100M

Exploring algorithmic design methodology
for emergency settlement design.

Education

2022 - 2023
Royal Academy - Master's in Architecture,
Strategic Design and Entrepreneurship

2021-2022
Royal Academy - Master's in Architecture,
Computation in Architecture

2017 - 2020
Royal Academy - Bachelor's in Architecture,
Architecture and Design

Experience

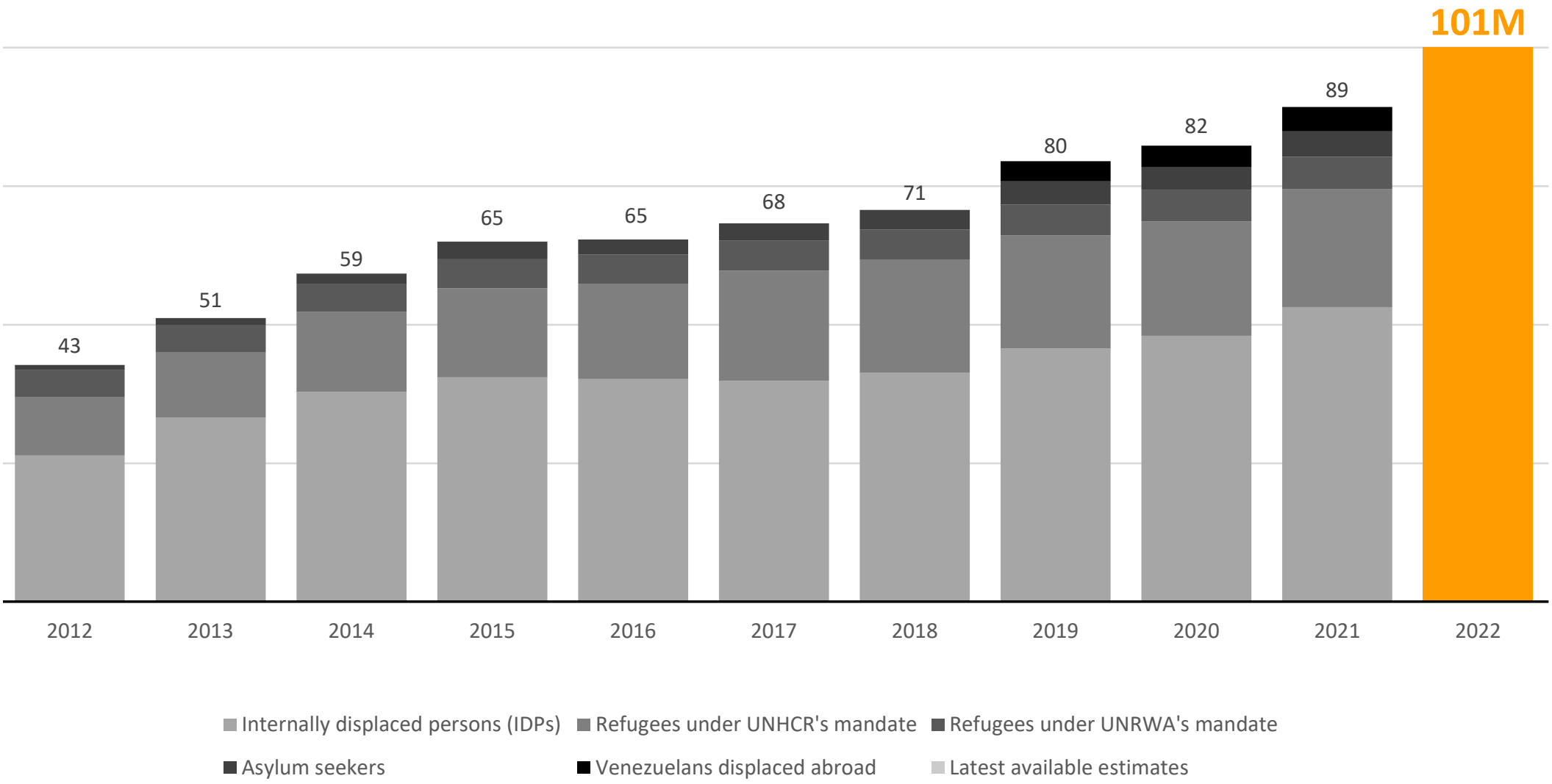
2022 - 2023
Enyday - Researcher,
Desktop research for sales, business cases and funding. Contact with stakeholders.

2021-2022
Bollinger+Grohmann - Freelance Research Assistant,
Assisting PhD Candidate, with DQN part of AI plugin for grasshopper

2017 - 2020
Cobe - Architect BA,
Design work on competitions and projects in Sweden

2017 - 2020
KHR - Architect BA,
Design Work on competition, model making

2017 - 2020
Adept - Architect Intern,
Design Work on competition, model making

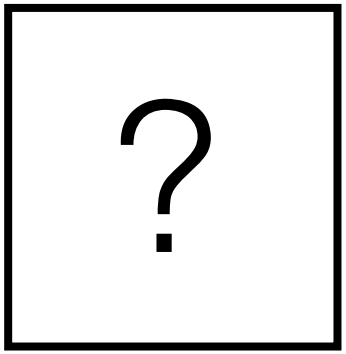


Graph recreated from existing data by UNHCR (UNHCR, 2021)

Decoding spaces

Urbano

Open AI



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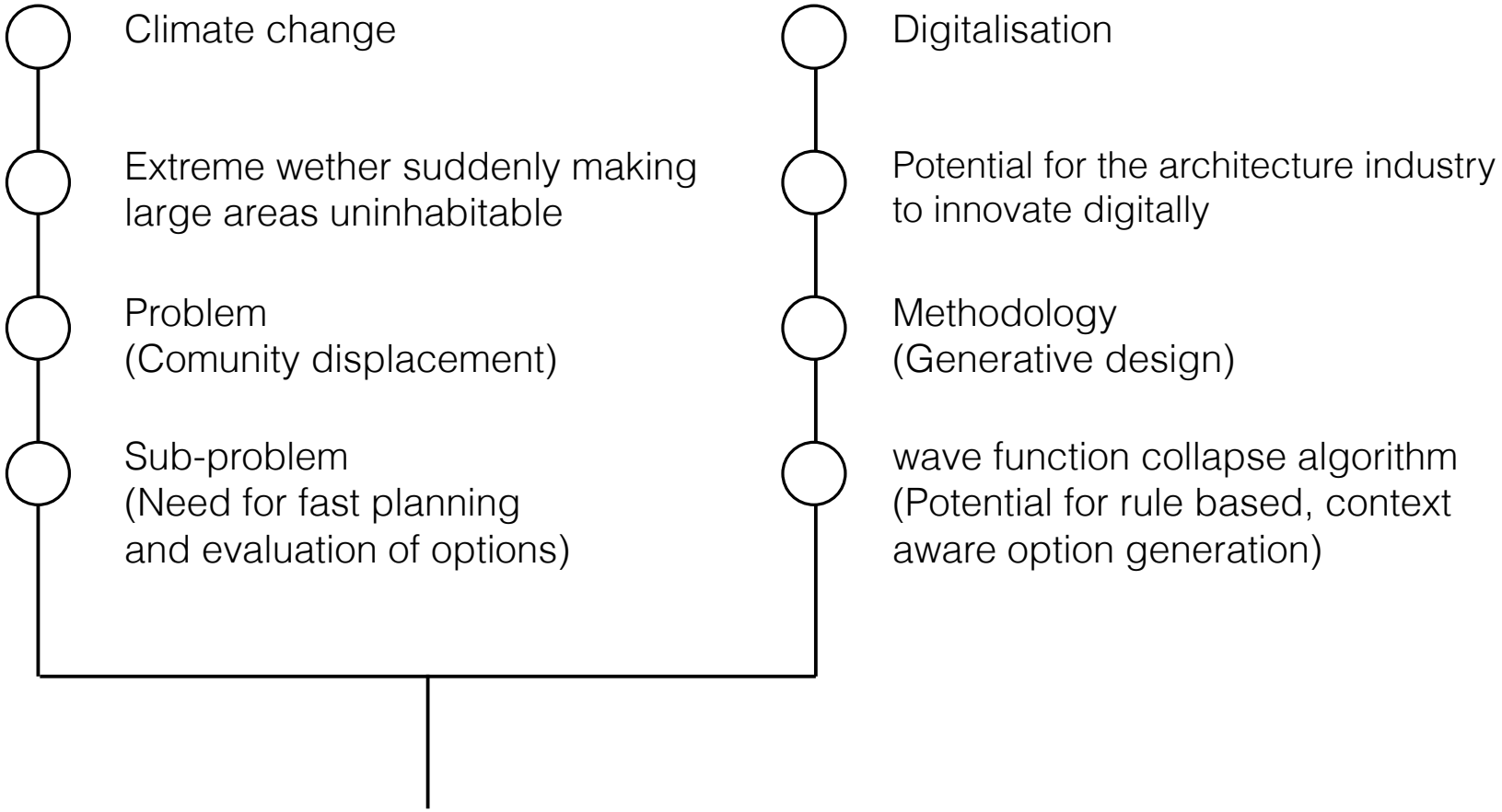
Wave function collapse



How can the wave function collapse algorithm help speed up, and, or improve the planning of emergency settlements by fast generation of design proposals?

Project objectives are:

1. To explore the wave function collapses potential as a design methodology.

2. To demonstrate how it can be applied through a case study, producing an alternative design to Azraq, Jordan.

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Case selection

Problem definition

Approach

Methodology

Application

Design

Discussion

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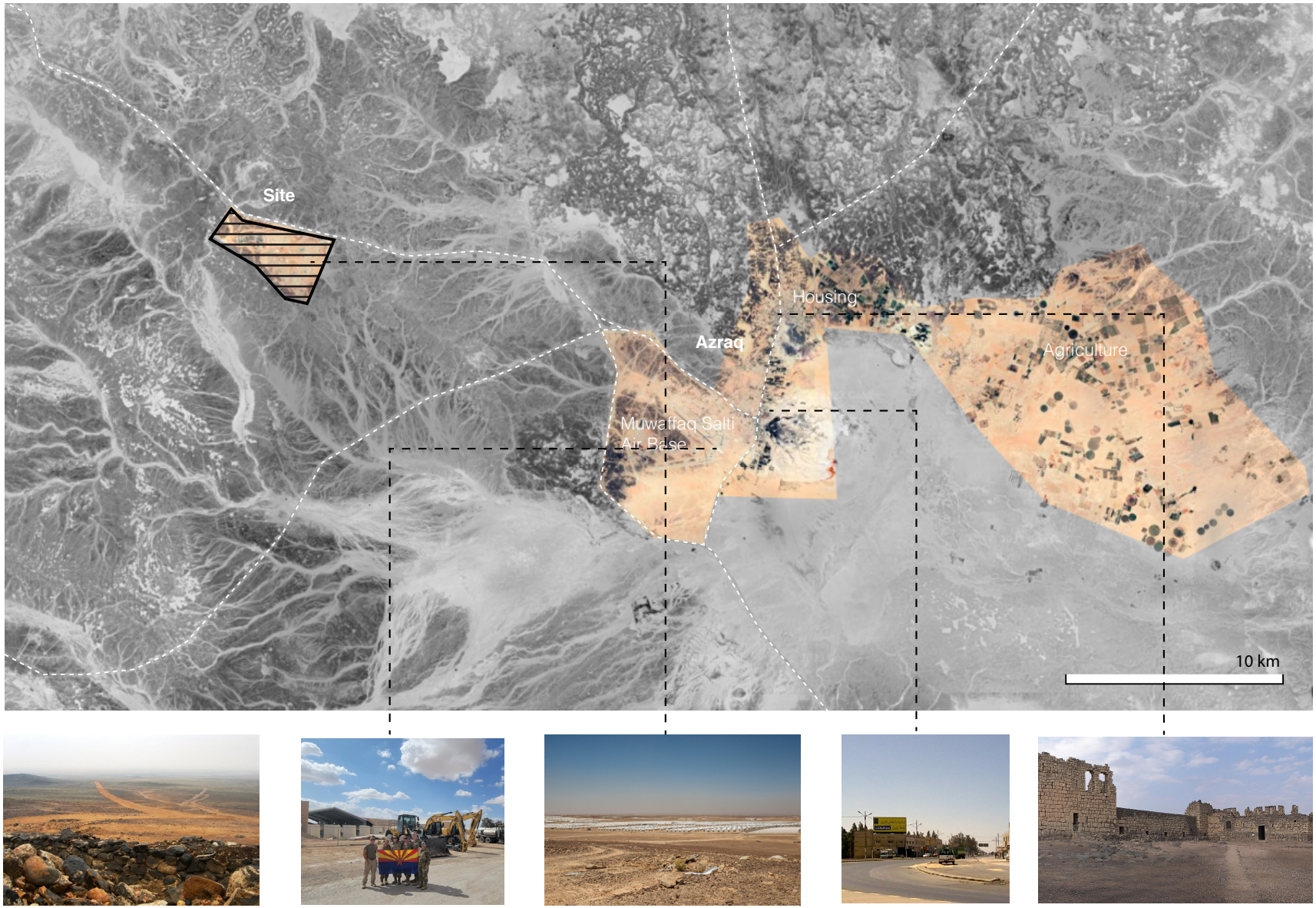

Site
Azraq
Housing
Agriculture
Muwaffaq Salti
Air Base
10 km

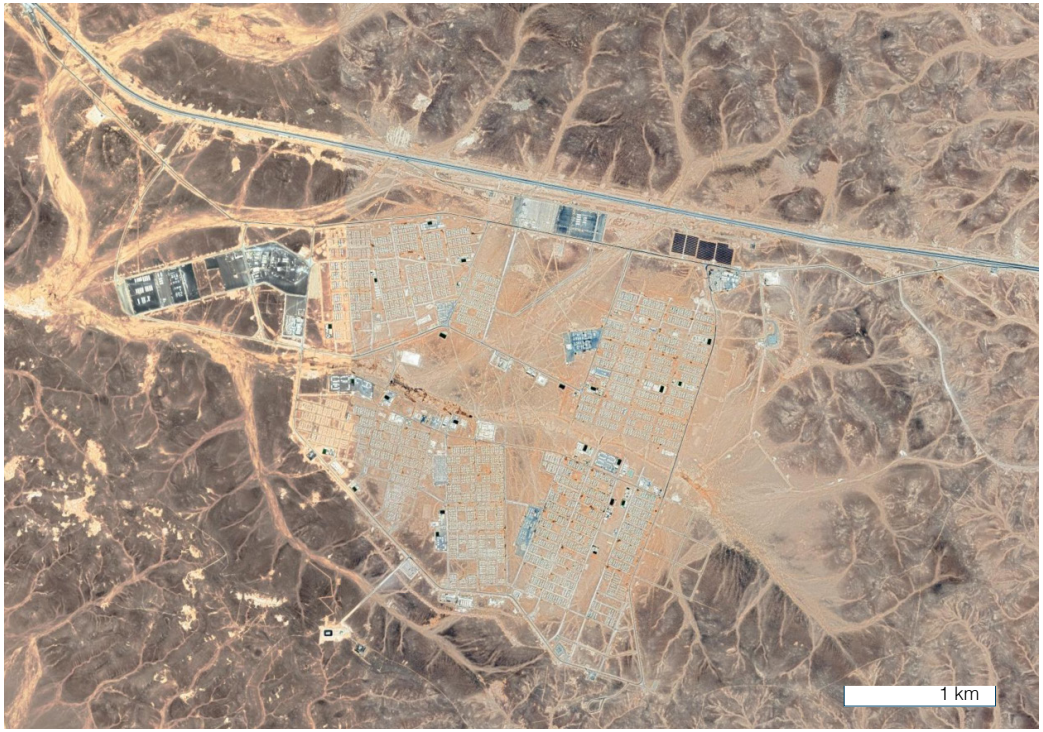


Fig 1

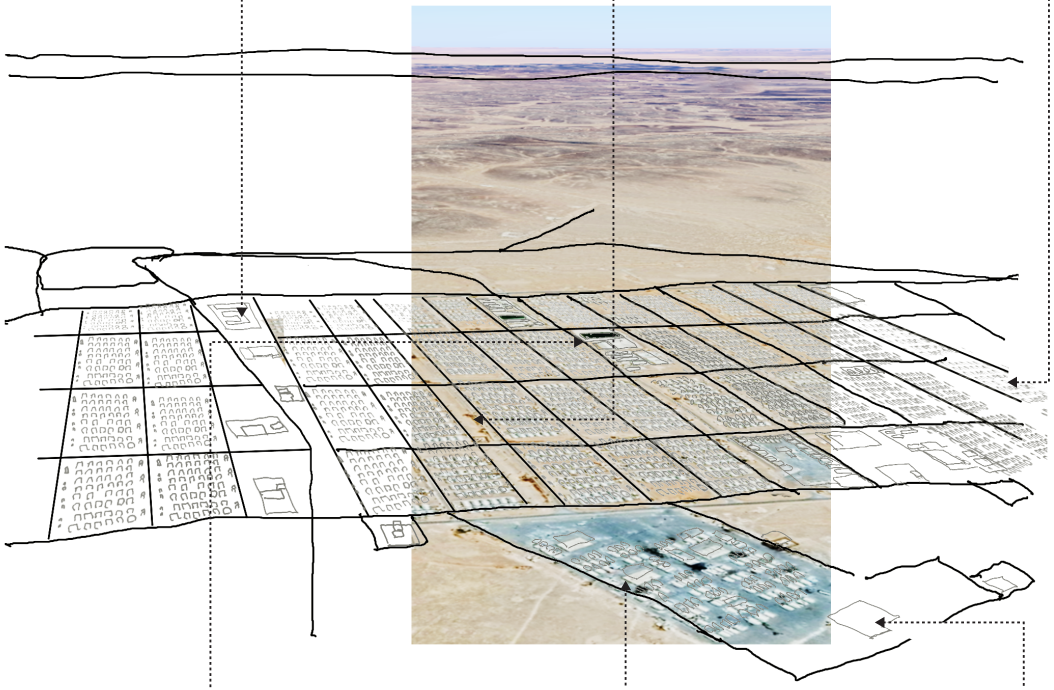
Fig 2

[1] Azraq view (Google Earth, 2023) (1), [2] Copenhagen view (Google Earth, 2023)

School

Wash units

Shelters

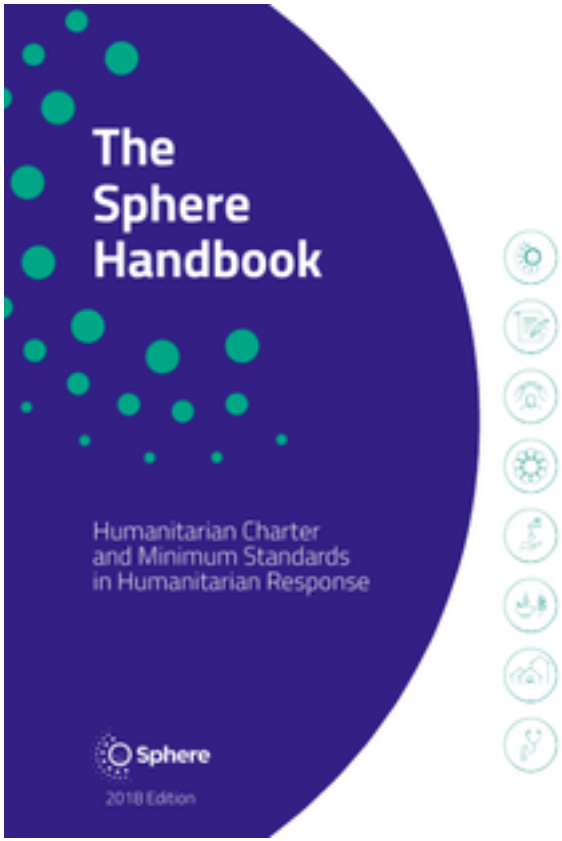


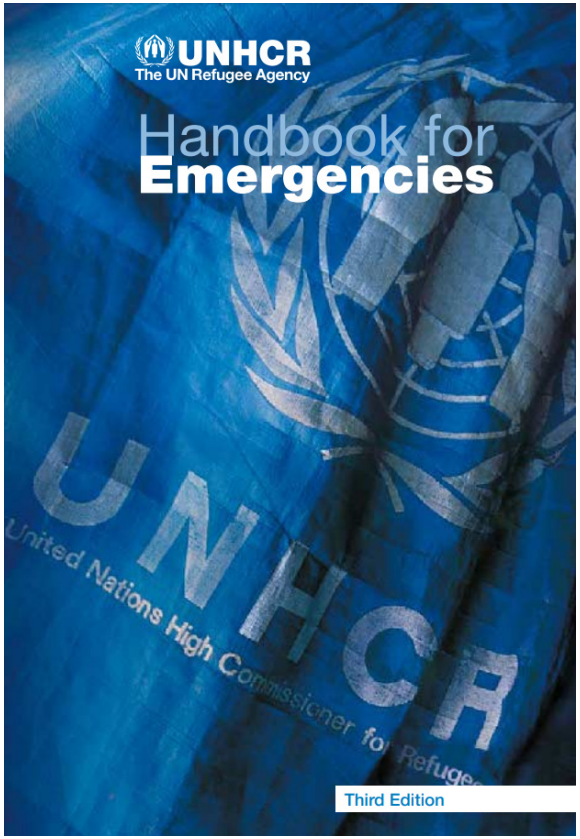
Recreation

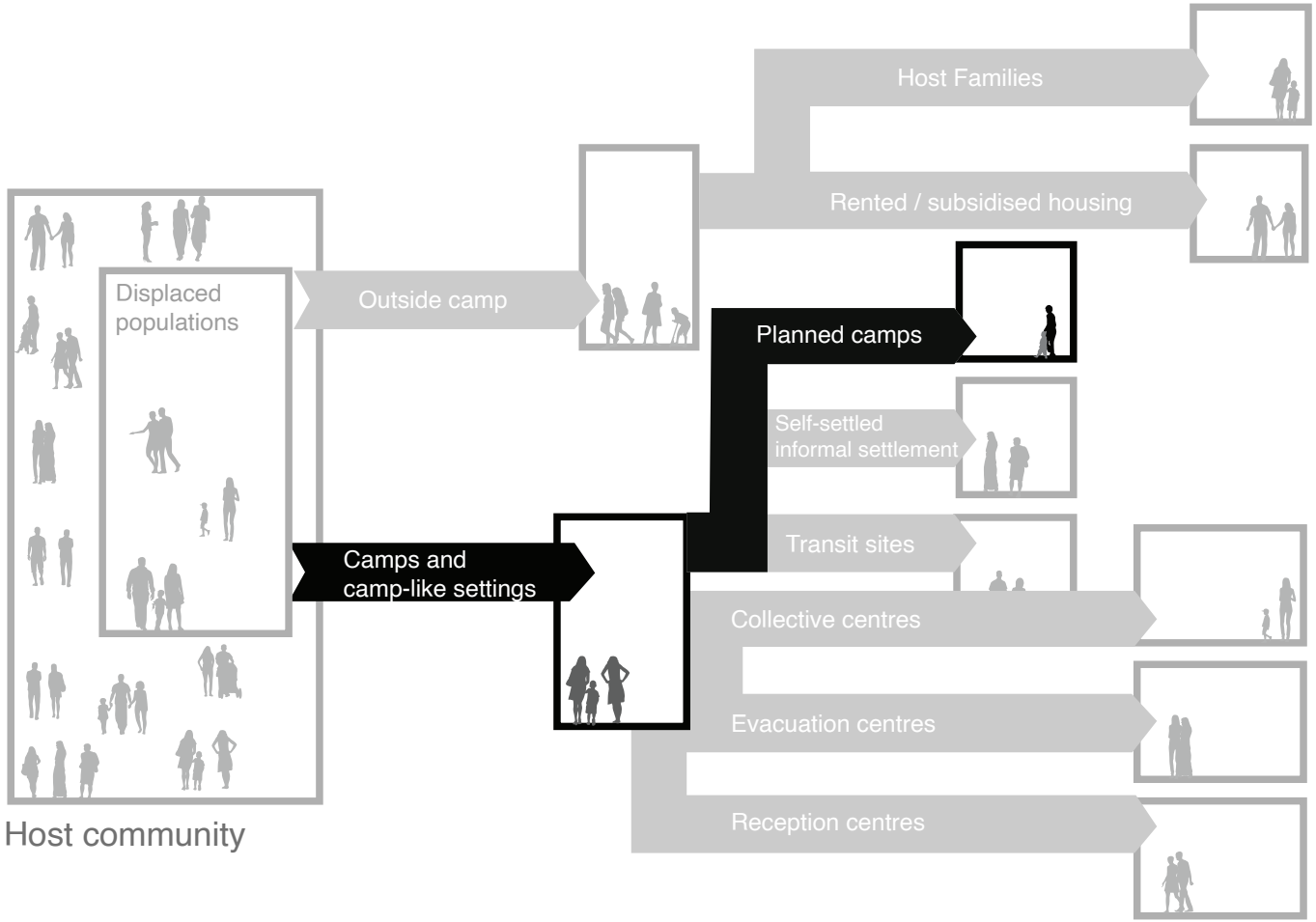
Market

Religion

Cities in the Desert: Life Inside Jordan's Refugee Camps (M. Power, 2023)


The Sphere Handbook
Humanitarian Charter and Minimum Standards in Humanitarian Response
Sphere
2018 Edition


UNHCR
The UN Refugee Agency
Handbook for Emergencies
Third Edition



Recreated diagram solutions for displacement (CCM cluster, 2021)

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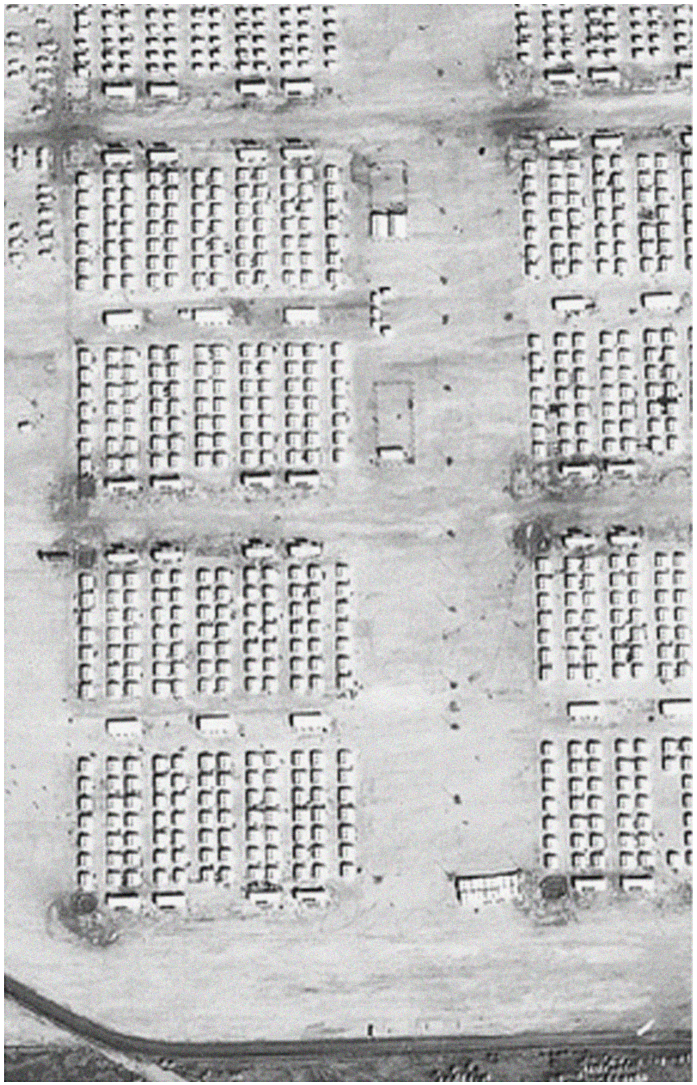
Alreal photo of Azraq settlement, Jordan (A. Harper 2014)

View inside Azraq settlement, Jordan (D.Fosas, 2021)

Aerial photo of refugee settlement at Cox Bazar, Bangladesh (Google Earth, 2023)

Fire at Cox Bazar (DW, 2023)



January 2013 - Structured rows

February 2013 - Addition of shelters

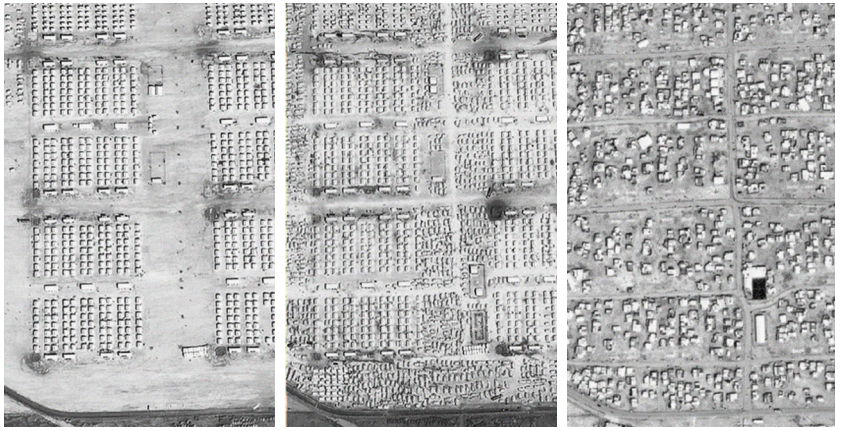
July 2017 - Natural clusters

Agency impact on Zaatari over time (A. Dalal, 2018)

Aerial view of main street in Zaatari, Jordan, (US State Department 2013)

- If we dont design fast enough people settle in unsafe ways

- If we don’t look at how people want to live, they change the design in unsafe ways



- Planned camps are often grid like and overly functionalistic, lacking urban design and human scale

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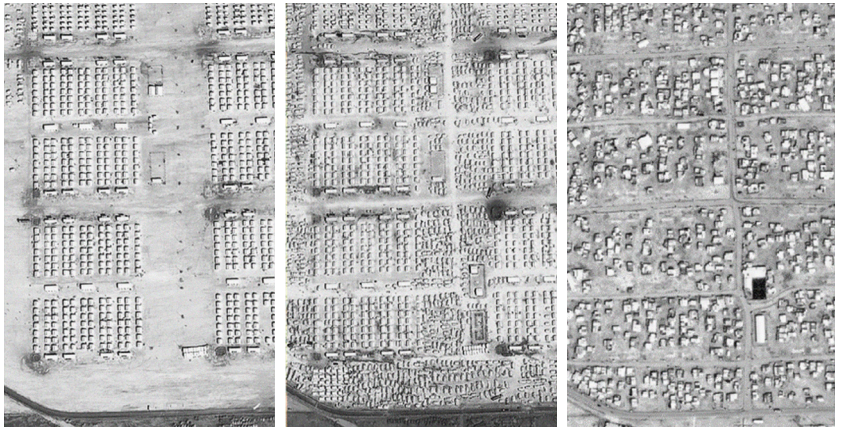

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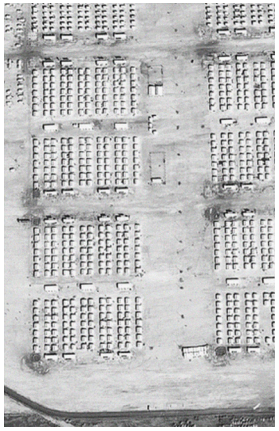

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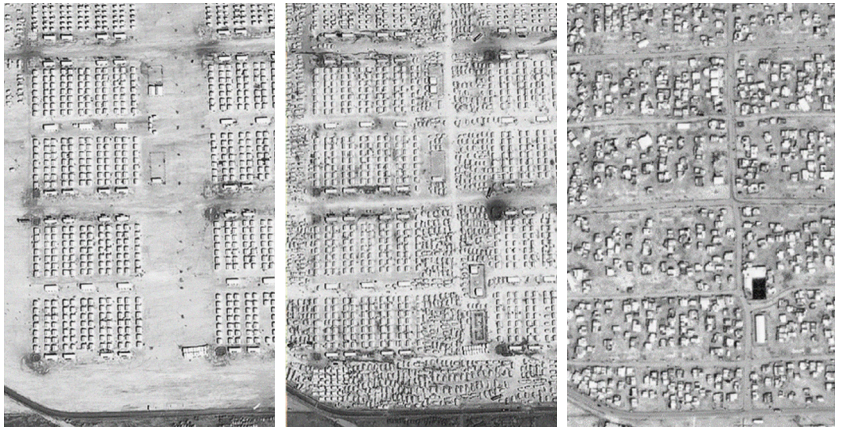

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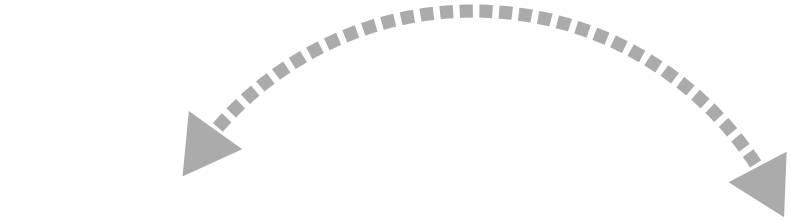
SIGILLUM REGIÆ ACADEMIÆ PICTOR: SCULPTOR: ARCHITECTORUMQVE

Camilla Hedegaard Møller
Josep Cayuelas Mateu
Marja Edén

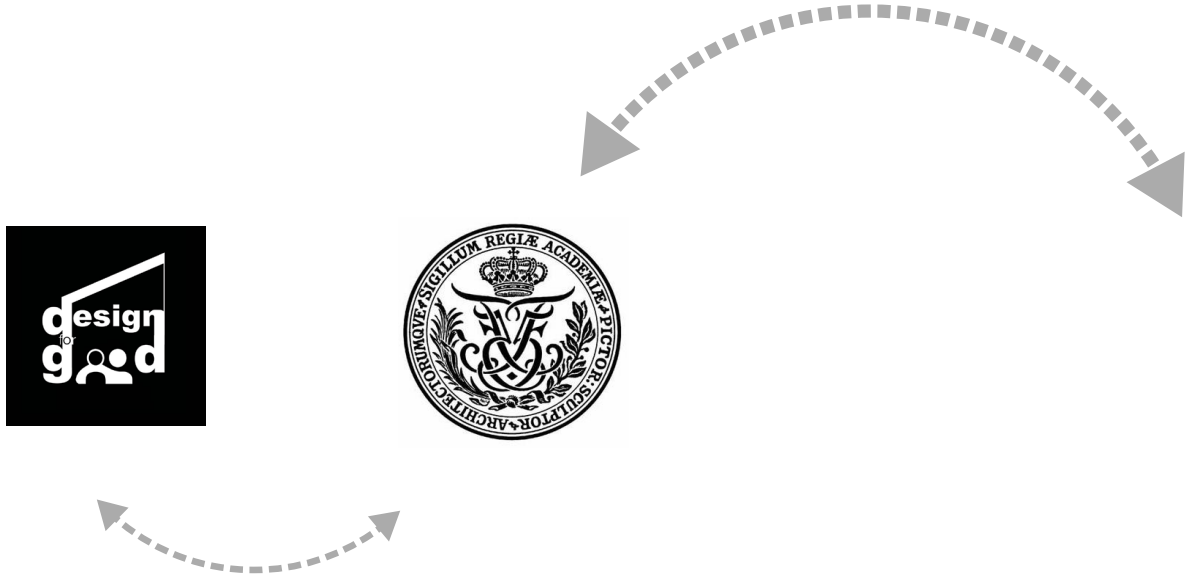


Camilla Hedegaard Møller
Josep Cayuelas Mateu
Marja Edén

Dennis Solberg Kjeldsen
Cecilie Marie Conrad

Step Haiselden,
(global emergency shelter team leader)

Edward Tonkin,
(Sites and Settlemetns Group Coordinator)



Lulia Cistelecan.
Design wfor good. Architect

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Fiona de Heer,
CANADEM. Shelter expert
and urban planner

Camilla Hedegaard Møller
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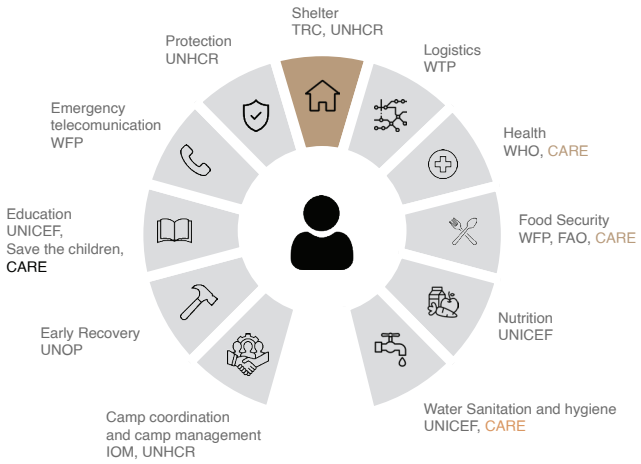
CARE and other Service providers

NGO (CARE)

CARE's programmes in the developing world address a broad range of topics including emergency response, food security, water and sanitation, economic development, climate change, agriculture, education, and health. CARE also advocates at the local, national, a nd international levels for policy change and the rights of poor people.
Within each of these areas, CARE focuses on empowering and meeting the needs of women and girls and promoting gender equality



General stakeholder relations

Architects (Me), (Design for good)

Usually UNHCR with UNHCR

Camp Coordination Agency

The primary objective of the Camp Coordination function is to create the humanitarian space necessary for the effective delivery of protection and assistance. (Humanitarian space includes access to displaced populations and assurance of security and operational space for agency staff.)
Inter camp coordination

Enabelling and ensuring quality in planning and governance

Camp Administration

Usually UNHCR, and sometimes together with host government
designating, opening, and closing camps
securing land and occupancy rights for a temporary settlement
resolving disputes arising from land appropriation and preventing claims against individuals and agencies living and/or working in a camp
providing security, maintaining law and order, and guaranteeing the civilian character of a camp
organising a registration system
issuing documentation, permits and licenses (such as birth certificates, ID cards and travel permits) to camp residents
protecting citizens and preventing evictions, relocations or further displacement of those living in the camp
facilitating access to camps by humanitarian agencies.

Planning and management

Establish links with the comunity
Mitigate fears and tensions

Host population

Strain on local recources
Can also be affected by situation and have dire needs.
Tension may develop with camp population
especially if there are major cultural differences.

Potentially tense relation

Camp Management Agency

Camp governance, ensuring delivery of services
community participation, training of management agency staff,
maintaining camp infrasstructure, manage information on population needs. Disseminate information to population and stakeholders,
participating in strategic planning with relevant stakeholders around issues of contingency planning, environment, exit strategy,
camp closure and facilitation of durable solutions.

Building productive relationship

Camp Population

Different demographics and needs
Minorities, religions, sub groups.
Recognize capabiliites, avoid passivity
Ensure participation to build trust
Ensure equitable access, security protection and empowerment

Enable delivery of
appropriate, timely assistance.
Empower equitable and impartial assitance

Control and
Advocate for civilian forces

Maintain law and order

Security Forces

Use of preventive measures and cooperation with national law-enforcement authorities
deployment of civilian or police monitors
deployment of a UN Peacekeeping Operation or a multinational or regional force.

Provide equitable access to services

Service Providers

INGOs
NGOs
UN agencies
National athorities
Private sector, civil society actors

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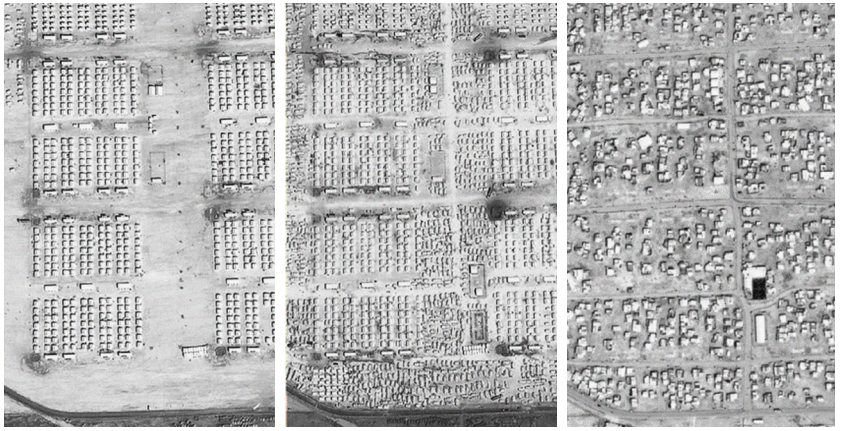

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Speed

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Quality

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Speed

Streamline execution of standards

- Risk of fire
- Risk of flooding
- Risk of landslides

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Quality

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Quality

Find Algorithms potential to improve planning

- Community at different scales
- A central street

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- A varied and human scaled environment

Fire Safety

- A 30 m fire corridor every 300 m.
- Shelters placed minimum 2 m apart. Ideally distance is larger or equal to 1 - 3 times the shelter height

Flooding

- Construction should be avoided in spaces that flood during rainfall.
- These spaces can instead be green recreational spaces. Trees help against flooding.

Land slides

- Avoid steep slopes
- Assess soil condition
- If building in slope lay stable foundation.

Safety priciples for shelter planning (UNHCR, 2007)

Different scales of community

- Two shaded spaces for every community
- Winding paths connecting the communities to “neighborhoods”
- One large central space for every 1-2 blocks.
- One part of the city ring for every village.
- One city ring for every camp

A varied and human scaled environment

- Find a balance between the way people socially cluster and the standards
- Winding paths that create more varied and interesting sightlines.
- Support systems for agency, that creates a better living environment

A central street

- A city ring is better than a core, it is less dense and more equitable
- Make it possible to rent a commercial stand at the street.

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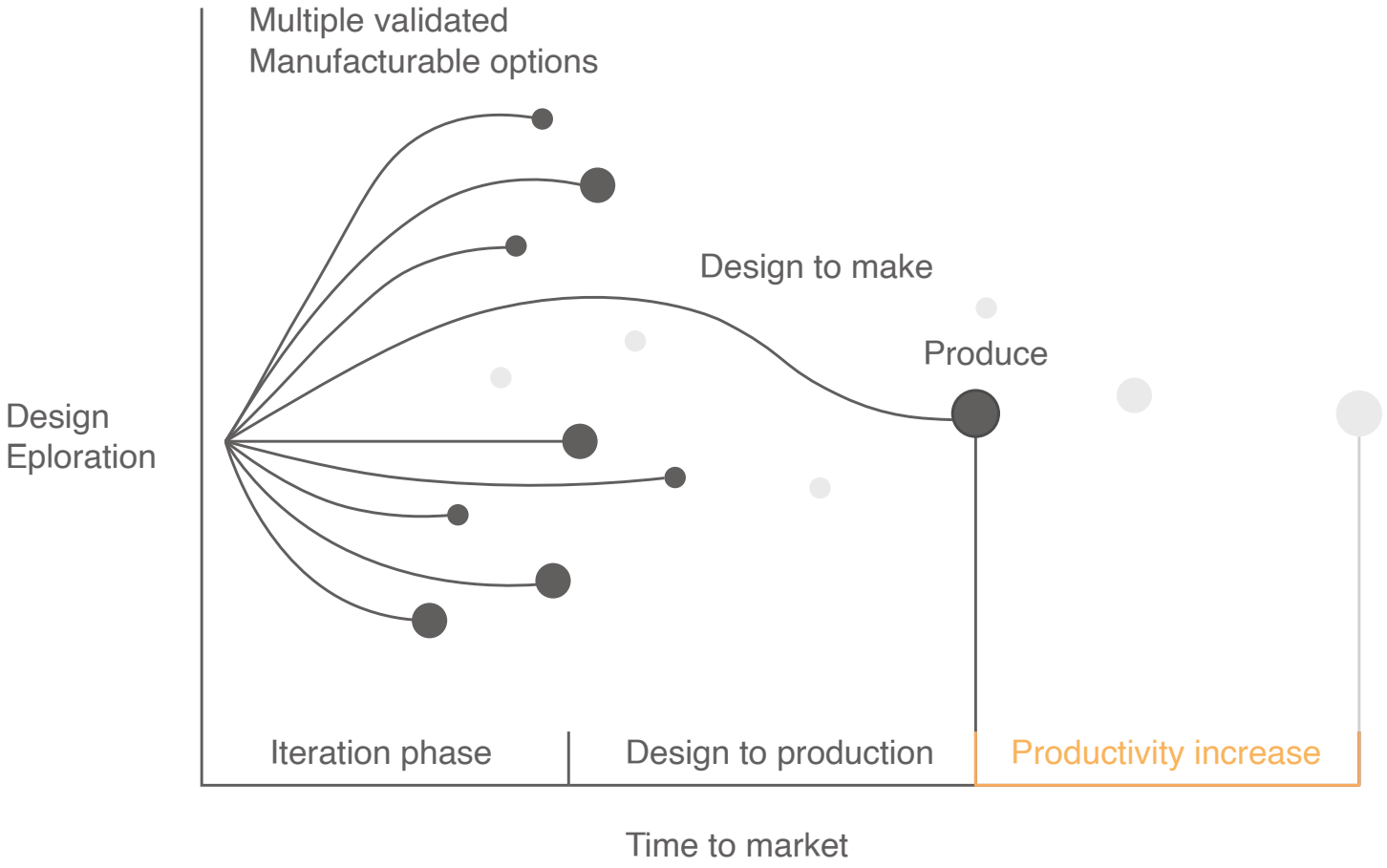
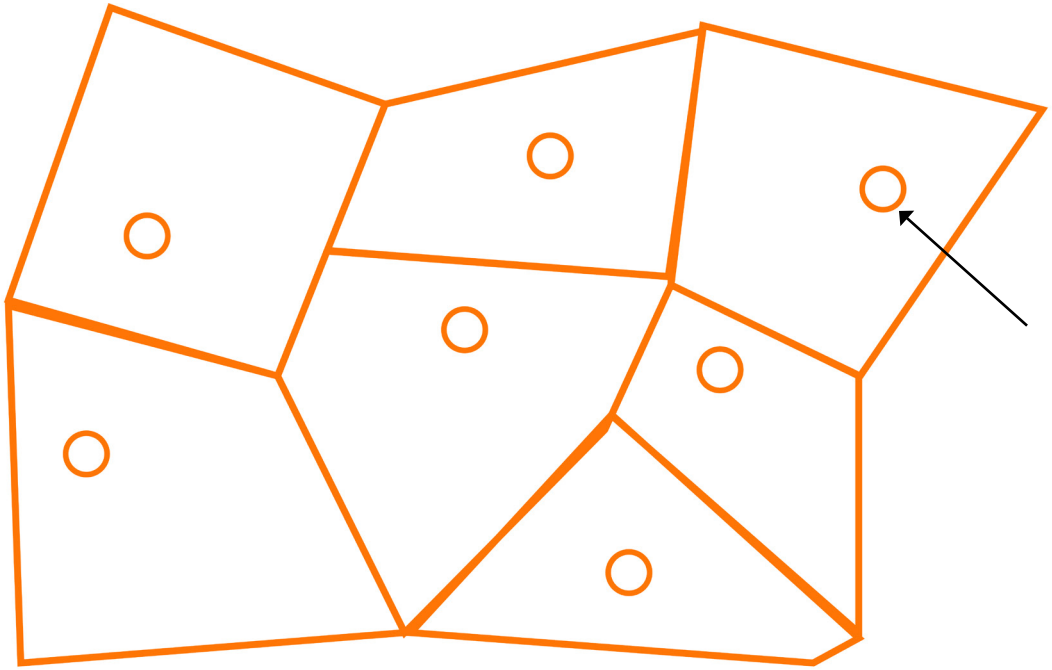
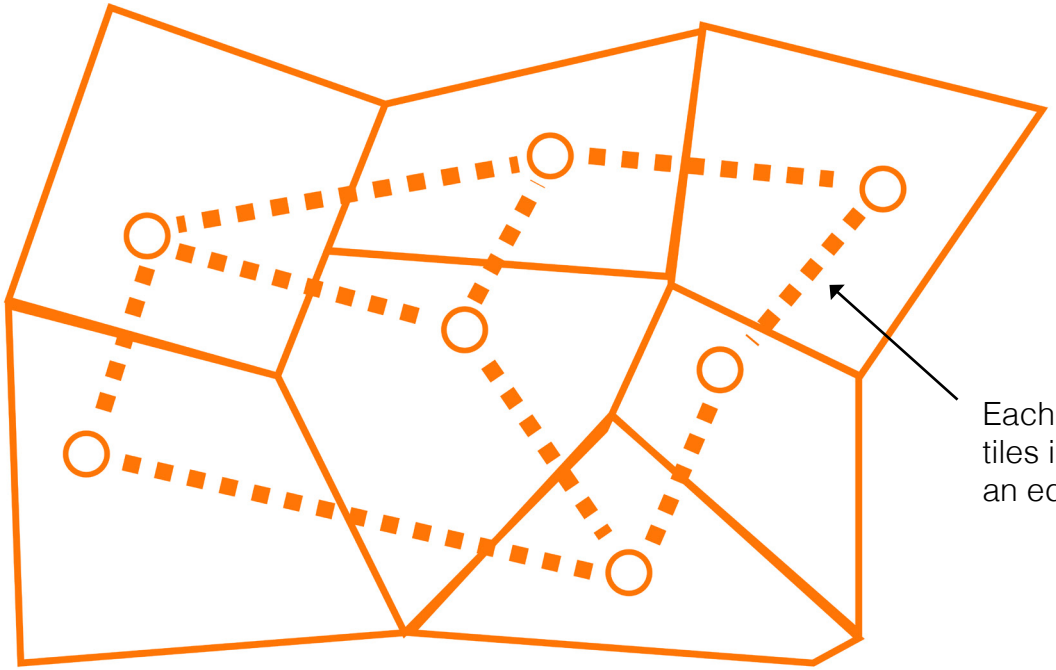


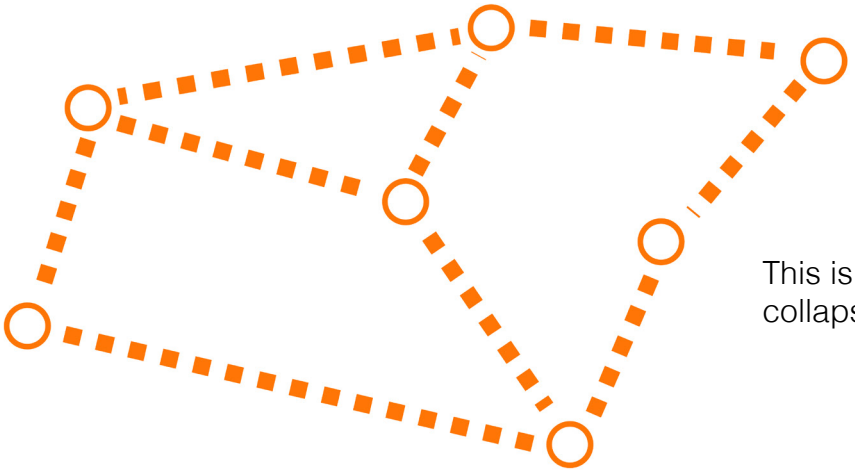
Recreated graph about the generative design process (Autodesk, 2019)

Wave function collapse algorithm?

An Instant Town-builder (Hey Pro Player, 2021)


Each plot is represented
by a node


Each adjacency of
tiles is represented as
an edge.

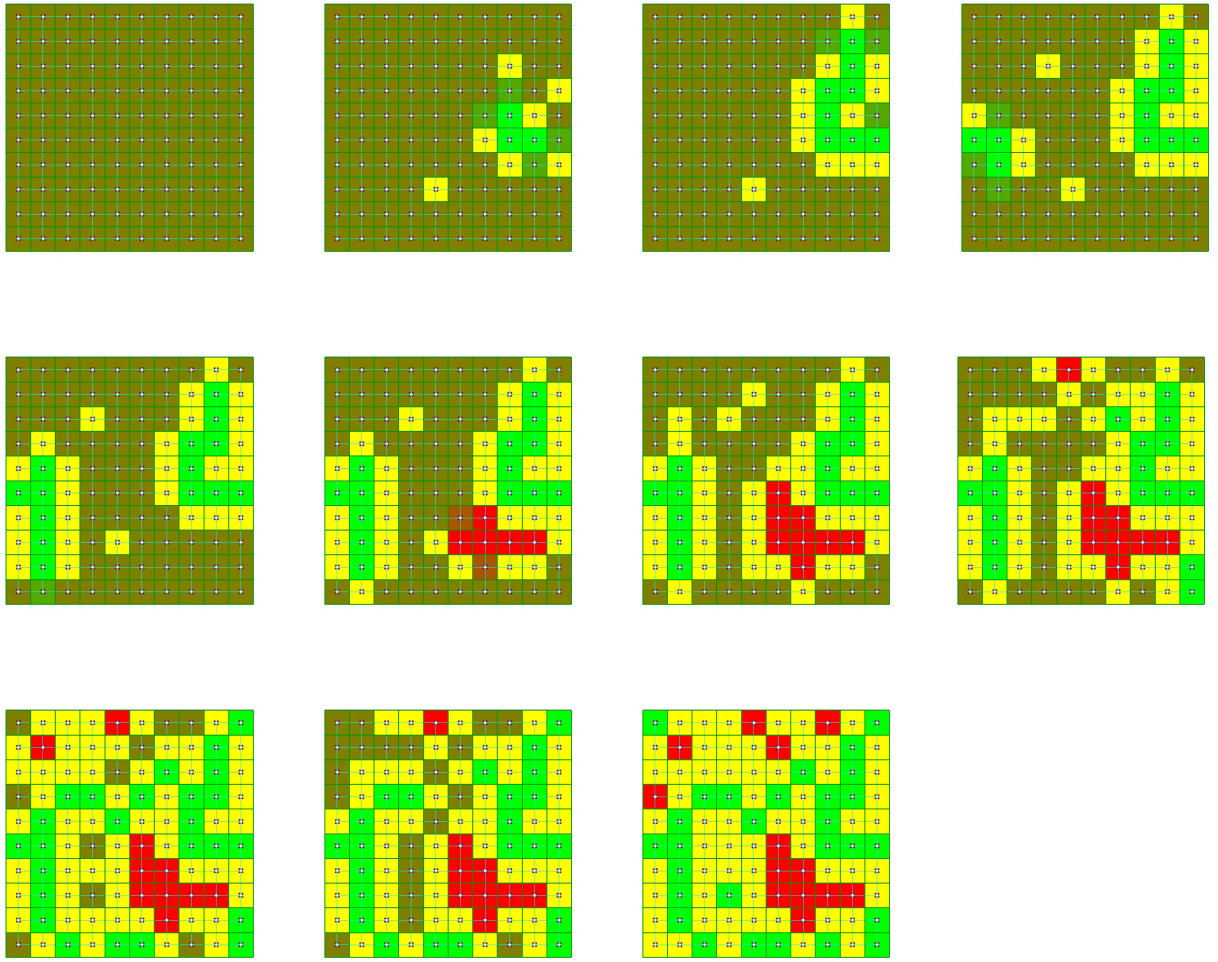


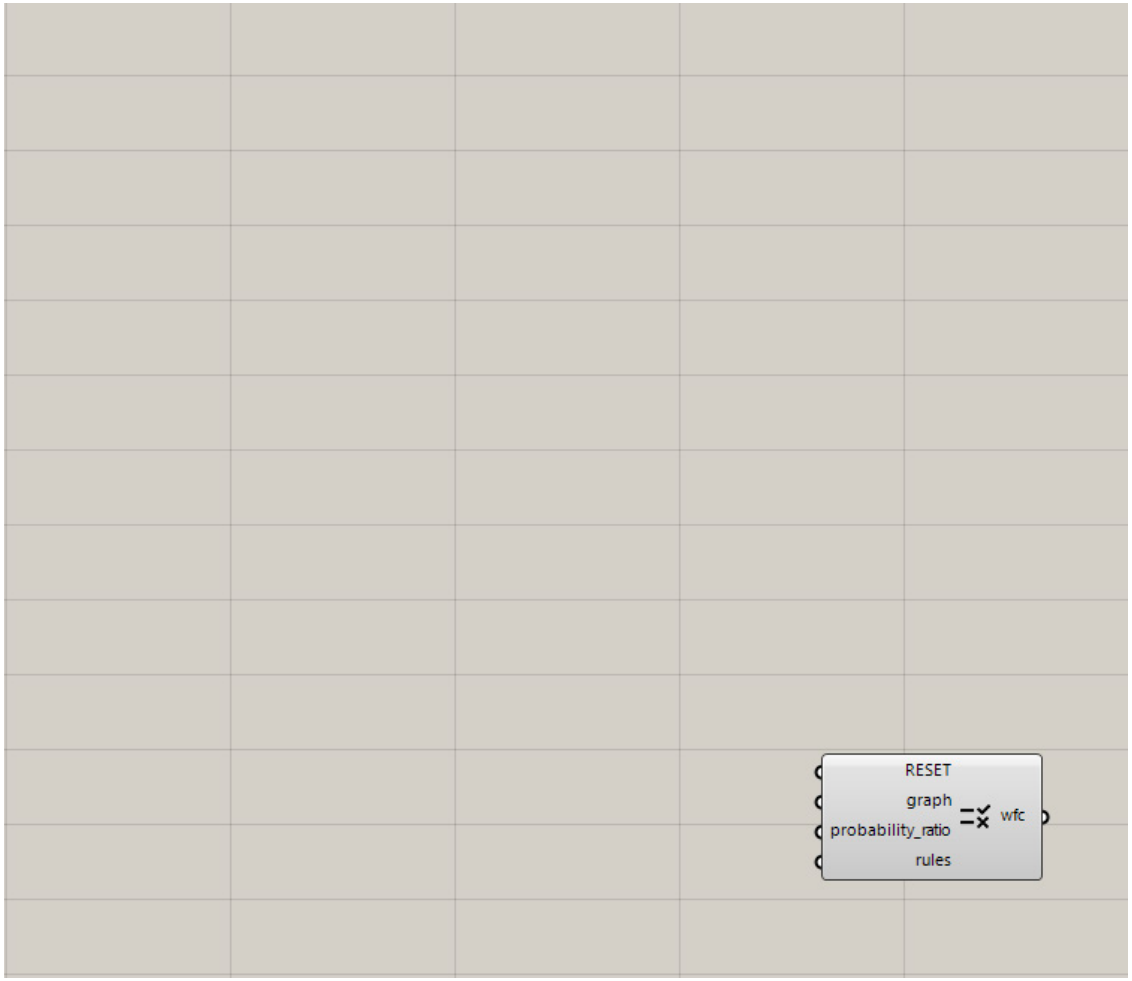
This is the input the wave function collapse algorithm takes.

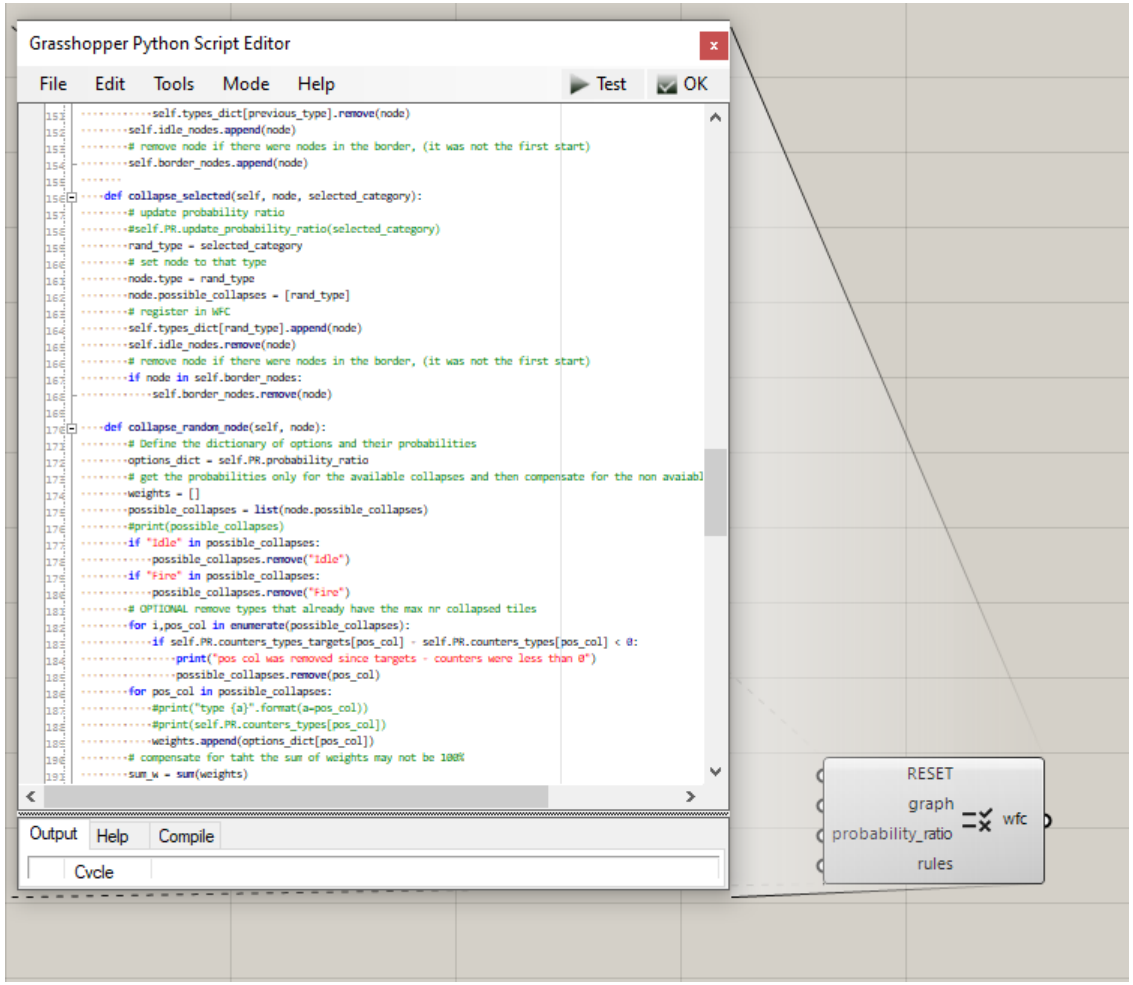
Ajecency rules:

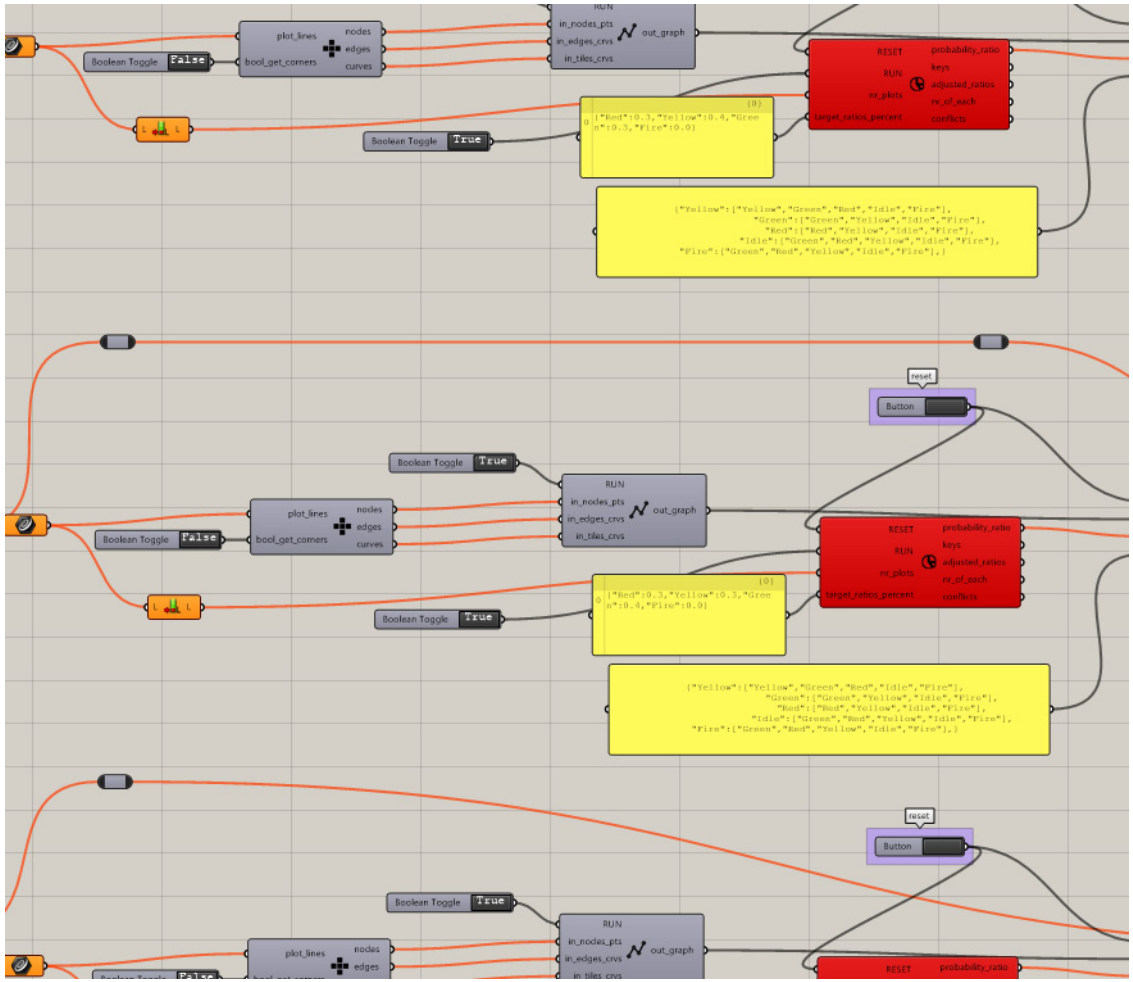
Color:	Can be next to:
Green	Green, Yellow
Yellow	Yellow, Green, Red
Red	Red, Yellow

Generated output based on rules:




RESET
graph
probability_ratio
rules
wfc


Grasshopper Python Script Editor
File
Edit
Tools
Mode
Help
Test
OK
Output
Help
Compile
Cycle
RESET
graph
probability_ratio
rules
wfc


Boolean Toggle False
plot_lines
bool_get_corners
nodes
edges
curves
RUN
in_nodes_pts
in_edges_crvs
in_tiles_crvs
out_graph
Boolean Toggle True
RESET
RUN
nr_plots
target_ratios_percent
probability_ratio
keys
adjusted_ratios
nr_of_each
conflicts
{"Red":0.3,"Yellow":0.4,"Gree
n":0.3,"Fire":0.0}
{"Yellow":["Yellow","Green","Red","Idle","Fire"],
"Green":["Green","Yellow","Idle","Fire"],
"Red":["Red","Yellow","Idle","Fire"],
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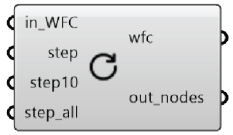
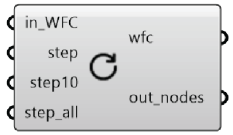
"Fire":["Green","Red","Yellow","Idle","Fire"],}
reset
Button

Let’s design a design method!

What features do we need?



Run the WFC algorithm



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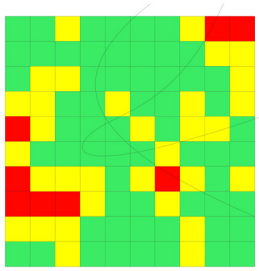
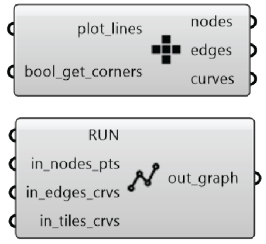
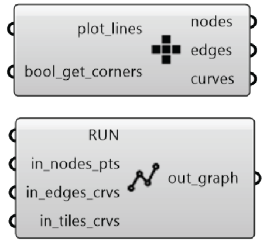




Create a graph

Run the WFC



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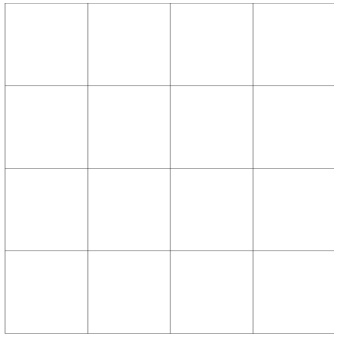

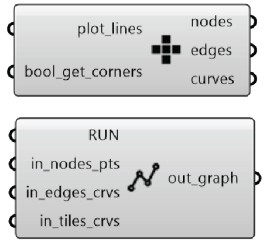

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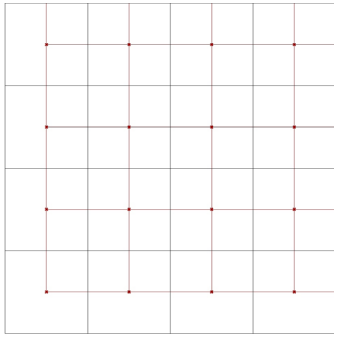

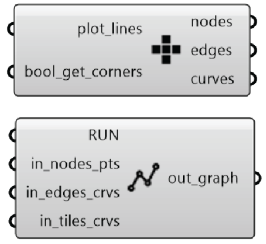

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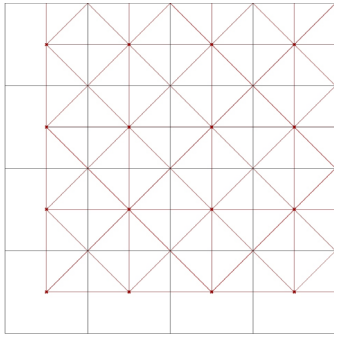
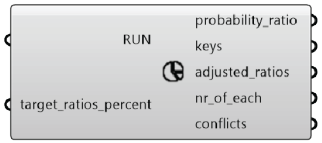


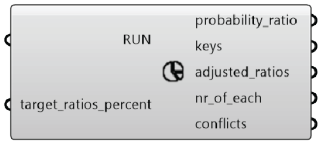
Create a graph



Input ratios of functions

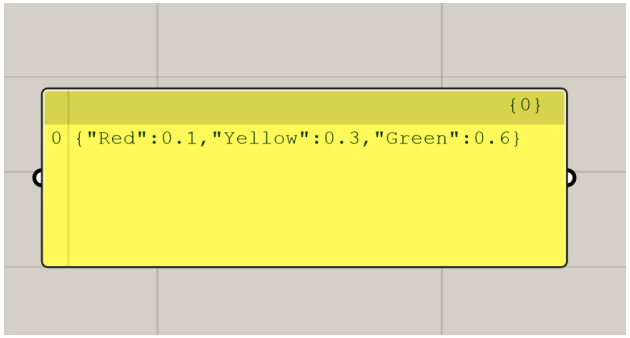
Run the WFC

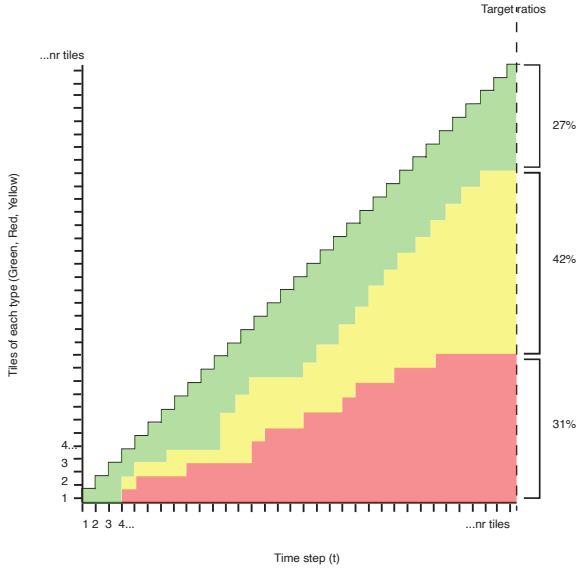
Create a graph



Input ratios of functions

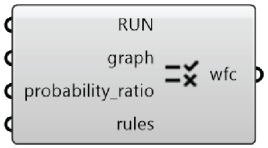
Run the WFC





Create a graph

Input ratios of functions

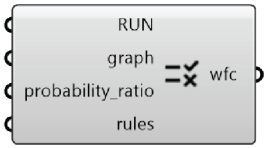


Input how they relate

Run the WFC

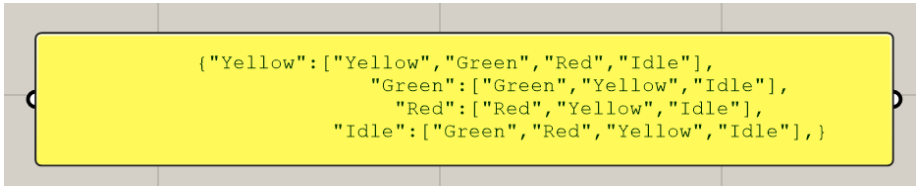
Create a graph

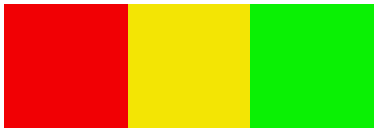
Input ratios of functions

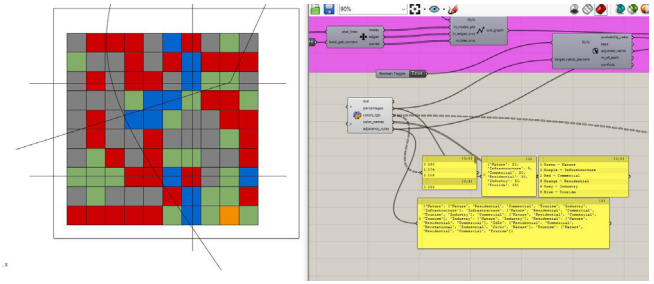


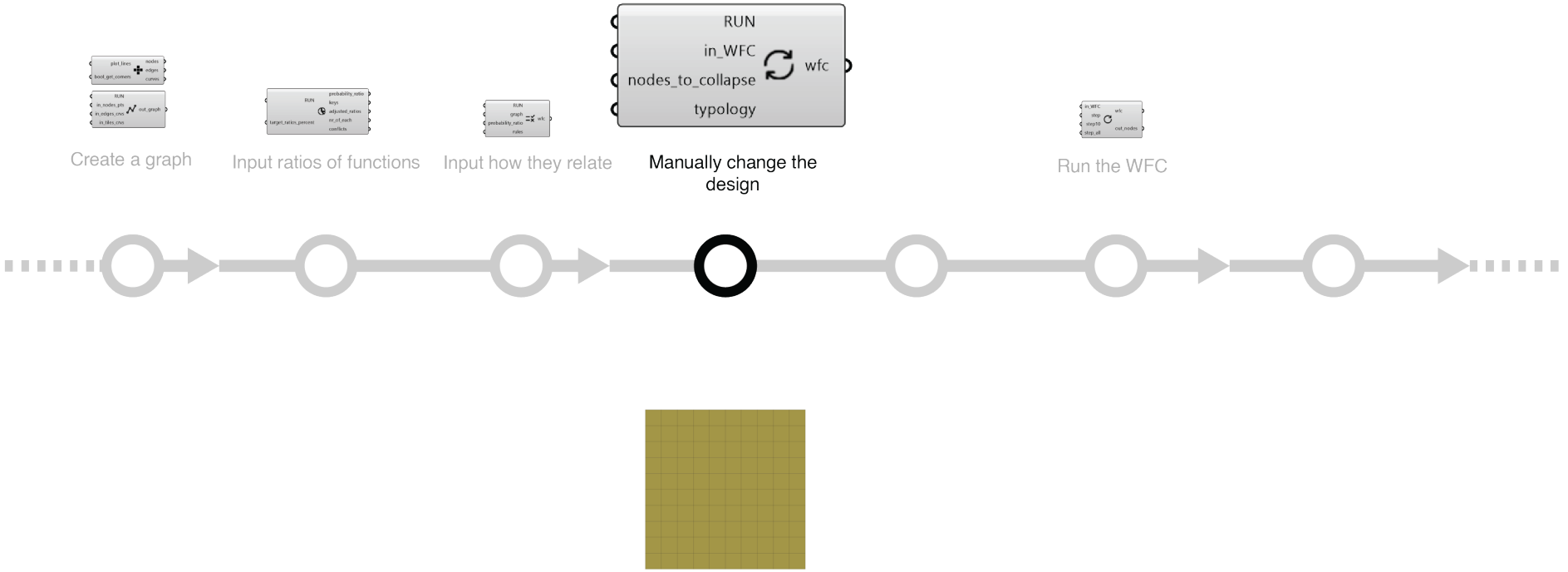
Input how they relate

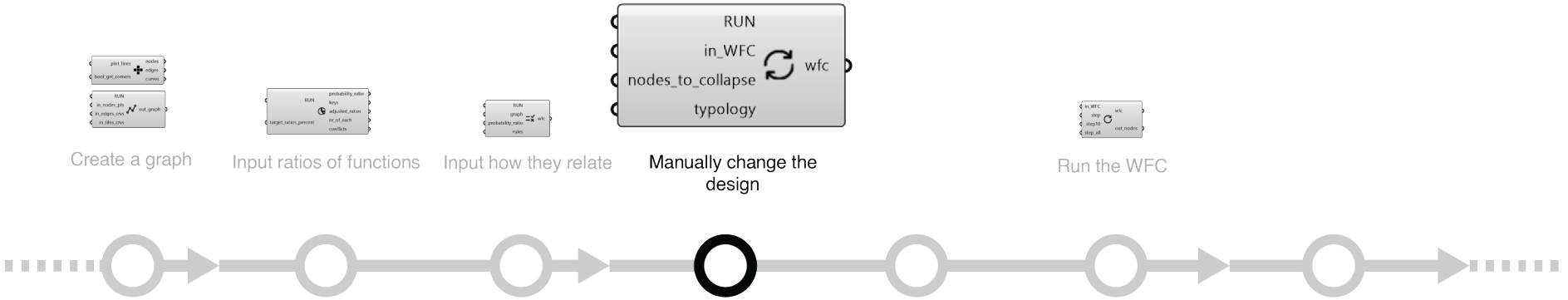
Run the WFC

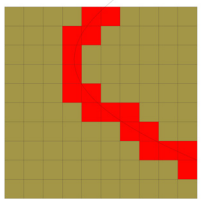


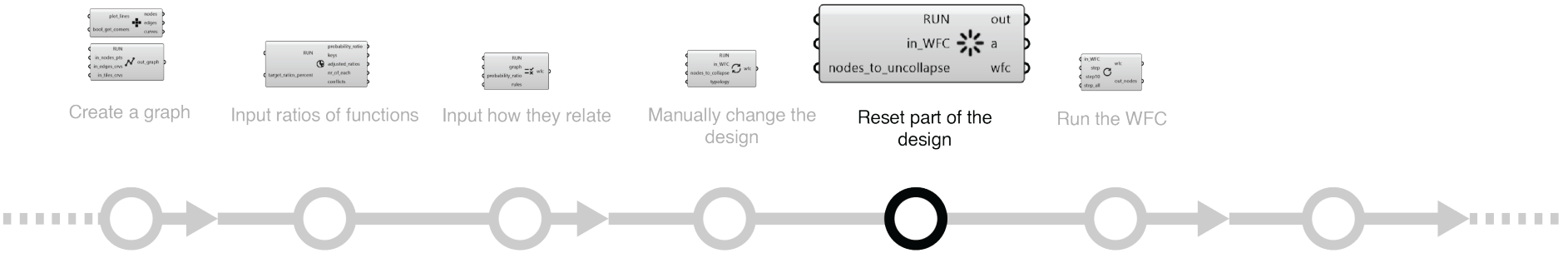





RUN
in_WFC
nodes_to_collapse
wfc
typology
Create a graph
Input ratios of functions
Input how they relate
Manually change the design
Run the WFC


RUN
in_WFC
nodes_to_collapse
wfc
typology
Create a graph
Input ratios of functions
Input how they relate
Manually change the design
Run the WFC





Create a graph

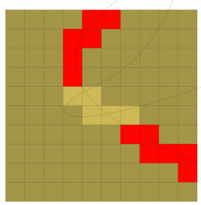
Input ratios of functions

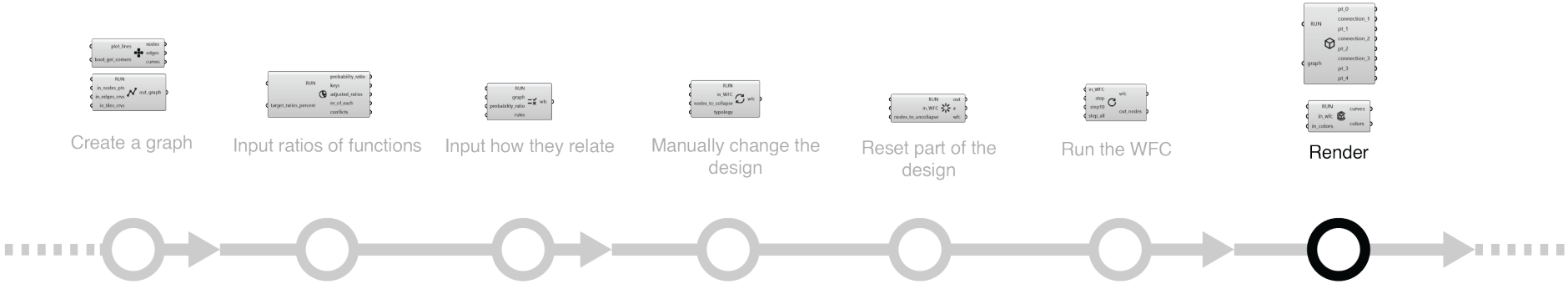
Input how they relate

Manually change the design

Reset part of the design

Run the WFC





Create a graph

Input ratios of functions

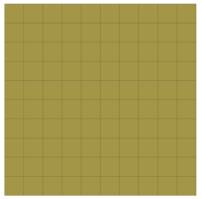
Input how they relate

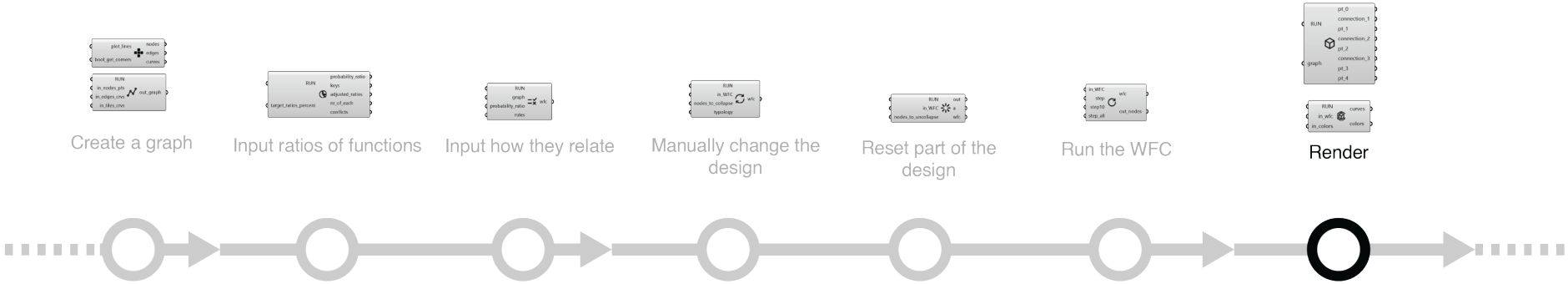
Manually change the design

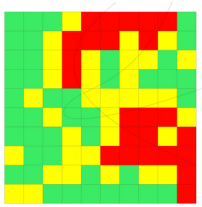
Reset part of the design

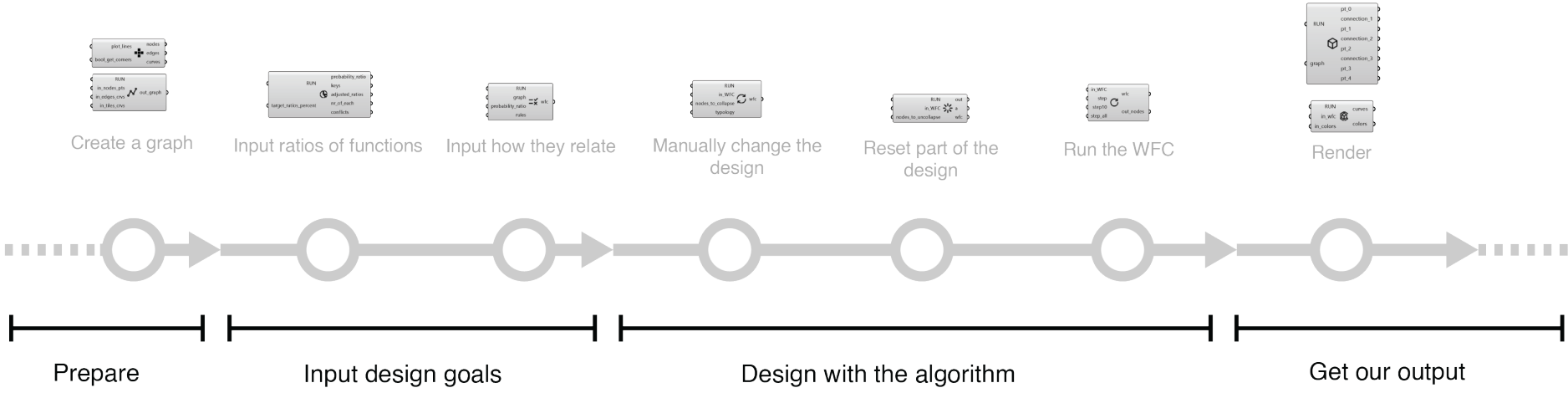
Run the WFC

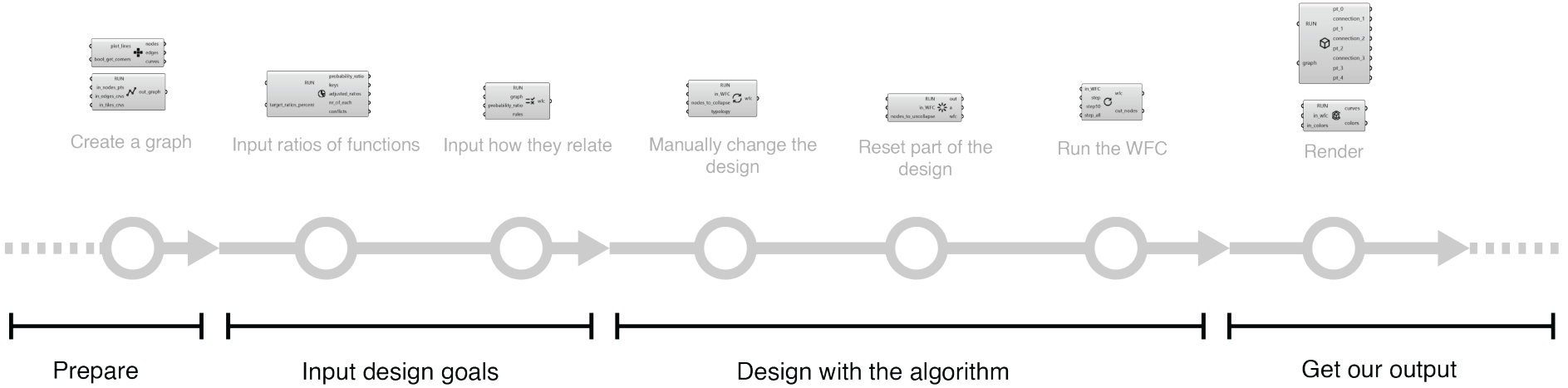
Render




Create a graph
Input ratios of functions
Input how they relate
Manually change the design
Reset part of the design
Run the WFC
Render




Create a graph
Input ratios of functions
Input how they relate
Manually change the design
Reset part of the design
Run the WFC
Render
Prepare
Input design goals
Design with the algorithm
Get our output


Create a graph
Input ratios of functions
Input how they relate
Manually change the design
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Run the WFC
Render
Prepare
Input design goals
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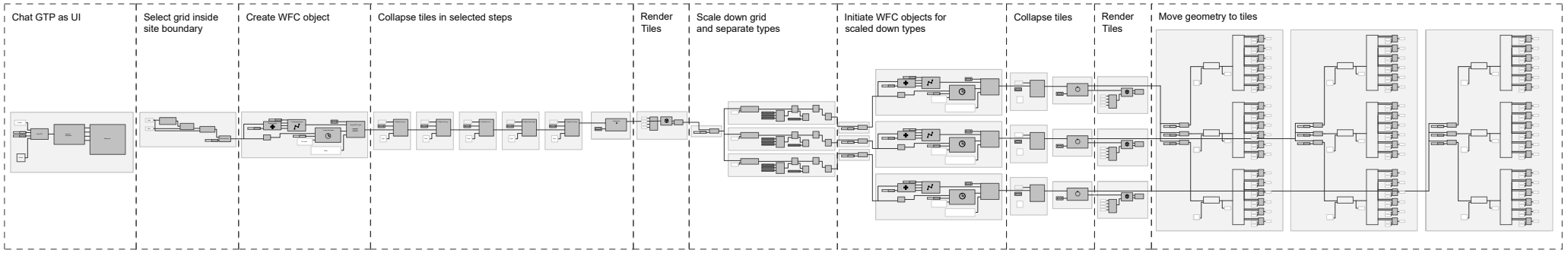
Get our output


Chat GTP as UI
Select grid inside site boundary
Create WFC object
Collapse tiles in selected steps
Render Tiles
Scale down grid and separate types
Initiate WFC objects for scaled down types
Collapse tiles
Render Tiles
Move geometry to tiles

Case selection

Problem definition

Approach

Methodology

Application

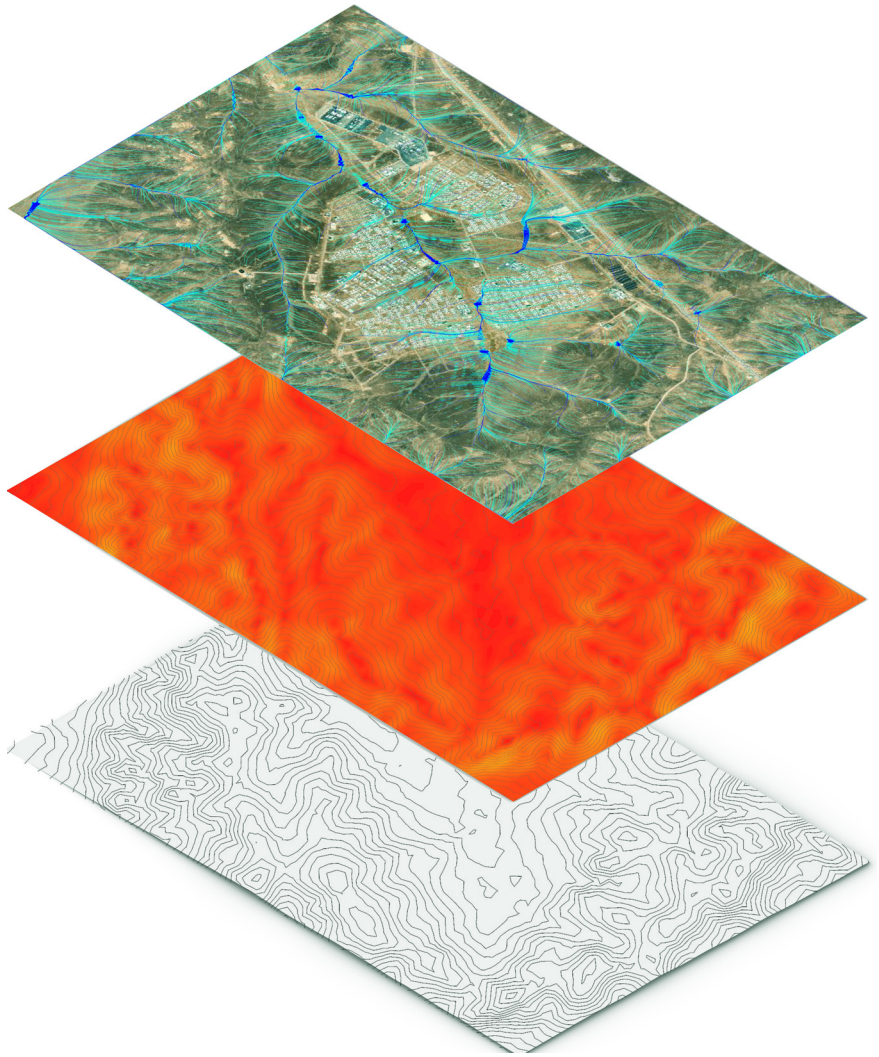
Design

Discussion

Geometric information

Flood water analysis

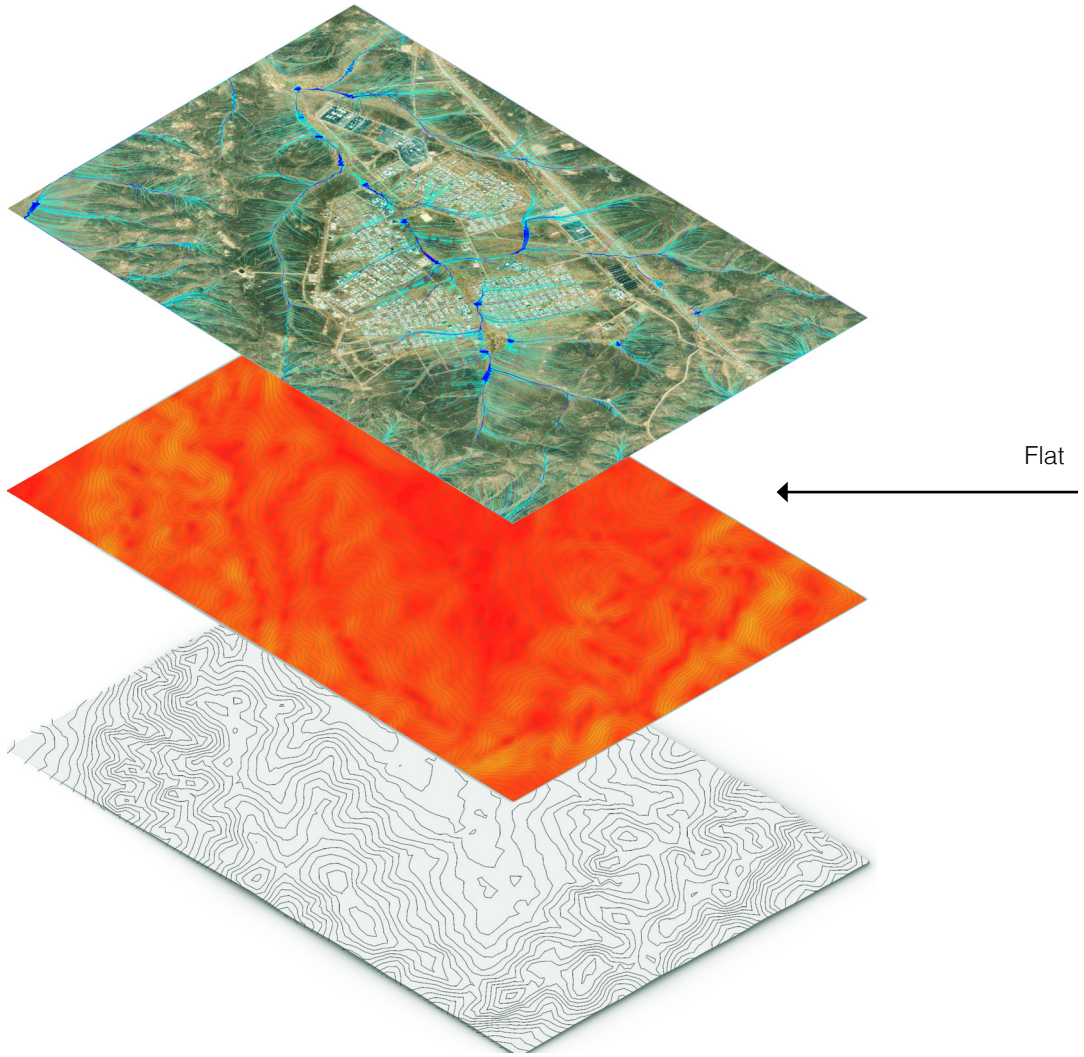
Slope and landslide analysis

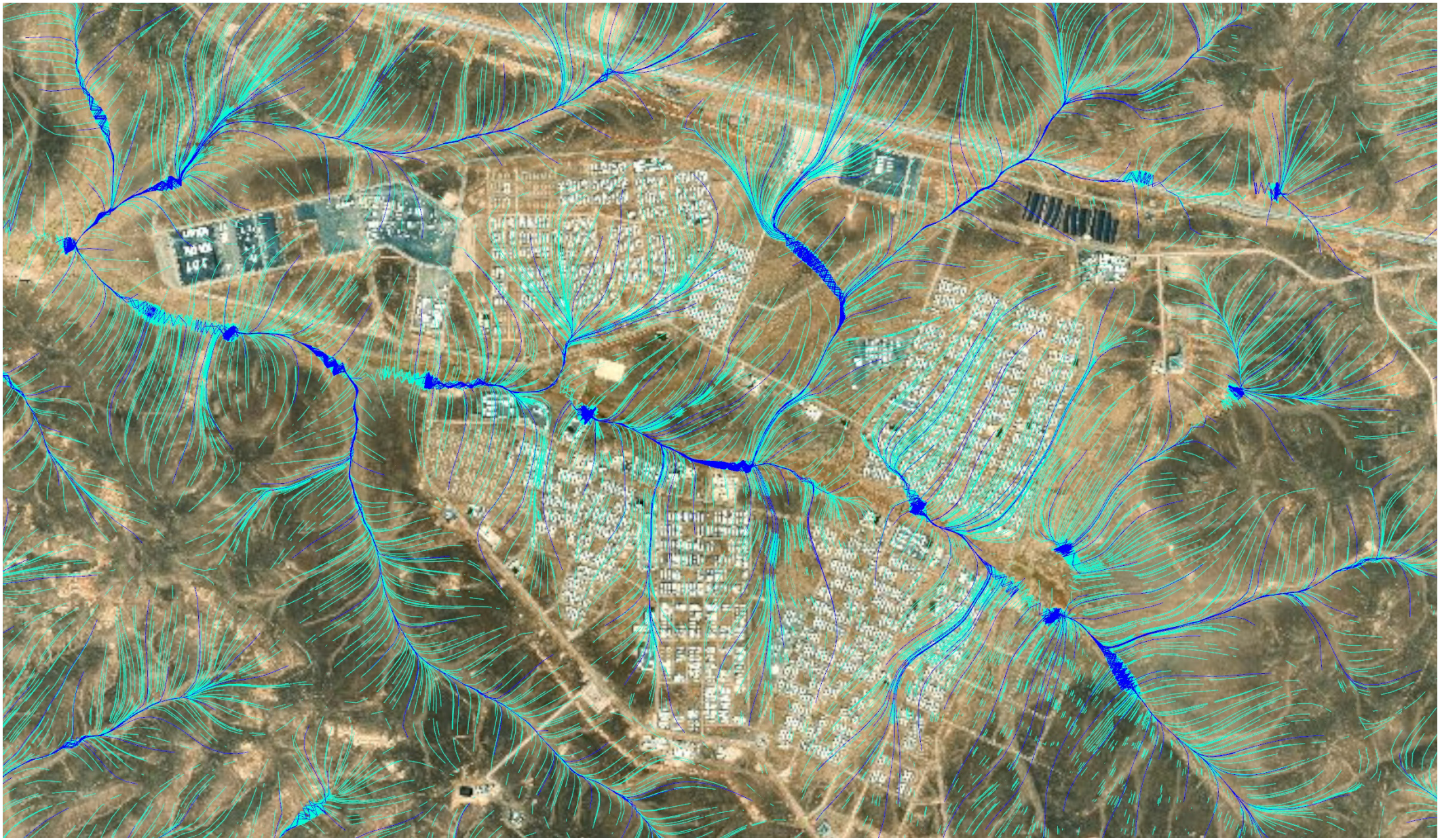


Geometric information

Flood water analysis

Slope and landslide analysis





Terrain analysis using Bison plugin to Grasshopper

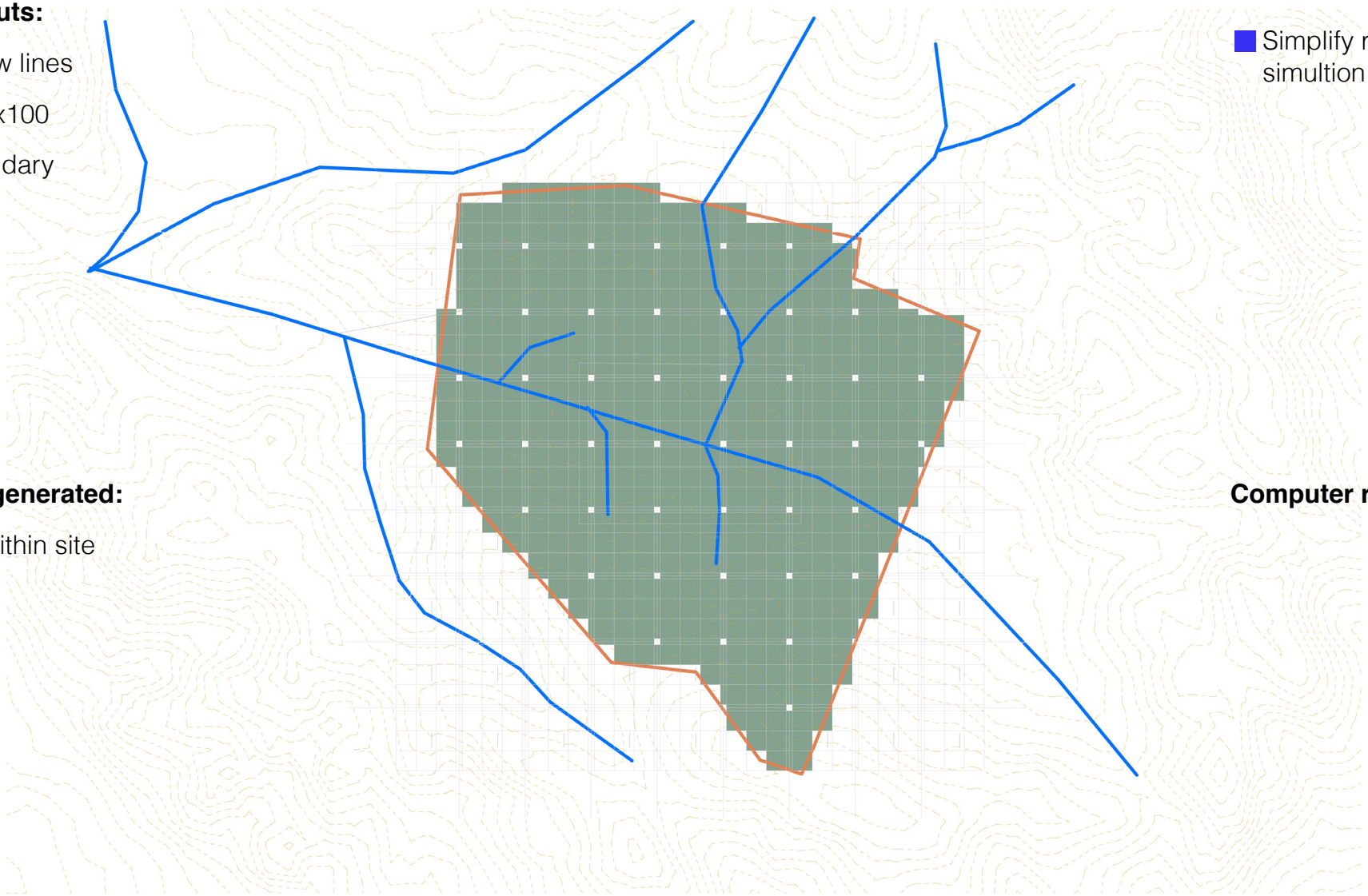
Step1: Water shed analysis

Manual inputs:

- Water flow lines
- Grid 100x100
- Site boundary

Manual rules:

- Simplify result from simultion



Computer generated:

- Sqares within site

Computer rules:

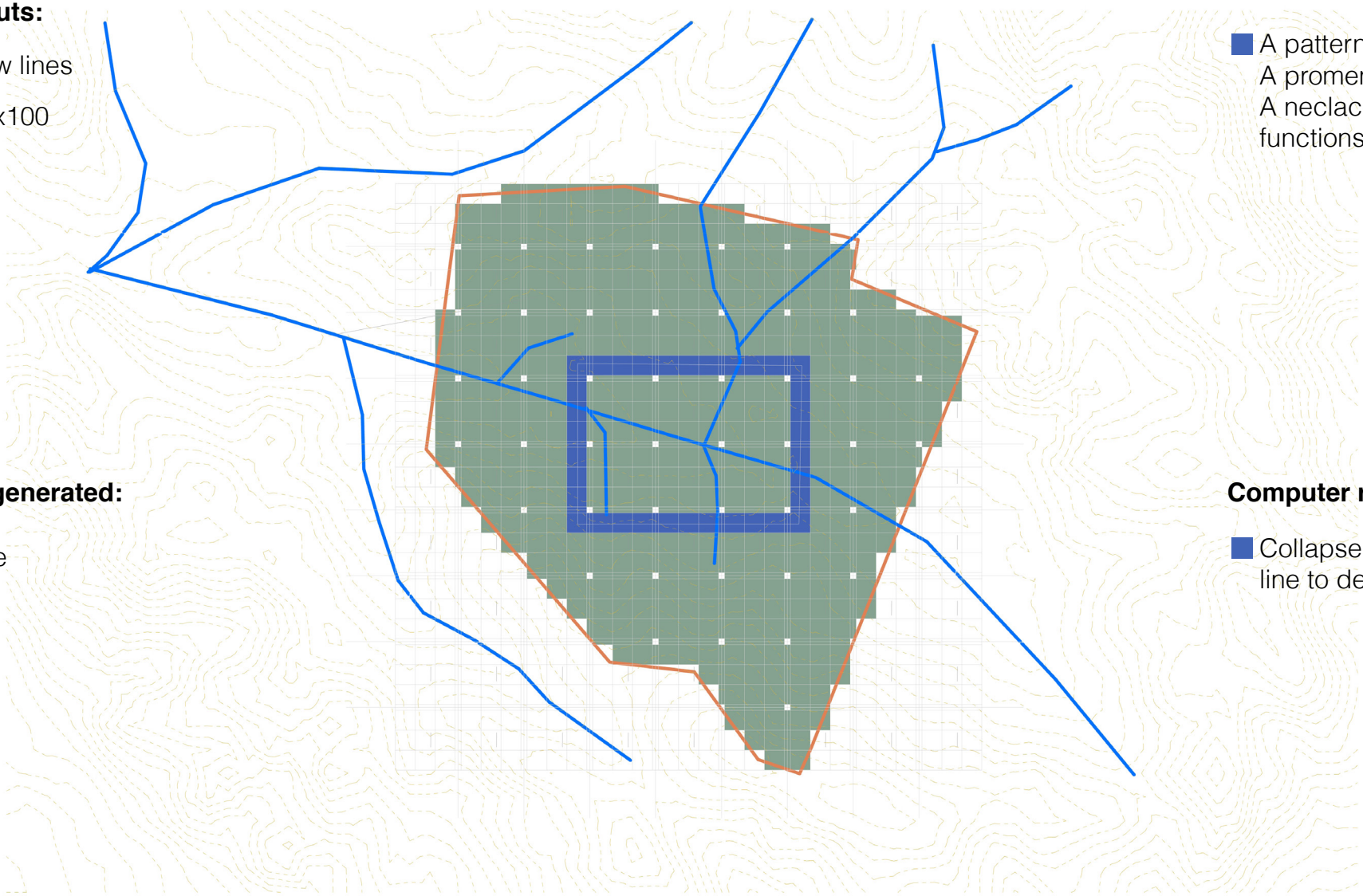
Step 2: Collapse connection to dense tile type

Manual inputs:

- Water flow lines
- Grid 100x100

Manual rules:

- A pattern language:
  A promenade
  A neclace of public functions



Computer generated:

- Dense tile

Computer rules:

- Collapse tiles under line to dense type

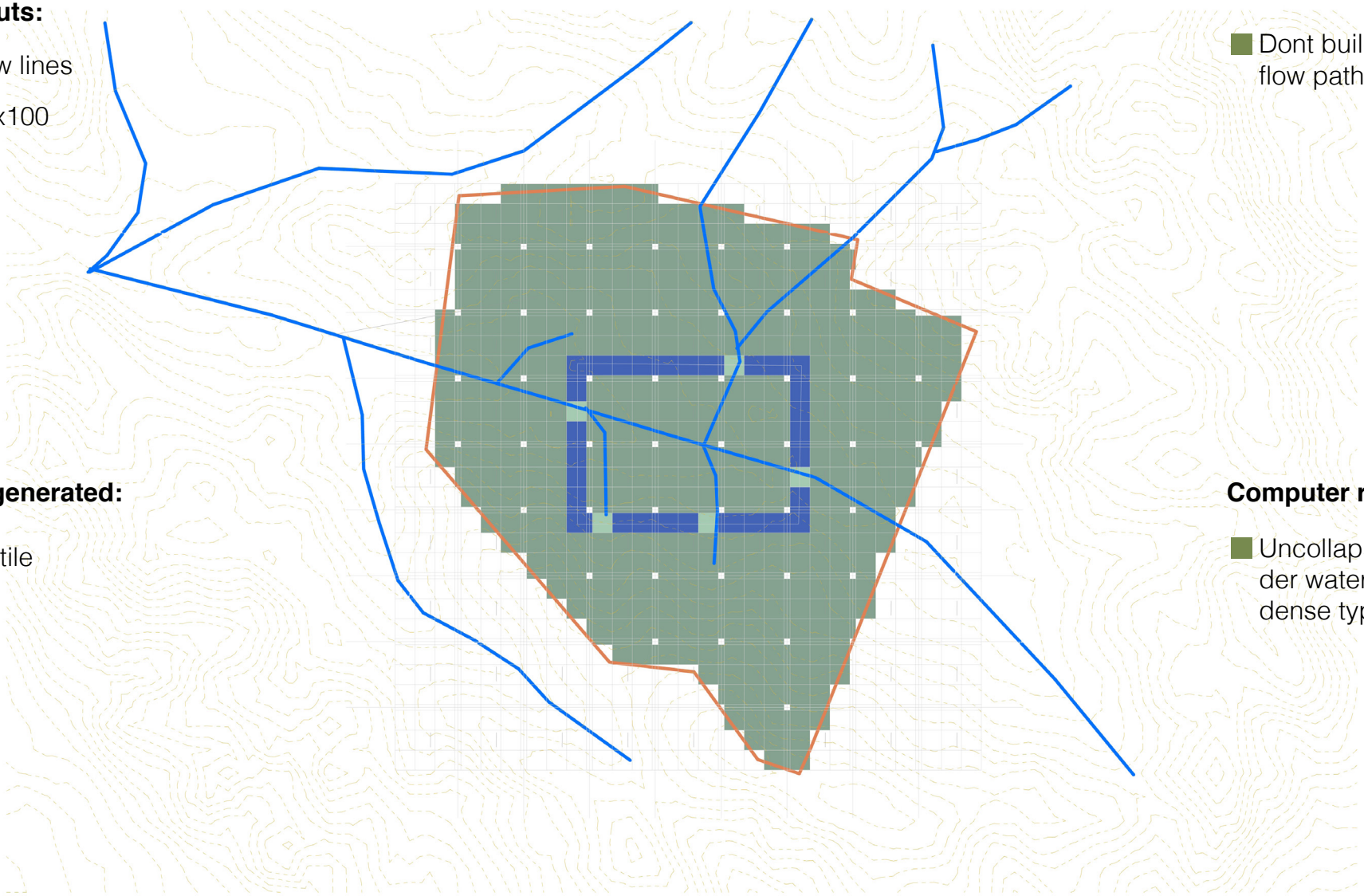
Step 3: Uncollapse tiles on water flow paths

Manual inputs:

- Water flow lines
- Grid 100x100

Manual rules:

- Dont build on water flow paths



Computer generated:

- Idle type tile

Computer rules:

- Uncollapse tiles under water flow line of dense type

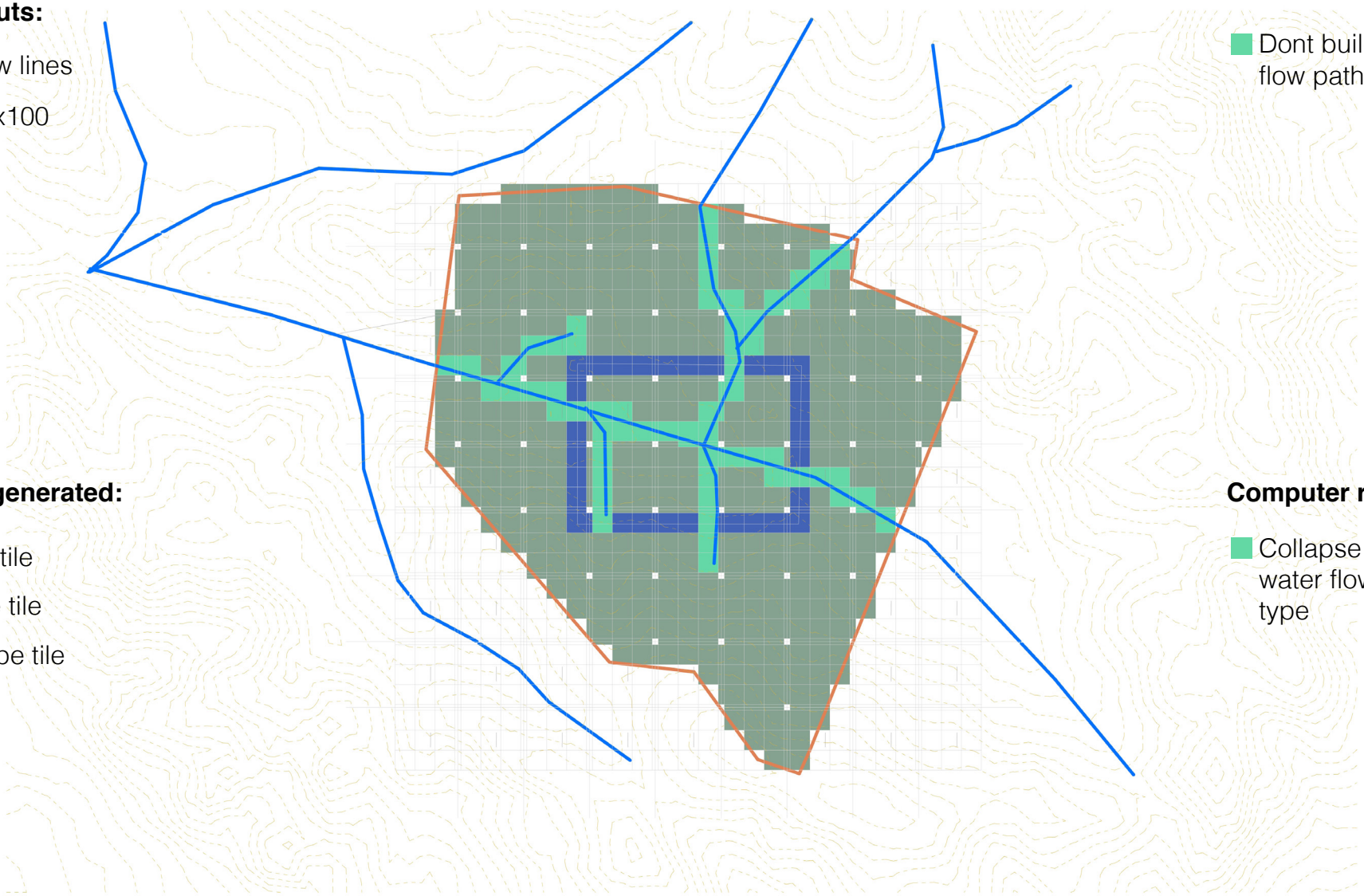
Step 4: Create parks on water flow paths

Manual inputs:

- Water flow lines
- Grid 100x100

Manual rules:

- Dont build on water flow paths



Computer generated:

- Idle type tile
- Park type tile
- Dense type tile

Computer rules:

- Collapse tiles under water flow line to park type

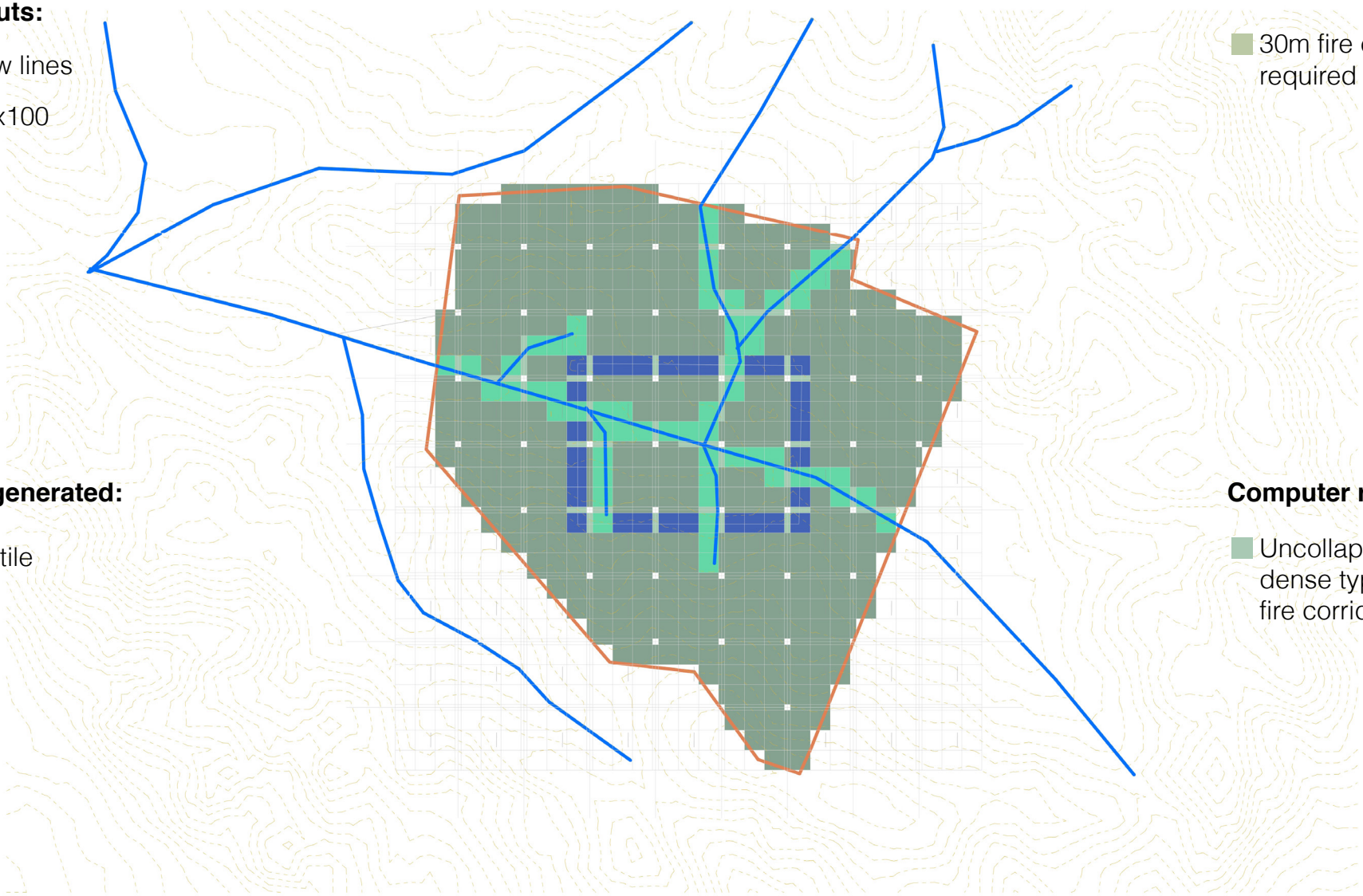
Step 5: Uncollapse tiles in fire corridors - dense typology

Manual inputs:

- Water flow lines
- Grid 100x100

Manual rules:

- 30m fire corridor is required every 300m.



Computer generated:

- Idle type tile

Computer rules:

- Uncollapse tiles in dense typology unde fire corridors

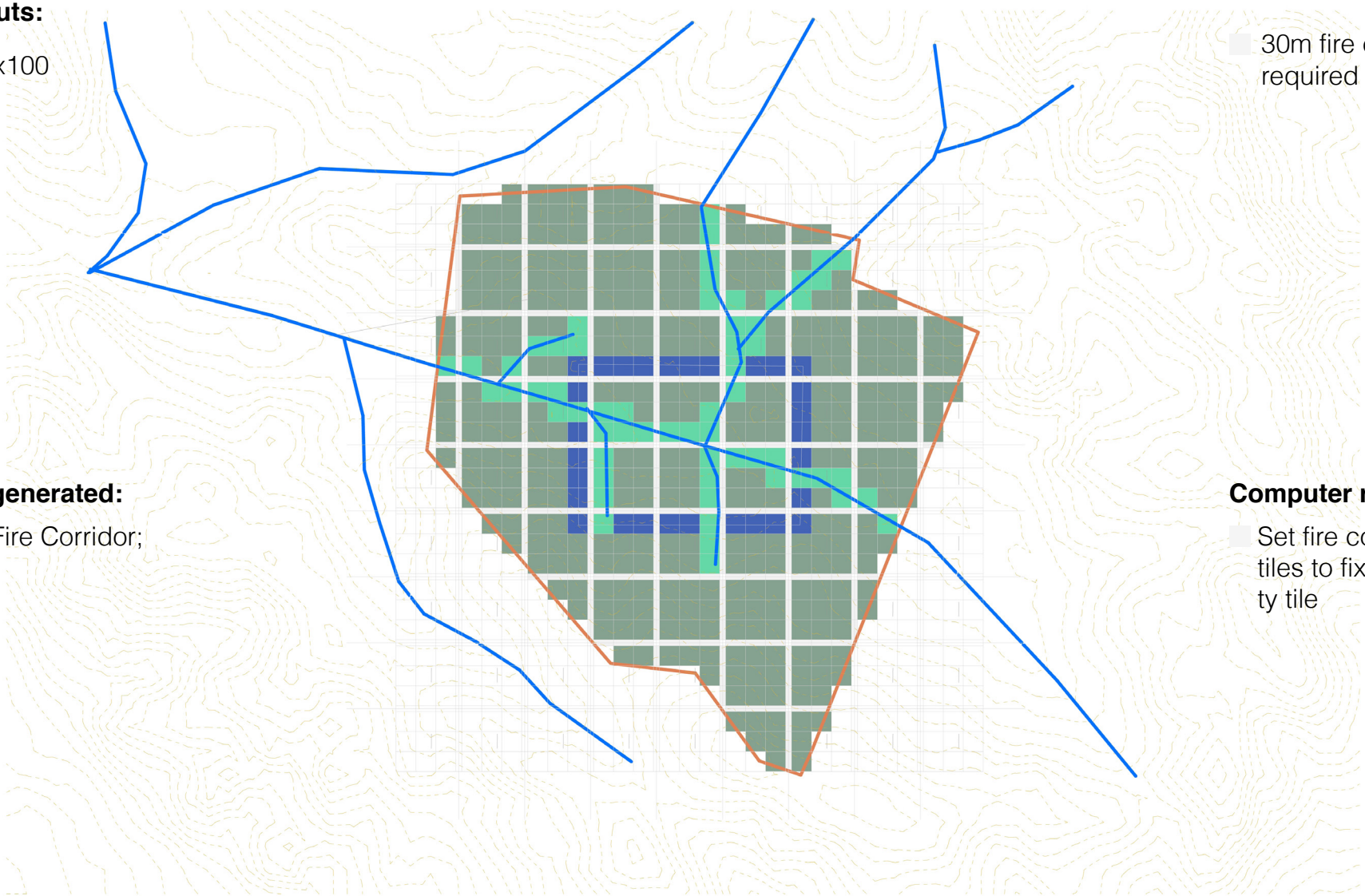
Step 6: Collapse fire corridors

Manual inputs:

- Grid 100x100

Manual rules:

- 30m fire corridor is required every 300m.



Computer generated:

- Tile type Fire Corridor;

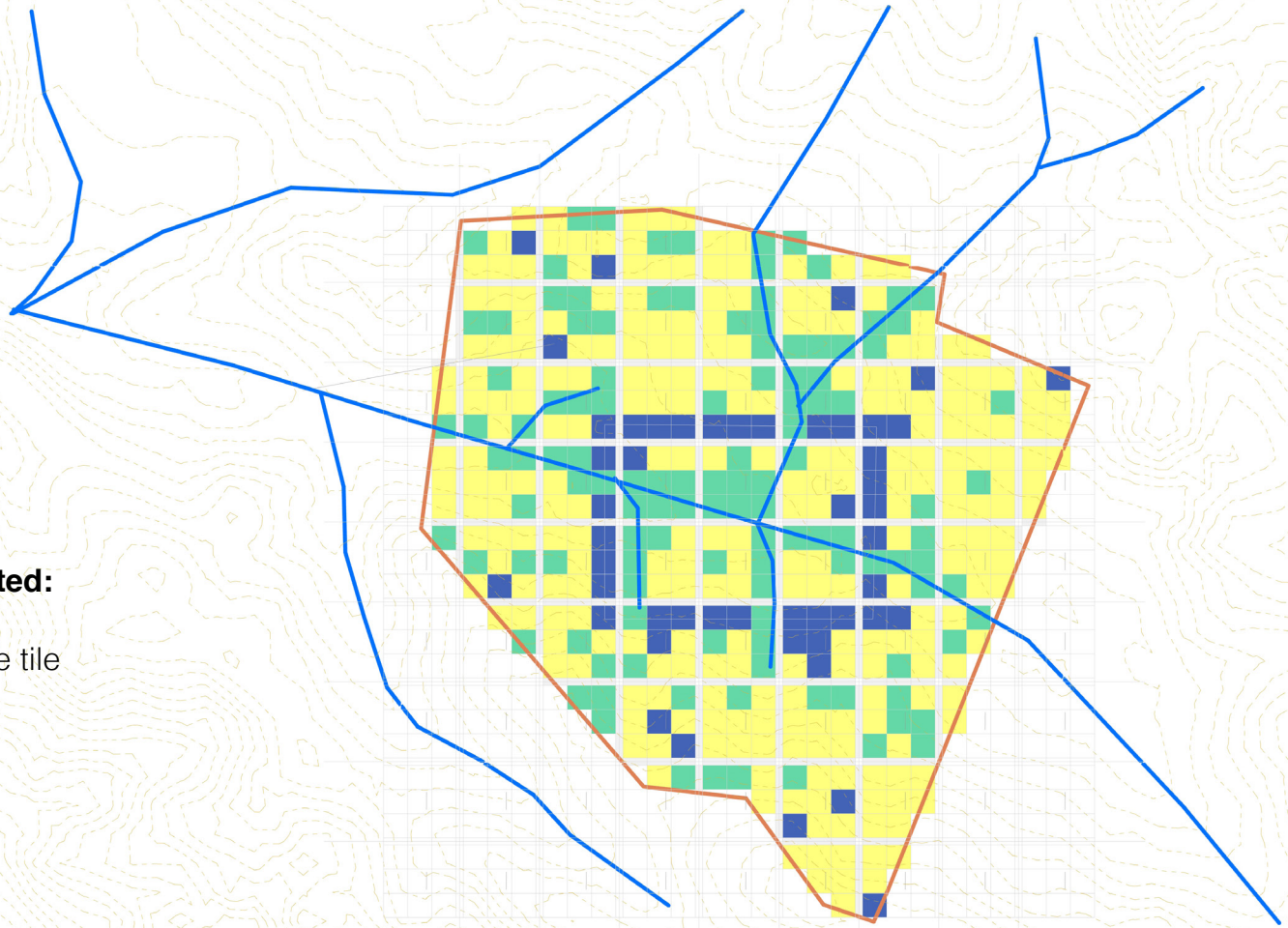
Computer rules:

- Set fire corridor tiles to fixed empty tile

Step 7: Fill in the rest

Manual inputs:

- Grid 100x100



Manual rules:

- Ease the transition between open space and dense space

Computer generated:

- Low density type tile
- Park type tile
- Dense type tile

Computer rules:

- Every tile can be next to themselves or an idle tile. Park can be next to low density. Low density can be next to park or high density. High density can be next to low density.

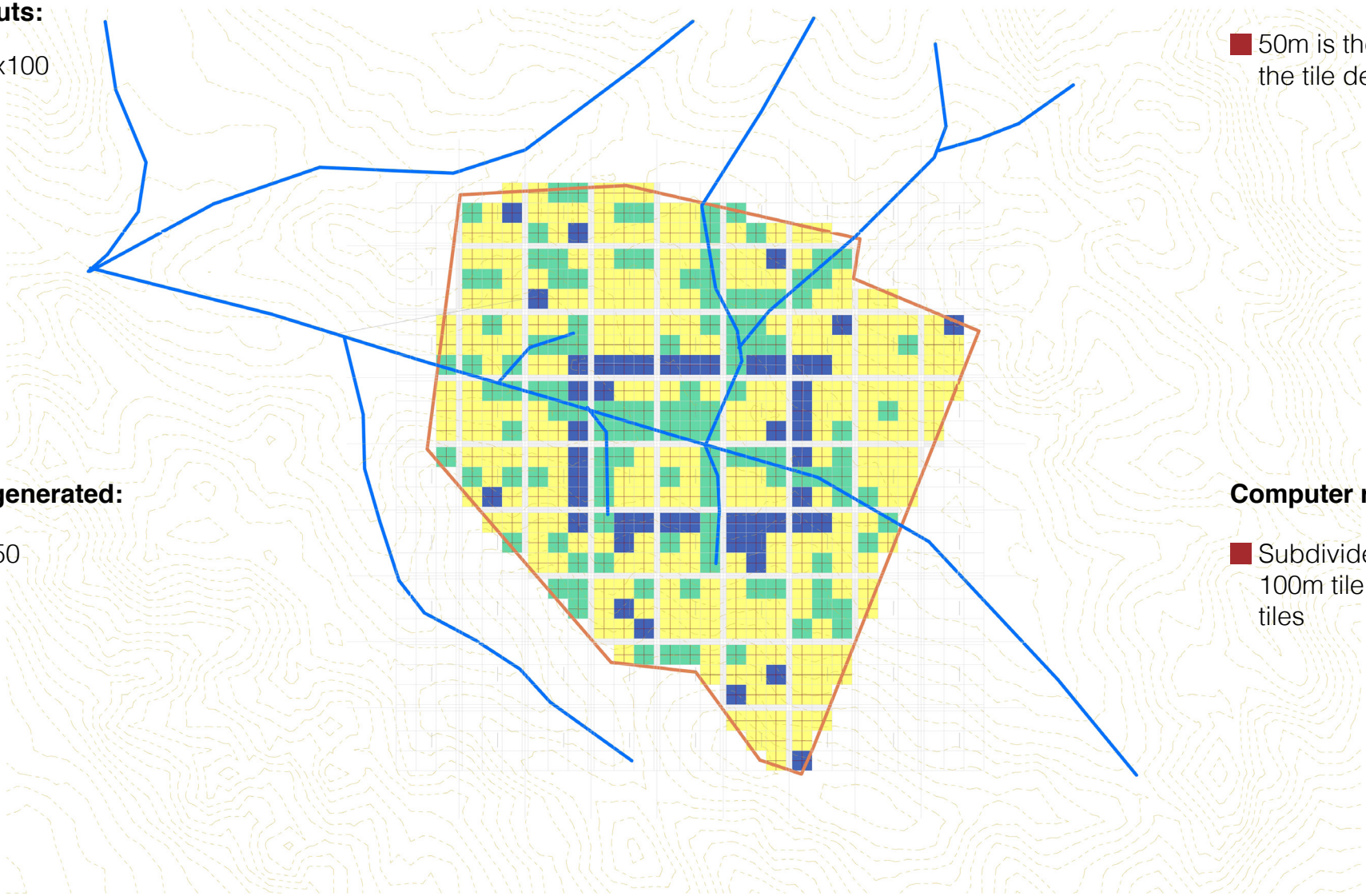
Step 8: Subdivide grid

Manual inputs:

- Grid 100x100

Manual rules:

- 50m is the size of the tile design



Computer generated:

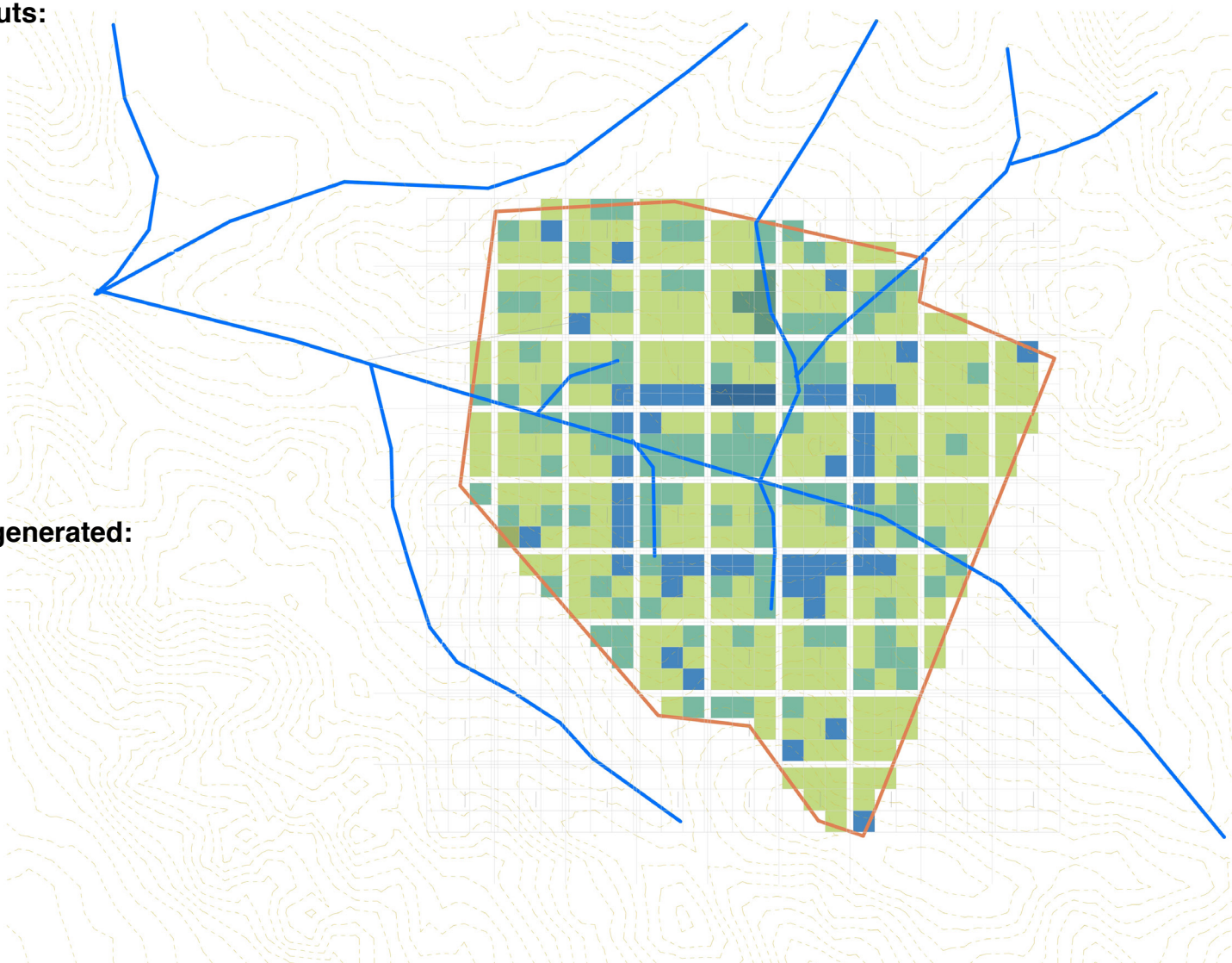
- Grid 50x50

Computer rules:

- Subdivide every 100m tile into 4 tiles

Step 9: Read in new WFC for individual colors

Manual inputs:



Manual rules:

Running the WFC on two grids in different scale creates hierachy in the design.

Computer generated:

Computer rules:

Select every dense tile in a dictionary keeping track of the tile types.

Reinitiate WFC objects of every color

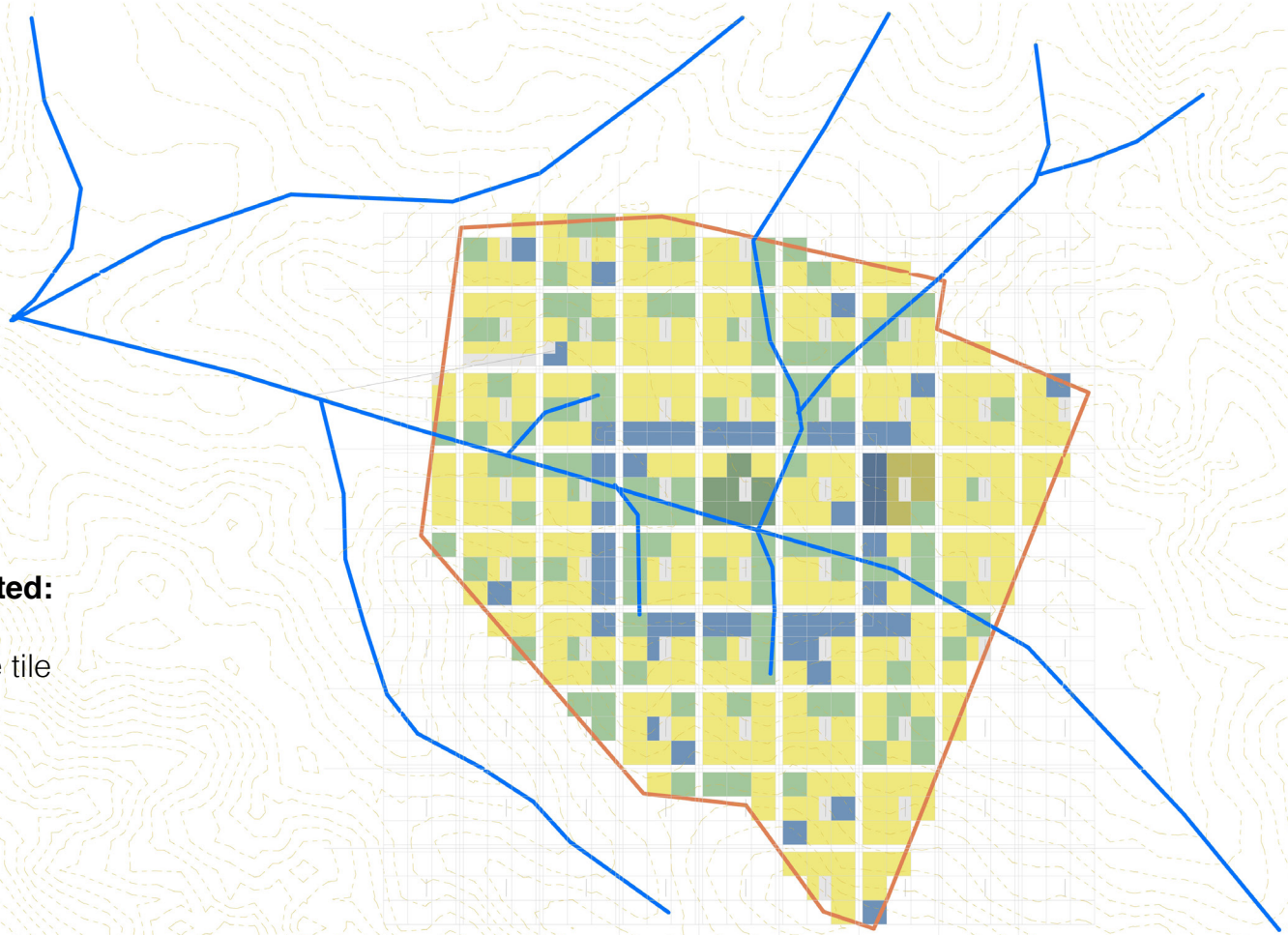
Step 10: Custom collapse community tiles in each sector

Manual inputs:

- Water flow lines
- Grid 100x100

Manual rules:

- A pattern language: Different scales of community



Computer generated:

- Community type tile

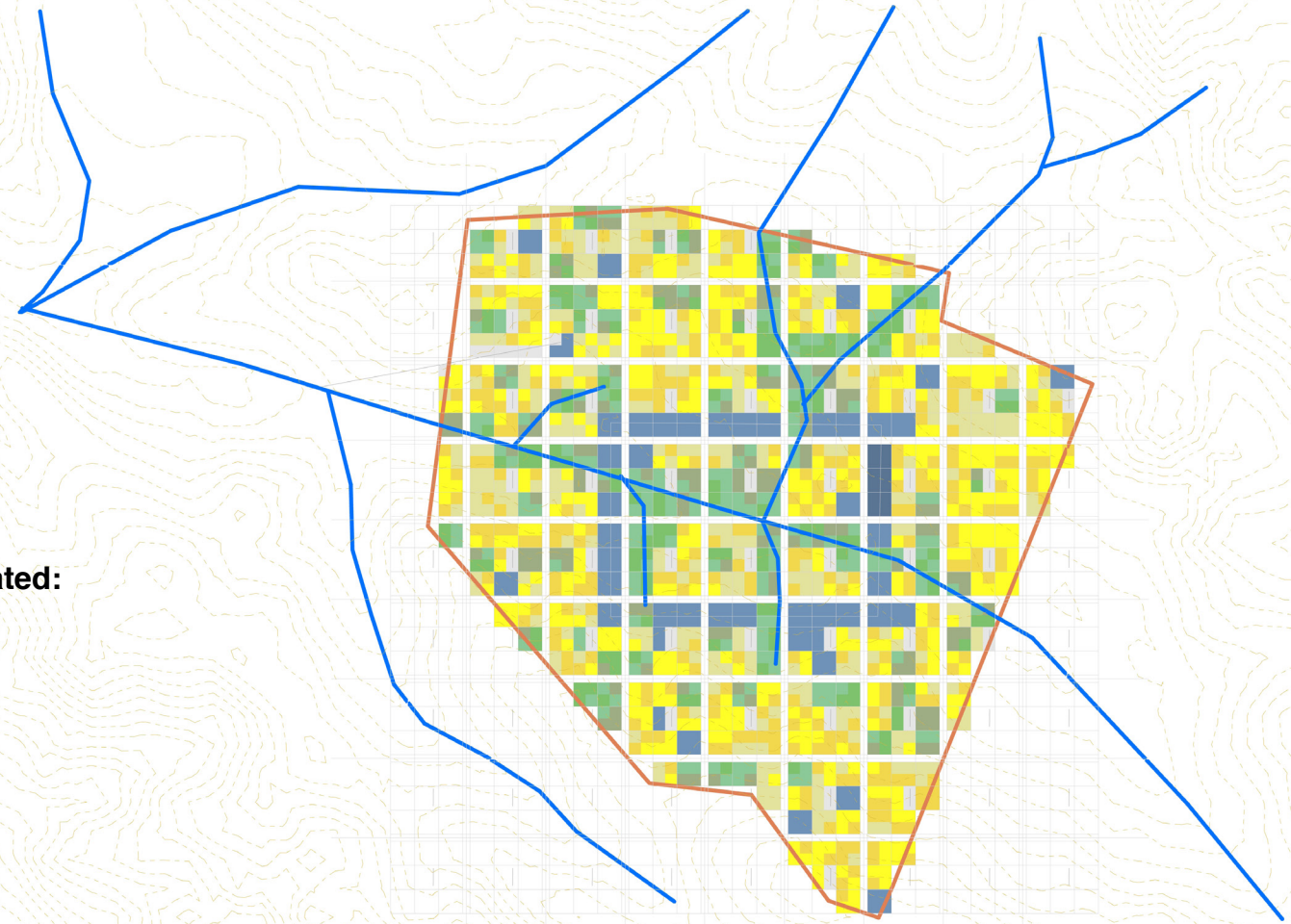
Computer rules:

- Collapse tiles under line to community type

Step 11: Collapse (low density and green areas)

Manual inputs:

- Water flow lines
- Grid 100x100



Computer generated:

- Low denisty
- Green areas

Manual rules:

A pattern language: Neighbourhoods

Prospect refuge theory: Varied sight lines

Theory of Aesthetics in perception of spaces - legibility, coherence, complexity and mystery: Introducing complexity and mystery

Computer rules:

Run separate instances of WFC for each colour each containing three different programs.

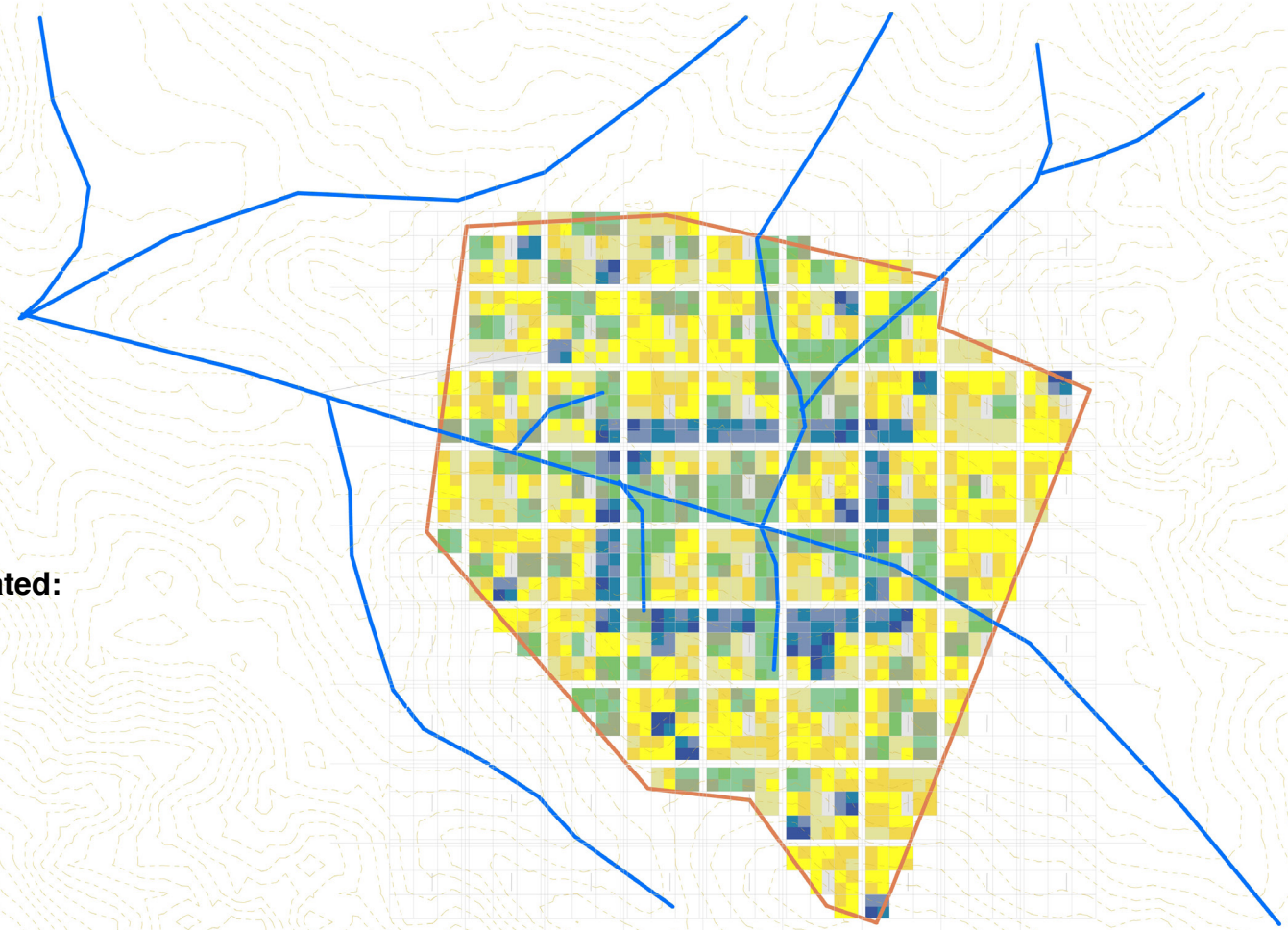
Step 11: Collapse (high density)

Manual inputs:

- Water flow lines
- Grid 100x100

Manual rules:

A pattern language:
Central prommenade
Aim to include agency through commercial forces in design.



Computer generated:

- Low denisty
- Green areas
- High denisty

Computer rules:

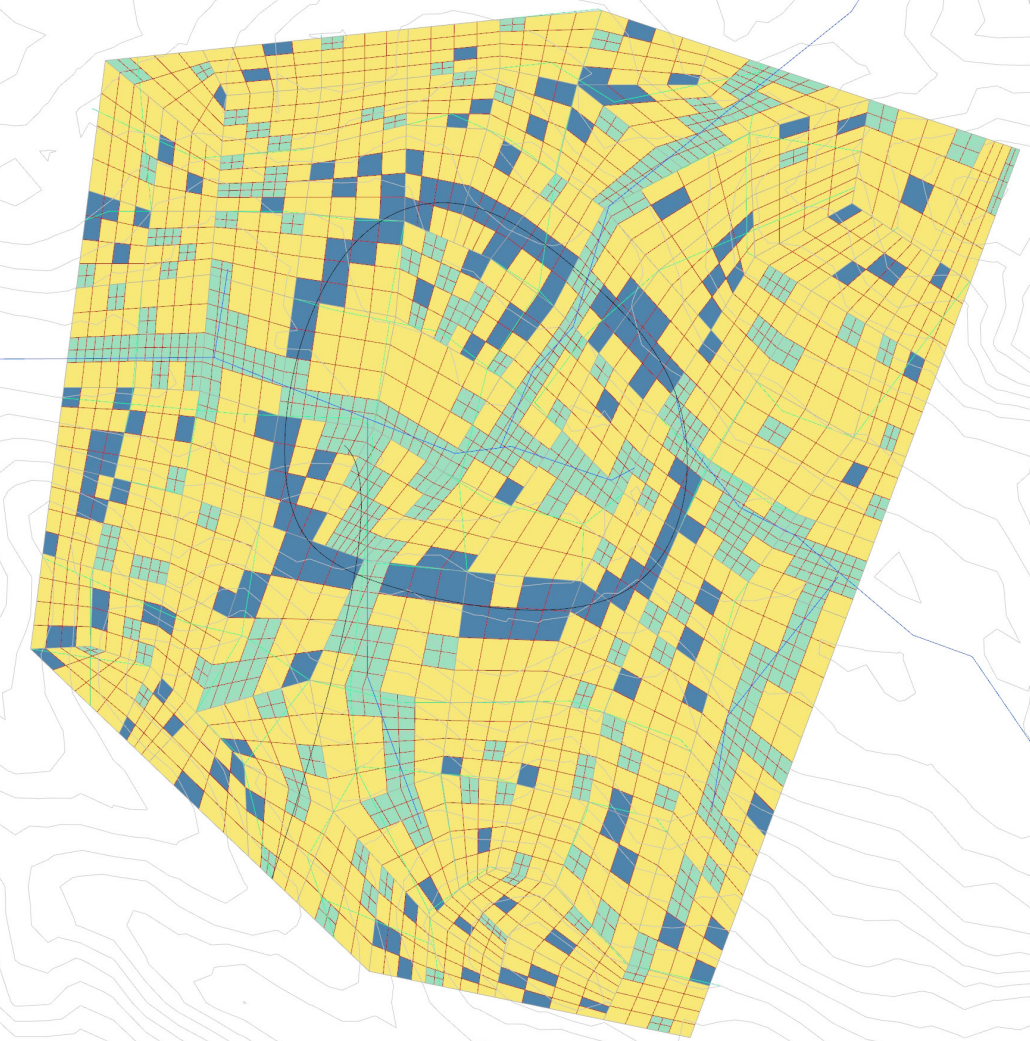
Run separate instanc-es of WFC for each colour each contain-ing three different programs.

Alternative: Non square variation

Manual inputs:

- Water flow lines
- Cusom grid

Manual rules:



Computer generated:

- Dense tile
- Low density tile
- Open Areas

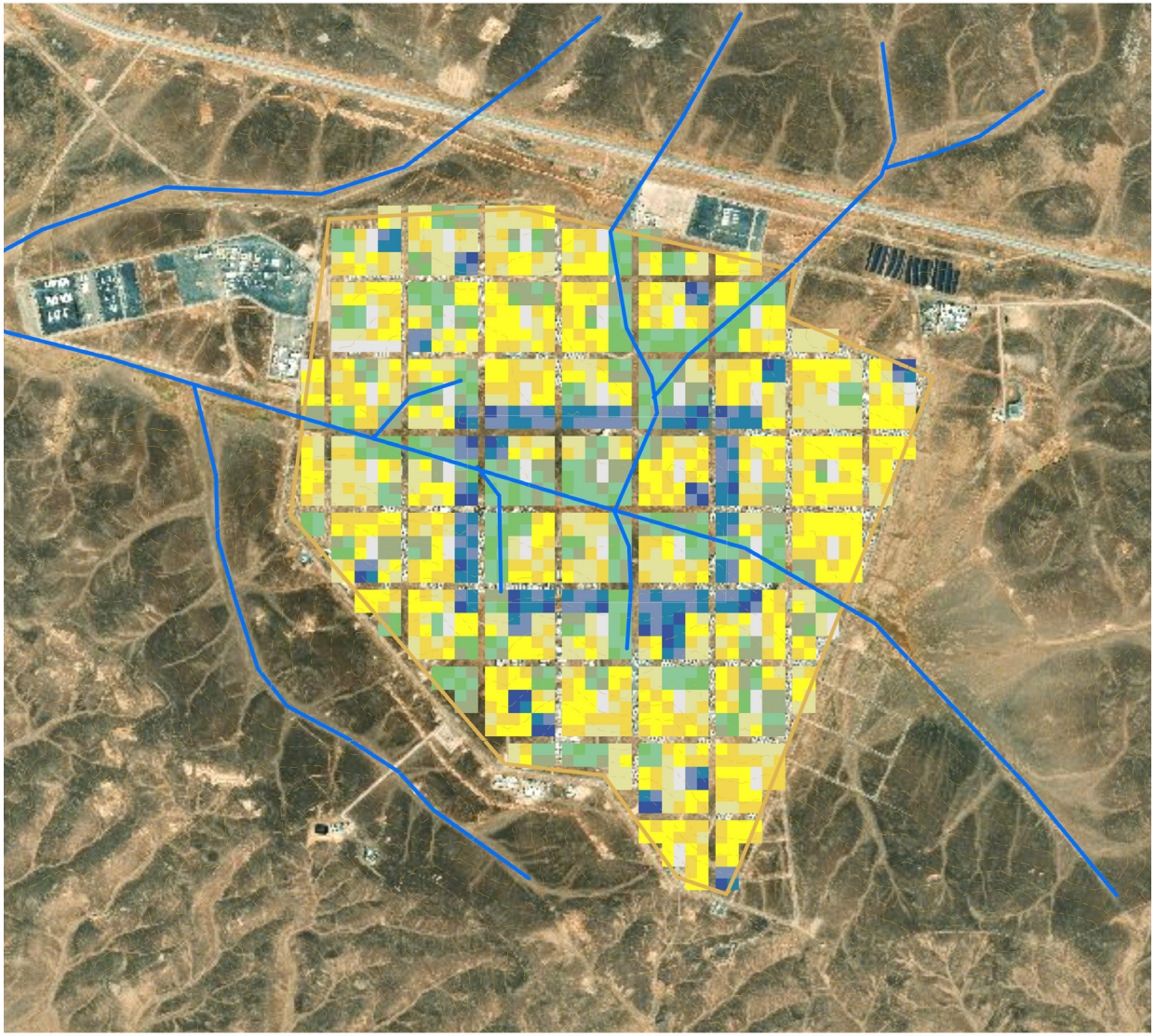
Computer rules:

Finished graph

Manual inputs:

- Water flow lines
- Grid 100x100

Manual rules:



Computer generated:

- Low denisty
- Green areas
- High denisty

Computer rules:

Case selection

Problem definition

Approach

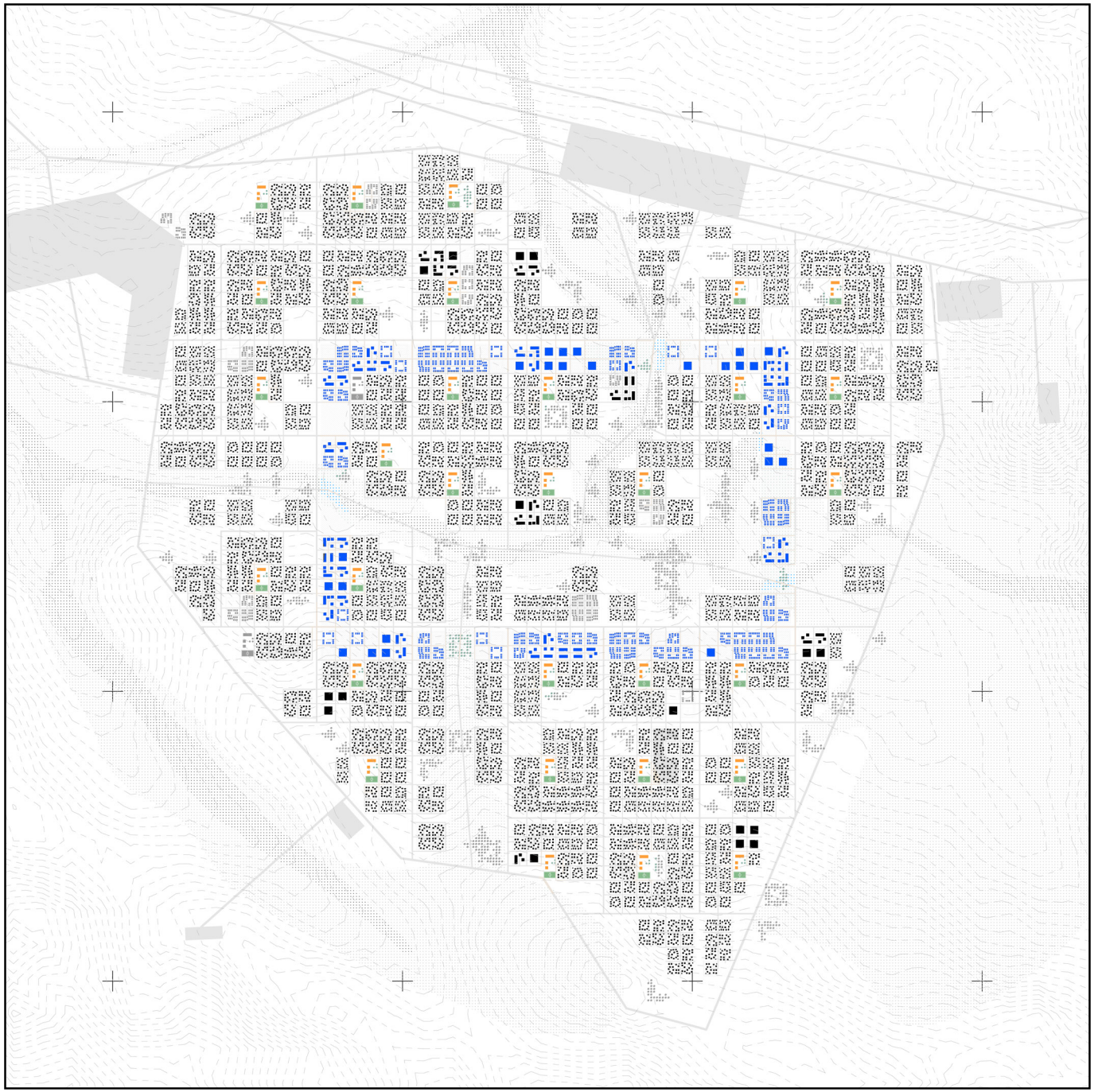
Methodology

Application

Design

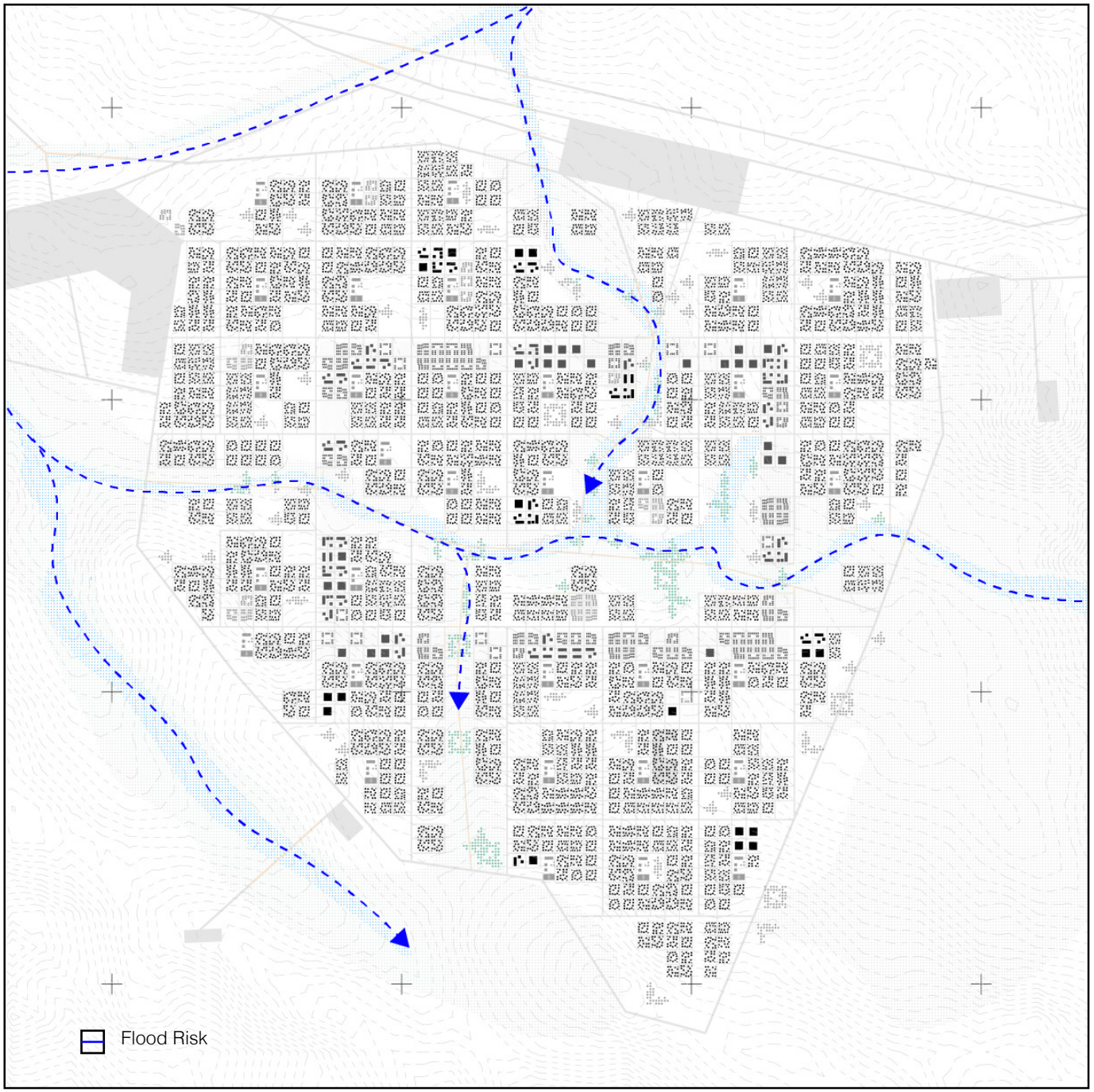
Discussion

Generated proposal



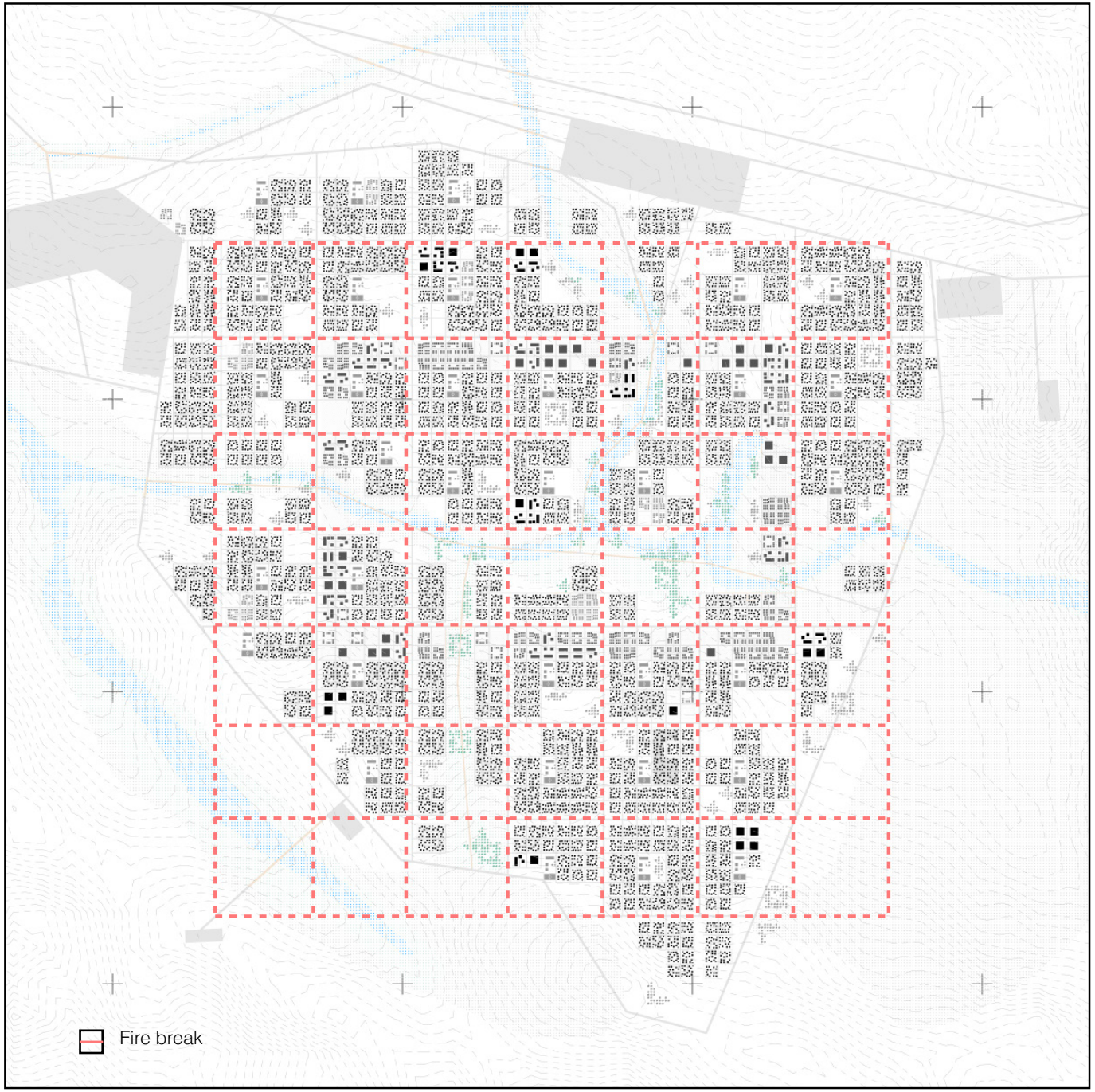
Flooding

- Construction should be avoided in spaces that flood during rainfall.
- These spaces can instead be green recreational spaces. Trees help against flooding.

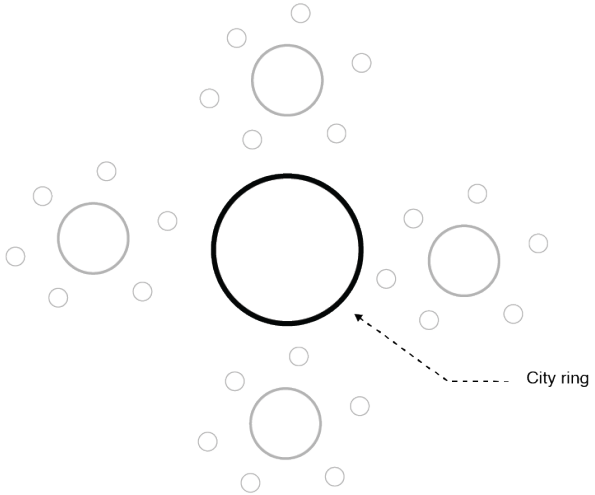


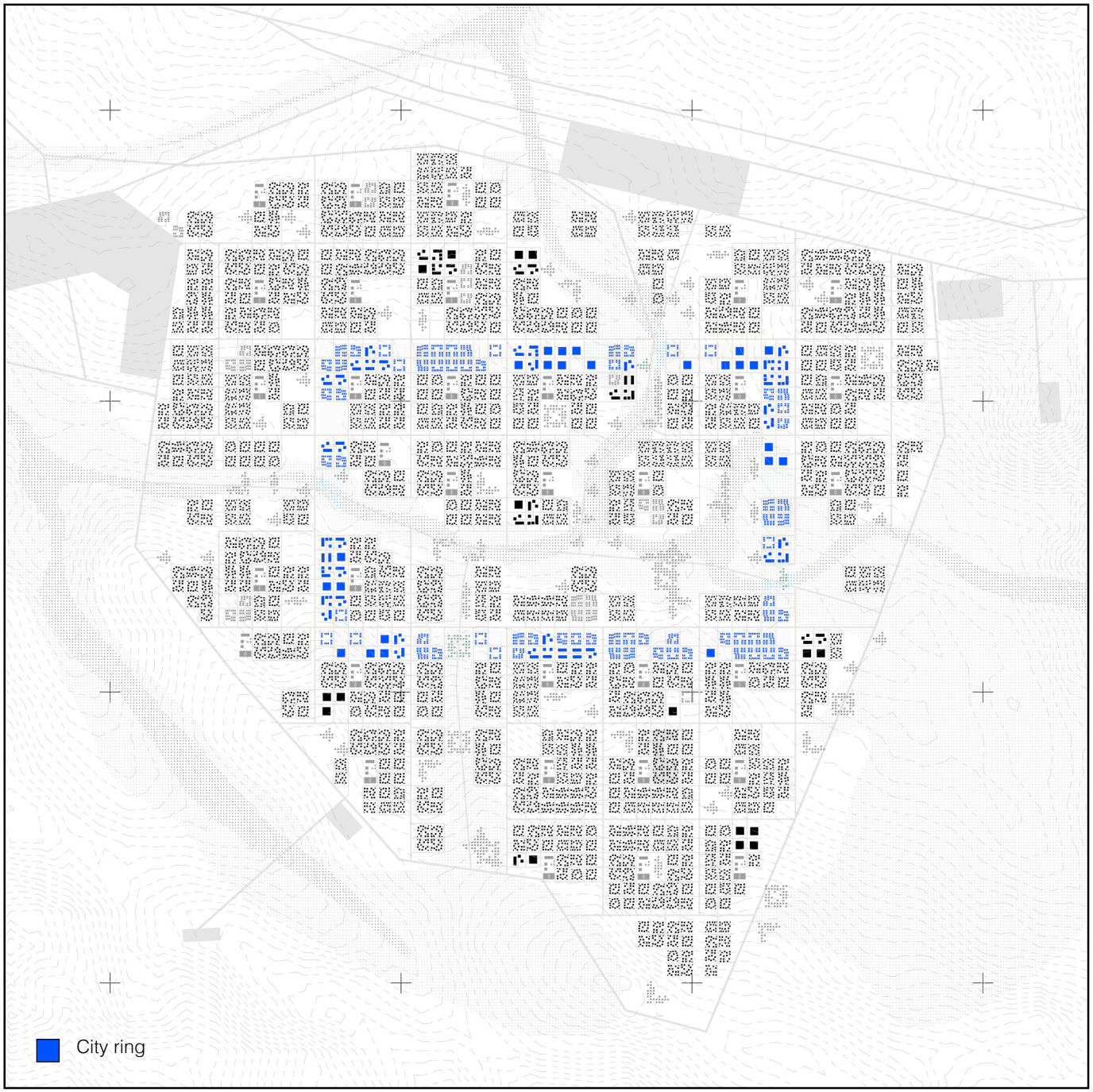
Fire Safety

- A 30 m fire corridor every 300 m.
- Shelters placed minimum 2 m apart. Ideally distance is larger or equal to height

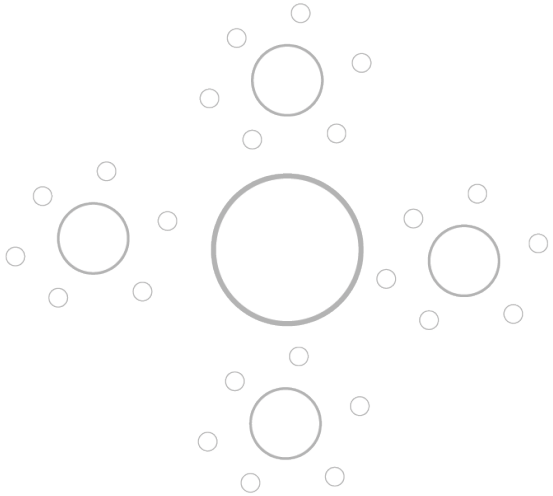


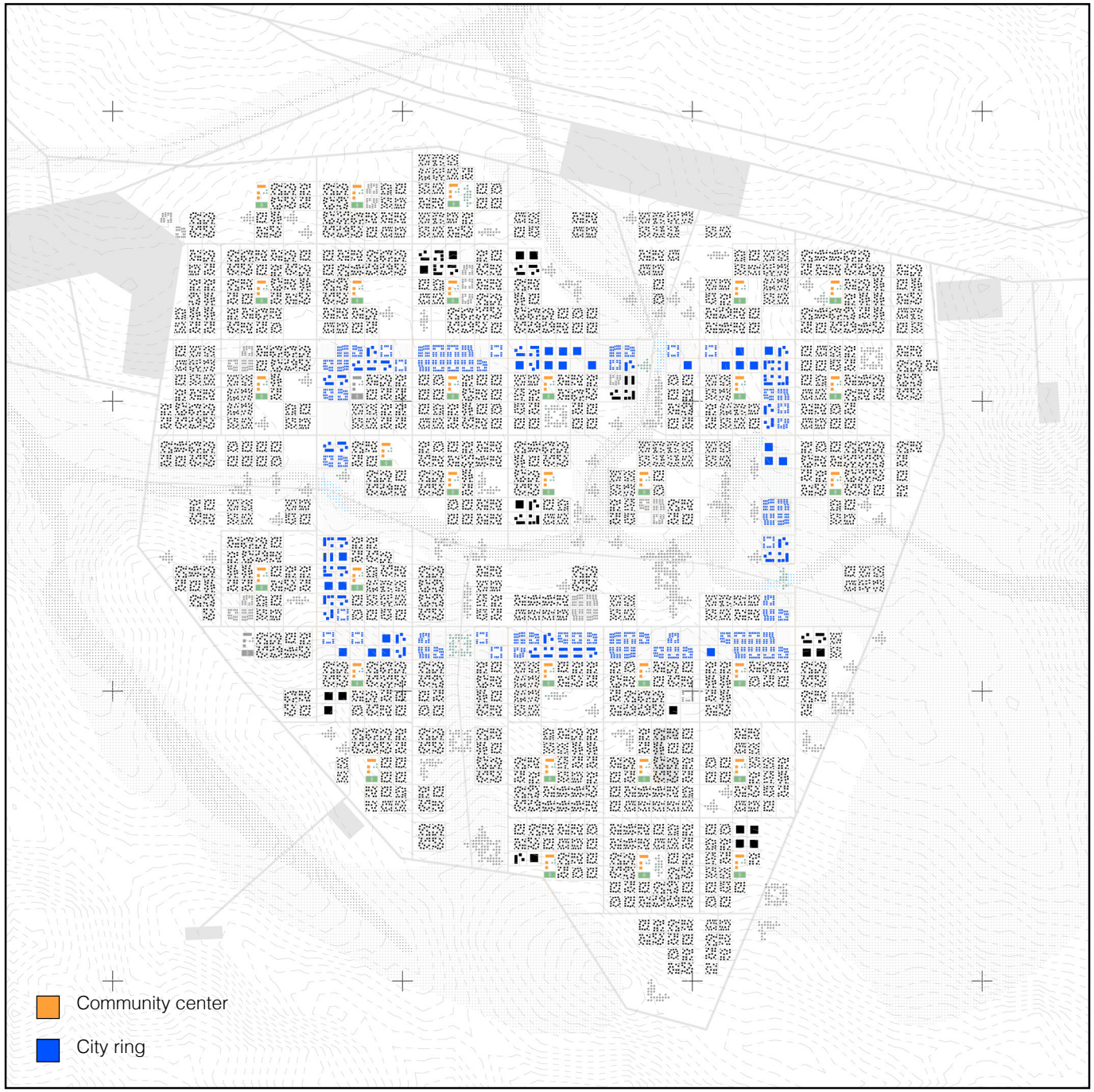
Quality:
A central street



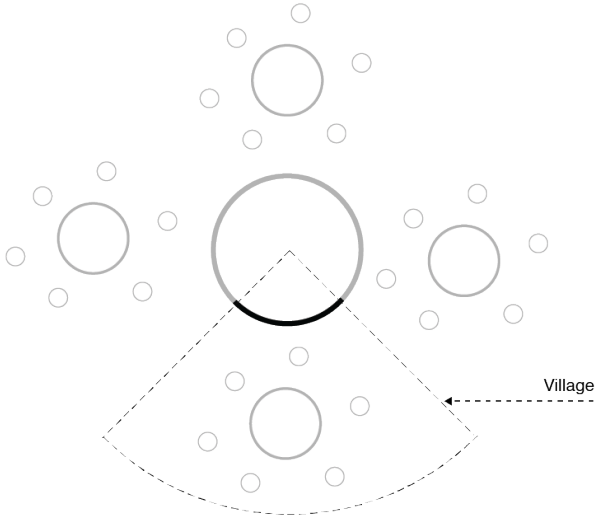


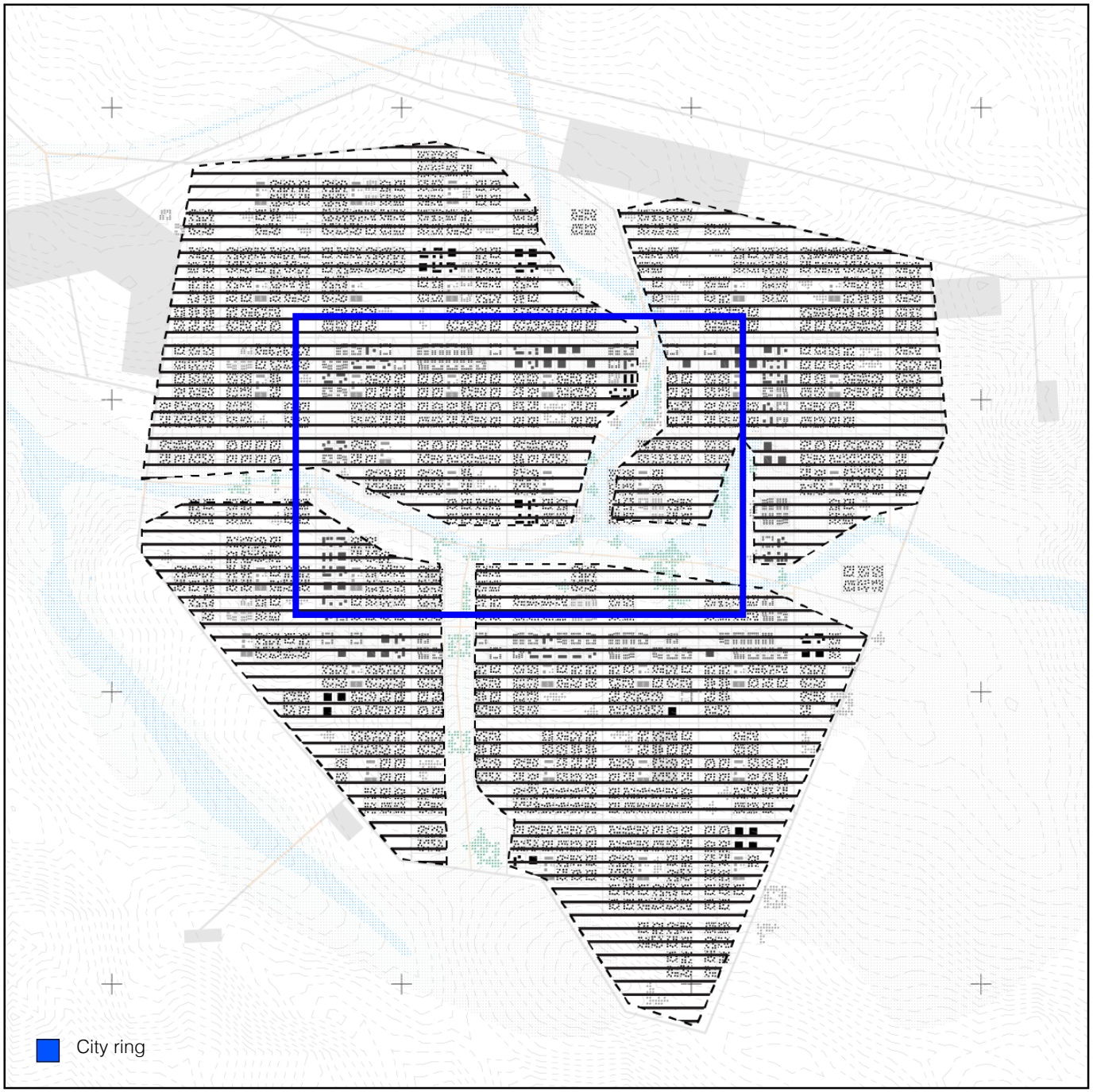
Quality:
Different scales of community
A central street



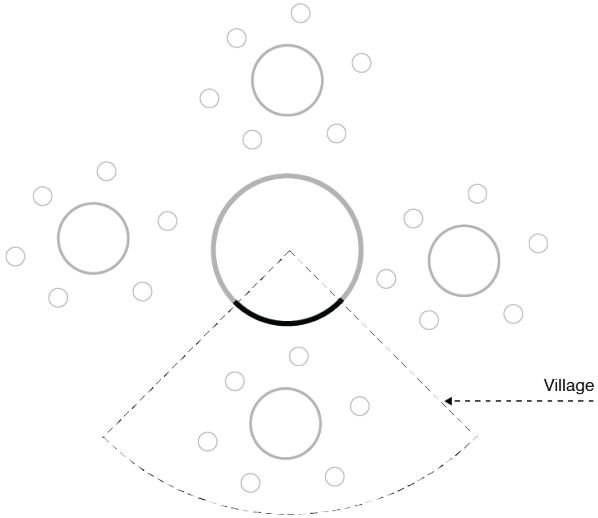


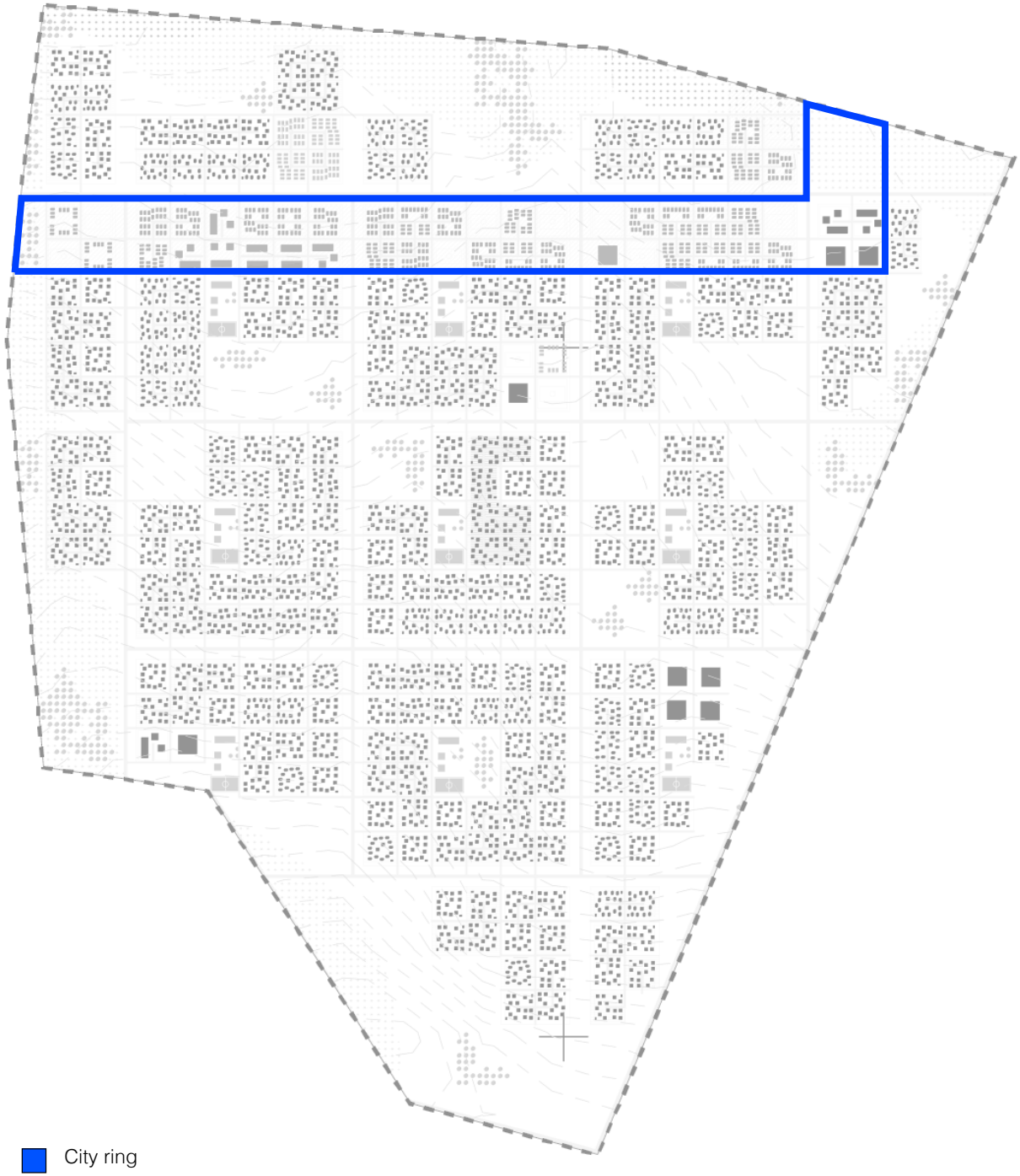
Quality:
Different scales of community
A central street



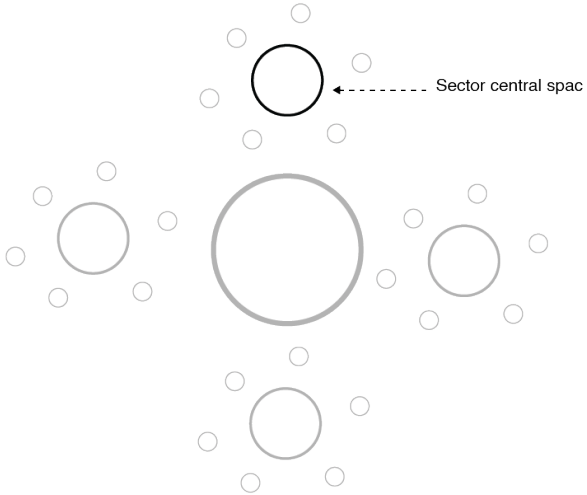


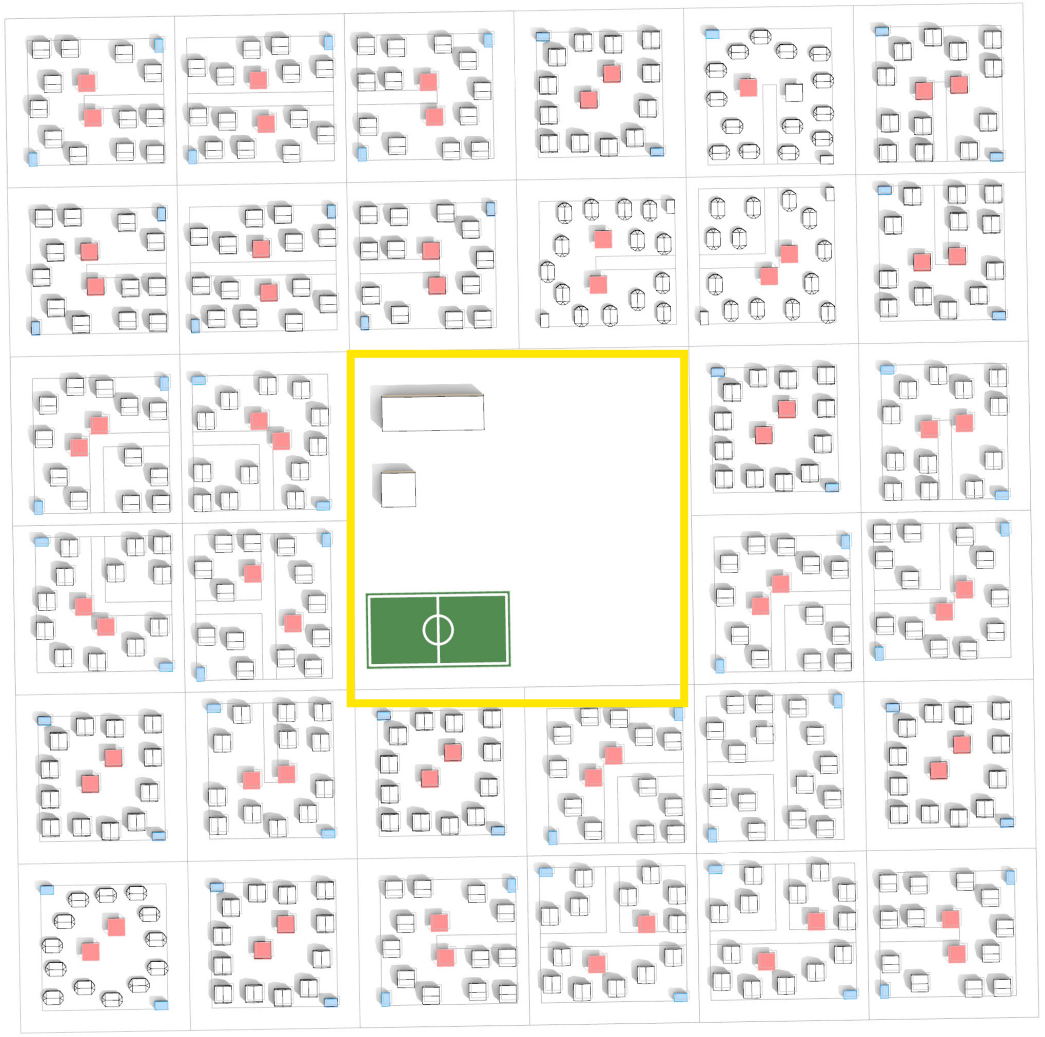
Quality:
Different scales of community
A central street





Quality:
Different scales of community
A varied human scale environment





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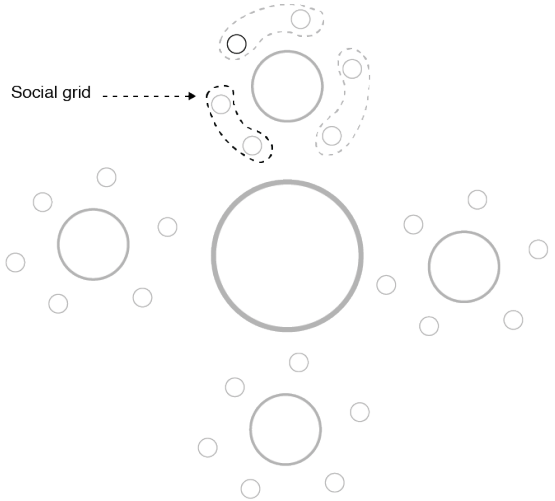
CASE STUDY - DESIGN
Functional grid



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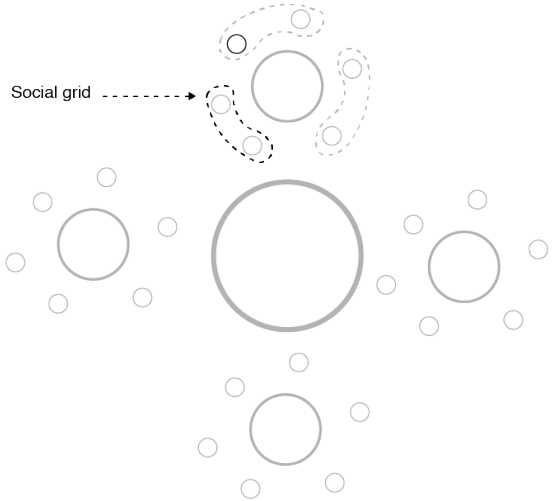
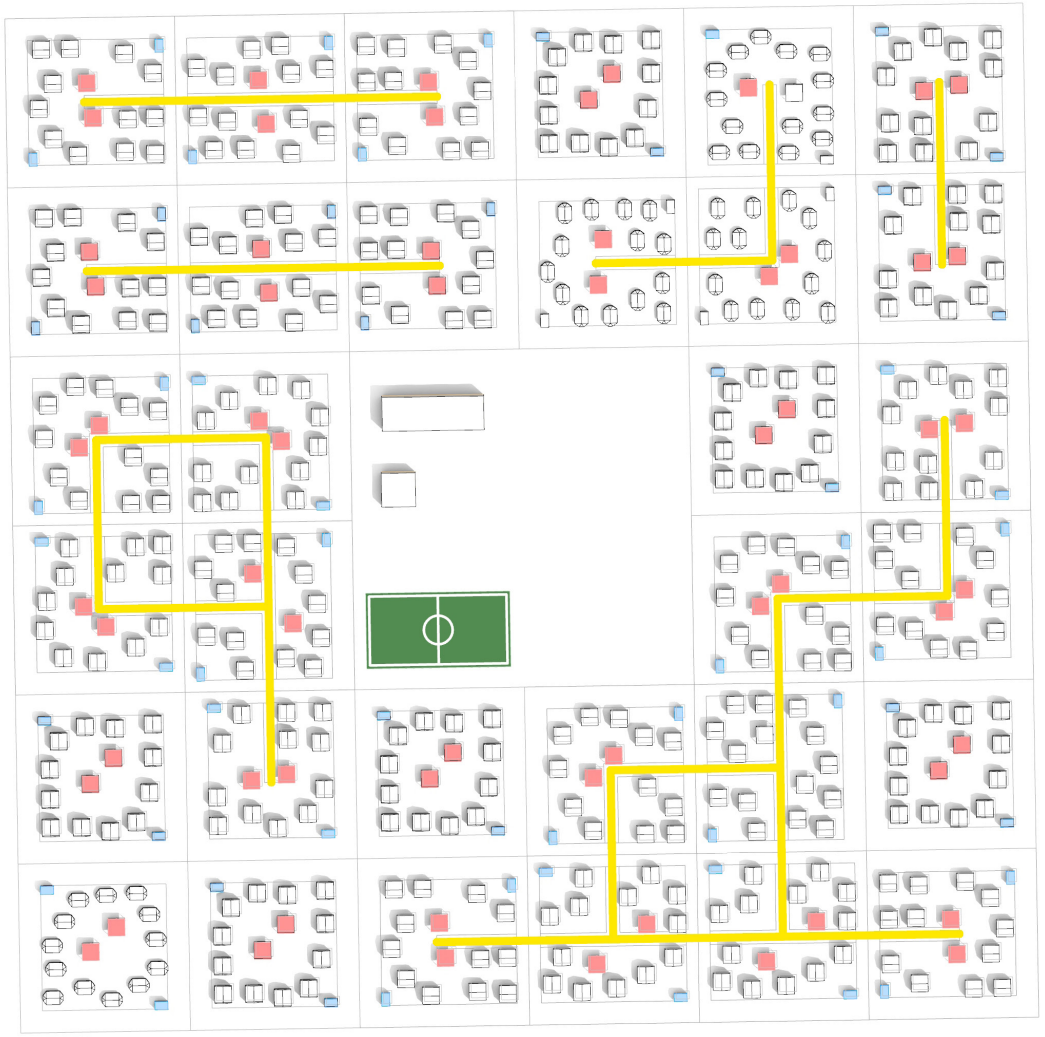
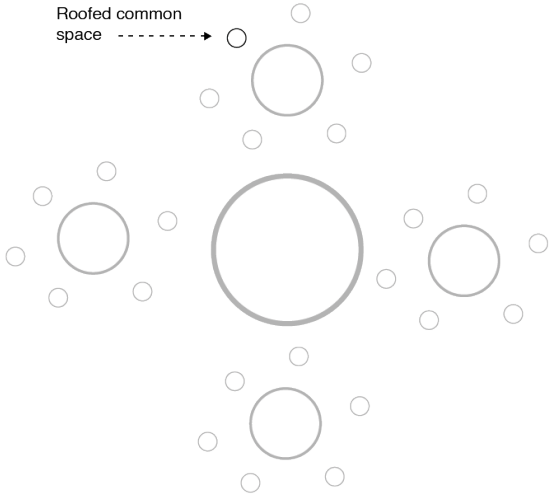
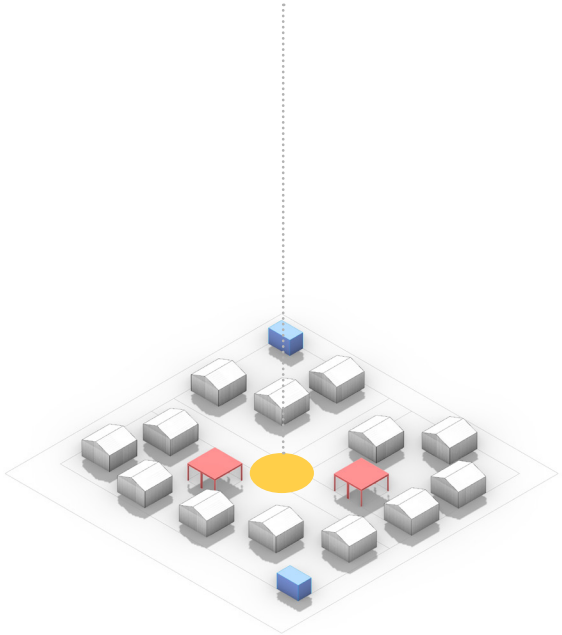






Social ownership of semi public street network could make it more safe



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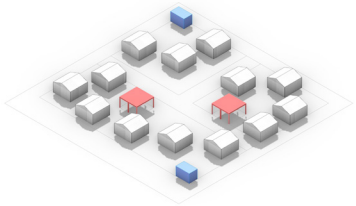
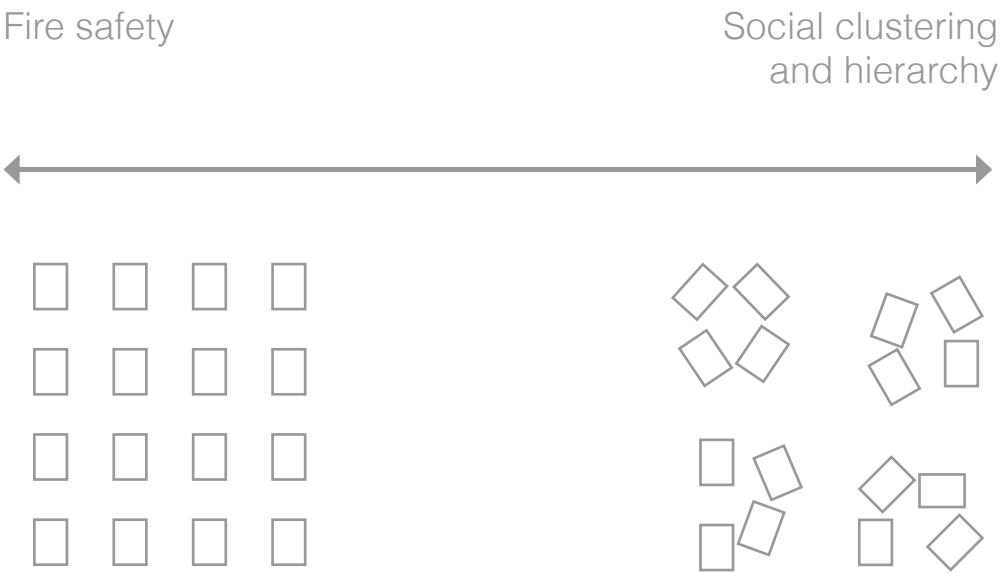
Speed - Automation:
Fire Safety





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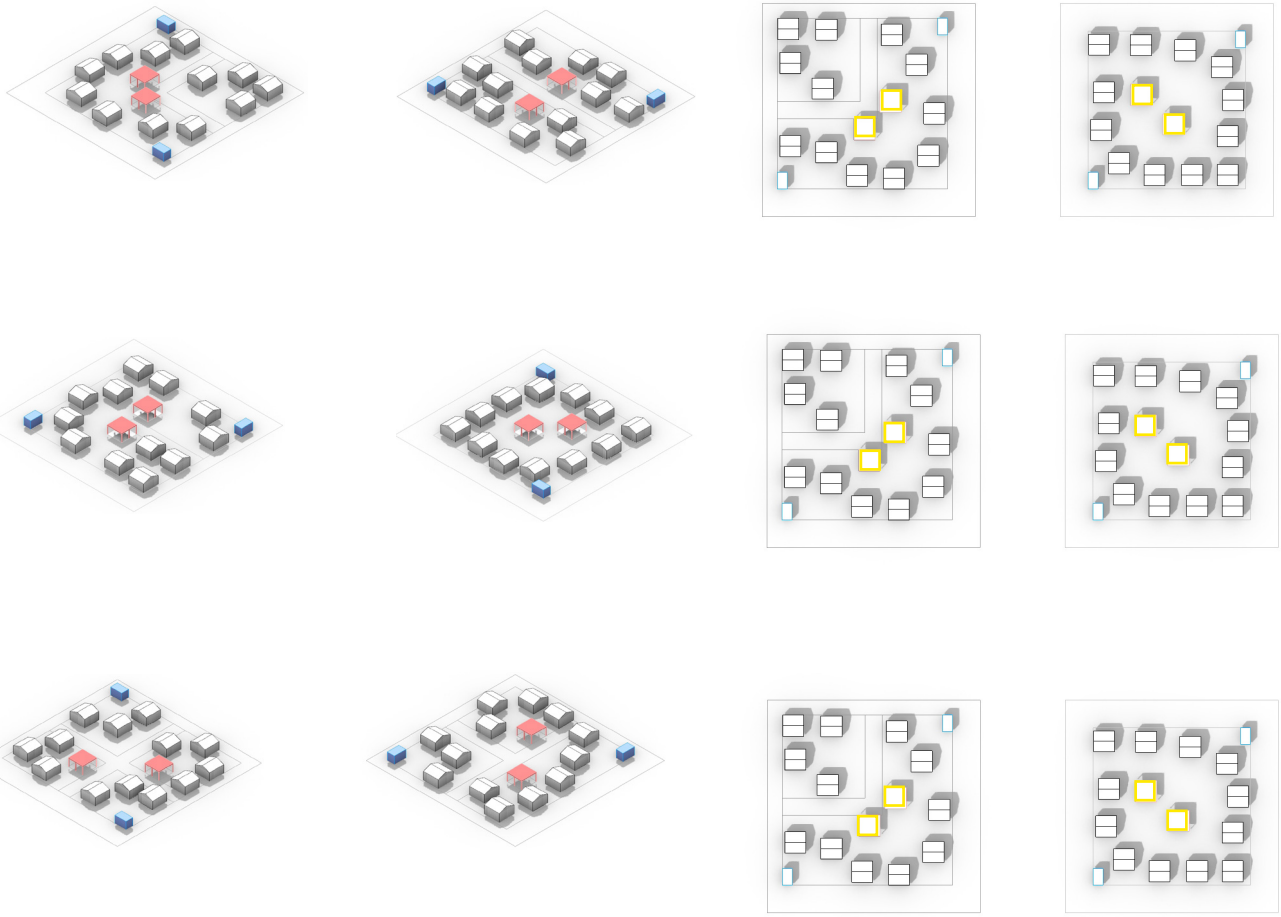
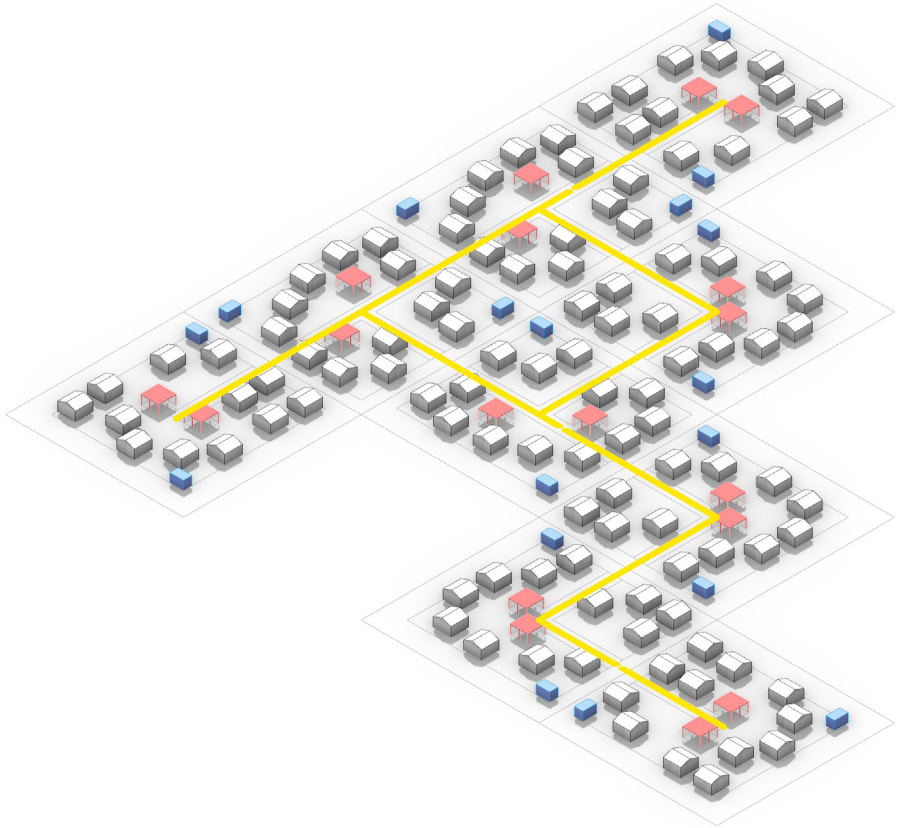
CASE STUDY - DESIGN
The tile



The graph in a physical context
Social streets



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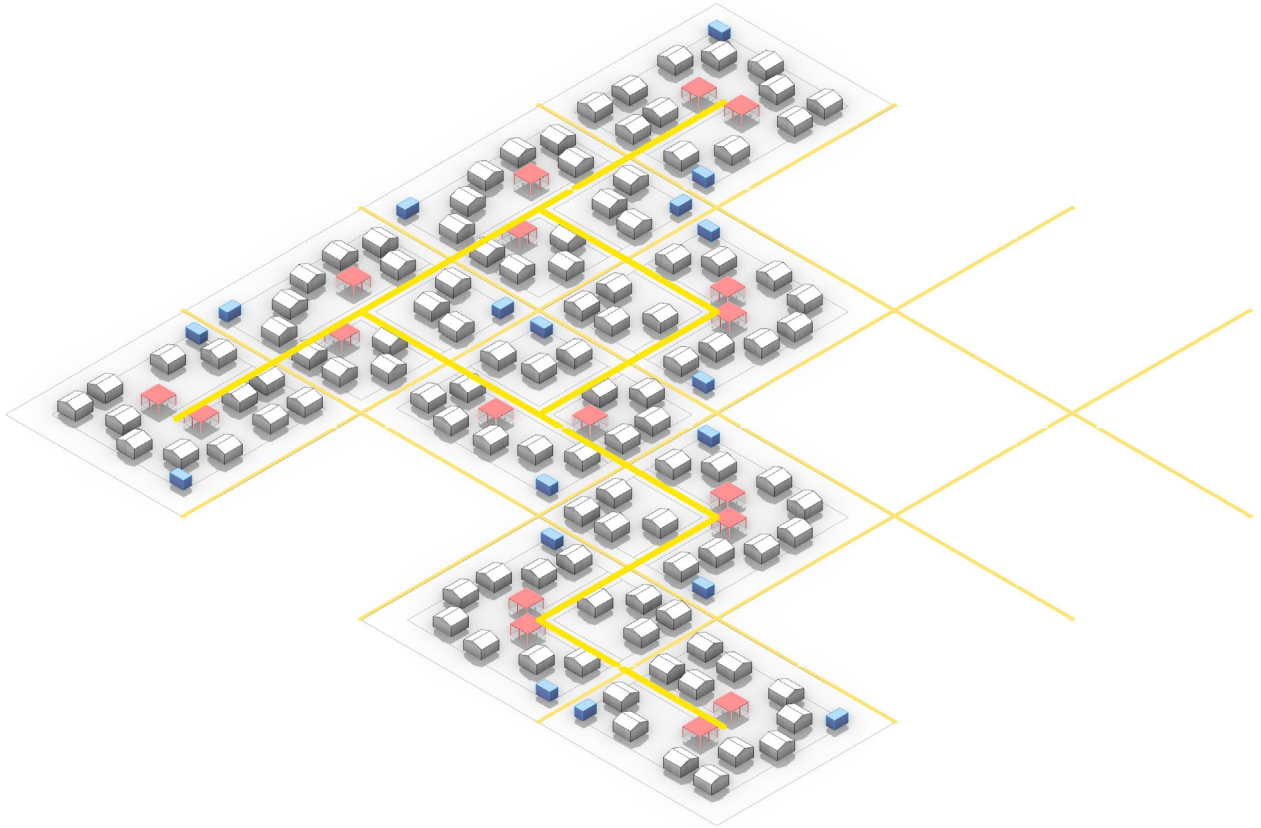
CASE STUDY - DESIGN
Application of the graph

Maintain a rigid grid for maintenance
access and security



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CASE STUDY - DESIGN
Overview

Rows of shelters Azraq, Jordan (S. Gormley, 2014)

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View inside Azraq settlement, Jordan (D.Fosas, 2021)

View inside Azraq settlement, Jordan (D.Fosas, 2021)

View inside Azraq settlement, Jordan (D.Fosas, 2021)

Case selection

Problem definition

Approach

Methodology

Application

Design

Discussion

Process based limitations:

- The algorithm is not better than the data fed into it
- It requires expertise to customize the framework
- The framework is not suitable for all cases

Case related limitations:

- The case does not represent a complete master planning approach there are many more considerations to be made

Computational limitations:

- It is unfeasible to draw organic grids by hand

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Process based potentials:

- Faster iterations could help increase community input
- Faster design can let decision maker order materials faster and make fewer mistakes
- Making simulations or visualizations to raise funding

Case related potentials:

- Include strategic planning taking temporality and exit strategies into account.
- Create a comprehensive master plan taking more nuances into account.

Computational potentials:

- Further integration of AI (chat GTP) for rule generation could make the tool faster and easier to use.
- A grid generation tool could complement the algorithm and help address organic sites.

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Reserach question:

How can the wave function collapse algorithm help **speed up**, and, or improve the **quality** of master planning of emergency settlements by fast generation of design proposals?

Conclusion:

This project has shown that it is possible to use procedural generation to introduce more complex urban patterns.

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Speed: The case study for Azraq, showed that this new framework makes it possible to produce large designs of high detail in a short time frame in a way that was previously not possible.

Conclusion:

This project has shown that it is possible to use procedural generation to introduce more complex urban patterns.

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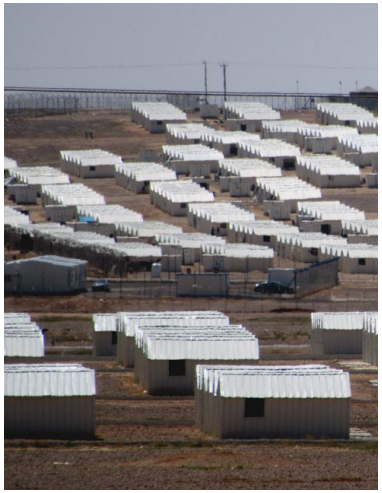
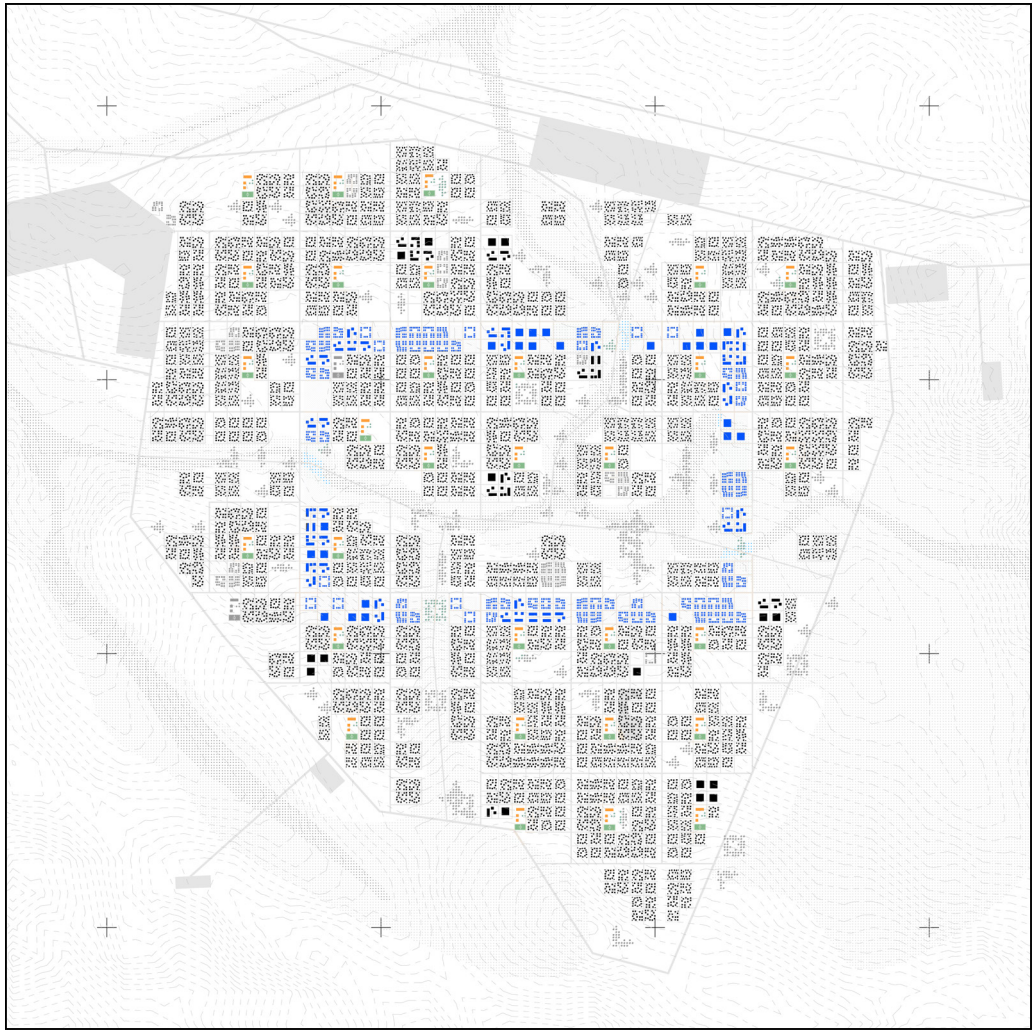
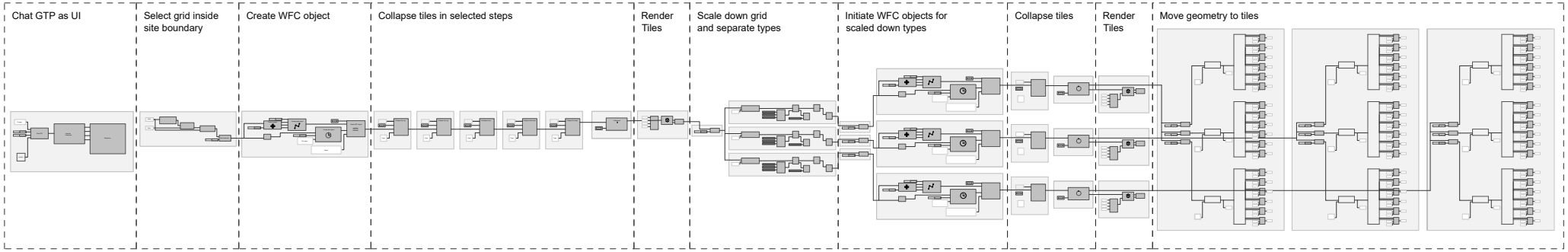
Quality: The case for Azraq showed that these patterns can be used to address problems such as repetitiveness and general lack of de sign that account for social and economic preferences.

Thank you for so much for listening






Chat GTP as UI
Select grid inside site boundary
Create WFC object
Collapse tiles in selected steps
Render Tiles
Scale down grid and separate types
Initiate WFC objects for scaled down types
Collapse tiles
Render Tiles
Move geometry to tiles