netWoroKed syStems

A Food Hub For Paris

TU DELFT HYPERBODY STUDIO
GRADUATION PROJECT
MANUEL ZUCCHI
LOCATION AND OBJECTIVES

- PARIS
  - Relevant situation in the panorama of urban agriculture
  - It is one of the largest conurbations in Europe
  - It is one of the most visited cities in the world
  - All the food consumed is produced outside the city and transported with high costs in terms of money and pollution

What could be a possible solution to feed in a more sustainable way a big metropole like Paris?
URBAN STUDIES

PARIS POPULATION ANALYSIS:
- 2.2 Millions - City Center
- 6 Millions - Small Crown
- 12 Millions - Grand Paris
- 25 Millions - Tourist/Year

AREA:
- 105 km²
- 760 km² (Small Crown)

FOOD CONSUMPTION:
- FOOD CONSUMPTION per person per year:
  - for cropland: 2500 m²
  - for grazing: 5500 m²
  - Approximately 1.5 soccer fields per year

VERTICAL FARM TO FEED THE CENTRAL AREA OF PARIS

DEMOGRAPHIC AND FOOD INFRASTRUCTURE MAPPING

Demographic map
Population per arrondissement

Food infrastructure map
Presence of food commercial business every inhabitants

<table>
<thead>
<tr>
<th>Arr.</th>
<th>Surface (km²)</th>
<th>Population</th>
<th>Supermarket C.B. x Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,83</td>
<td>16,900</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
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<td>44,898</td>
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<td>7</td>
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<td>56,432</td>
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<td>9</td>
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<tr>
<td>10</td>
<td>2,89</td>
<td>89,612</td>
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<tr>
<td>11</td>
<td>3,67</td>
<td>149,102</td>
<td>9</td>
</tr>
<tr>
<td>12</td>
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</tr>
<tr>
<td>13</td>
<td>7,15</td>
<td>171,892</td>
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<td>17</td>
<td>5,67</td>
<td>160,858</td>
<td>11</td>
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<tr>
<td>18</td>
<td>6,01</td>
<td>184,587</td>
<td>16</td>
</tr>
<tr>
<td>19</td>
<td>6,79</td>
<td>172,761</td>
<td>8</td>
</tr>
<tr>
<td>20</td>
<td>5,98</td>
<td>182,952</td>
<td>4</td>
</tr>
</tbody>
</table>
URBAN VISION AND SITE LOCATION

• PETITE CEINTURE
  - Dismissed old railway line that divide the city center from the periphery (32 km)
  - Biggest waste land in Paris, it provides an heterogeneous landscape with several microclimates
  - It provides an infrastructural system (railway and pedestrian paths) and along it there are several unused spots of land
  - It has connections with all the mayor train stations and with several parks

SYSTEM STRATEGY

FOOD HUB
- Various urban settlements for the production and distribution of food

FOOD INFRASTRUCTURE
- Railway infrastructure for the transportation of food produced in the various food hub

PARK ROUTE
- Pedestrian route into the petite ceinture integrated with public gardens and private gardens
PROJECT'S SITE

- SITE
  - Located in the South-East of the city between the 13th and 14th arrondissement
  - Dismissed train depot nearby the Petite Ceinture
  - Big urban void between the city centre and the periphery
  - Heterogeneous surrounding
  - Total area: 23,000 square meters
PROJECT'S STRATEGY

PROJECT: FOOD HUB
- Combine
  - Intensive production of food
  - Local conditions and communities

LOCAL INTEGRATION
- Provide functions
  - Housing
  - Shop
  - Parking
  - Open spaces
  - Bar/restaurant
  - Office

INFRASTRUCTURE
- Connect urban tissue
- Facilitate flows through the site
- Provide access to the petit ceinture

URBAN AGRICULTURE
- Production
  - Through greenhouses
- Sale
  - Through market
ANALYSIS: INFRASTRUCTURAL NETWORK

- LEGEND
  - RER Station
  - METRO Station
  - TRAM Station
  - RER Line
  - METRO Line
  - TRAM Line

NORD-SUD PARIS TRAIN LINE THROUGH CITY CENTER, END ORLY AIRPORT

NORD-SUD PARIS METRO LINE THROUGH CITY CENTER, GARE DU NORD, GARE DE L'EST

NORD-OUEST-SUD METRO LINE THROUGH CITY CENTER, SEINE BANK AND GARE ST. LAZARE
SUN RADIATION EVALUATION
The sun radiation on the site during the day was analyzed. The main shadows projected on the site were analyzed.
VEHICULAR TRAFFIC EVALUATION
The vehicular traffic around the site during the day was analyzed. The most busy streets and crossroads were considered as attractors.
SITE ANALYSIS

PEDESTRIAN TRAFFIC EVALUATION
The pedestrian traffic around the site during the day was analyzed. The most busy paths used to reach the main attractors were considered.

- Hospital/National Health Institute
- Supermarket/High School
- Metro station/Parking
- BNR Station/University Campus
- Sport center/Stadium
- Tram stop/Metro station
NOISE LEVELS EVALUATION
The noise levels around the site during the day were analyzed. Various elements were evaluated in base on the possible amount of noise that can be produced.
SITE ANALYSIS

ATTRACTIVE ACTIVITIES EVALUATION
The activities around the site during the day were analyzed. The activities were evaluated in base on their potential as attractors.
ANALYSIS: EXTERNAL FACTORS CHART

EXTERNAL FACTORS THAT INFLUENCE THE FUNCTIONS ARE CHANGING DURING THE DAY ACOORDING TO CERTAIN HOURS-RANGE

<table>
<thead>
<tr>
<th>Rush</th>
<th>07.00</th>
<th>12.00</th>
<th>18.00</th>
<th>24.00</th>
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<tr>
<td>SUN RADIATION</td>
<td><img src="image" alt="Sun Radiation 07.00" /></td>
<td><img src="image" alt="Sun Radiation 12.00" /></td>
<td><img src="image" alt="Sun Radiation 18.00" /></td>
<td><img src="image" alt="Sun Radiation 24.00" /></td>
</tr>
<tr>
<td>VEHICULAR TRAFFIC</td>
<td><img src="image" alt="Vehicular Traffic 07.00" /></td>
<td><img src="image" alt="Vehicular Traffic 12.00" /></td>
<td><img src="image" alt="Vehicular Traffic 18.00" /></td>
<td><img src="image" alt="Vehicular Traffic 24.00" /></td>
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<tr>
<td>PEDESTRIAN TRAFFIC</td>
<td><img src="image" alt="Pedestrian Traffic 07.00" /></td>
<td><img src="image" alt="Pedestrian Traffic 12.00" /></td>
<td><img src="image" alt="Pedestrian Traffic 18.00" /></td>
<td><img src="image" alt="Pedestrian Traffic 24.00" /></td>
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<tr>
<td>NOISE LEVELS</td>
<td><img src="image" alt="Noise Levels 07.00" /></td>
<td><img src="image" alt="Noise Levels 12.00" /></td>
<td><img src="image" alt="Noise Levels 18.00" /></td>
<td><img src="image" alt="Noise Levels 24.00" /></td>
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<td>ATTRACTION ACTIVITIES</td>
<td><img src="image" alt="Attraction Activities 07.00" /></td>
<td><img src="image" alt="Attraction Activities 12.00" /></td>
<td><img src="image" alt="Attraction Activities 18.00" /></td>
<td><img src="image" alt="Attraction Activities 24.00" /></td>
</tr>
</tbody>
</table>
# FUNCTIONS CATEGORIES

## HOUSING
- 15 Units 70 m²
- 10 Units 80 m²
- 5 Units 50 m²

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>2100</td>
</tr>
</tbody>
</table>

## MARKET
- Market Hall 700 m²
- Market Hall 400 m²
- Market Hall 400 m²

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1500</td>
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</tbody>
</table>

## GREENHOUSES
- 3 Greenhouses 2500 m² (each)
- Administration Spaces
- Services Spaces

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>9000</td>
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</tbody>
</table>

## SHOP
- 19 Various Shop
- Pharmacy

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
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</thead>
<tbody>
<tr>
<td>20</td>
<td>600</td>
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</table>

## PARKING
- Housing Parking Lots
- Market Hall - Shops
- Parking Lots
- Greenhouses Parking Lots

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>900</td>
</tr>
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</table>

## OPEN SPACES
- Public Plaza
- Playground - Performances Space
- 4 Green Areas
- 4 Sheltered Spaces

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>5000</td>
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</tbody>
</table>

## TECHNICAL SPACES
- Magazines Shops
- Magazines Greenhouses
- Technical Rooms
- Security Spaces

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1000</td>
</tr>
</tbody>
</table>

## BAR/RESTAURANT
- 3 Bars
- 2 Restaurant

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>400</td>
</tr>
</tbody>
</table>

## OFFICE
- 10 Offices

<table>
<thead>
<tr>
<th>Amount</th>
<th>Square Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>500</td>
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</tbody>
</table>
### Functions Interaction Logics

<table>
<thead>
<tr>
<th>Function</th>
<th>Separation Zone</th>
<th>Desired Neighbours</th>
<th>Undesired Neighbours</th>
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</thead>
<tbody>
<tr>
<td>Housing</td>
<td>6 Meters</td>
<td>Parking - Housing - Shop</td>
<td>Market - Greenhouses Technical Spaces</td>
</tr>
<tr>
<td>Market</td>
<td>8 Meters</td>
<td>Greenhouses - Parking Technical Spaces</td>
<td>Housing - Office - Market</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>6 Meters</td>
<td>Market - Parking Technical Spaces</td>
<td>Housing - Office</td>
</tr>
<tr>
<td>Shop</td>
<td>3 Meters</td>
<td>Housing - Parking - Shop Office - Bar/Restaurant</td>
<td>Market - Greenhouses Technical Spaces</td>
</tr>
<tr>
<td>Parking</td>
<td>8 Meters</td>
<td>Housing - Market - Greenhouses - Shop - Bar/Restaurant - Office</td>
<td>Parking</td>
</tr>
<tr>
<td>Open Spaces</td>
<td>7 Meters</td>
<td>Open Spaces - Bar/Restaurant - Office</td>
<td>Parking - Technical Space</td>
</tr>
<tr>
<td>Technical Spaces</td>
<td>2 Meters</td>
<td>Market - Greenhouses</td>
<td>Housing - Office Open Spaces</td>
</tr>
<tr>
<td>Bar/Restaurant</td>
<td>3 Meters</td>
<td>Shop - Parking - Open Spaces - Office</td>
<td>Market - Technical Spaces Bar/Restaurant</td>
</tr>
<tr>
<td>Office</td>
<td>6 Meters</td>
<td>Parking - Shop - Open Spaces - Bar/Restaurant</td>
<td>Market - Technical Spaces</td>
</tr>
</tbody>
</table>
## FUNCTIONS CLUSTERING CONDITIONS

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>PERCENTAGE m²</th>
<th>NUM. AGENTS</th>
<th>NUM. CLUSTER</th>
<th>DIAMETER X-Y</th>
<th>DIMENSION Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOUSING</td>
<td>10%</td>
<td>30</td>
<td>1</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>MARKET</td>
<td>7%</td>
<td>21</td>
<td>3</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>GREENHOUSES</td>
<td>40%</td>
<td>120</td>
<td>3</td>
<td>10</td>
<td>25</td>
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<tr>
<td>SHOP</td>
<td>3%</td>
<td>9</td>
<td>1</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>PARKING</td>
<td>5%</td>
<td>15</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>OPEN SPACES</td>
<td>24%</td>
<td>72</td>
<td>6</td>
<td>9</td>
<td>5</td>
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<tr>
<td>TECHNICAL SPACES</td>
<td>5%</td>
<td>15</td>
<td>3</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>BAR/RESTAURANT</td>
<td>3%</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>OFFICE</td>
<td>3%</td>
<td>15</td>
<td>1</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>
**ANALYSIS: EXTERNAL FACTORS AND FUNCTIONS RELATIONS**

**MAIN ATTRACTIONS ZONES WITHIN THE SITE - TABLE OF RELATIONS BETWEEN ATTRACTIONS AND FUNCTIONS**

### HOUSING
- **Factor:** Sun Radiation
  - **Behavior:** Attract
- **Factor:** Vehicular Traffic
  - **Behavior:** Attract
- **Factor:** Pedestrian Traffic
  - **Behavior:** Attract
- **Factor:** Noise Levels
  - **Behavior:** Repulse
- **Factor:** Attractive Activities
  - **Behavior:** Neutral

### MARKET
- **Factor:** Sun Radiation
  - **Behavior:** Neutral
- **Factor:** Vehicular Traffic
  - **Behavior:** Attract
- **Factor:** Pedestrian Traffic
  - **Behavior:** Attract
- **Factor:** Noise Levels
  - **Behavior:** Neutral
- **Factor:** Attractive Activities
  - **Behavior:** Attract

### GREENHOUSES
- **Factor:** Sun Radiation
  - **Behavior:** Attract
- **Factor:** Vehicular Traffic
  - **Behavior:** Attract
- **Factor:** Pedestrian Traffic
  - **Behavior:** Attract
- **Factor:** Noise Levels
  - **Behavior:** Neutral
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### SHOP
- **Factor:** Sun Radiation
  - **Behavior:** Neutral
- **Factor:** Vehicular Traffic
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- **Factor:** Pedestrian Traffic
  - **Behavior:** Attract
- **Factor:** Noise Levels
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- **Factor:** Attractive Activities
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### PARKING
- **Factor:** Sun Radiation
  - **Behavior:** Attract
- **Factor:** Vehicular Traffic
  - **Behavior:** Repulse
- **Factor:** Pedestrian Traffic
  - **Behavior:** Repulse
- **Factor:** Noise Levels
  - **Behavior:** Neutral
- **Factor:** Attractive Activities
  - **Behavior:** Attract

### OPEN SPACES
- **Factor:** Sun Radiation
  - **Behavior:** Neutral
- **Factor:** Vehicular Traffic
  - **Behavior:** Repulse
- **Factor:** Pedestrian Traffic
  - **Behavior:** Attract
- **Factor:** Noise Levels
  - **Behavior:** Neutral
- **Factor:** Attractive Activities
  - **Behavior:** Neutral

### TECH. SPACES
- **Factor:** Sun Radiation
  - **Behavior:** Repulse
- **Factor:** Vehicular Traffic
  - **Behavior:** Attract
- **Factor:** Pedestrian Traffic
  - **Behavior:** Repulse
- **Factor:** Noise Levels
  - **Behavior:** Repulse
- **Factor:** Attractive Activities
  - **Behavior:** Neutral

### BAR/RESTAUR.
- **Factor:** Sun Radiation
  - **Behavior:** Attract
- **Factor:** Vehicular Traffic
  - **Behavior:** Attract
- **Factor:** Pedestrian Traffic
  - **Behavior:** Attract
- **Factor:** Noise Levels
  - **Behavior:** Repulse
- **Factor:** Attractive Activities
  - **Behavior:** Attract

### OFFICE
- **Factor:** Sun Radiation
  - **Behavior:** Attract
- **Factor:** Vehicular Traffic
  - **Behavior:** Repulse
- **Factor:** Pedestrian Traffic
  - **Behavior:** Attract
- **Factor:** Noise Levels
  - **Behavior:** Repulse
- **Factor:** Attractive Activities
  - **Behavior:** Neutral

---

**THE ANALYSIS OF THE VARIOUS INFLUENCE FACTORS PER RUSH HOURS WERE COMBINED TO OBTAIN THE MAIN ZONES WITHIN THE SITE.**

**THESE ANALYSIS WILL BE USED TO SET THE MAIN ATTRACTIONS POINTS WITHIN THE REAL-TIME SIMULATION TO INFLUENCE THE FUNCTIONS' ALLOCATION.**
REAL TIME SIMULATION SET-UP

**INPUT**
- **FUNCTIONS**
  - Set of functions was selected to satisfy the requirements of the strategy and to integrate the project with the surrounding

**OUTPUT**
- Best allocation of functions based on the negotiation between external and internal factors

**INNER FACTORS**
- Different relations between all the functions affect their behaviour and consequently their movement within the projects' site

**OUTER FACTORS**
- Different parameters both environmental and not attract and repulse the various functions. These parameters change during the day
SIMULATION OUTPUT ANALYSIS

EVALUATION'S PARAMETERS 12:00

1. SPATIAL NETWORK CONTINUITY  2. INFRASTRUCTURAL RESPONSE  3. SYSTEM'S NEGOTIATION  4. RESPONSE ON THE 24 H

EVALUATION: B=BAD; G=GOOD; VG=VERY GOOD


1. VG  2. G  3. G

1. VG  2. B  3. B


1. G  2. B  3. VG
SIMULATION OUTPUT ANALYSIS

1. SPATIAL NETWORK CONTINUITY
2. INFRASTRUCTURAL RESPONSE
3. SYSTEM'S NEGOTIATION
4. RESPONSE ON THE 24 H

EVALUATION:
B = BAD; G = GOOD; VG = VERY GOOD
SIMULATION OUTPUT ANALYSIS

1. SPATIAL NETWORK CONTINUITY  2. INFRASTRUCTURAL RESPONSE  3. SYSTEM’S NEGOTIATION  4. RESPONSE ON THE 24 H

EVALUATION: B=BAD; G=GOOD; VG=VERY GOOD
SIMULATION OUTPUT ANALYSIS AND SELECTION

EVALUATION’S PARAMETERS

1. SPATIAL NETWORK CONTINUITY  
2. INFRASTRUCTURAL RESPONSE  
3. SYSTEM’S NEGOTIATION  
4. RESPONSE ON THE 24 H

EVALUATION: B=BAD; G=GOOD; VG=VERY GOOD

THE FINAL OUTPUT CHOICE WAS BASED ON THE EVALUATION PARAMETERS AND TRIES TO RESPOND EFFICIENTLY FOR THE ENTIRE DURATION OF THE DAY. THE PARAMETERS WERE CHOSEN TO SATISFY THE PROJECT’S GOALS BOTH AT THE PROJECT’S SCALE AND AT THE URBAN SCALE.
MASTERPLAN CONFIGURATION ANALYSIS

01  HOUSING
Agents n°: 30
Radius: 3m
Boundaries:
X = 33
Y = 39
Z = 30

02  MARKET
Agents n°: 21
Radius: 8m
Boundaries:
X = 100
Y = 160
Z = 5

03  FOOD
Agents n°: 112
Radius: 4m
Boundaries:
X = 33
Y = 48
Z = 70

04  SHOP
Agents n°: 9
Radius: 2m
Boundaries:
X = 27
Y = 23
Z = 4

05  PARKING
Agents n°: 15
Radius: 10m
Boundaries:
X = 60
Y = 170
Z = 3

06  OPEN SPACES
Agents n°: 79
Radius: 4m
Boundaries:
X = 100
Y = 231
Z = 8

07  TECH. SPACES
Agents n°: 22
Radius: 6m
Boundaries:
X = 50
Y = 150
Z = 5

08  BAR/RESTAURANT
Agents n°: 5
Radius: 4m
Boundaries:
X = 80
Y = 135
Z = 6

09  OFFICE
Agents n°: 15
Radius: 4m
Boundaries:
X = 21
Y = 23
Z = 12
MASTERPLAN CONFIGURATION ANALYSIS

PATH OPTIMIZATION THROUGH HAIR DYNAMICS

PRIMARY PATHS

01
ATTRACTION VALUE = 0

02
ATTRACTION VALUE = 5

03
ATTRACTION VALUE = 15

SECONDARY PATHS

04
ATTRACTION VALUE = 0

05
ATTRACTION VALUE = 5

06
ATTRACTION VALUE = 15

PRIMARY AND SECONDARY PATHS

07
ATTRACTION VALUE = 0

08
ATTRACTION VALUE = 5

09
ATTRACTION VALUE = 15
MASTERPLAN CONFIGURATION ANALYSIS

MASTERPLAN TOP VIEW

- SHELTERED SPACES
- PUBLIC FOOD ROUTE
- PLAYGROUND
- PLAZA
- MAIN GREEN SPACE
TOPOLOGY PROCESS OVERVIEW

REAL-TIME SIMULATION OUTPUT

URBAN SCALE
- Functional allocation within site
- Infrastructural network between site and surrounding
- Network between certain functions and surrounding

BUILDING SCALE
- Set of relations in terms of circulation between functions
- Set of relations in terms of spatial continuity between functions
- Agents' spatial disposition for every cluster

ARCHITECTURAL DESIGN FOCUS

Food Tower + Housing Tower + Market & Public Spaces

Through a process of morphological formation that combines:
- Tectonic - Environmental Control - Structure

- Tectonic: Provides different spatial conditions for various types of cultivation (microclimates)
- Environmental Control: Embodies different climatic conditions
- Structure: Provides support for the tower

PROCESS' STEPS

Morphological steps that define the process and the formation of the topology:
- Metaball formation
- Circulation
- Vertical enclosure
- Cultivation spaces morphology
- Structural response
- Skin formation and control
AGRICULTURAL STRATEGY: POLYDOME SYSTEM

POLYCULTURE SYSTEM ADVANTAGES

- BIODIVERSITY:
  - Different species coexisting and benefiting one from the other
- FEEDBACK LOOP:
  - The whole system relies on a good feedback loop that saves energy and implement productivity and efficiency
- MICROCLIMATE:
  - Maximize benefits from different microclimate through different crops placement
- ECONOMIC RESILIENCE:
  - Differentiation allows a more economic resilience in case of crisis
- TRANSPORTATION REDUCTION:
  - The polyculture system reduce the demand for the transportation of other species compared to the monoculture system

POLYCULTURE SYSTEM MODULES

- PRODUCTION MODULES:
  - Hydroponics - Perennial - Annual - Mushrooms - Vermiculture - Fish Aquaculture - Nursery Support Crops
- TECHNICAL MODULES:
  - Logistic Center - Processing Center - Harvesting Center - Storage

POLYCULTURE BIODIVERSITY LOOP DIAGRAM

- BIODIVERSITY
  - HYDROPONICS
  - ANNUAL CROPS
  - PERENNIAL CROPS
  - MUSHROOMS
  - FISH AQUACULTURE
  - VERMICULTURE

- PRODUCTS
  - VEGETABLES
  - FRUITS
  - HERBS
  - SHITAKE - OYSTER
  - TILAPIA

- MARKET

- PLANT WASTE

- COMPOSTING

POLYCULTURE BIODIVERSITY LIST

- PERENNIAL:
  - APRICOT
  - ARTICHOKE
  - ARUGULA
  - ASPARAGUS
  - BASIL
  - BLACKBERRY
  - BLUEBERRY
  - BOK CHOY
  - CHERRY
  - CHIVE
  - CILANTRO
  - CURRANT

- ANNUAL:
  - DILL
  - GARLIC
  - GRAPE
  - LATTICE
  - NECTARINE
  - OREGANO
  - PARSLEY
  - PEAR
  - RASPBERRY
  - SORREL
  - SPEARMINT
  - CURRANT

- TARRAGON
  - THYME
  - TOMATO
  - ZUCCHINI
  - BORAGE
  - COMFREY
  - OYSTER MUSHROOM
  - SHITAKE MUSHROOM
  - NURSERY/SUPPORT CROPS:
    - MARIGOLD
    - HYSSOP
    - NASTURTIUM
    - TURNIPS
    - FISH CULTURE:
      - TILAPIA
FUNCTIONAL DISTRIBUTION STRATEGY

FOOD POINT CLOUD

FUNCTIONS

- CULTIVATION TYPE 1 (PERENNIAL)
- CULTIVATION TYPE 2 (MUSHROOMS)
- CULTIVATION TYPE 3 (ANNUAL)
- EXHIBITION SPACE
- PUBLIC GARDEN
- MARKET SHOPS
- LABORATORIES
- HARVESTING CORE
- PROCESSING CORE
- STORAGE

SPATIAL PERCENTAGE

- CULTIVATION TYPE 1: 41%
- CULTIVATION TYPE 2: 9%
- CULTIVATION TYPE 3: 25%
- HARVESTING: 5%
- PROCESSING: 4%
- STORAGE: 5%
- PUBLIC GARDEN: 2%
- MARKET-SHOPS: 6%
- LABORATORIES: 2%
- EXHIBITION SPACE: 1%

AGENTS' NUMBER

- 34
- 8
- 20
- 1
- 3
- 5
- 3
- 4
- 3
- 4
<table>
<thead>
<tr>
<th>FUNCTIONS</th>
<th>ORIENTATION</th>
<th>PROXIMITY RELATIONS</th>
<th>NATURAL LIGHT DEMAND</th>
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</thead>
</table>
| CULTIVATION TYPE 1 (PERENNIAL) |             | CULTIVATION TYPE 2  
                                   |                        | CULTIVATION TYPE 3    |
| CULTIVATION TYPE 2 (MUSHROOMS) |             | CULTIVATION TYPE 1  
                                   |                        | CULTIVATION TYPE 3    |
| CULTIVATION TYPE 3 (ANNUAL)  |             | CULTIVATION TYPE 1  
                                   |                        | CULTIVATION TYPE 2    |
| EXHIBITION SPACE           |             | PUBLIC GARDEN - LABORATORIES         |                      |
| PUBLIC GARDEN              |             | EXHIBITION SPACE - LABORATORIES      |                      |
| MARKET - SHOPS             |             | STORAGE - PUBLIC SPACES              |                      |
| LABORATORIES               |             | EXHIBITION SPACE - PUBLIC GARDEN     |                      |
| HARVESTING CORE            |             | PROCESSING CORE - STORAGE            |                      |
| PROCESSING CORE            |             | HARVESTING CORE - STORAGE            |                      |
| STORAGE                    |             | HARVESTING CORE - PROCESSING CORE    |                      |
MORPHOLOGY FORMATION: METABALL

CULTIVATION TYPE 1 (PERENNIAL)

STARTING POINT CLOUD

AGGREGATION VALUE: HIGH
FLOOR HEIGHT: 6 meters

PLANT REQUIREMENTS CONSIDERED:
- Plant Height
- Plant light demand
- Plant dimensions

PLANT TYPOLOGY:
FRUIT TREE - MEDIUM and LOW RISE PLANTS
- Apricot
- Artichoke
- Arugula
- Asparagus
- Basil
- BlackBerry
- Bluberry
- Bok choy
- Cherry
- Chive
- Cilantro
-Currant
- Dill

CULTIVATION TYPE 2 (MUSHROOM)

STARTING POINT CLOUD

AGGREGATION VALUE: LOW
FLOOR HEIGHT: 2.5 meters

PLANT REQUIREMENTS CONSIDERED:
- Plant Height
- Plant light demand
- Plant dimensions

PLANT TYPOLOGY:
MUSHROOM
- Oyster mushroom
- Shiitake mushroom
- Worms
- Compost

CULTIVATION TYPE 2 (ANNUAL)

STARTING POINT CLOUD

AGGREGATION VALUE: MEDIUM
FLOOR HEIGHT: 4 meters

PLANT REQUIREMENTS CONSIDERED:
- Plant Height
- Plant light demand
- Plant dimensions

PLANT TYPOLOGY:
MEDIUM and LOW RISE PLANTS
- Bay laurel
- Bean green
- Carrot
- Cucumber
- Fig
- Marjoram
- Onion
- Peas
- Pepper
- Rosemary
- Spinach
- Strawberry
- Tarragon

- Thyme
- Tomato
- Zucchini
- Nectarine
- Borage
- Comfrey
- Marigold
- Hyssop
- Nasturtium
- Turnips
MORPHOLOGY FORMATION: VERTICAL ENCLOSURE

VERTICAL CONNECTION STRUCTURAL

6th
5th
4th
3rd
2nd
1st

PATTERN STUDY

ZIG ZAG PATTERN
- Fluid structural line that connects the slabs from the top to the bottom transferring the loads

HONEYCOMB PATTERN
- The zig zag is used to generate a continuous fluid enclosure that enclose the various cultivation

PATTERN STUDY: VARIATIONS
MORPHOLOGY FORMATION: ENVIRONMENTAL ANALYSIS

Sun December

Cumulative radiation on tower

Sun April

Shadow range 09:00 to 18:00 in december and june

Sun June
MORPHOLOGY FORMATION: ENVIRONMENTAL ANALYSIS

Shadow analysis on cumulative radiation in December:

- 09:00 south side
- 12:00 south side
- 17:00 south side
- 09:00 north side
- 12:00 north side
- 17:00 north side

Shadow analysis on cumulative radiation in June:

- 08:00 south side
- 12:00 south side
- 19:00 south side
- 08:00 north side
- 12:00 north side
- 19:00 north side
MORPHOLOGY FORMATION: LIGHT SHAFT

SHAFT CREATION
Central Shaft

CENTRAL SHAFT
- Light
- Circulation
- Visual Connection

Slabs Shafts

SLABS SHAFTS
- Light
- Cultivation requirements

PS: Manuel Zurchi
MORPHOLOGY FORMATION: CULTIVATION SPACES

CULTIVATION TYPE 1: PERENNIAL
INPUT CONDITIONS:
PLANTS TYPOLOGY
- Fruit tree
- Medium rise plants
- Low rise plants
WORKFLOW
- Accessibility to all plants
- Inner circulation
- Plants control
ENVIRONMENTAL REQUIREMENTS
- Winter required chill hours
- Various light types
MORPHOLOGICAL CONSEQUENCES
OUTPUT CONDITIONS:
PLANTS TYPOLOGY
- Ticker slabs to support tree’s soil
- High value of metabolall aggregation to support tree’s soil weight
- High floors
WORKFLOW
- Medium floor perforated to reach tree’s top part
- Enclosed cluster of plants
ENVIRONMENTAL REQUIREMENTS
- Perimetral enclosure

CULTIVATION TYPE 2: MUSHROOMS
INPUT CONDITIONS:
PLANTS TYPOLOGY
- Oyster mushrooms
- Shiitake mushrooms
WORKFLOW
- Accessibility to all plants
ENVIRONMENTAL REQUIREMENTS
- Isolation from other cultivation
- High level of light control
MORPHOLOGICAL CONSEQUENCES
OUTPUT CONDITIONS:
PLANTS TYPOLOGY
- Metabolall aggregation that support the creation of cluster’s connected through paths
- Low floors (2,50 m)
WORKFLOW
- Accessibility to all cultivation
ENVIRONMENTAL REQUIREMENTS
- Total enclosure
- Puntual lights

CULTIVATION TYPE 3: ANNUAL
INPUT CONDITIONS:
PLANTS TYPOLOGY
- Water plants + fish
- Medium rise plants
- Low rise plants
WORKFLOW
- Accessibility to all plants
- Closed loop for water treatment
- Inner circulation
- Plants control
ENVIRONMENTAL REQUIREMENTS
- Water treatment
- Various light types
MORPHOLOGICAL CONSEQUENCES
OUTPUT CONDITIONS:
PLANTS TYPOLOGY
- Ticker slabs to host water and systems
- High value of metabolall aggregation to support
- Medium-High floors
WORKFLOW
- Enclosed cluster creation
- Create various terrain
ENVIRONMENTAL REQUIREMENTS
- Open circulation
MASTERPLAN DRAWINGS

Simulation output of the masterplan

Topology output of the masterplan
PROJECT’S FACILITIES AND USERS

PARKING and STORAGE
The underground level is dedicated to parking lots and to the food storage and transportation.

MARKET and PUBLIC SPACES
The open and covered market space offers fresh food produced into the tower. Other public facilities like an open theatre and a playground are offered.

HOUSING
The tower provides various type of units with several enclosed public spaces like vegetables and hanging gardens. Future workers are fostered to live within the system.

SKY BRIDGES
The sky bridges provide a smooth transition from the public spaces of the food tower to the public spaces of the housing.

PRODUCTION UNITS
The major part of the tower is dedicated to the production of food. There are various units with different configurations according to the cultivation type.

PROCESSING and HARVESTING CORE
In this part of the tower right above the market and the shops all the food produced into the tower is harvested and processed for the sell.

SHOPS
At the base of the tower open onto the public spaces different shops sell the various products produced into the tower.
PLAN VIEW SCALE 1/3000

LEGEND
1 MARKET SPACES
2 PERFORMANCES' OPEN SPACE
3 FOOD TOWERS
4 HOUSING TOWER
5 PLAYGROUND
MASTERPLAN DRAWINGS

LONGITUDINAL SECTION C-C'}
MASTERPLAN DRAWINGS

View of one of the overpass access

View of the covered space of the market
MARTERPLAN DRAWINGS

View of elevated green promenade

View of the covered market from the street
MORPHOLOGY IMPLEMENTATION: STRUCTURAL SYSTEMS

COMPLETE STRUCTURE

MAIN STRUCTURAL ELEMENTS

Main vertical and horizontal structure

Vertical cores (stairs and lift)

Slabs
MORPHOLOGY IMPLEMENTATION: STRUCTURAL SYSTEMS

VERTICAL STRUCTURAL CONTINUITY
A zig-zag pattern defines a vertical stability

LOADS PATH DIAGRAM
Loads are transferred through the zig-zag pattern and main nodes

NODES REINFORCEMENT DIAGRAMS
The nodes along the pattern are reinforced because they have to support more loads. Their backward position allows the slabs to be thinner on the elevation.
MORPHOLOGY IMPLEMENTATION: STRUCTURAL SYSTEMS

**STRUCTURAL EXPLODE**
Vertical and horizontal main structure and slabs

**STRUCTURAL DIFFERENTIATION OF THE SLABS**
3 main structural systems are implied for the construction of the slabs

- **Slab case 1**
  - STEEL STRUCTURE
  - The slab is supported by a steel structure anchored to the vertical core

- **Slab case 2**
  - FULLY CONCRETE SLAB
  - This system can be used for the smaller slabs that have to support lighter loads. There is no distinction between the main structure and the slab

- **Slab case 3**
  - SUPPORT STRUCTURE
  - The slab could be supported by a web of steel beams or by ribs made of concrete.
# Morphology Implementation: Skin Systems

## Input:
- Cultivation Light Control
- Evaluation Solar Radiation Incidence
- Light Type Requirements

## Output:
- Density Structure Subdivision
- Pattern Definition
- Opacity of the Components

### Skin Parameters

<table>
<thead>
<tr>
<th>Function</th>
<th>Light Amount</th>
<th>Light Type</th>
<th>Permeability</th>
<th>Subdivision Control</th>
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<tbody>
<tr>
<td>Perennial Cultivation</td>
<td>Light</td>
<td>Direct</td>
<td>High</td>
<td>High</td>
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<tr>
<td>Food Processing Core</td>
<td>Light</td>
<td>Direct</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Annual Cultivation</td>
<td>Light</td>
<td>Direct</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Main Storage</td>
<td>Light</td>
<td>Direct</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Market</td>
<td>Light</td>
<td>Direct</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Shop</td>
<td>Light</td>
<td>Direct</td>
<td>High</td>
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<tr>
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<tr>
<td>Hanging Gardens</td>
<td>Light</td>
<td>Direct</td>
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<tr>
<td>Mushrooms</td>
<td>Light</td>
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<tr>
<td>Belvedere</td>
<td>Light</td>
<td>Direct</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
MORPHOLOGY IMPLEMENTATION: SKIN SYSTEMS

GEOMETRIC DIAGRAMS  Starting from a planar surface a pattern is created using the median of a triangle

PATTERN FORMATION PROCESS

PATTERN DENSITY

PATTERN 1
TRIANGLE Nº6

PATTERN 2
TRIANGLE Nº14

PATTERN 3
TRIANGLE Nº24
MORPHOLOGY IMPLEMENTATION: SKIN SYSTEMS

CULTIVATION

PERENNIAL:
- TREES
- MEDIUM RISE PLANTS
- LOW RISE PLANTS
LIGHT AMOUNT: MEDIUM-HIGH
LIGHT TYPE: DIFFUSE-DIRECT
OPACITY: MEDIUM-LOW
SUBDIVISION CONTROL: MEDIUM

DENSITY

SURFACES SUBDIVISION CONTROL: 50%

SOLAR RADIATION ANALYSIS

SURFACES SOLAR RADIATION RANGE:
- DIFFUSE LIGHT
- DIRECT LIGHT
- NO LIGHT

OPACITY

SURFACES OPACITY:
- TRANSPARENT 50%
- OPAQUE 25%
- CLOSED 25%

PATTERN

ANNUAL:
- HYDROPONIC
- AQUACULTURE
LIGHT AMOUNT: MEDIUM-HIGH
LIGHT TYPE: DIFFUSE-DIRECT
OPACITY: MEDIUM-LOW
SUBDIVISION CONTROL: MEDIUM

SURFACES SUBDIVISION CONTROL: 60%

SURFACES SOLAR RADIATION RANGE:
- DIFFUSE LIGHT
- DIRECT LIGHT
- NO LIGHT

SURFACES OPACITY:
- TRANSPARENT 50%
- OPAQUE 35%
- CLOSED 15%

MUSHROOM:
- MUSHROOMS
LIGHT AMOUNT: LOW
LIGHT TYPE: INDIRECT
OPACITY: MEDIUM-HIGH
SUBDIVISION CONTROL: HIGH

SURFACES SUBDIVISION CONTROL: 80%

SURFACES SOLAR RADIATION RANGE:
- DIFFUSE LIGHT
- DIRECT LIGHT
- NO LIGHT

SURFACES OPACITY:
- TRANSPARENT 45%
- OPAQUE 15%
- CLOSED 55%
MORPHOLOGY IMPLEMENTATION: SKIN SYSTEMS

View of different light situations generated from the pattern
FRAGMENT SELECTION

AERIAL VIEW
FRAGMENT DRAWINGS

FRAGMENT EXTERNAL VIEW
FRAGMENT LONGITUDINAL SECTION - SCALE 1:200
FRAGMENT PLAN - SCALE 1:200

LEGEND
1 Housing unit type 1 (75 m²)
2 Housing unit type 2 (120 m²)
3 Common garden
4 Connection bridge
5 Enclosed cultivation spaces
6 Open cultivation spaces
7 Light shafts
FRAGMENT DRAWINGS

LEGEND
1 Housing unit type 2 (120 m²)
2 Common garden
3 Enclosed cultivation space
4 Open cultivation space
5 Light shafts
FRAGMENT DRAWINGS

Inside view of housing units and public spaces
FRAGMENT DRAWINGS

Laboratories

Laboratories and hydroponic in public spaces
FRAGMENT DRAWINGS

Big mushrooms cultivation

Small cultivation of mushrooms from outside
FRAGMENT DRAWINGS

Hydroponic cultivation

Inner view of different spaces
FRAGMENT DRAWINGS

Trees cultivation

Trees cultivation type 2
MATERIALIZATION & DIGITAL FABRICATION

EPS FOAM ADVANTAGES

- LIGHTWEIGHT:
  IT IS 90% MADE OF AIR, THIS MAKES IT EXTREMELY LIGHTWEIGHT

- REUSABLE:
  IT IS 100% FULLY REUSABLE, SCRAPS FROM FABRICATION CAN BE TOSS BACK INTO THE NEXT BATCH ALMOST FOR FREE

- CUSTOMIZATION:
  ITS MALLEABILITY ALLOWS FOR AN HIGH LEVEL OF CUSTOMIZATION OBTAINABLE THROUGH VARIOUS FABRICATION TECHNIQUES

- INSULATION CAPACITY:
  IT HAS A VERY GOOD LEVEL OF THERMIC INSULATION, IT IS USED IN GENERAL AS A FILL IN MATERIAL

- RESISTANCE TO COMPRESSION FORCES:
  ITS COMPOSITION ALLOWS FOR A VERY GOOD RESISTANCE TO THE COMPRESSION FORCES AND STRESS

SCALE UNIT DIAGRAM

- STANDARD CMU:
  HEIGHT: 20 cm
  WIDTH: 40 cm
  DEPTH: 20 cm
  WEIGHT: 14.51 kg

- EPS FOAM BLOCK UNIT:
  HEIGHT: 121 cm
  WIDTH: 243 cm
  DEPTH: 30 cm
  WEIGHT: 14.51 kg

FABRICATION TECHNIQUE: ROBOT HOT-WIRE CUTTING

ADVANTAGES
- LESS WASTED MATERIAL
- FAST FABRICATION PROCESS

DISADVANTAGES
- LIMITED BY THE ROBOT WIRE'S SIZE
- HIGH LEVEL OF MANUALLY IN THE POSITIONING OF THE BLOCK

GEOMETRIC CONSTRAINTS
THE MAIN GEOMETRIC CONSTRAINT OF THE HOT-WIRE ROBOT CUTTING IS THE USE OF THE RULED SURFACES. THE MAIN REASON FOR THE USE OF THIS SPECIFIC TYPE OF GEOMETRY IS DICTATED BY THE FACT THAT THE WIRE USED BY THE ROBOT IS STRAIGHT

FABRICATION & CUSTOMIZATION OF EPS FOAM BLOCKS IN THE PROJECT

- BUILDING DESIGN SCALE:
  EPS CUT TO FINISHING THE OUTER LAYER OF THE STRUCTURE

- INTERIOR DESIGN SCALE:
  EPS CUT TO GENERATE THE VARIOUS CUSTOMIZED TANKS AND FORNITURE USED FOR THE DIFFERENT TYPES OF CULTIVATION
MATERIALIZATION & DIGITAL FABRICATION

TANK FABRICATION PROCESS
FINAL GEOMETRY

GEOMETRY SUBDIVIDED IN COMPONENTS

COMPONENTS NESTED IN EPS BLOCK

COMPONENTS INTO THE BOUNDING BOX

FIRST CUT: LIMITS AND JOINTS

SECOND CUT: COMPONENT SHAPE

COMPONENTS INTO THE BOUNDING BOX

COMPONENTS READY FOR ASSEMBLY

COMPONENTS ASSEMBLED INTO FINAL GEOMETRY
MATERIALIZATION & DIGITAL FABRICATION

EXPLODED DIAGRAM OF THE TANKS' COMPOSITION

1. CONCRETE SUPPORTING LAYER
2. INSULATION LAYER
3. POLYURETANE FOAM - FINAL SMOOTHING AND WATERPROOF LAYER
4. EPS LEVELING AND STABILIZING LAYER
5. ASSEMBLED EPS TANK

VARIOUS TANKS GEOMETRIES

TANKS - SIT GEOMETRIES
MATERIALIZATION & DIGITAL FABRICATION

BOARDS READY FOR THE LASERCUT

FRAGMENT SELECTED AND PREPARED FOR ABS 3D PRINTING
MATERIALIZATION & DIGITAL FABRICATION

LASERCUT MODEL ASSEMBLY
LASERCUT MODEL ASSEMBLED

MATERIALIZATION & DIGITAL FABRICATION
PROJECT REFLECTIONS

PROJECT'S PRODUCTIVITY CALCULATIONS DIAGRAM

TOTAL

PERENNIAL 8000 m²

MUSHROOM 2000 m²

FISH FARMING 500 m²

HYDROPONIC 2500 m²

ANNUAL 2500 m²

15.500

51%

13%

4%

16%

16%

SUBDIVISION

TOTAL Amount of square meters of cultivation spaces

500 Kg

35 000 Kg

1 500 Kg

30 000 Kg

110 500 Kg

60 000 Kg

10 000 Kg

150 000 Kg

2 000 Kg

PRODUCTS

VEGETABLES

FRUIT

HERBS

FISH (TILAPIA)

MUSHROOMS

Kg/YEAR PRODUCED & PEOPLE SUPPLIED

Kg/YEAR produced: 60 500 - People supplied: 900

Kg/YEAR produced: 45 000 - People supplied: 500

Kg/YEAR produced: 165 000 - People supplied: 30 000

Kg/YEAR produced: 110 500 - People supplied: 5 000

Kg/YEAR produced: 30 000 - People supplied: 3 000

PROJECT'S ADVANTAGES EVALUATION

SOCIAL VALUE

▪ Involve and sensitize population

▪ Provide a closed loop on the food process for the community (work - production - processing - sell)

▪ Revitalize the urban tissue

CULTIVATION INNOVATION

▪ Polyculture system instead of monoculture (all advantages correlated)

DESIGN QUALITIES

▪ Enhance the qualities of spaces embedding performative principles into the process (climate, workflow, structure)

▪ Attempt to solve computationally problems related to agriculture

▪ Design integration with the local condition
THANK YOU FOR THE ATTENTION