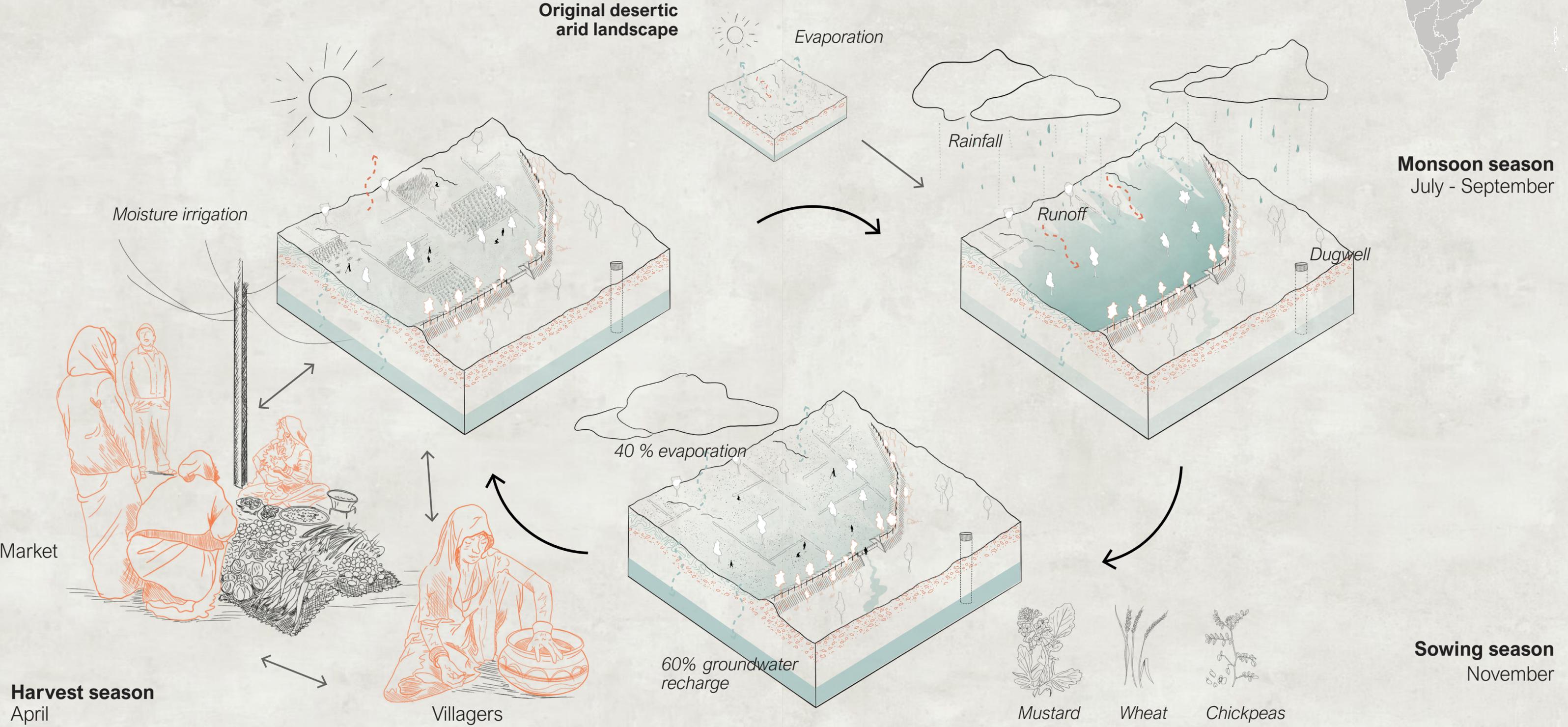
Rural landscape design

Indian case study - Hypothesis

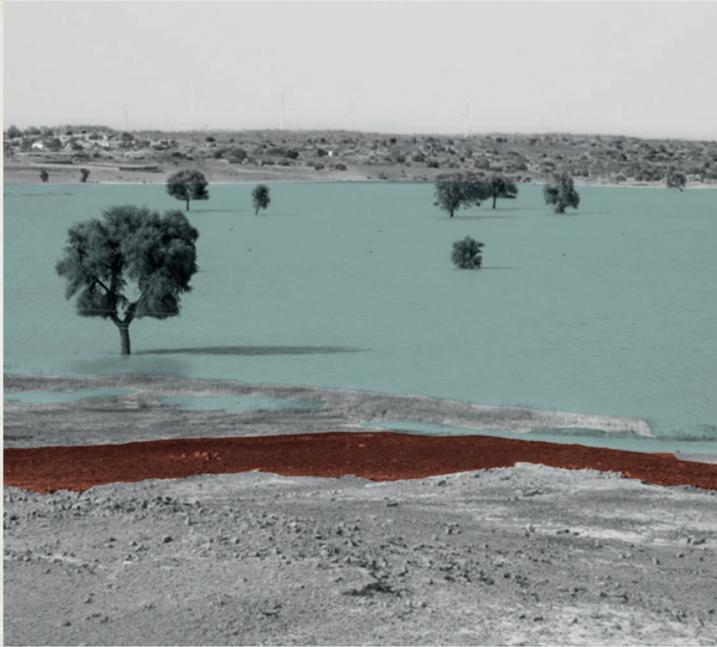


Traditional khadin water system

Case study and hypothesis



Human interactions



Khadin landscape after monsoon



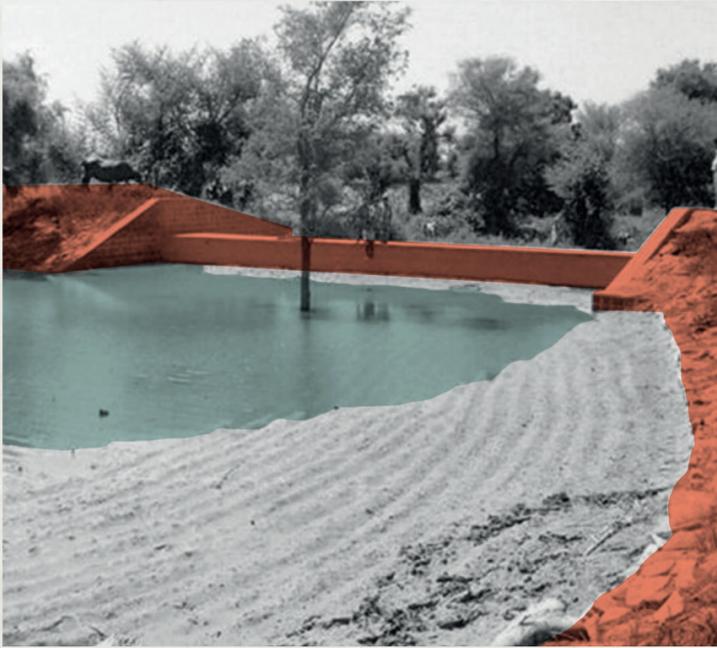
Tool used to measure the khadin water level



A farmer showing around his field during the dry season



"Rabi" crop



Khadin water work



Khadin embankment

Methodology

Case study and theories

Rwanda

Contacts

Graduation design location
Online meetings
Interviews

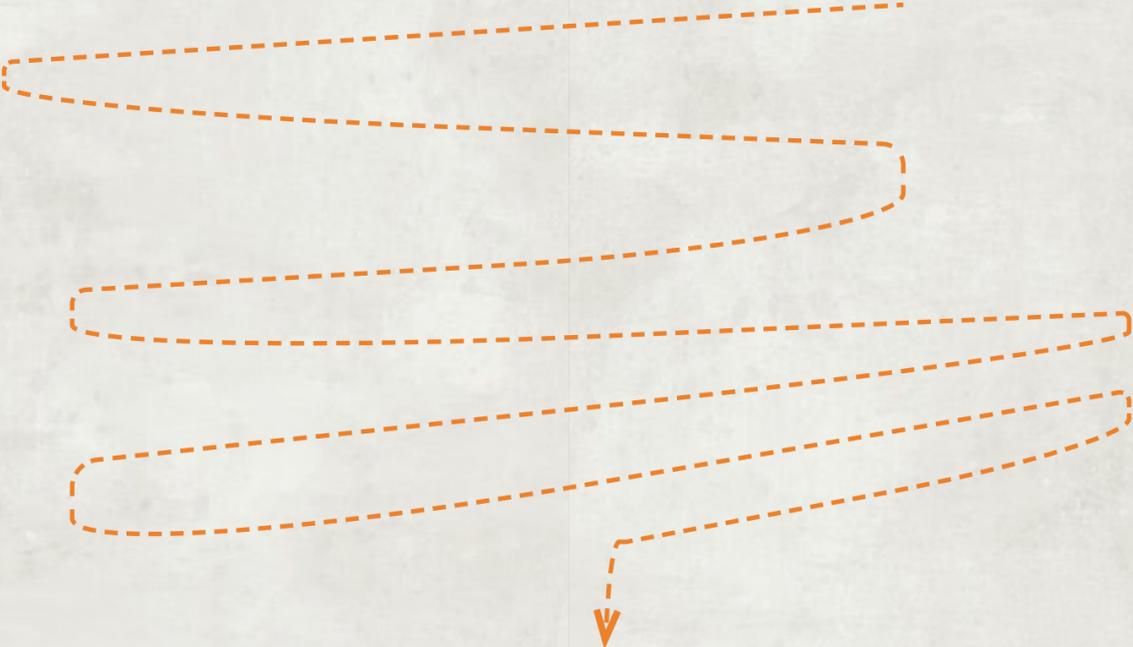
Decolonial theory

On site visit
Counter-cartography
Keniko comics (Paoletti)
Drawing time

Indian case study - Hypothesis

Traditional water system research
Circularity analysis
Learnings

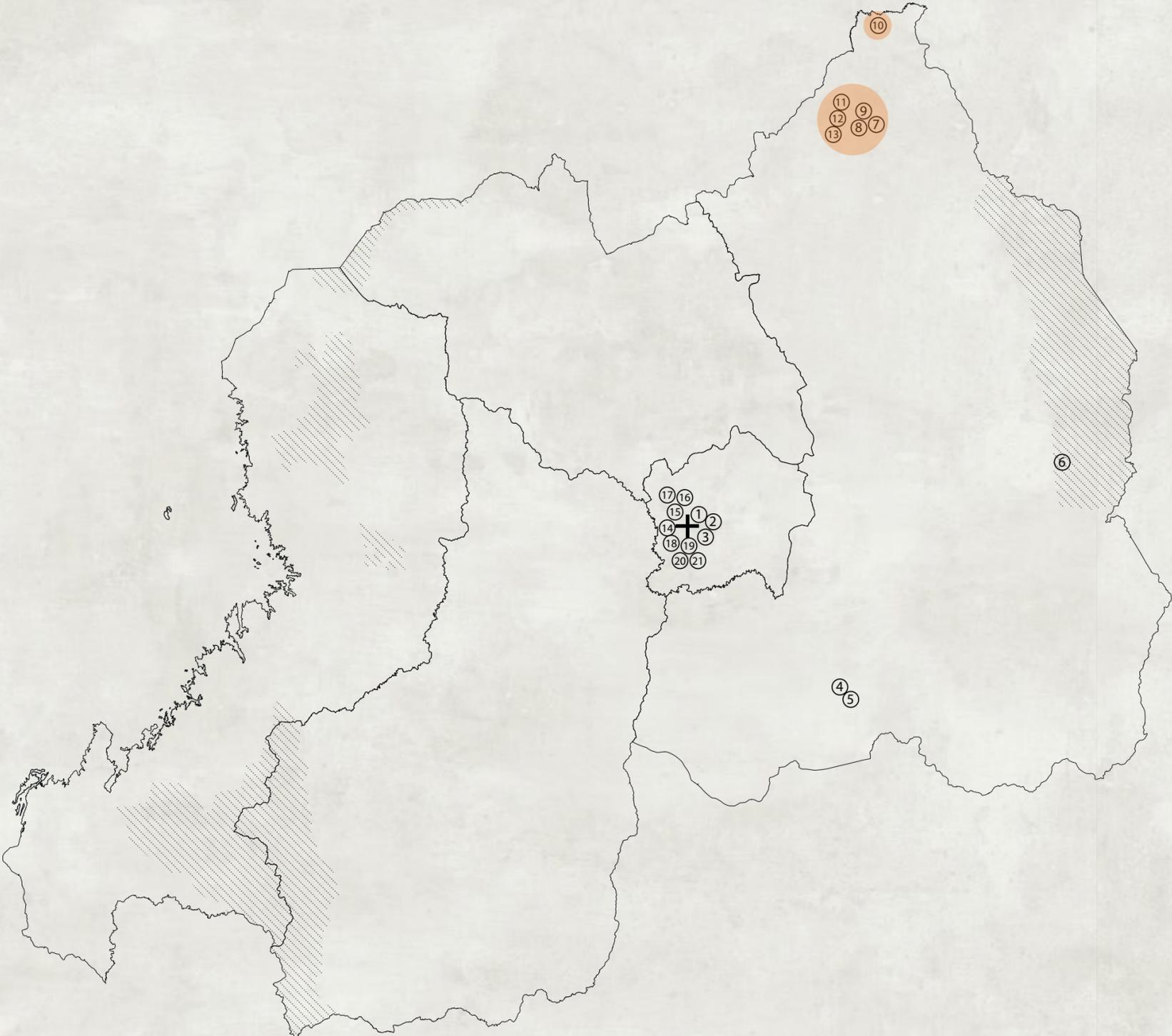
Principles



Design interventions

Rural landscape design

Contacts



Anselme and I at the RICA center

Methodology

Case study and theories

Rwanda

Contacts

Graduation design location
Online meetings
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Decolonial theory

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Indian case study - Hypothesis

Traditional water system research
Circularity analysis
Learnings

Principles

Design
interventions

Rural
landscape design

Decolonial theory methodology



Counter-mapping exploration of the Yanuncay river (Hernandez, 2022)

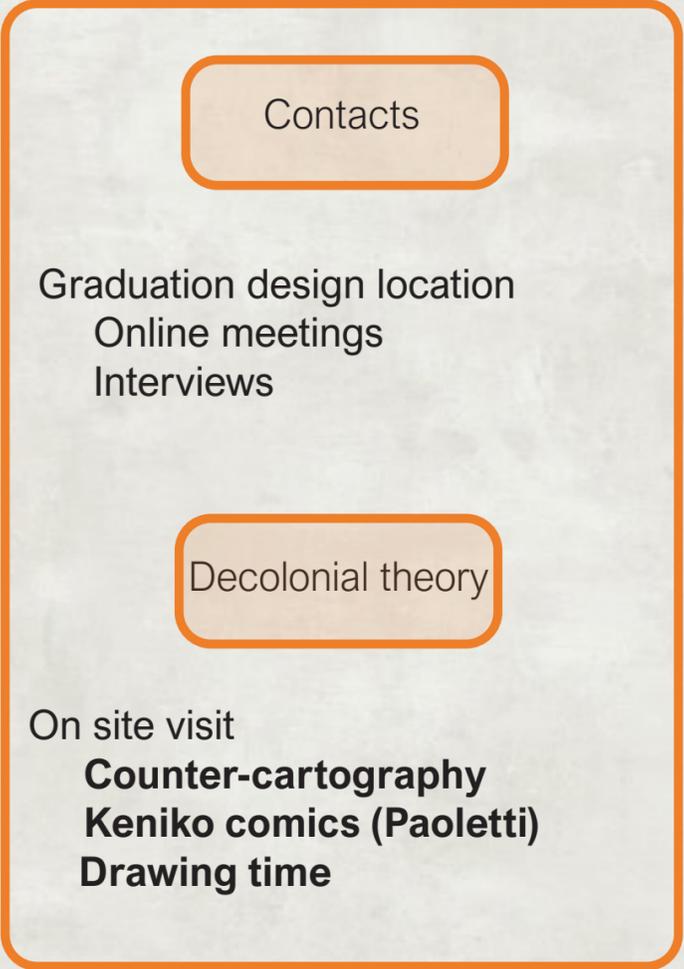


Keniko comics (Paoletti, 2021)

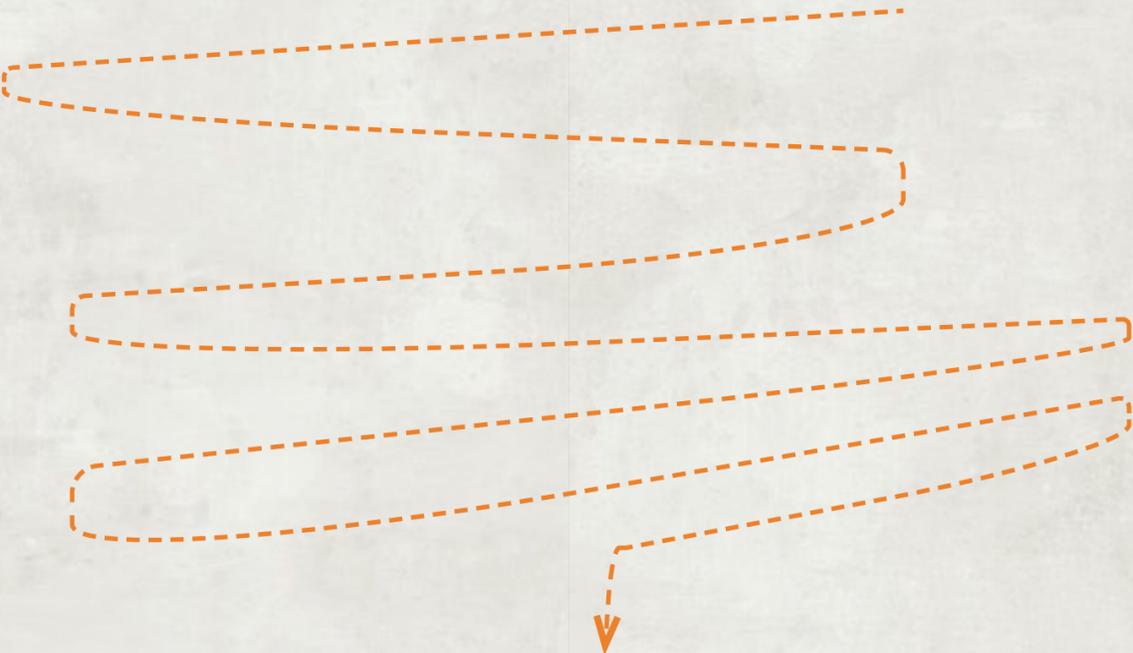
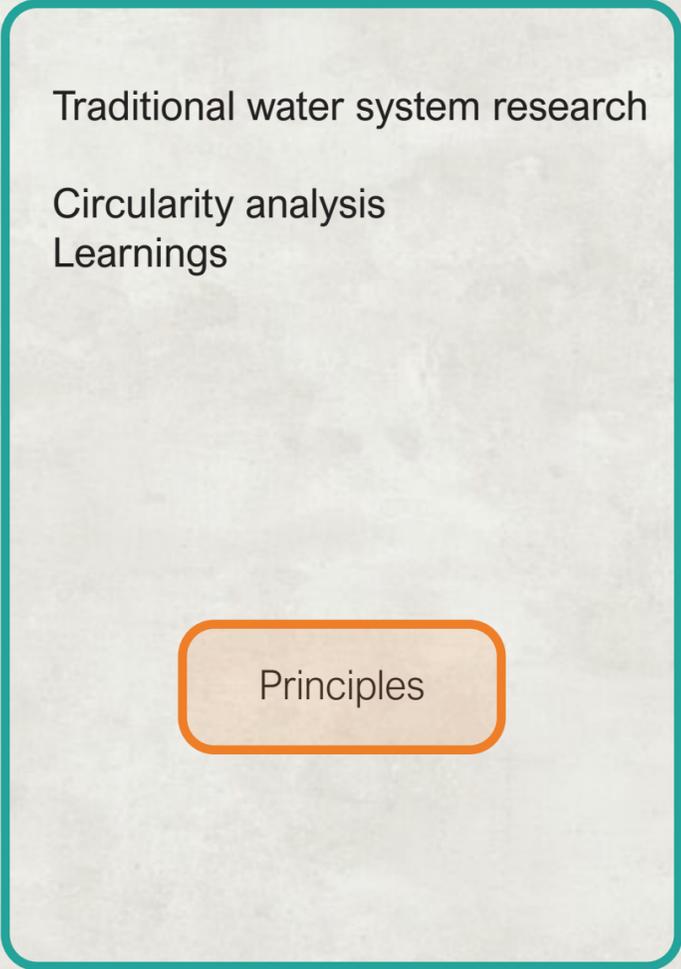
Methodology

Case study and theories

Rwanda



Indian case study - Hypothesis



Design interventions

Rural landscape design

Design theories

Design interventions

Nature-based solutions

Resilient landscape

Bioclimatic architecture

Water system

Arid traditional system

Communities

Rural transformation

Townscape, a Sense of Place



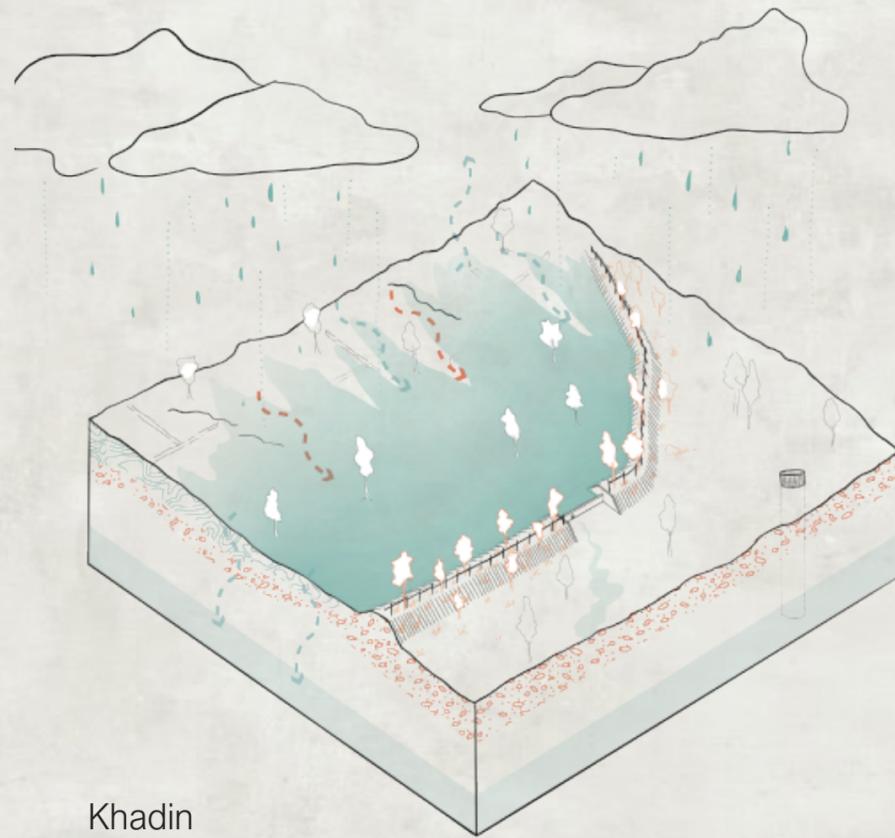
Design assignment

Spatial interventions for a dry and rain seasons mitigation system

Learnings

From the Khadin TWS case study

Amazi - Water
Amazi y'imvura - Rainwater



Khadin

LEARNINGS

- * **Soil fertility process**
- * **Soil moisture irrigation**
- * **Drought resilient**
- * **Site specific to topography and depression points**
- * Excess water caught with the next khadin
- * Attracting vegetation on the edges

Learnings

From the Khadin TWS case study

1. Soil characteristics



Sandy and rocky soil --> Loam and sometimes loam-clay soils
Quick infiltration --> Medium infiltration (9 to 13 mm/h)
(19 to 25 mm/h) --> High sedimentation

2. Two rainseasons

One regular season --> A long and a short irregular rainseasons
Longer and hotter dry season

3. Valley topography

One main slope --> Multiple complex slopes

4. Agriculture rythm

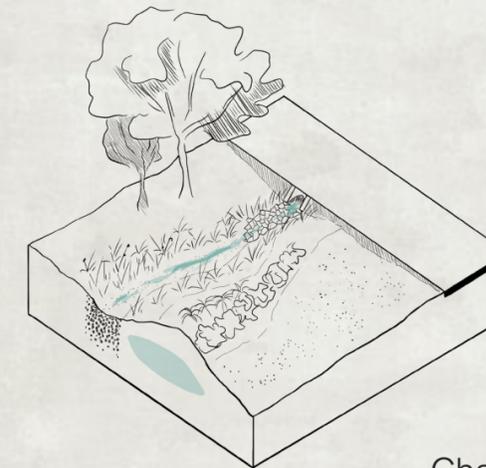
Subsidence --> Intensive
One sowing season --> Two sowing seasons

5. Infrastructure in towns and cities

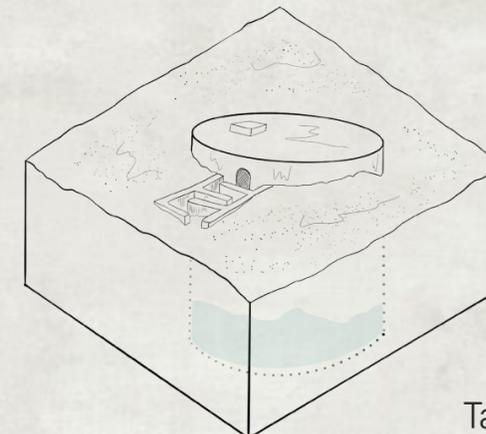
Independant --> Including cities' water infrastructure
- Rooftop rainwater harvesting
- Road gutters



Keyline design



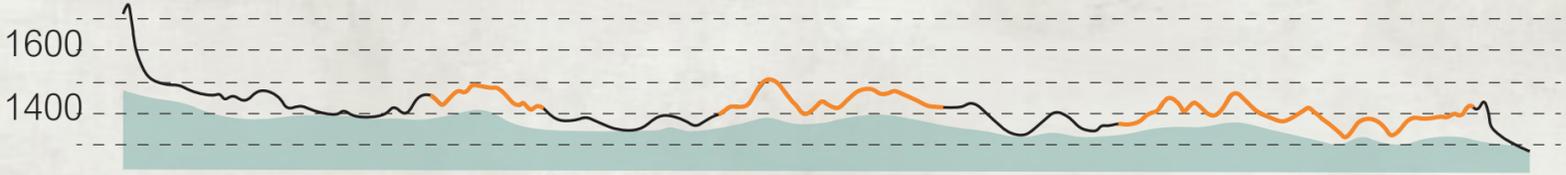
Channel



Taanka

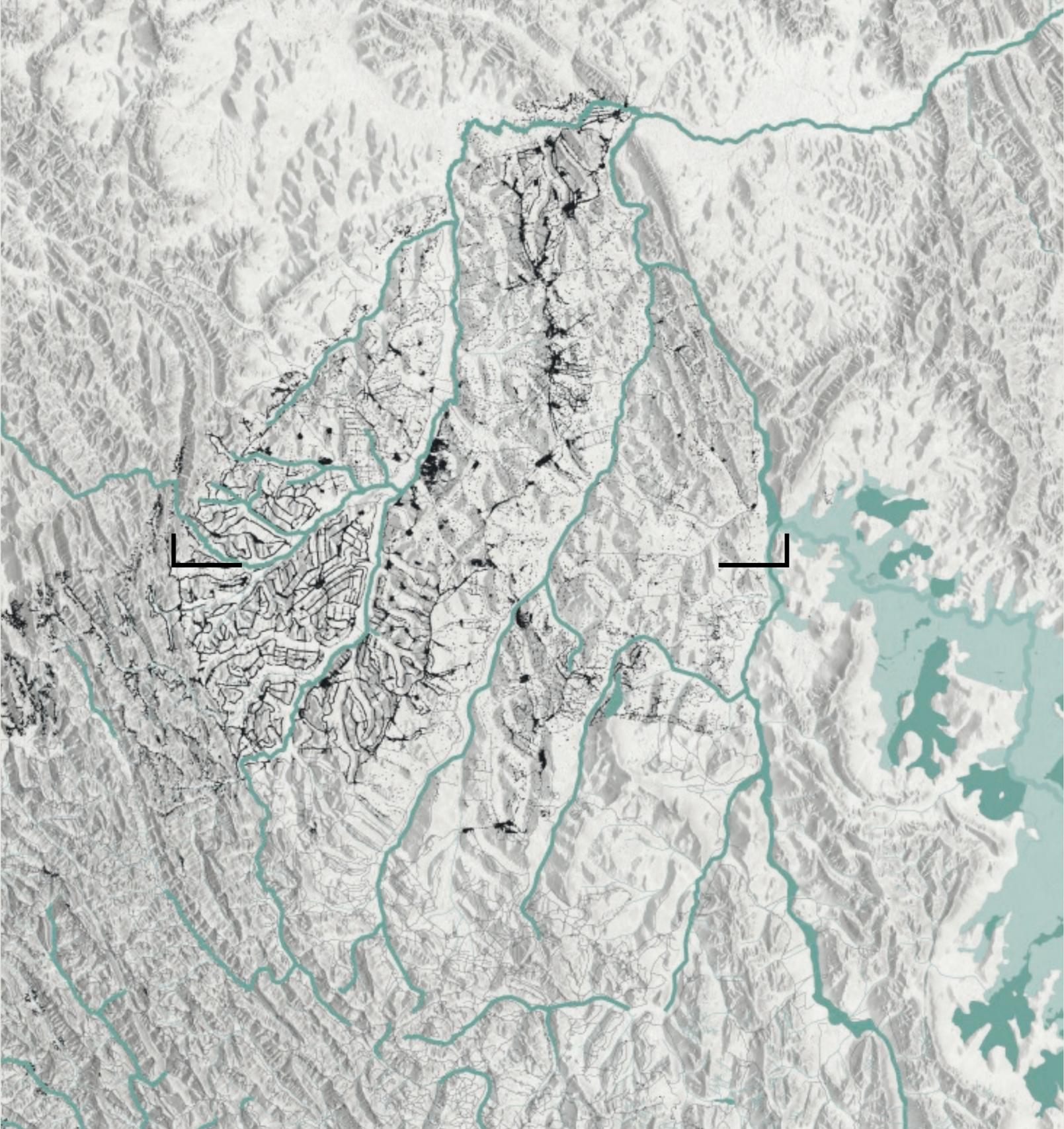
Savannah scale

Catchement potentials



Savannah W-E section

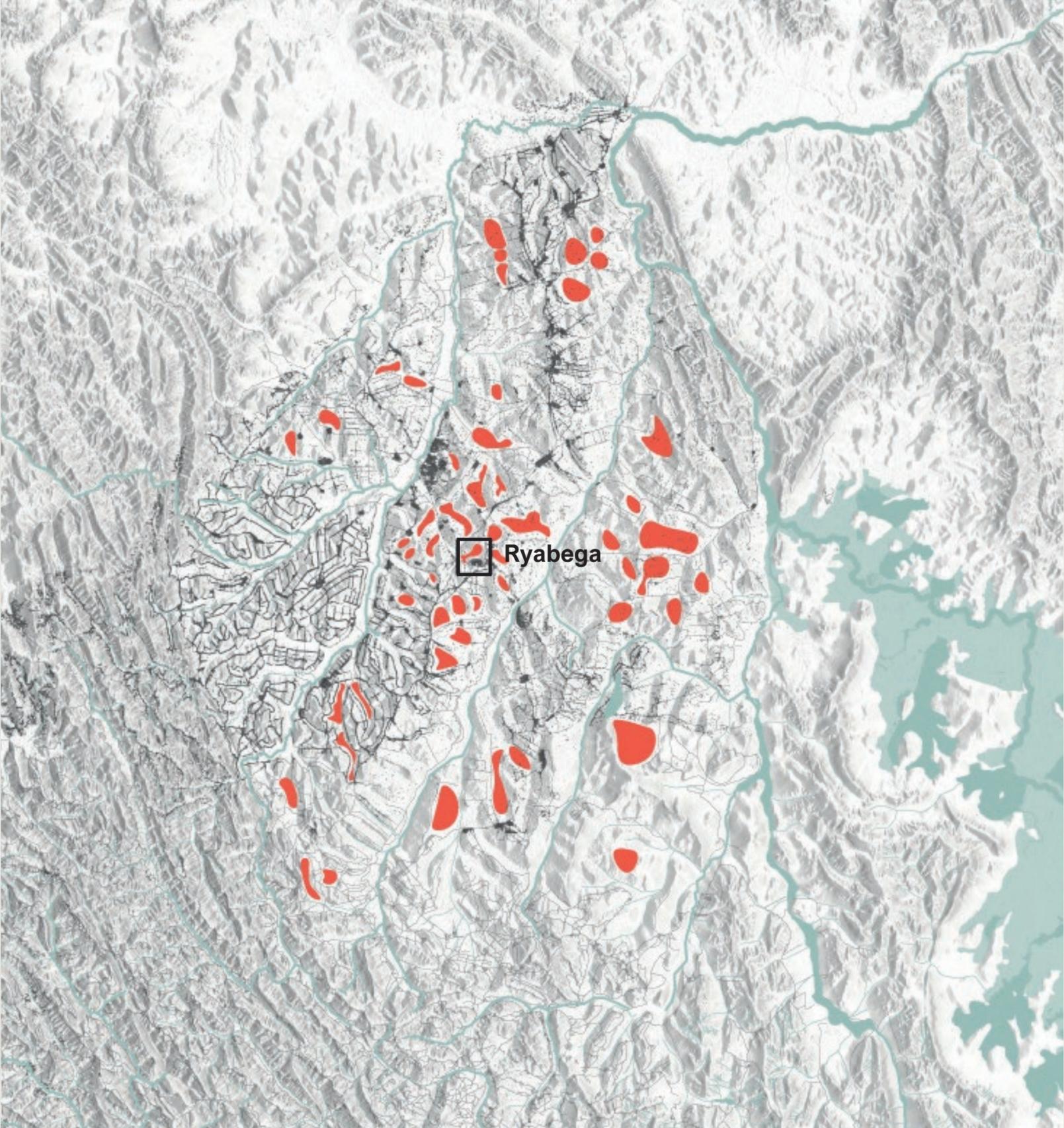
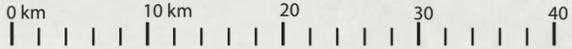
- Difficult access to nearby water sources
- Buildings
- Roads
- Water



Savannah scale

Catchement potentials

- Potential catchement areas
- Buildings
- Roads
- Water



Savannah scale

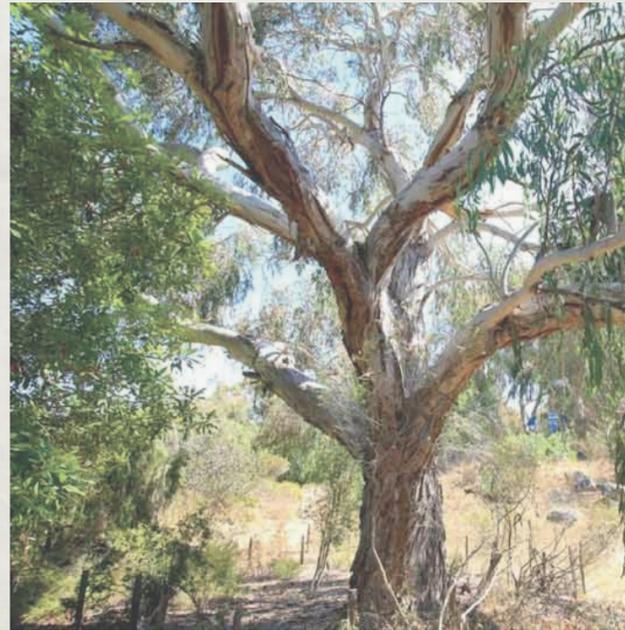
Governmental afforestation plan

- ▣ Reforestation (MoE)
- ▣ Agroforestry opportunities (MoE)
- Buildings
- Roads
- Water



Savannah scale

Governmental afforestation species



Eucalyptus (n.a., n.d.)



Grevillea (Grimshaw, n.d.)



Euphorbia (n.a., n.d.)

Problematics



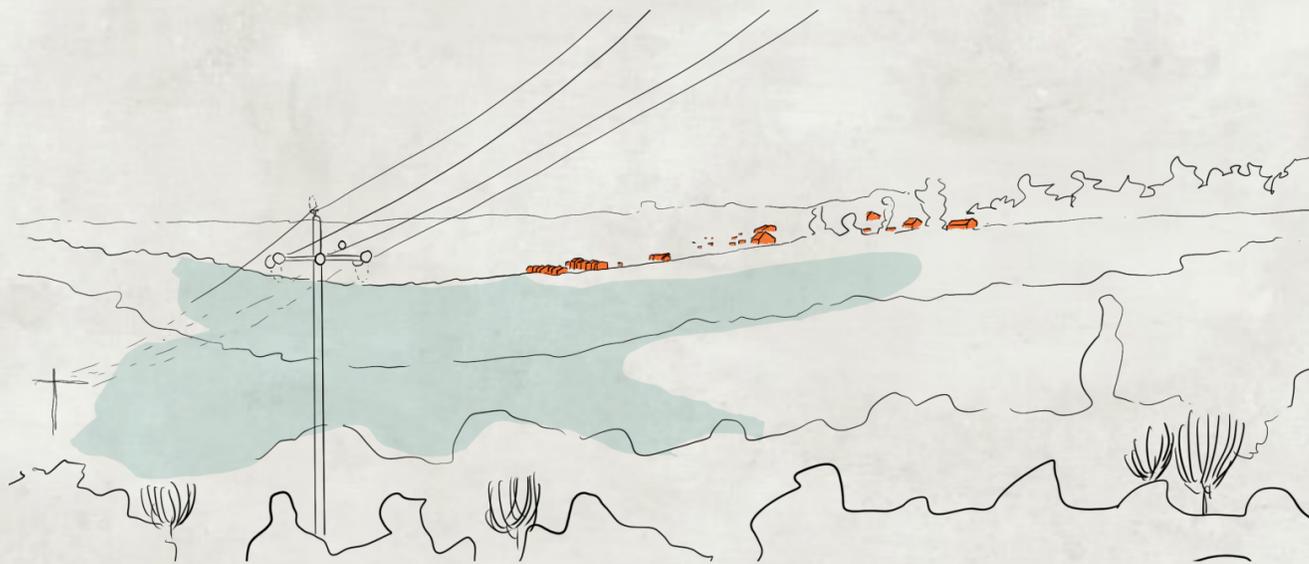


Bushwillows (*Combretum*)

Acacia

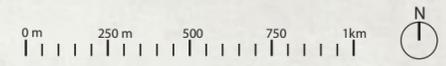
Ryabega town scale

The valley of Ryabega



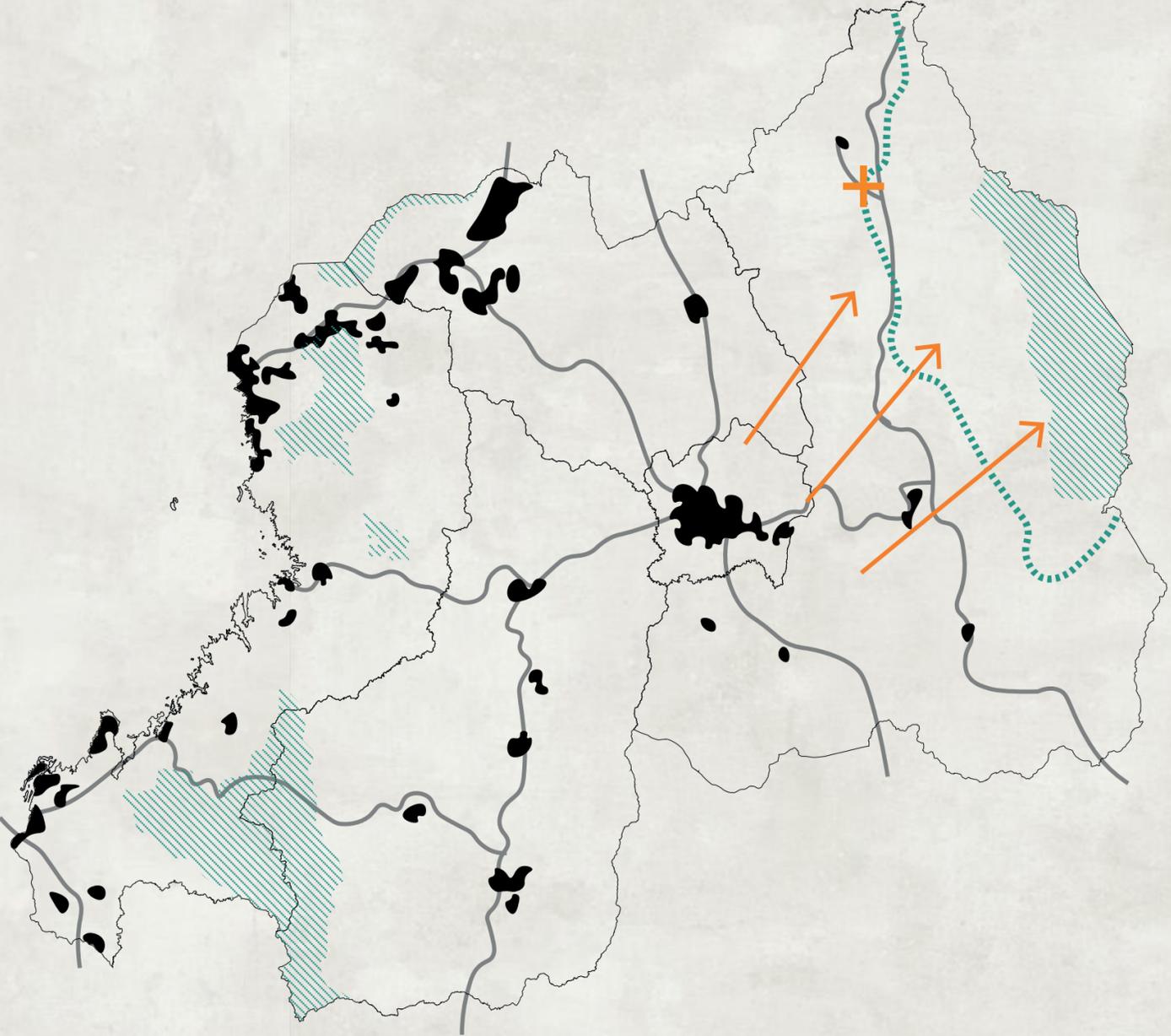
Viewpoint on the catchment area potential

Valley topography



History

Ryabega town creation and expansion

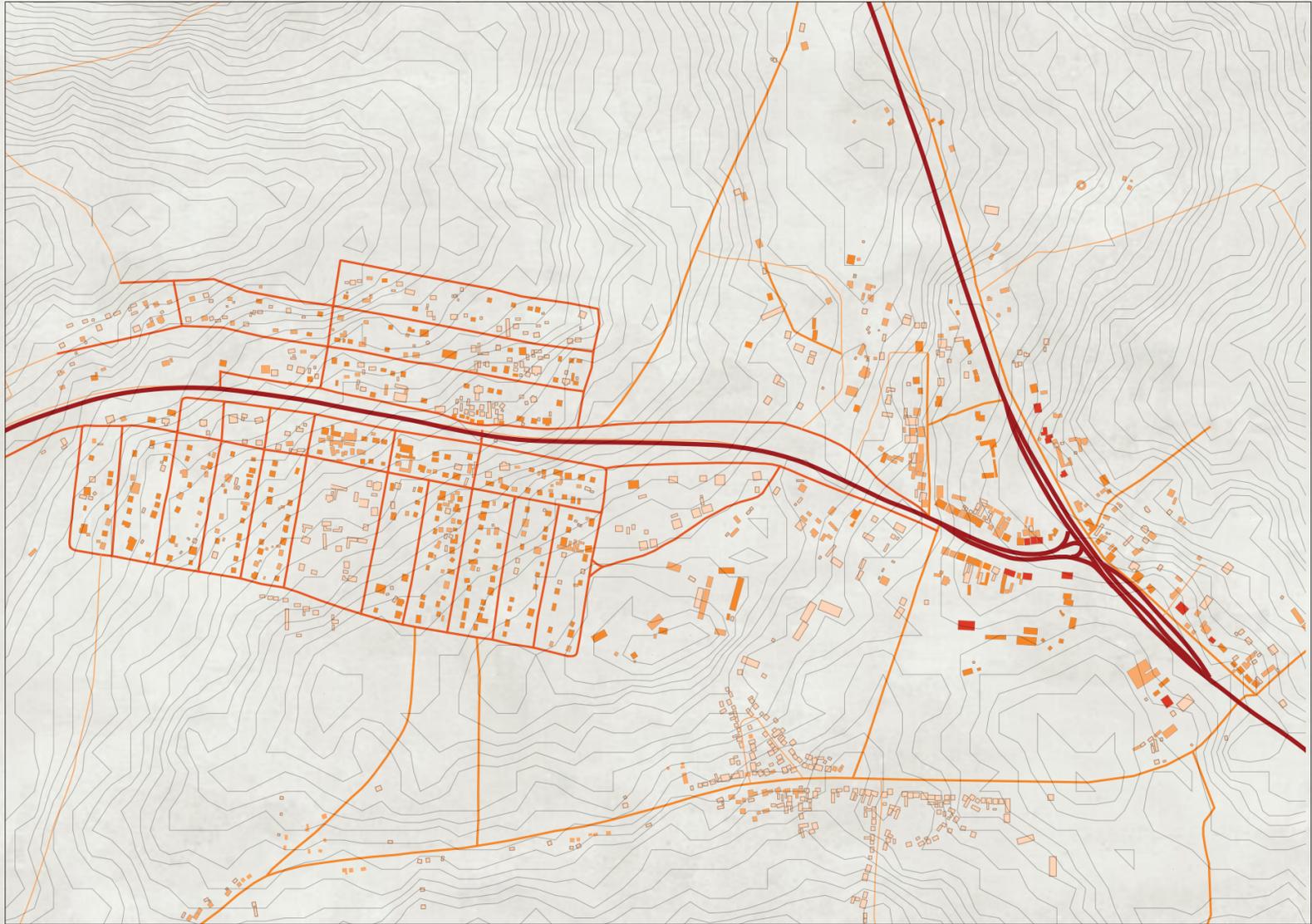


- Akagera national park
- - - Previous Akagera borders
- National road
- City
- People' mouvement

Population hiding in the national park during the genocide of 1994

History

Ryabega town creation and expansion



Urbanization development

- Before 1984
- 1999
- Crops 1999-2004
- 2006
- 2011
- 2014 to now

History

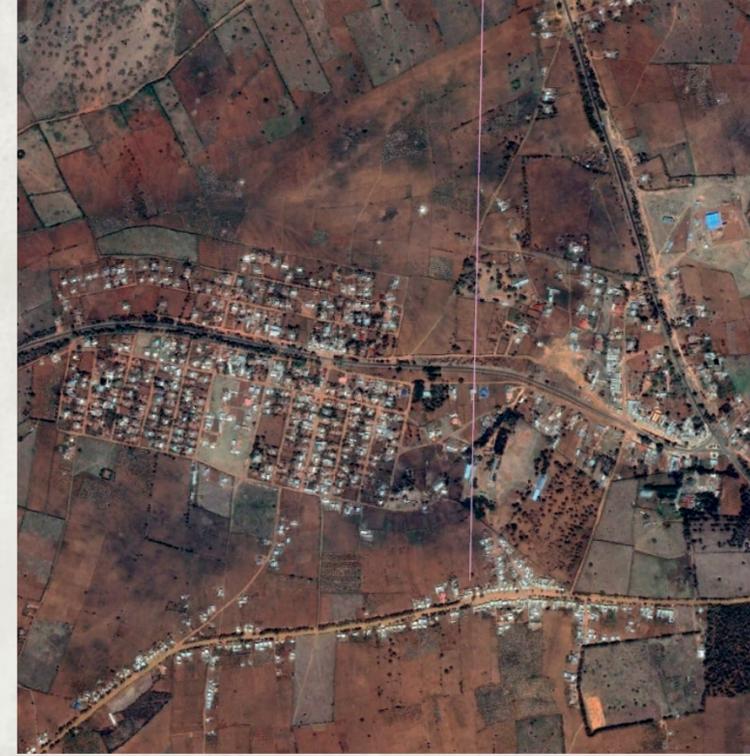
Ryabega town creation and expansion



1985



June 2006
Dry season



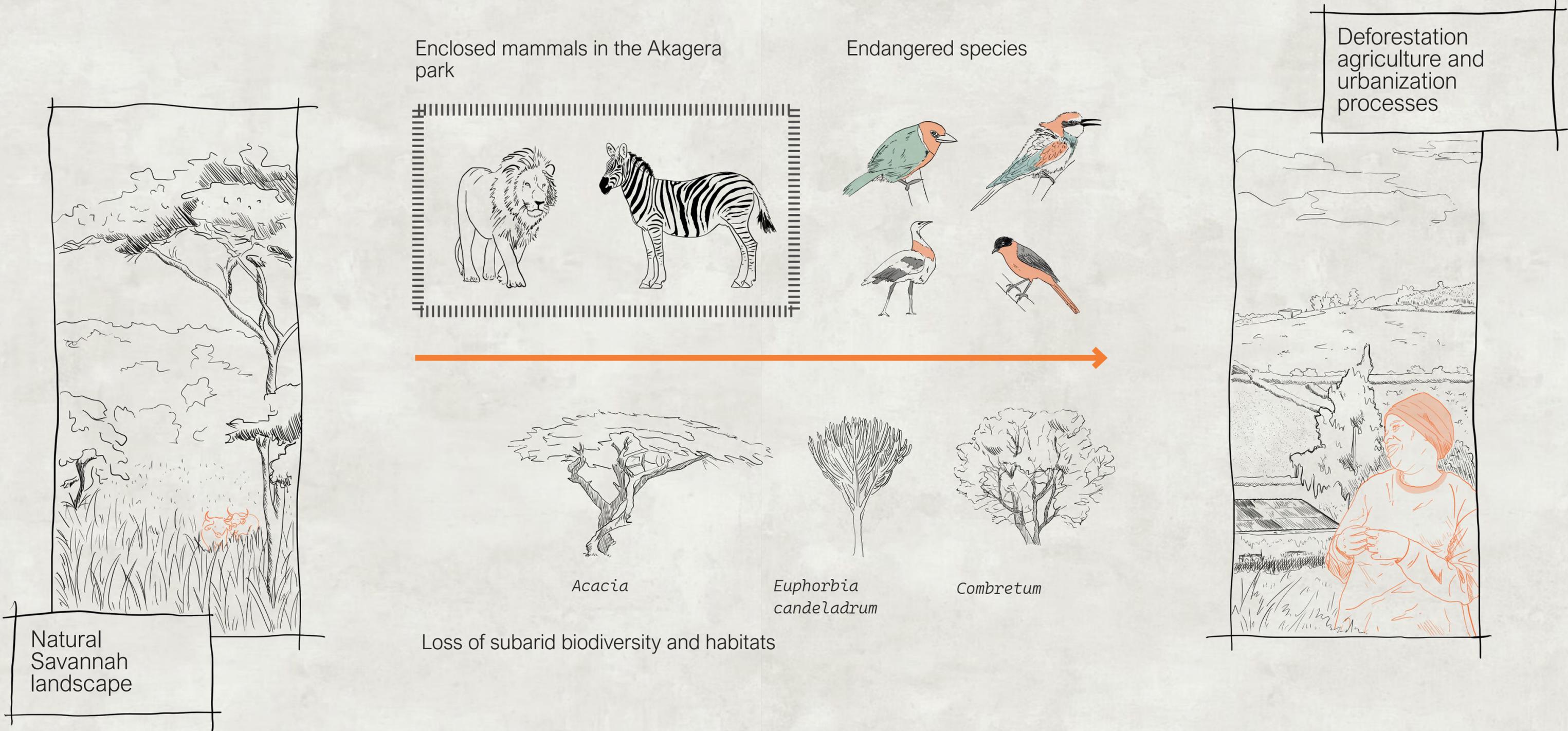
October 2017
Rain season



August 2020
Dry season

History

Ryabega town creation and expansion consequences on landscape and biodiversity

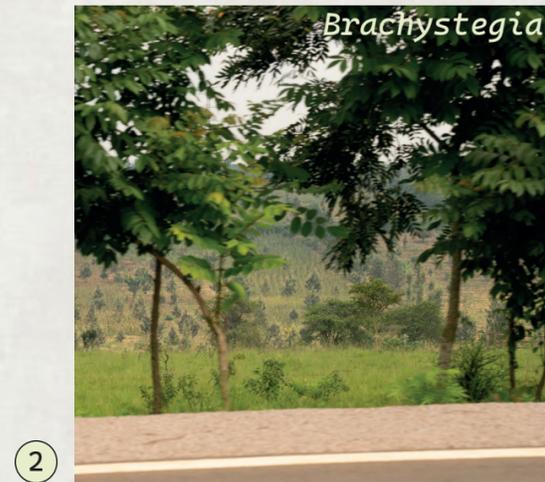


Ryabega

Savannah landscape, agriculture and town



3



2



1



4



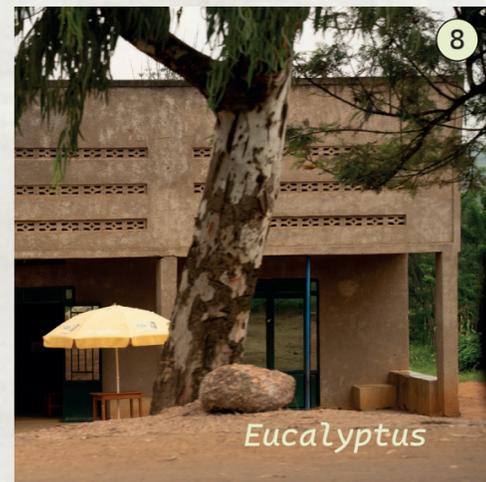
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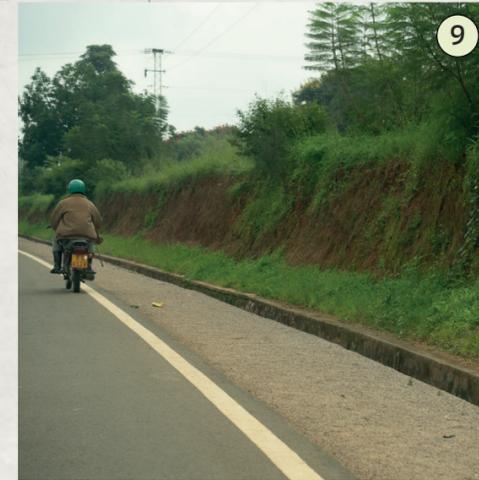
7



8



10



9

Activities

In informal spaces



6:30 am Start of the day: farmers are off to their crops

Activities

In informal spaces



8:00 am Farmers are working on the crops in the morning

Activities

In informal spaces



12:00 am Highly animated : coming back from the crops, leading the cattle to the grazing fields and shopping

max t° 27°C+2°

Activities

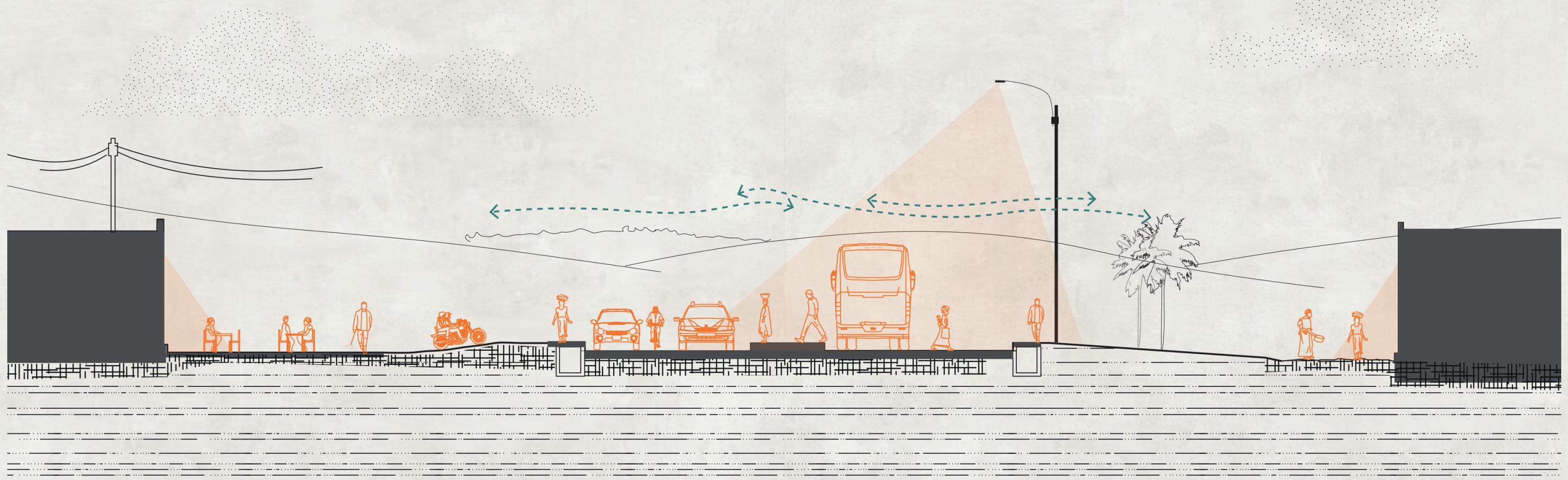
In informal spaces



04:00 pm End of the school day: children are walking back to their houses

Activities

In informal spaces

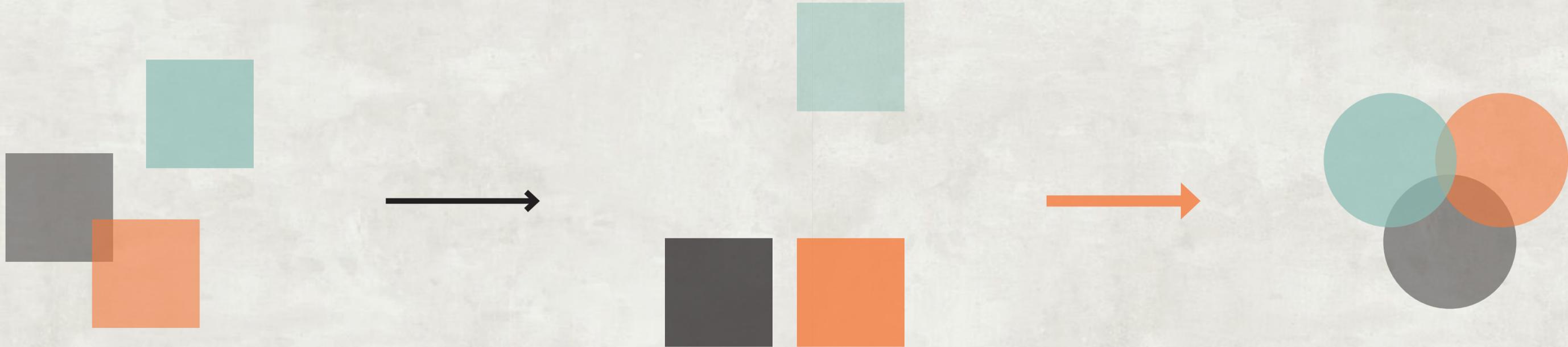


06:00 pm End of the day: it is dark early and the center is highly animated : shopping and having a beer with friends

max t° 16°C+2°

Connecting landscape and people

Design intention



Now

Surroundings tendencies

Cohesion and connection

Zoning of the territory components, micro-agricultural practices

Zoning of the territory components, urbanization intensification, agriculture intensification, landscape biodiversity scarcity

Cohesion strategies between the territory components

- > Connectivity
- > Autonomy/Resilience
- > Meaningful landscape
- > Formal spatial spaces

■ Landscape
■ Agriculture
■ Urbanization

Brachystegia

Brachystegia

Design interventions

Andropogon
Hyparrhenia

Analysis approach

Two intervention scales



Catchment scale



Town scale

Intervention principles

Alongside analysis

Rain and dry season mitigation system

Mechanisms :

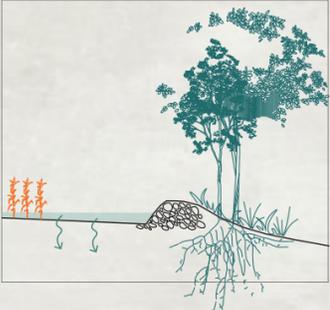
- Humidity
- Soil moisture
- Water conservation
- Drinking water access



- Qualitative urban spaces
- Locally sourced materials
- Town autonomy
- Landscape connections
- Water circularity



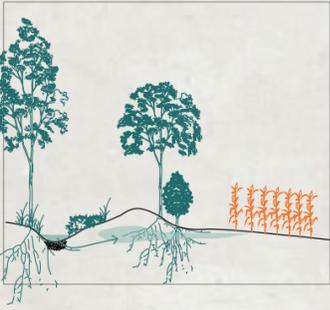
Interventions Catalogue



Seasonal agricultural basin



Reservoir basin



Channel



Tree line improvement



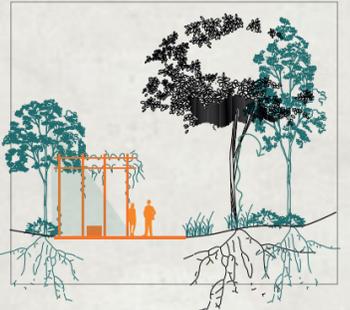
Green hedge improvement



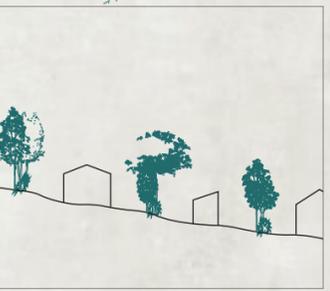
New water conservation park



New green urban park



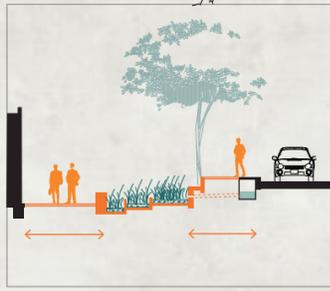
New green arches social pockets



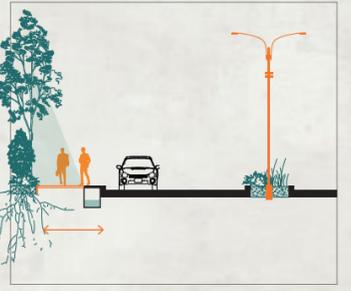
Residential green improvement



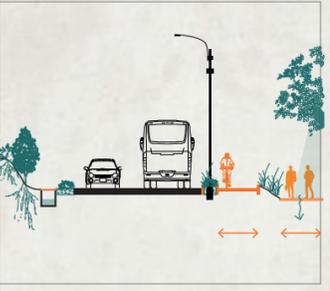
New resilient housing



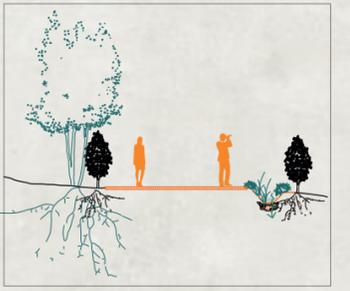
New urban features



New main road profile



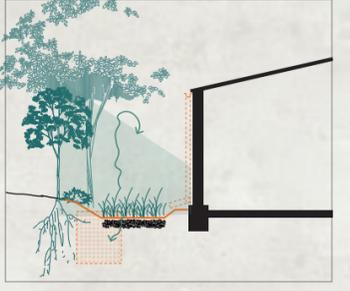
New road profile



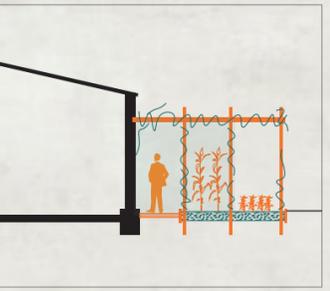
New street profil



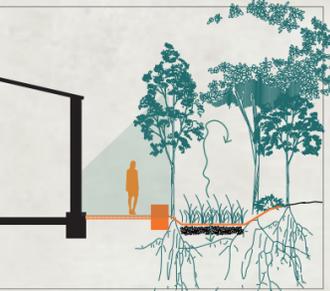
New main road gutter



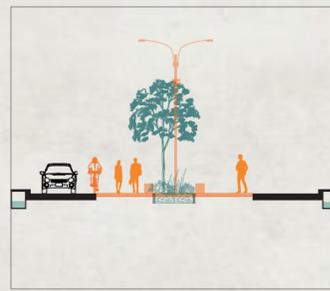
Roof water collecting Private tankaa



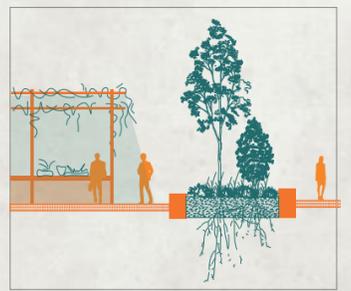
Sheltered productive garden



Private rain garden

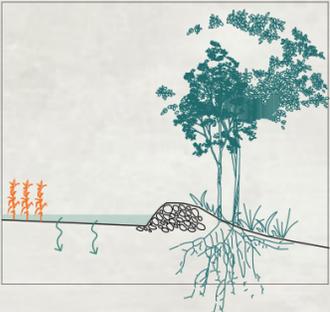


The road as part of the public spaces



Drought resilient market place

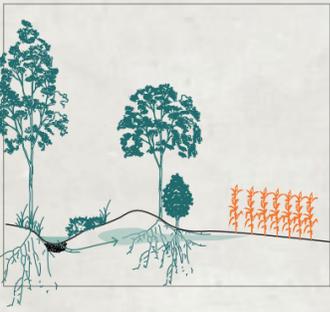
Interventions Catalogue



Seasonal agricultural basin



Reservoir basin



Channel



Tree line improvement



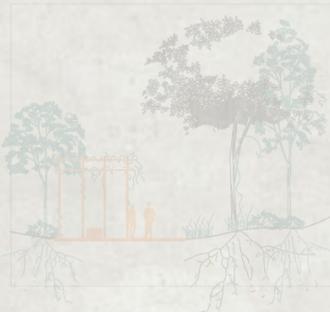
Green hedge improvement



New water conservation park



New green urban park



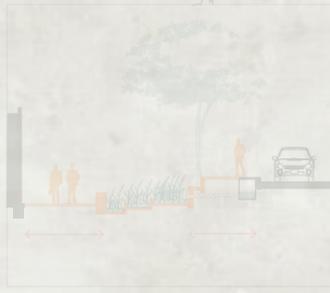
New green arches social pockets



Residential green improvement



New resilient housing



New urban features



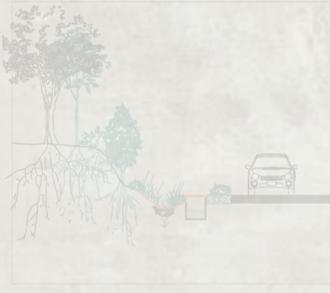
New main road profile



New road profile



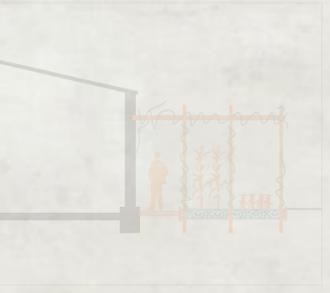
New street profil



New main road gutter



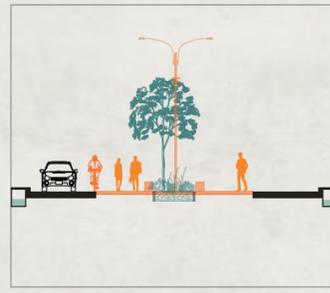
Roof water collecting Private tankaa



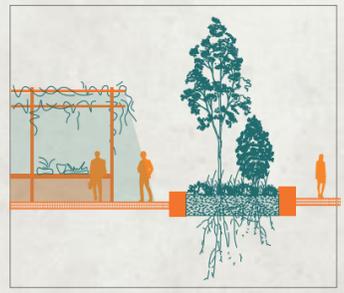
Sheltered productive garden



Private rain garden



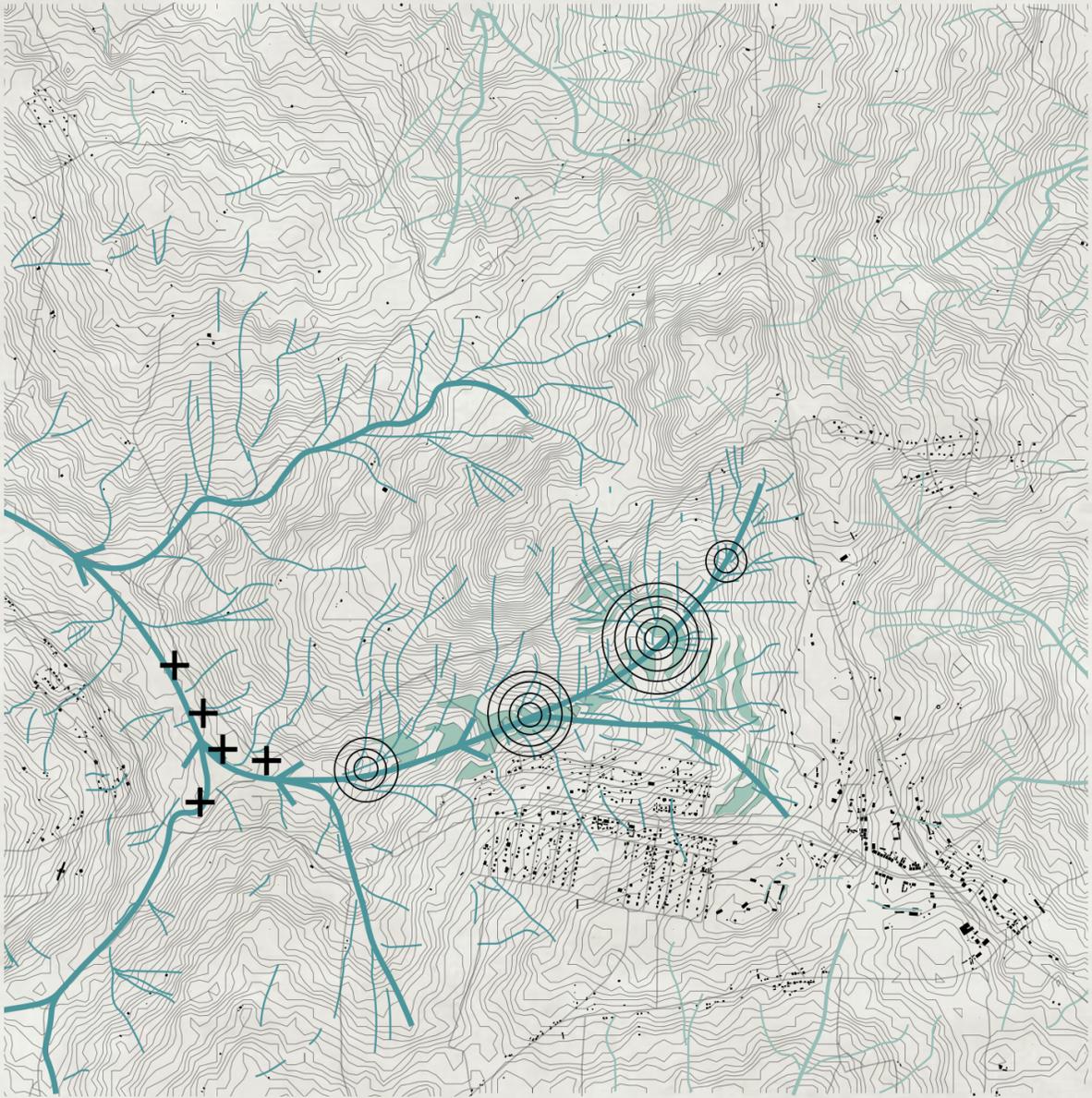
The road as part of the public spaces



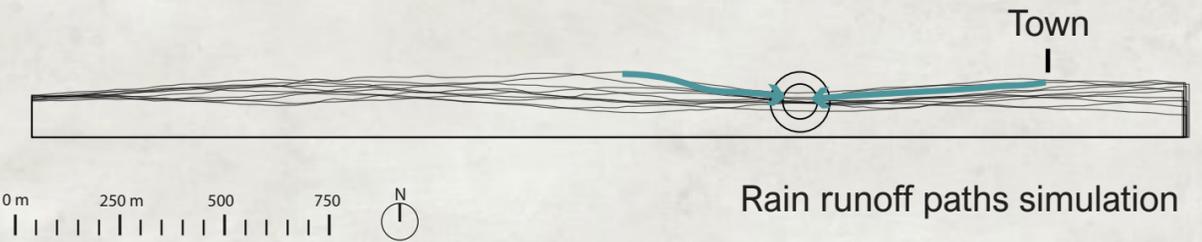
Drought resilient market place

Topography analysis

Micro-topography and rain paths

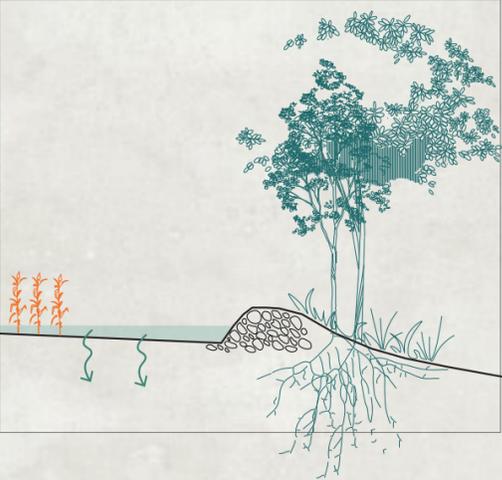


- Contour lines 2m
- Road
- Runoff paths for chosen catchement
- Other runoff paths
- ⊙ Concentration
- Buildings
- Potentiel basins and reservoirs
- + Natural humid zone



Interventions

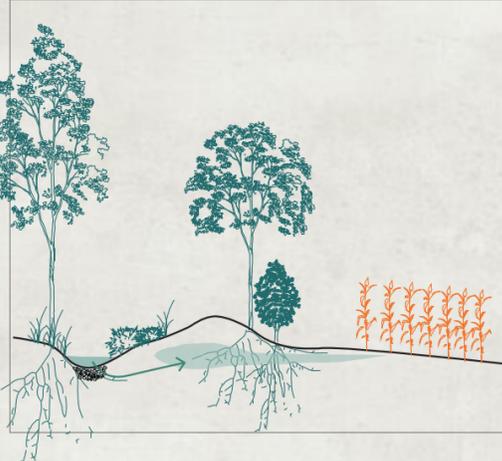
⊙
Agricultural basins
catching in the
depression



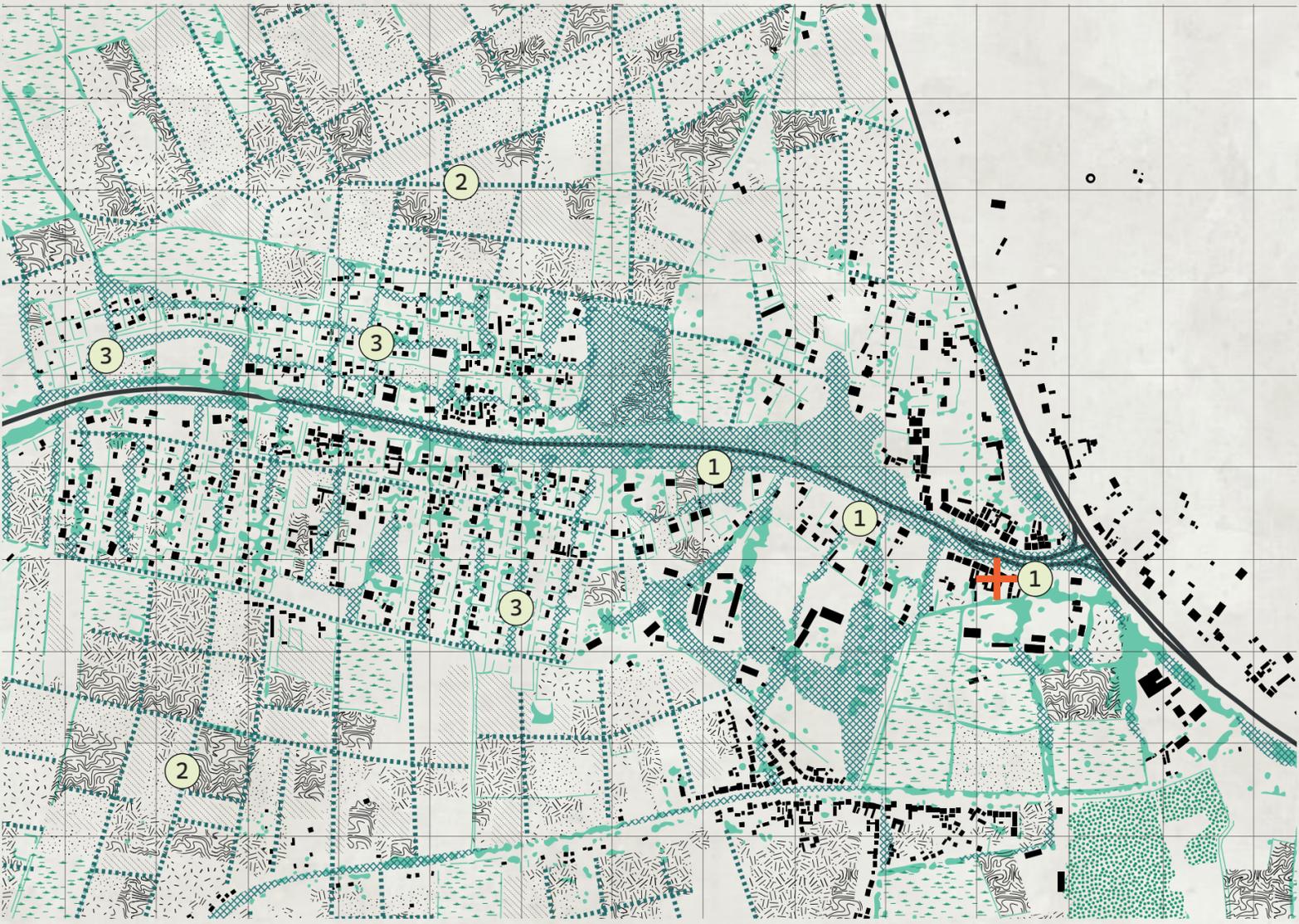
—
Reservoirs along
the rainpath



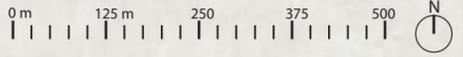
Channel :
topograpgy
irrigation



Fragmented green structure



- Contour lines 2m
- Road
- Buildings
- ▣ Crops
- ▤ Grazing
- Vegetation
- + Commercial area
- 150m
- ▣ New green patch
- ▤ New green hedge

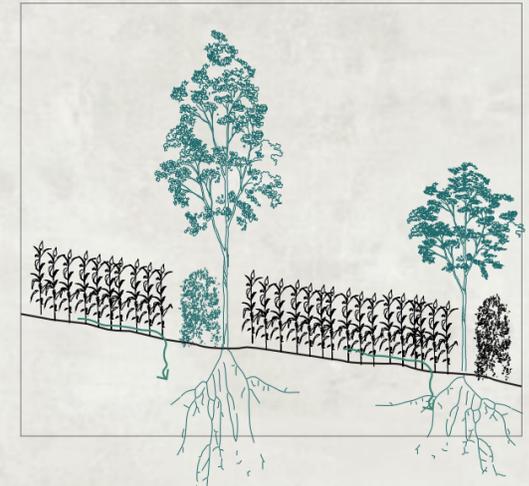


Interventions

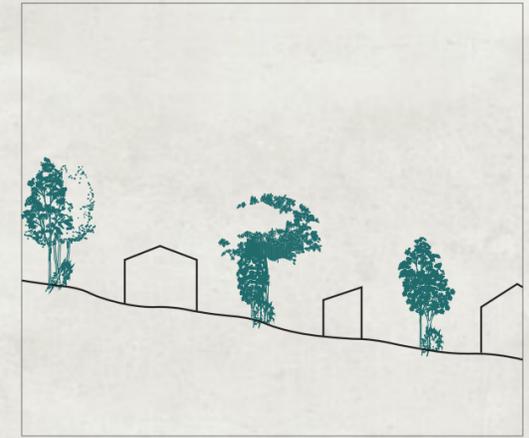
①
Tree line
improvement along
the main road



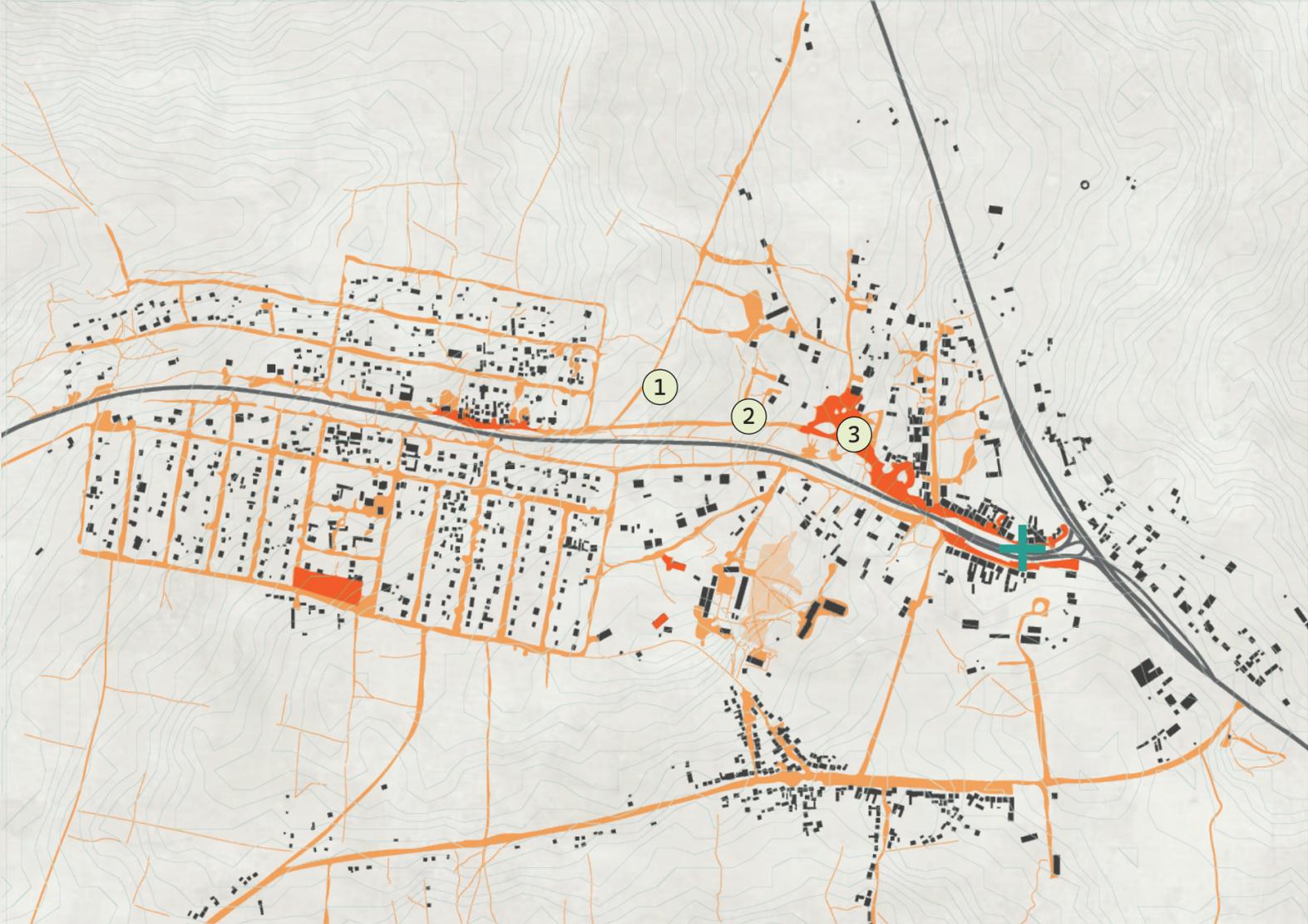
②
Hedge line
improvement along
the crops



③
Residential green
improvement in the
plots



Public spaces



- Road
- Buildings
- Social spaces
- + Commercial area



Interventions



①
Formal water conservation park
Humid microclimate landscape



②
Formal urban parks
Humid microclimate landscape

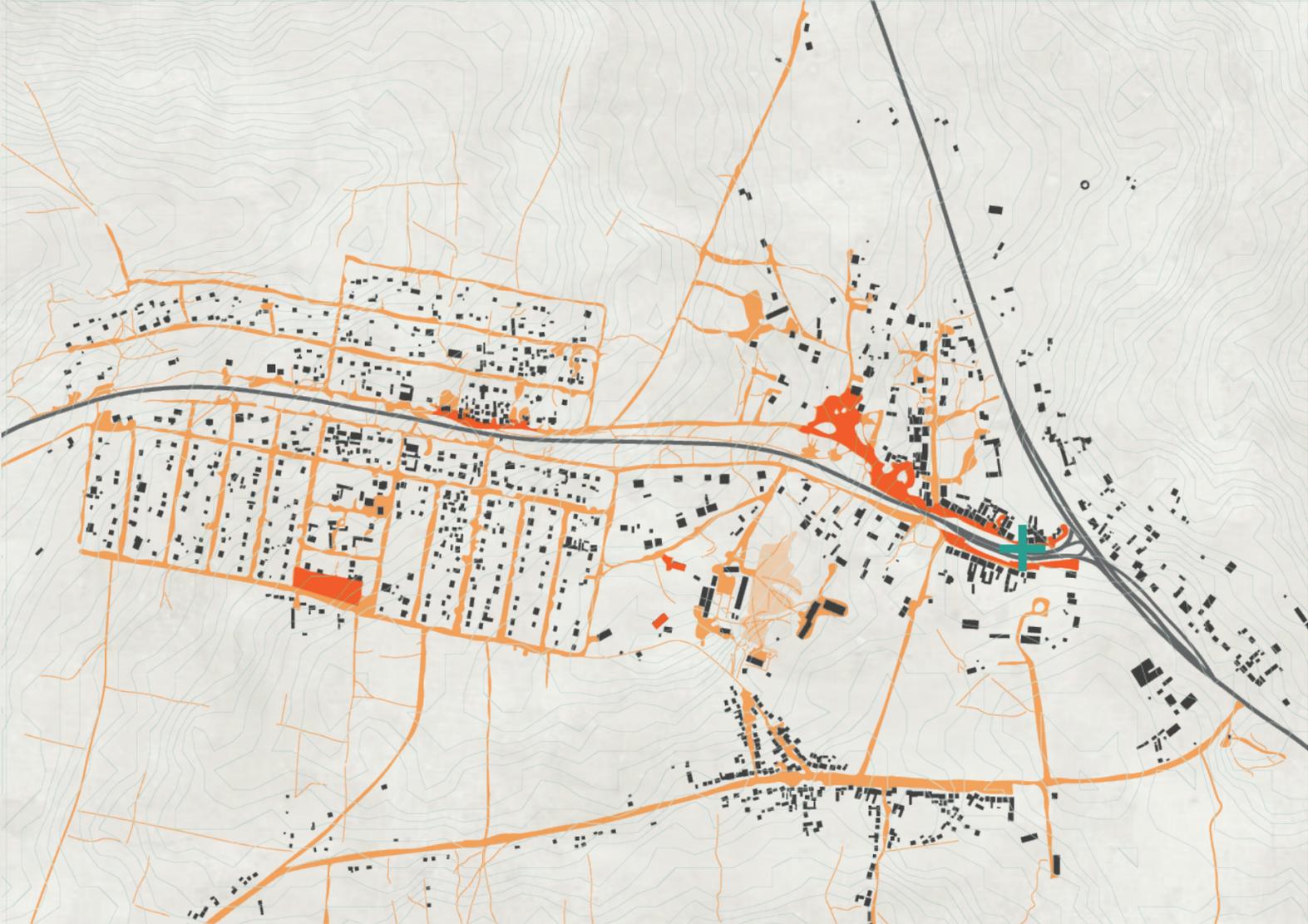


③
Formal market place
Drought resilient plants

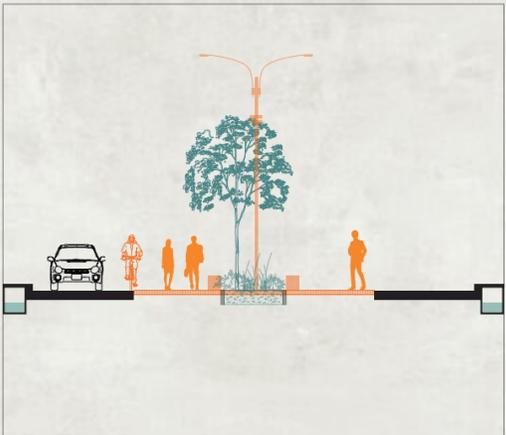


Public spaces

Intervention



+
Road as a public
space profile
Urban biodiversity

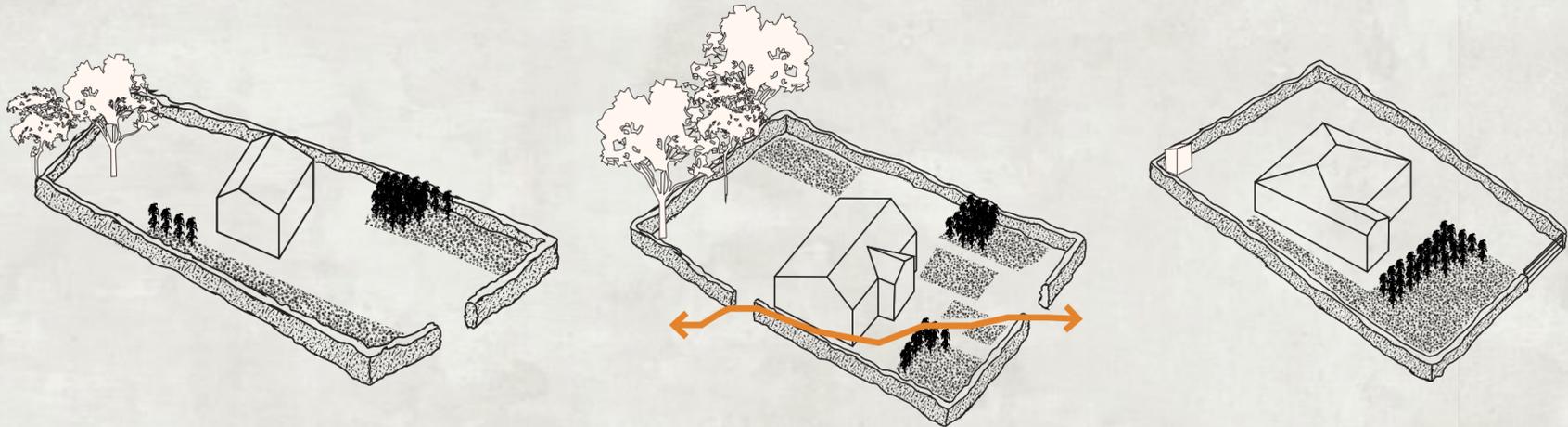


- Road
- Buildings
- Social spaces
- + Commercial area



New housing

Intervention

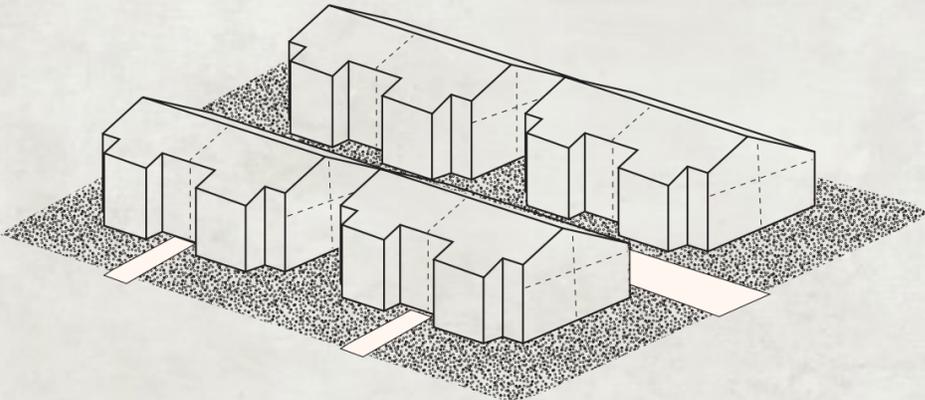


One entrance

Two entrances - walk through

Gated

Current living situation in Ryabega

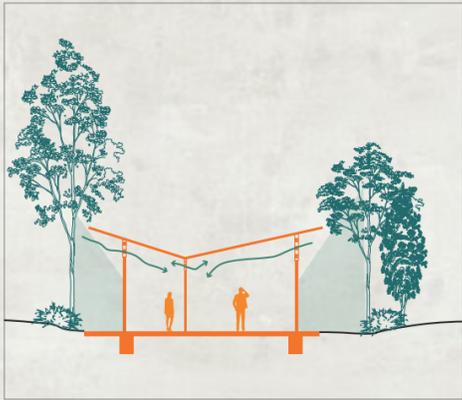


«Imidugudu» units in Nyagatare - Town nextdoor
Efficiency over spatial quality and living quality

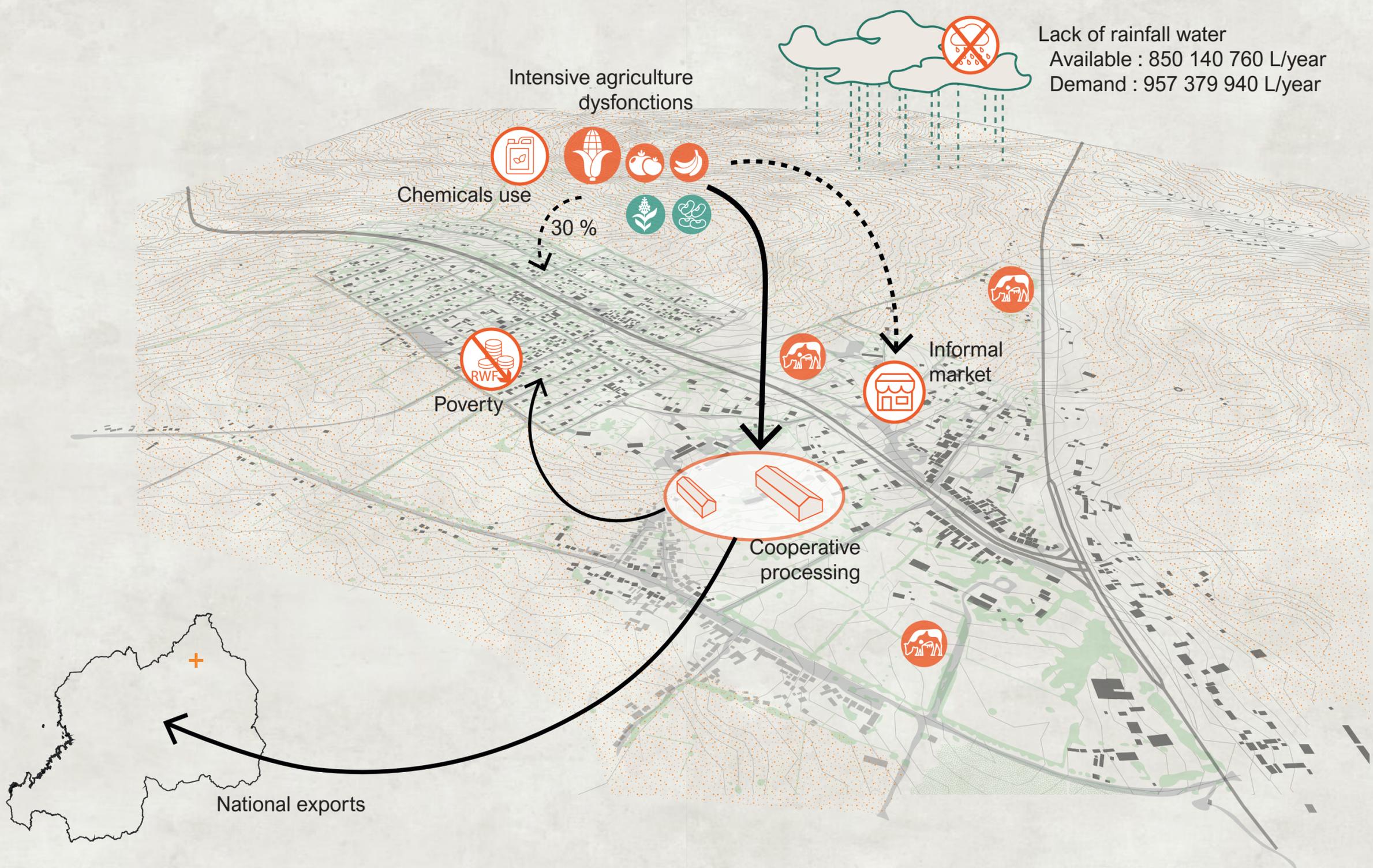
Surroundings tendencies



New resilient housing
+ units variations
Bioclimatic architecture



Intensive agriculture system



Transition

From Intensive agriculture system
To Revised rural landscape system

Rural transformation theory



→ **Cooperative organisations**

Revised rural landscape system

Interventions

New possibilities of productive landscape

Multifunctional productive landscape :
- Arid tolerant crops
- Local wood production

Transition to heat tolerant crops and less water needs

Alternative agriculture practices



Lack of rainfall water
Available : 850 140 760 L/year
New demand : - 30% than previous

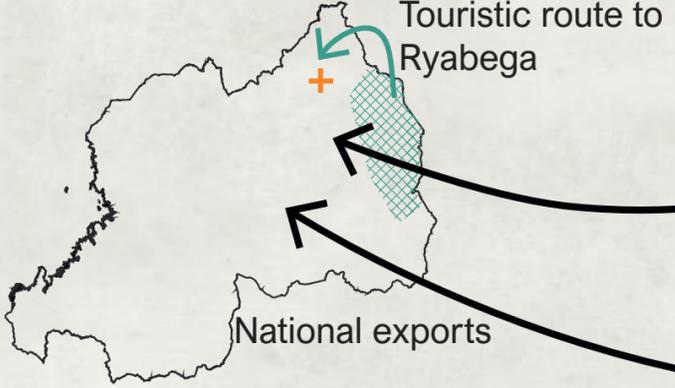
New activities



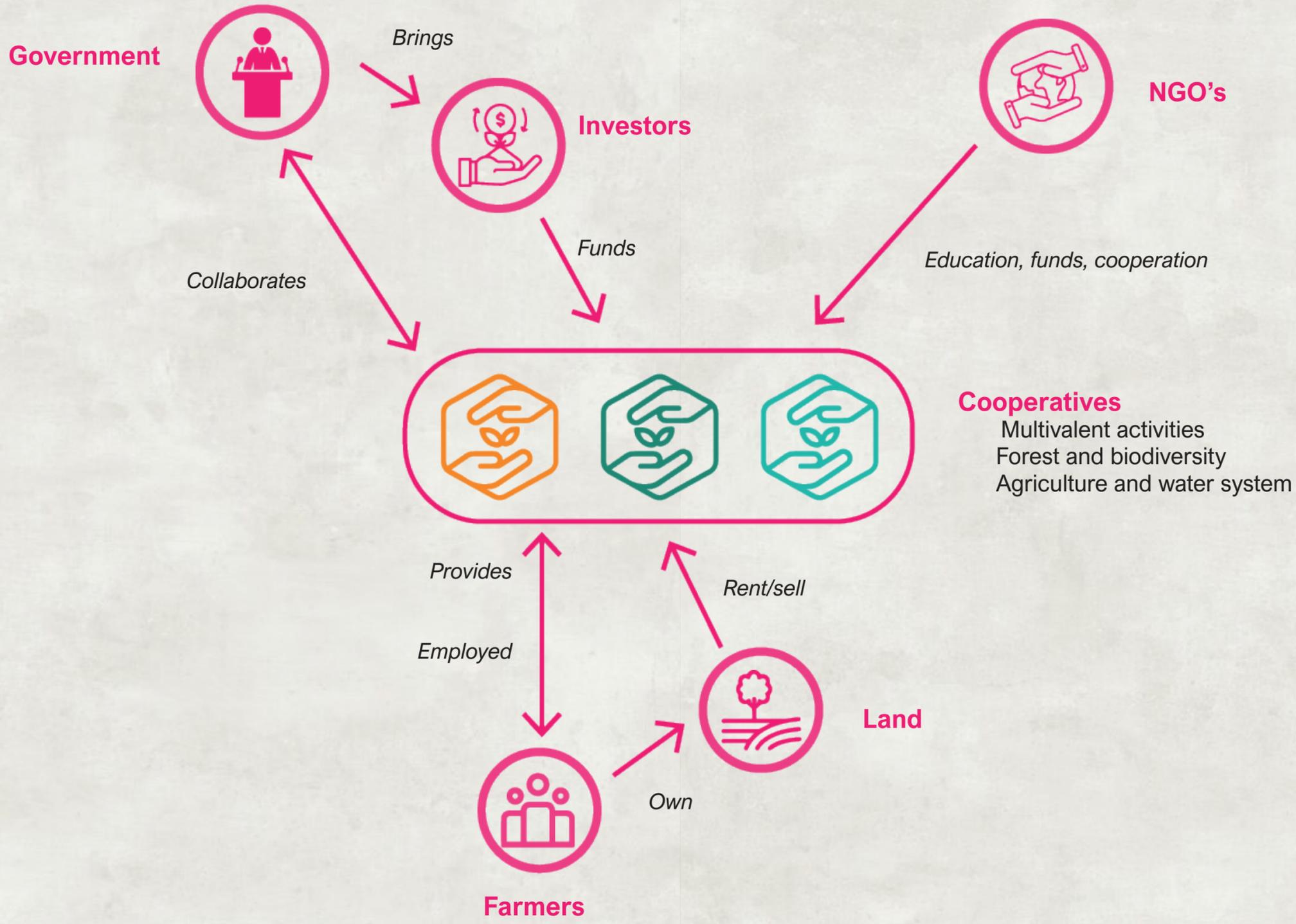
Town cooperatives for water and landscape management

Formal market place

Cooperative processing units



Land ownership



Conclusion

Potentials and landscape intentions

- Potentials basins/reservoirs
 - ▨ Spatial design intervention potential
 - Existing social space
 - ⊕ Zoom-in intervention
 - Rainwater runoff
 - ⊙ Rainwater concentration
 - Public drinking water access
 - Buildings
 - Road
 - Contour lines 2m
- 200m





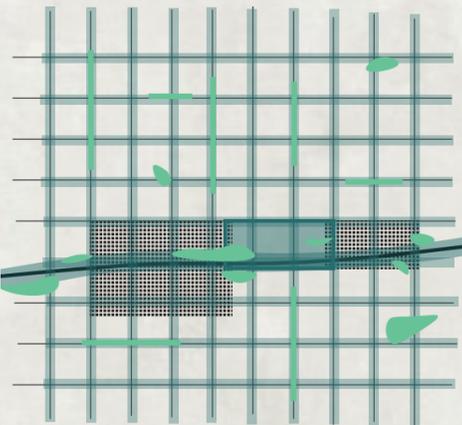
Euphorbia candelabrum

Living with droughts

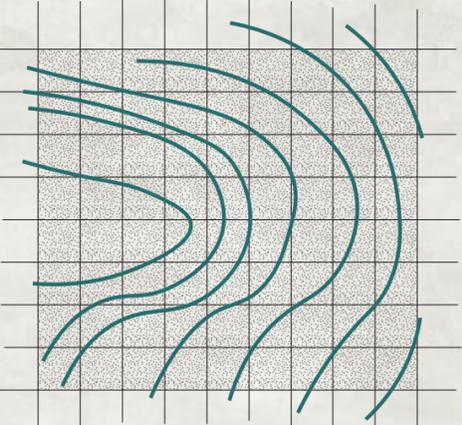
Pennisetum purpureum

Design concept

Green, water and social layers



Fragmented to structured green



Water connections to the landscape



Social and urban connections



Concept diagram

Concept steps

Master plan

Interventions and program

-  New urban green and water conservation park
-  New green village : rain gardens, roof harvesting
-  Seasonal agricultural basin
-  Reservoir
-  Reserves for bird habitats development, bird watching
-  Productive forest
-  New green structure
-  Existing fragmented green structure
-  New gutter system
-  Swale, irrigation channel
-  Linear raingarden channel
-  Public drinking water access
-  Contour lines 2m



Master plan

Productive rural landscape



Irrigated agriculture with the water system

Afforestation and productive forests

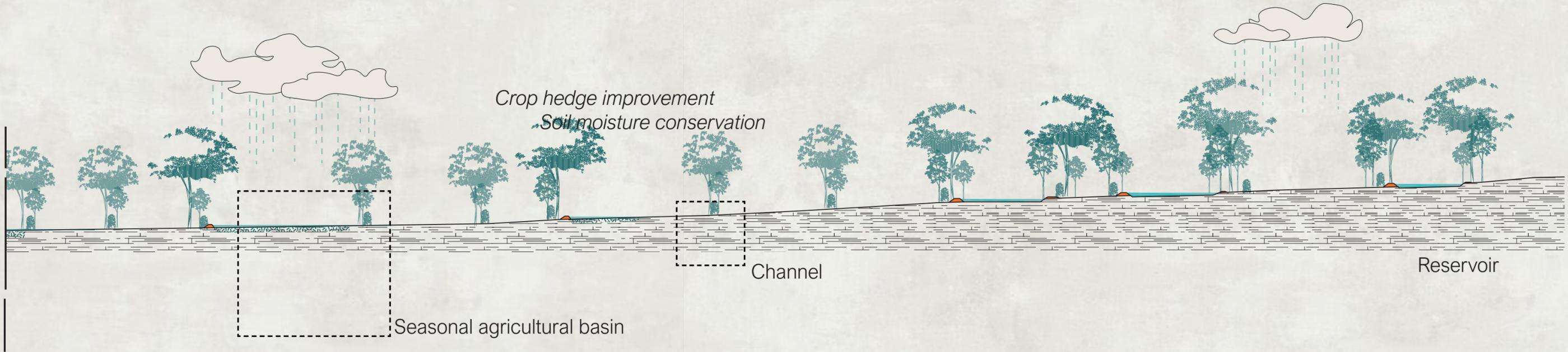
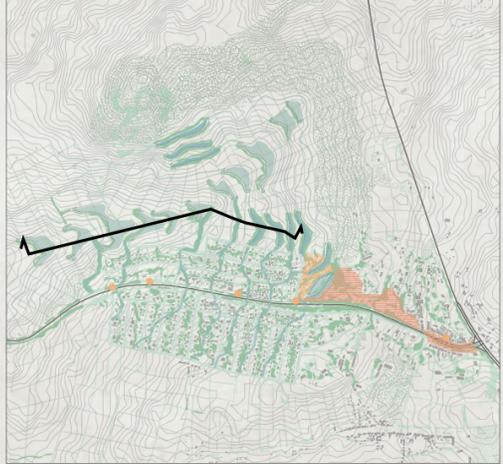
Multivalent productive landscape

Housing development opportunities

Seasonal basins: 88 196,77 m²
Reservoirs: 21 234.9 m²
Reservoirs can collect 31 852 350 L/year
Irrigation capacity : 63% of current crops.

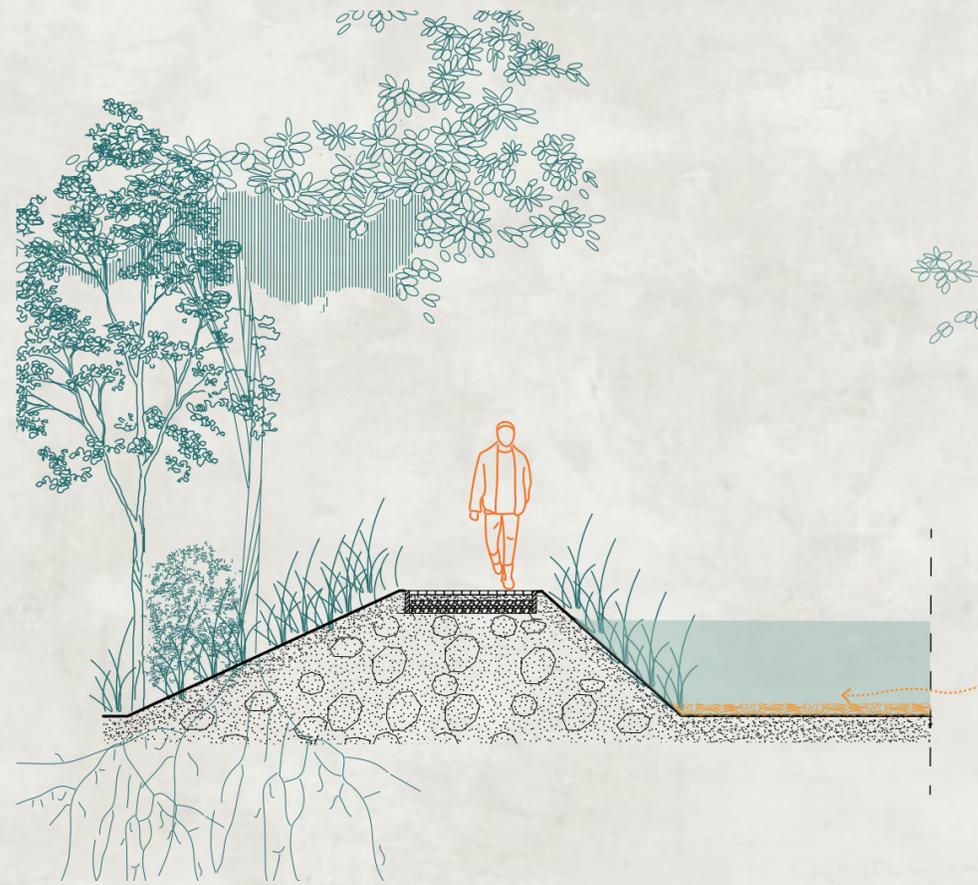
Water system

Water journey section

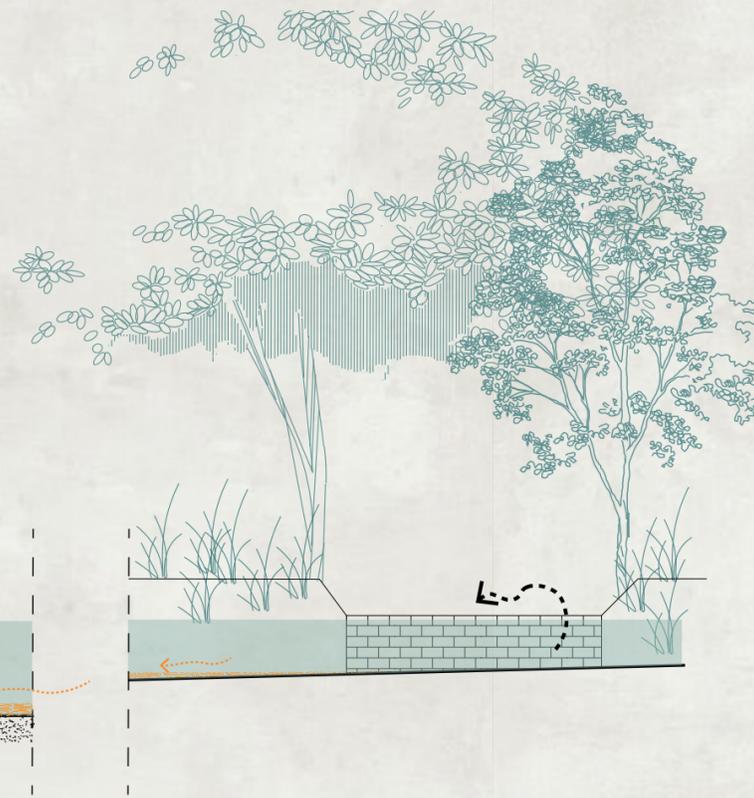


Water system

Collecting and distributing



Agricultural basin detail



Overflow wall detail



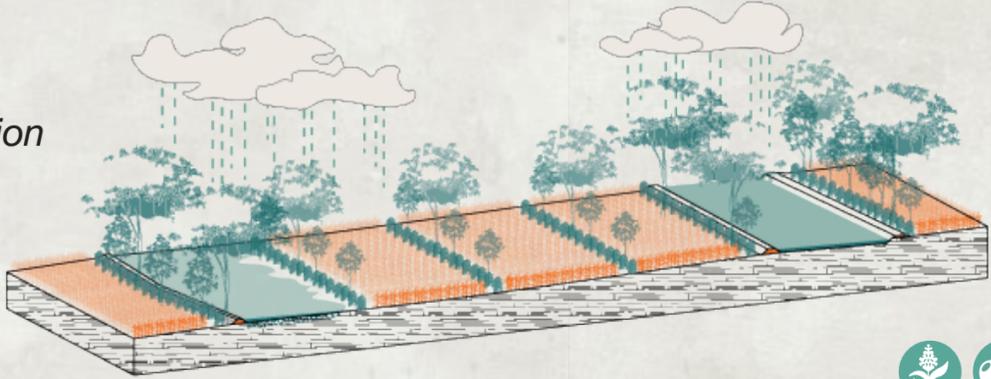
Irrigation channel detail



Water system

Seasonality

Long rain season
September -
Growth - Rain irrigation

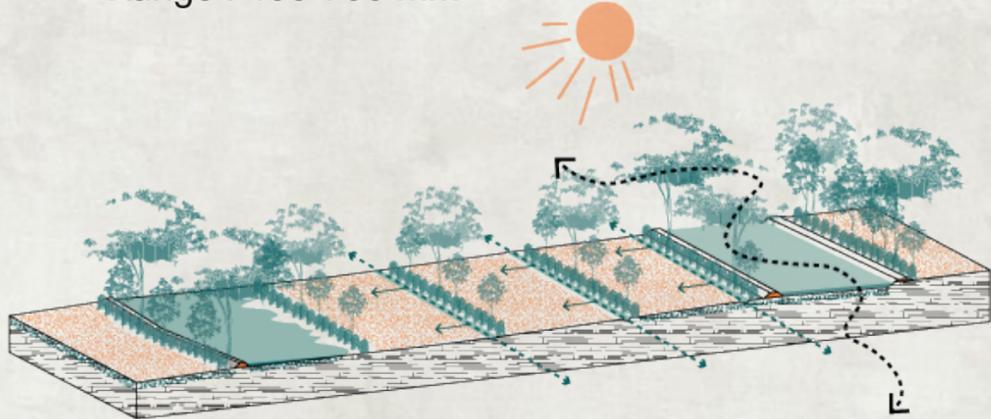



Range : 400-700 mm



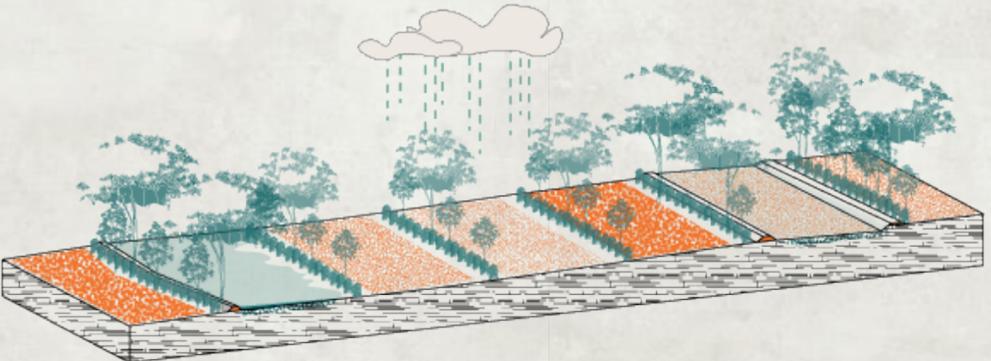
Long dry season
June - September
Growth - Seasonal basins irrigation


Arid crop types



Short dry season
February - April
Sowing - Reservoirs and channel irrigation

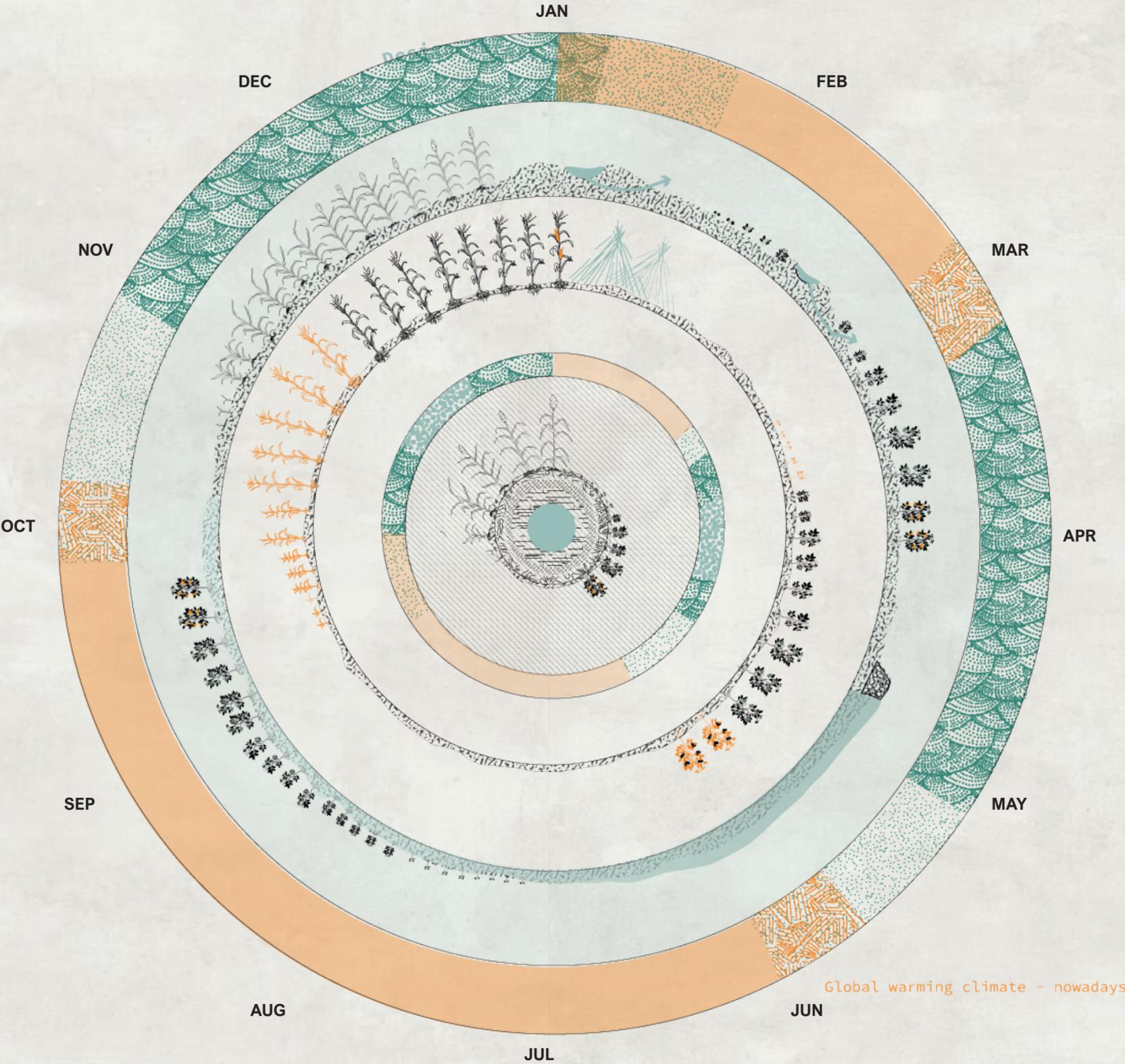

Range : 300-500 mm



Short rain season
March - June
Growth - Rain irrigation

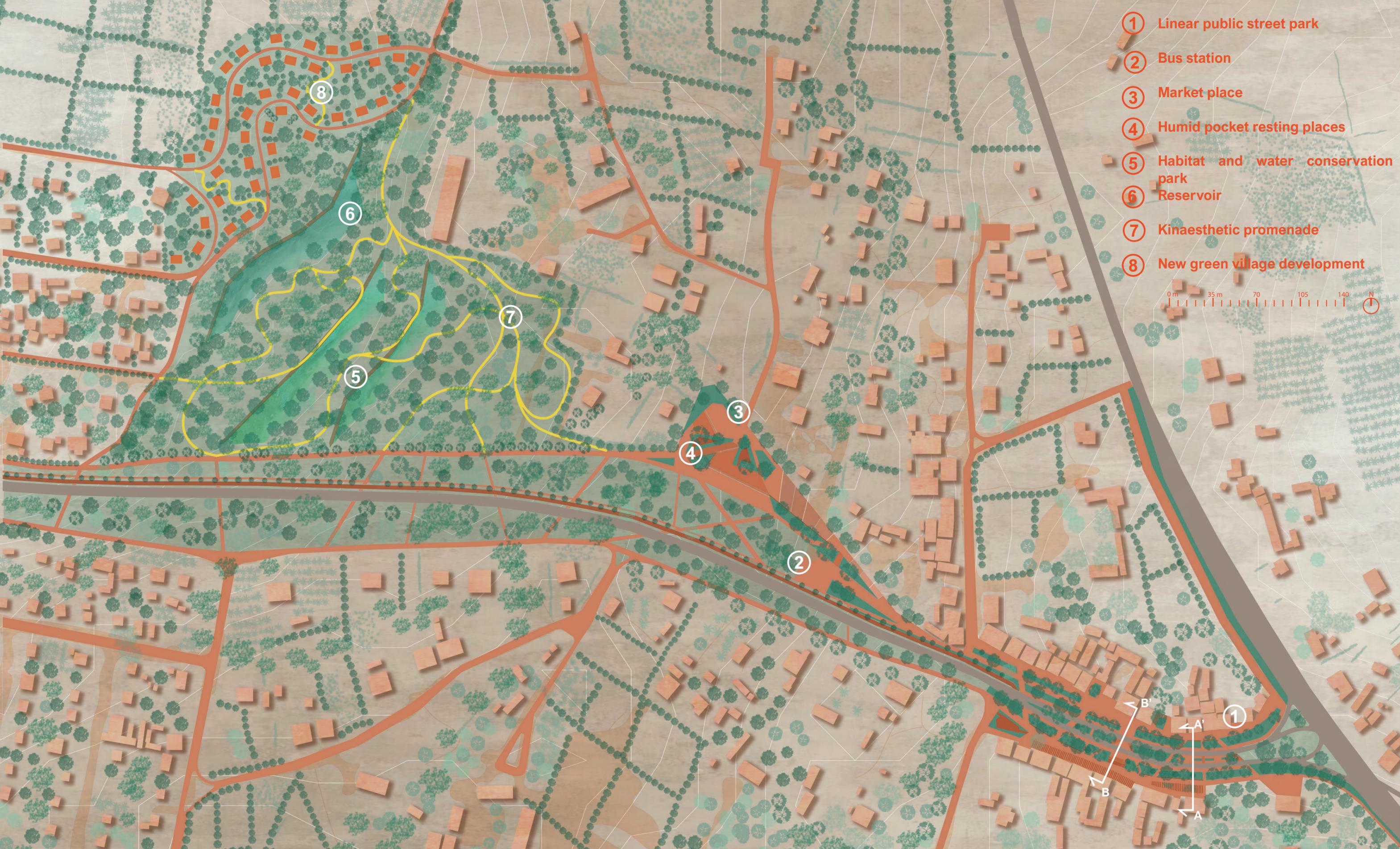
Water system

Year cycle

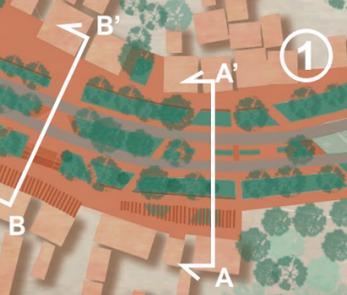




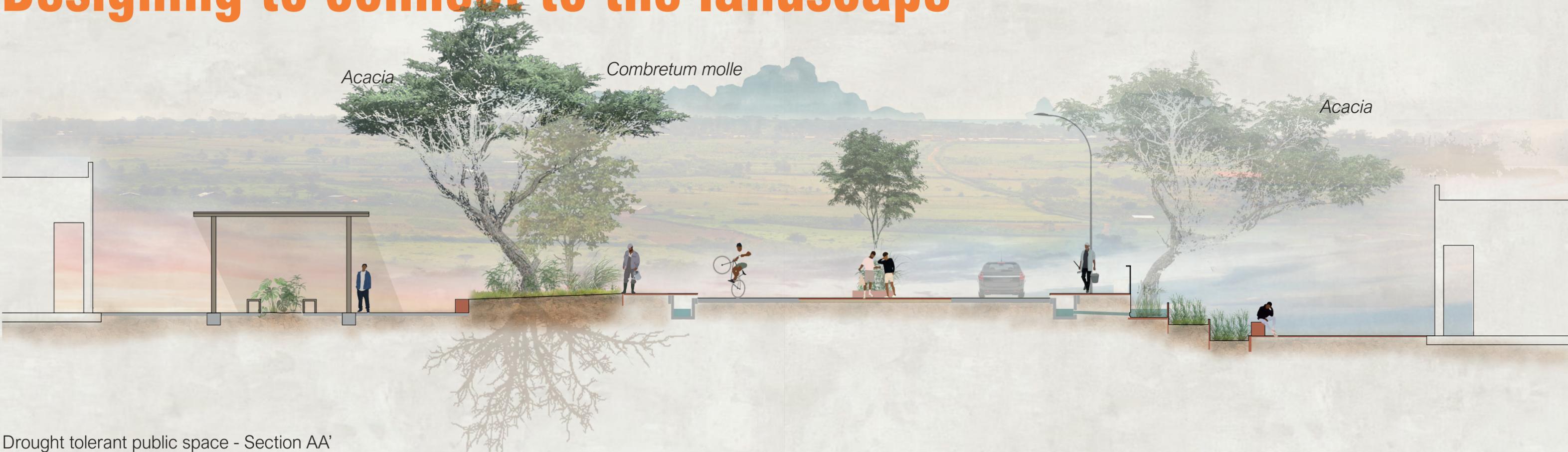
Rural design zoom-in



- ① Linear public street park
- ② Bus station
- ③ Market place
- ④ Humid pocket resting places
- ⑤ Habitat and water conservation park
- ⑥ Reservoir
- ⑦ Kinaesthetic promenade
- ⑧ New green village development



Designing to connect to the landscape



Drought tolerant public space - Section AA'



The road as part of the public space - Section BB'

0m 125cm 250 375 500



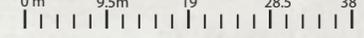
Designing to connect to the landscape



Market place - Section CC'



From residence to natural park - Section DD'





Designing to live in the landscape

Microclimates ecology



Building experiences with soil and earthen materials



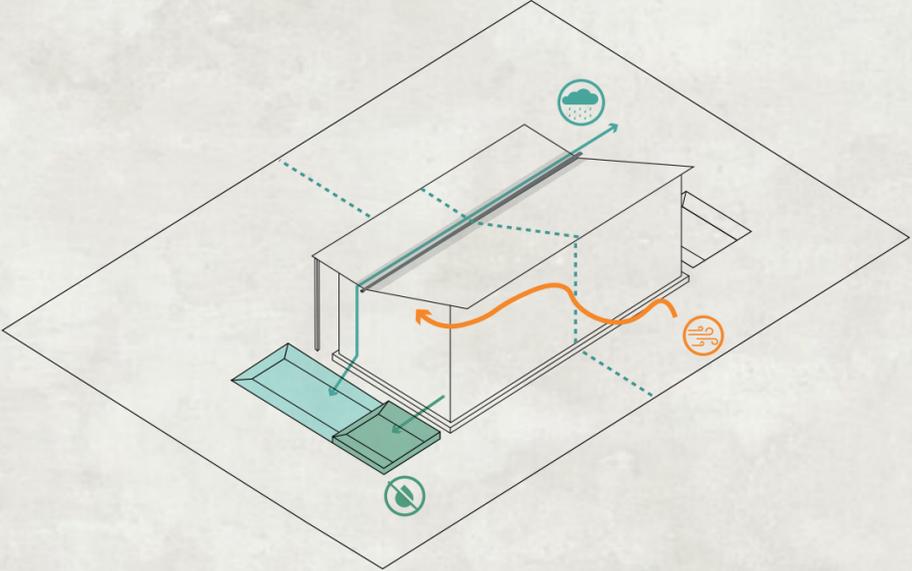
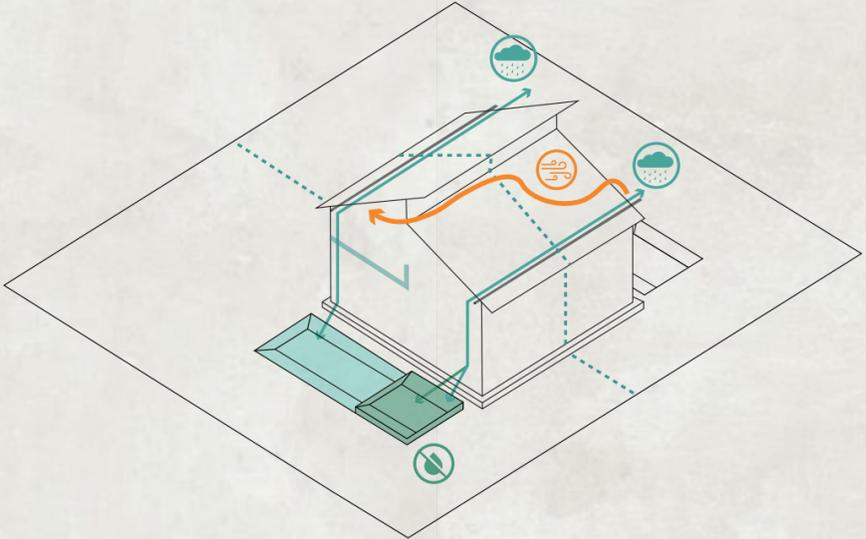
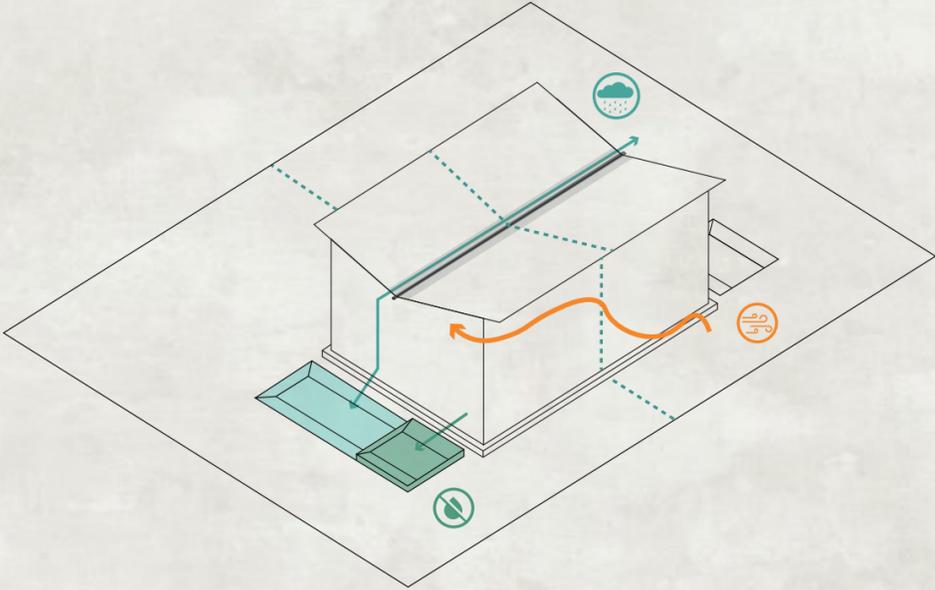
Urban humid pocket



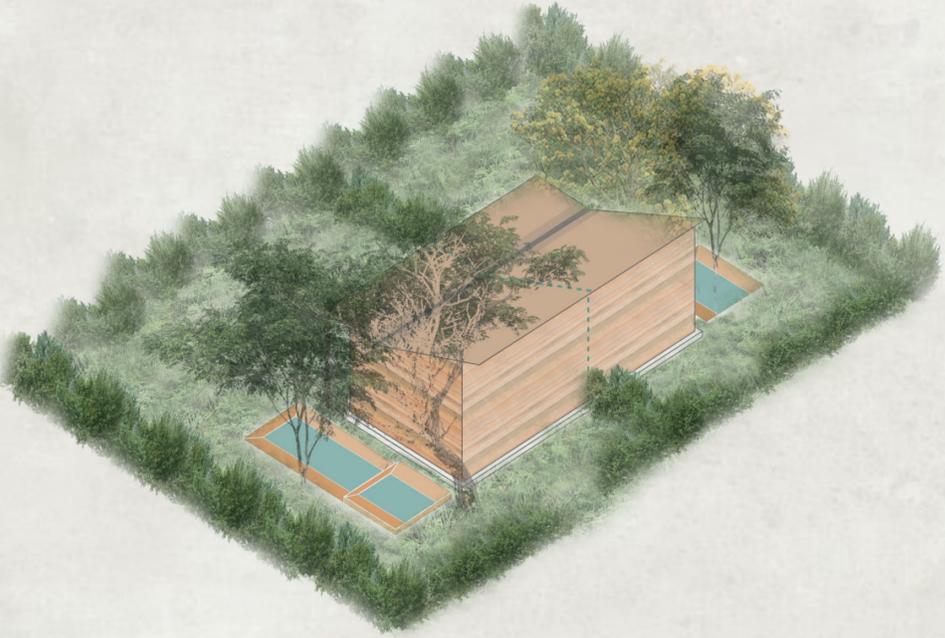
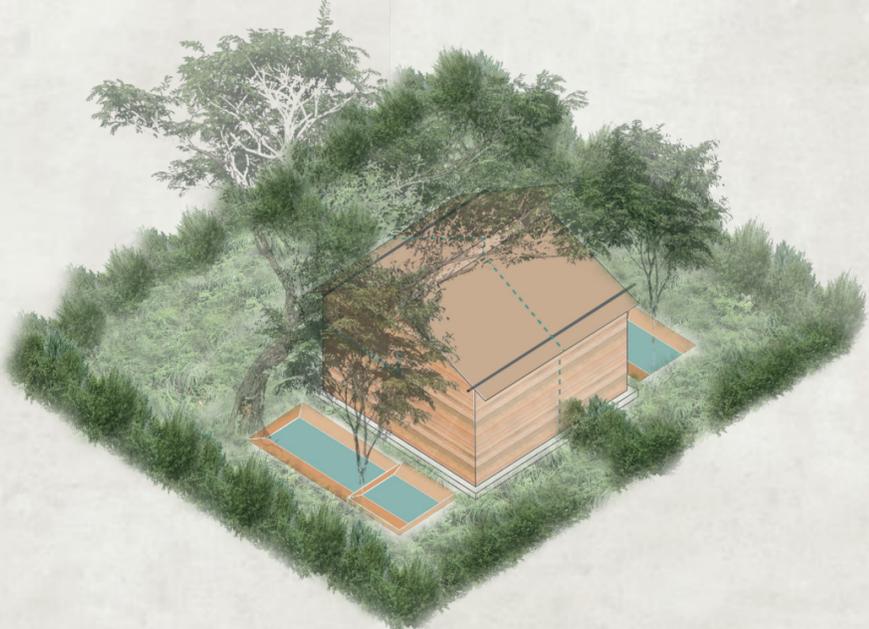
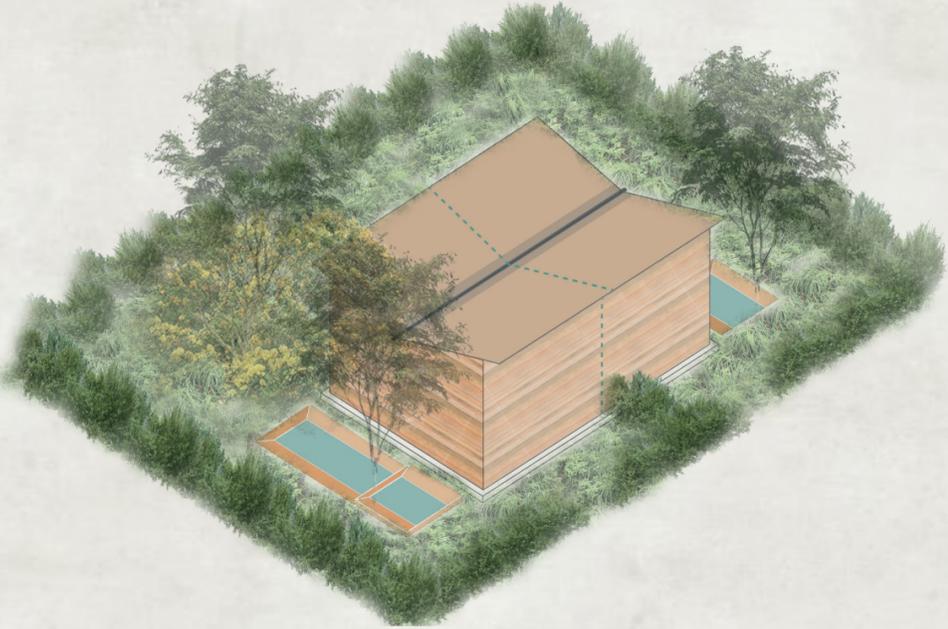
Resilient housing

0 m 55cm 110 165 220

Two-units houses - Rain and wind harvesting roof techniques



Bioclimatic architecture - Humidity conservation

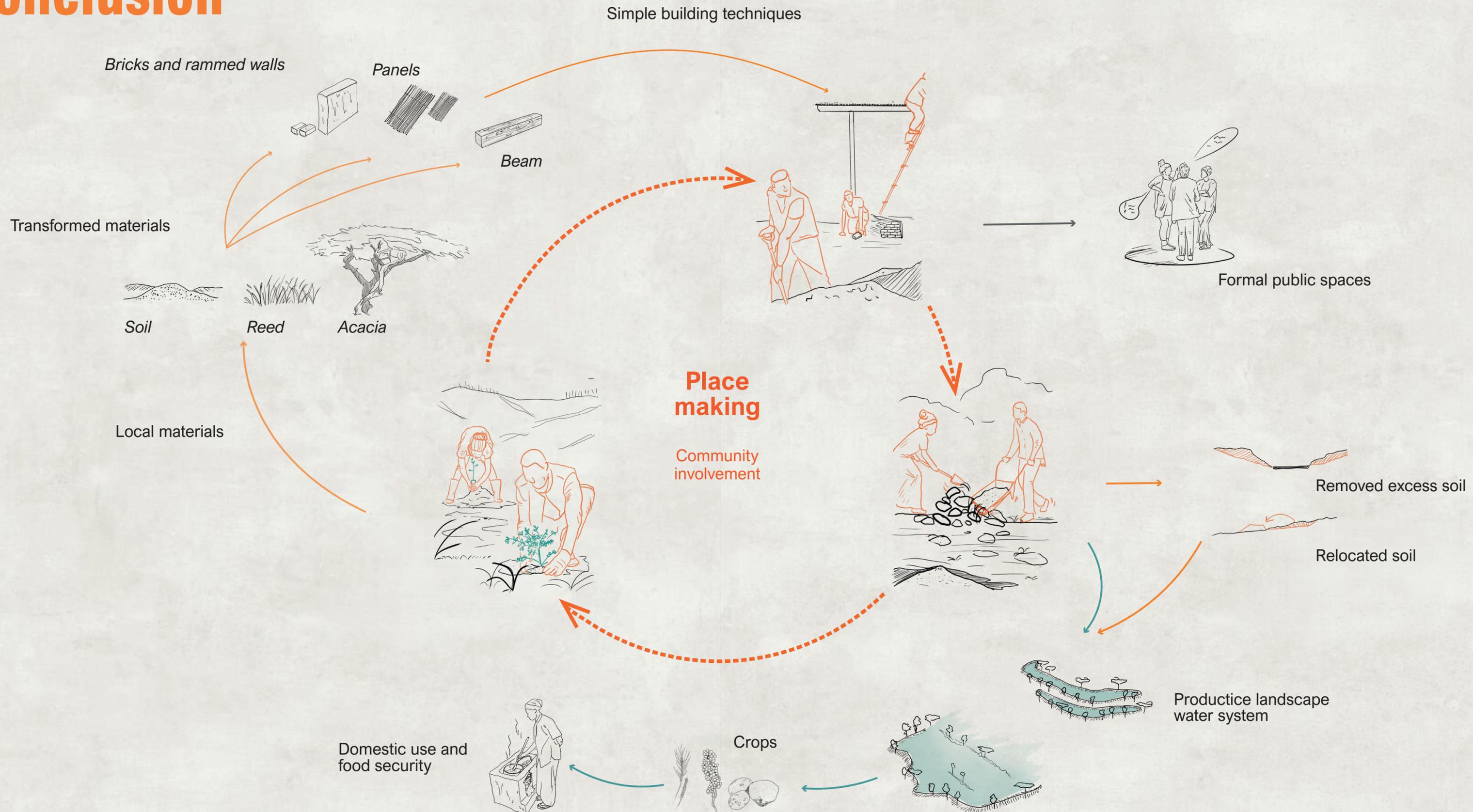


Double slope roof

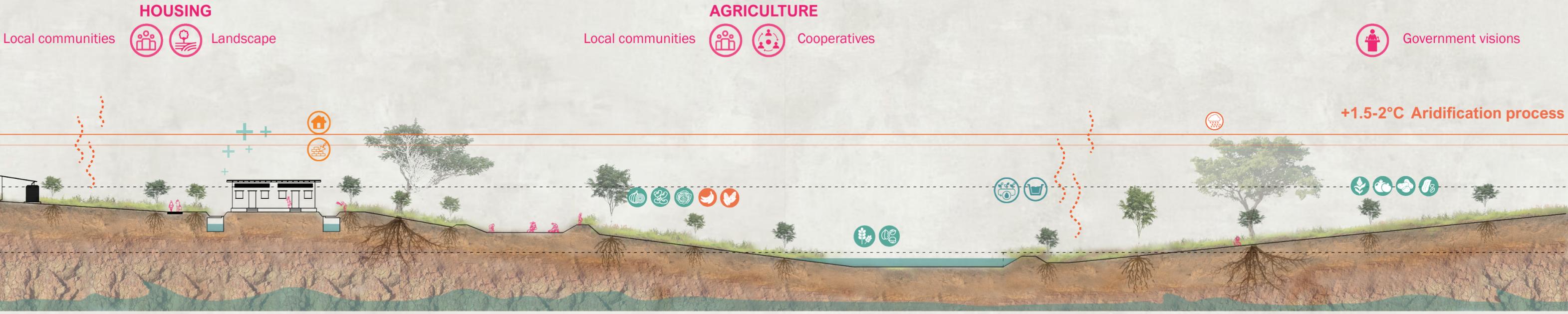
Two-level house

Private pergola roof

Conclusion



Reflection



Ryabega landscape and soil story - Now to 2 years

HOUSING

Local communities Landscape



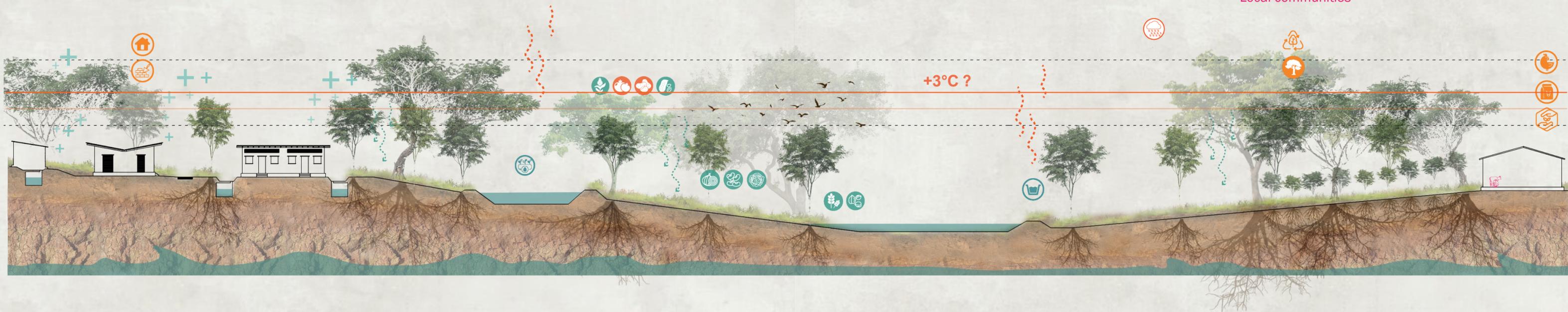
AGRICULTURE

Local communities Cooperatives Landscape

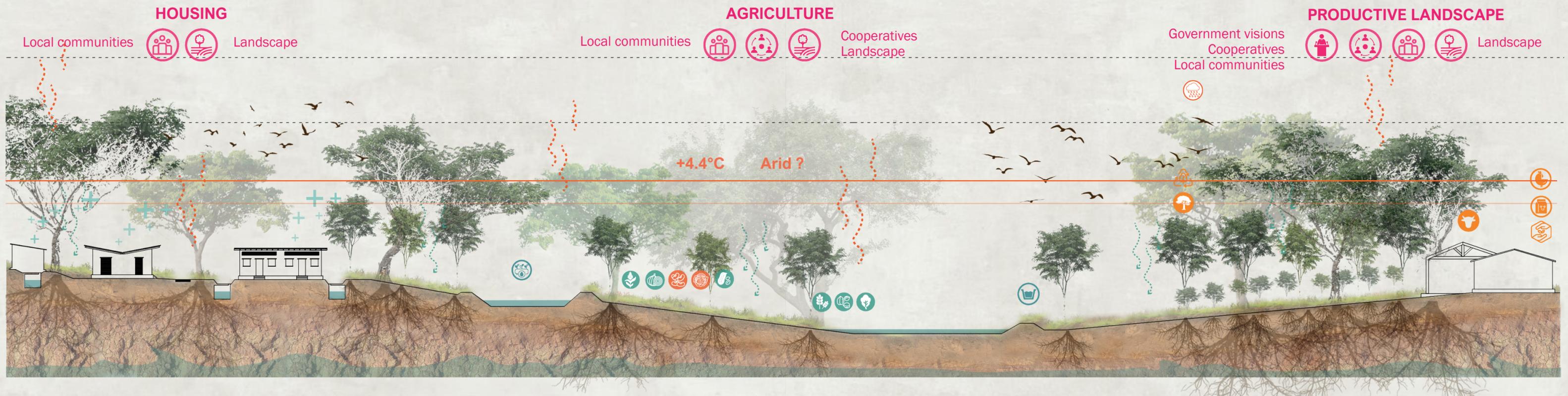


PRODUCTIVE LANDSCAPE

Government visions
Cooperatives
Local communities



Ryabega landscape and soil story - 2 years to 10 years



Ryabega landscape and soil story - 20 years to 100 years

Thank you!
Merci !
Dank u wel!

