SYSTEMATIC INTEGRATION OF URBAN FARMING INTO URBAN METABOLISMS

Waste As A Resource For Urban Food Production

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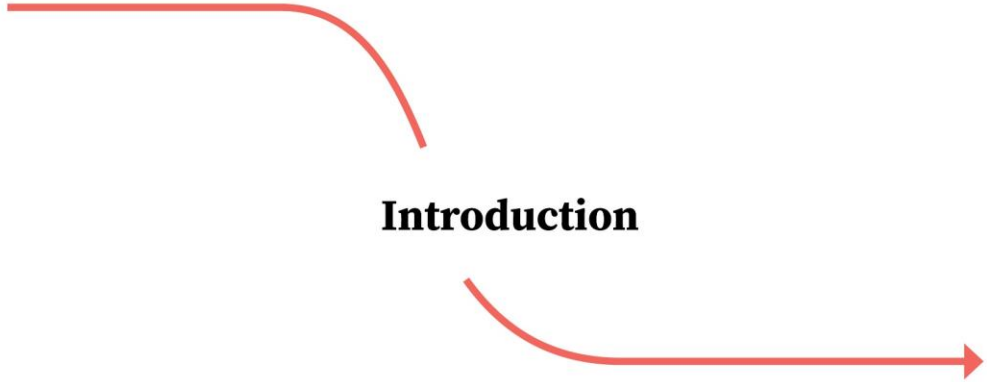
Presentation 5

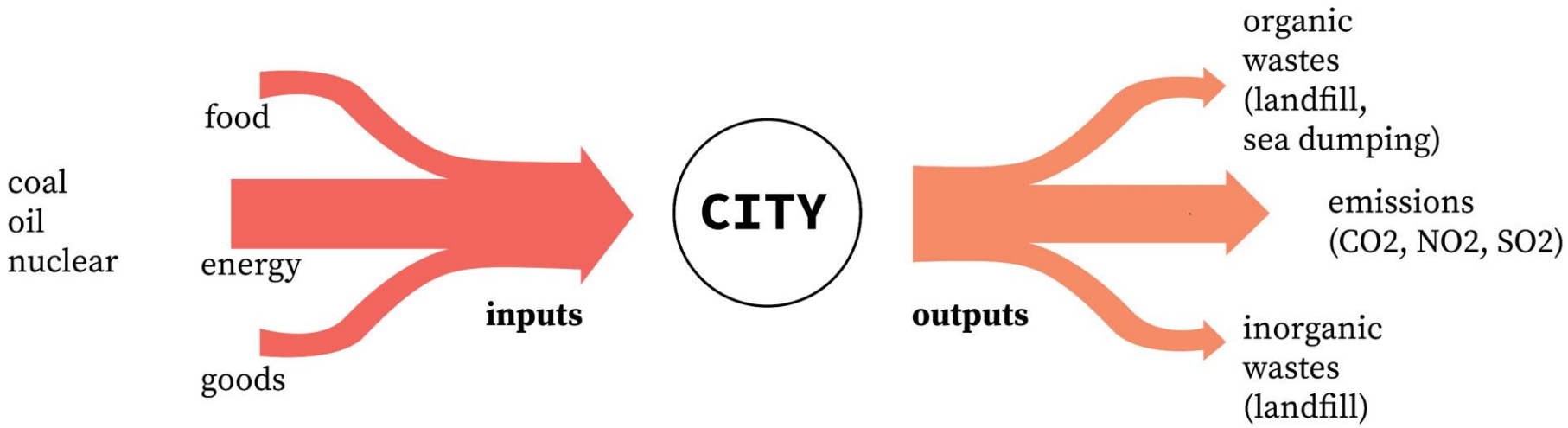
Contents



Introduction

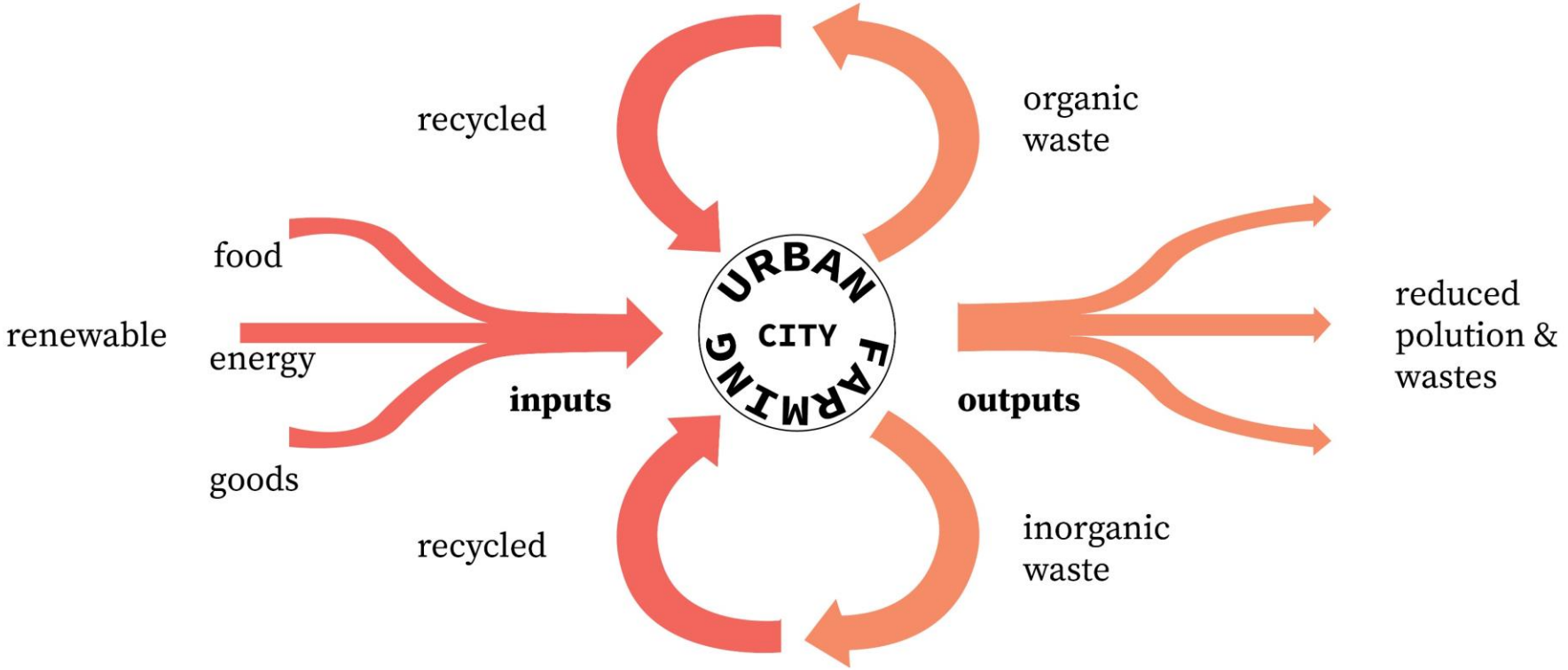
Problem
Possible Solution
Why A Decision Making Tool Is Necessary
Research Questions

Linear Metabolism



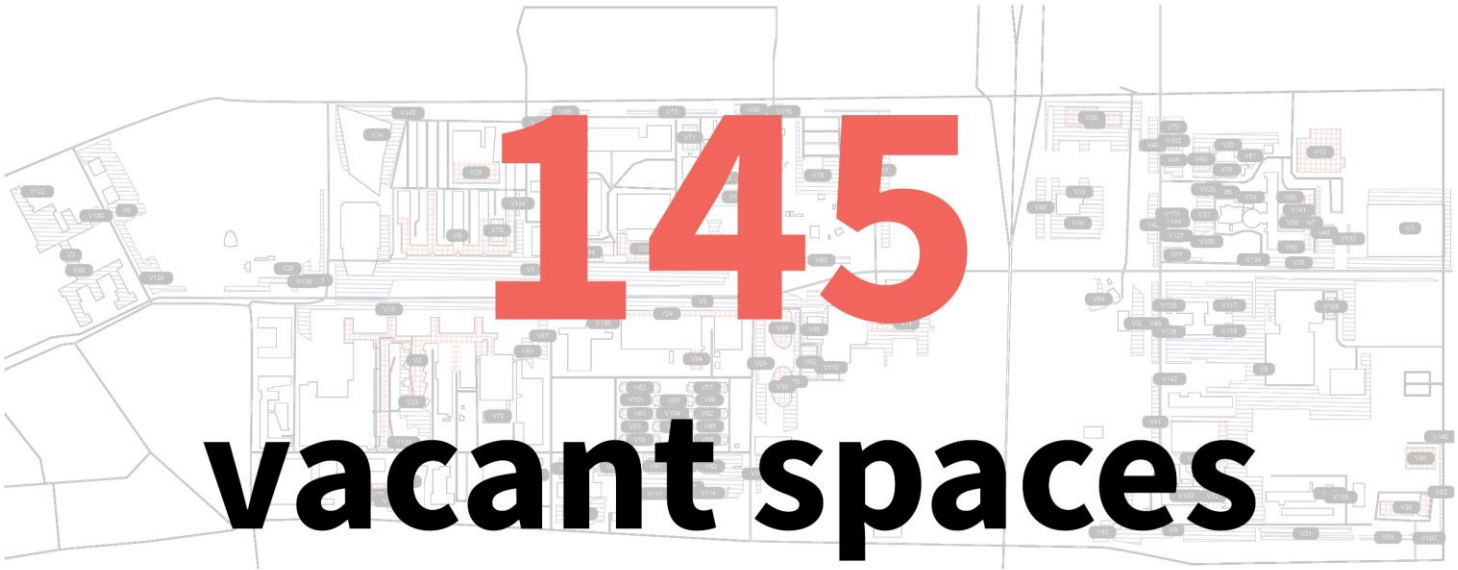
credit: Redrawn from Cities for a Smal Planet pg. 31, 1997

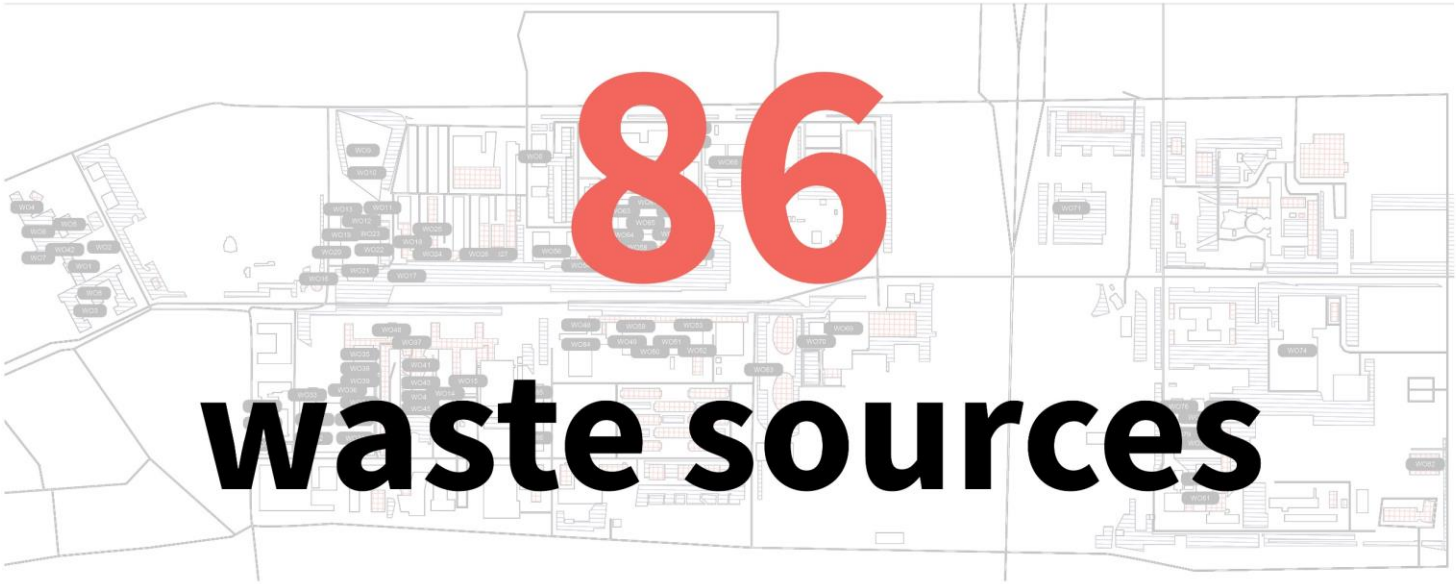
Problem Statement



credit: Adapted from Cities for a Smal Planet pg. 31, 1997

Problem Statement





Research Question

In which situations can different **URBAN FARMING SYSTEMS** employ different **URBAN WASTE FLOWS** in order to promote the circularity of food production and resources in urban contexts by augmenting the design process with **DECISION SUPPORT SYSTEMS**?

Research Question

Which kind of **WASTE FLOWS** are viable to be utilised by the urban farm economically, environmentally and from a public safety perspective?

Which kind of **URBAN FARMING SYSTEMS** are suitable to repurpose the urban waste flows including water, CO2, heat, organic waste?

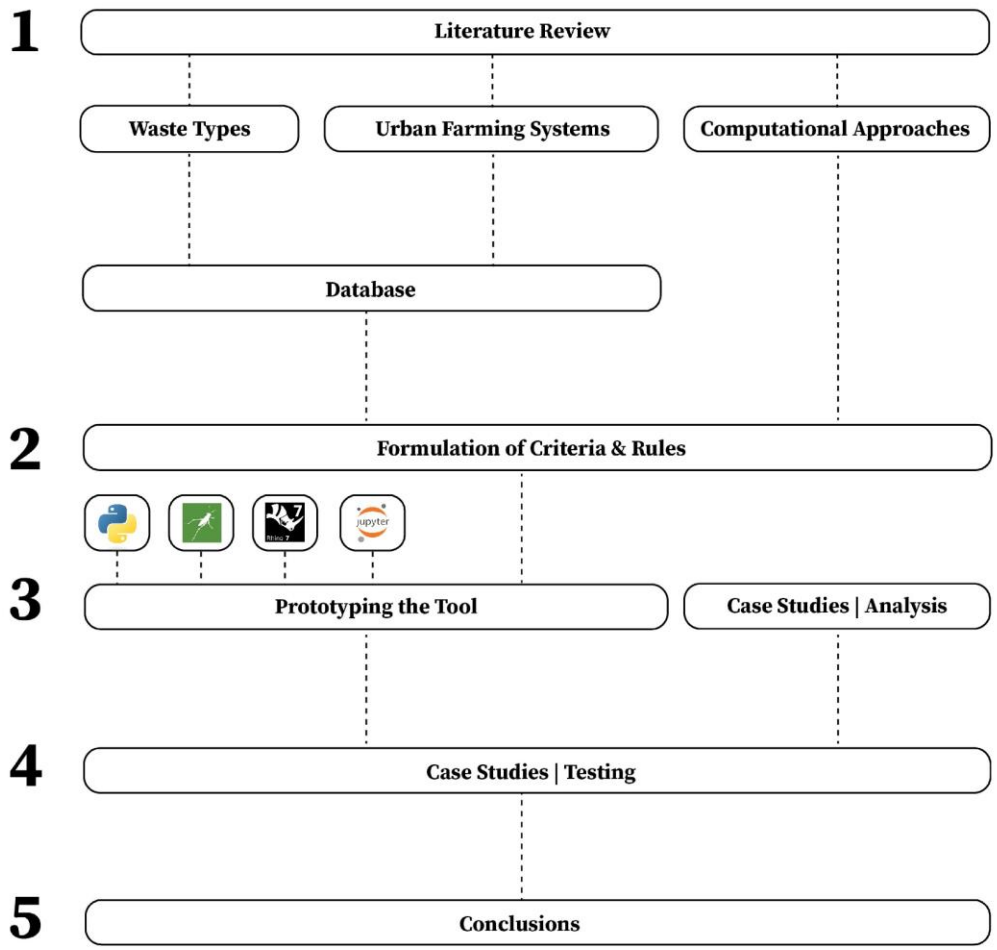
How can urban farming systems be combined and have a **SYMBIOTIC RELATIONSHIP** to close the loop within the urban metabolism?

Which **COMPUTATIONAL APPROACHES** are feasible to construct the decision making tool serving the purpose of generating a network of inputs, outputs, and urban farming systems (operators) with given criteria and rules to design?

Research & Design Approach

Methodology
Waste As A Sources
Produce
Urban Farming As An Exchange Hub
Database
Rule Based Decision Making

Methodology



Waste As A Resource

Food Waste

Spent Coffee Grounds

Sawdust/Paper/...

Residual Heat

CO2

Rainwater

Product Types

Fruits & Vegetables

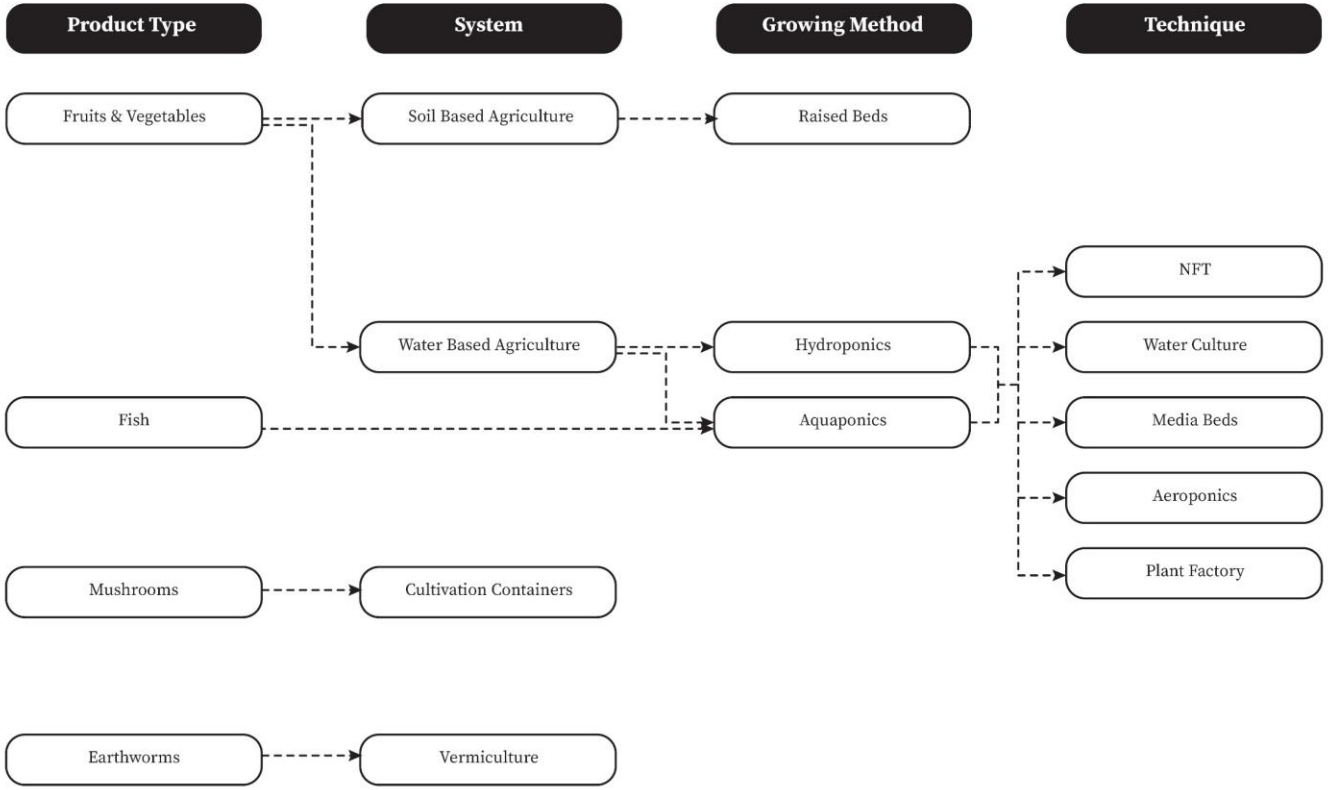
Fish

Mushrooms

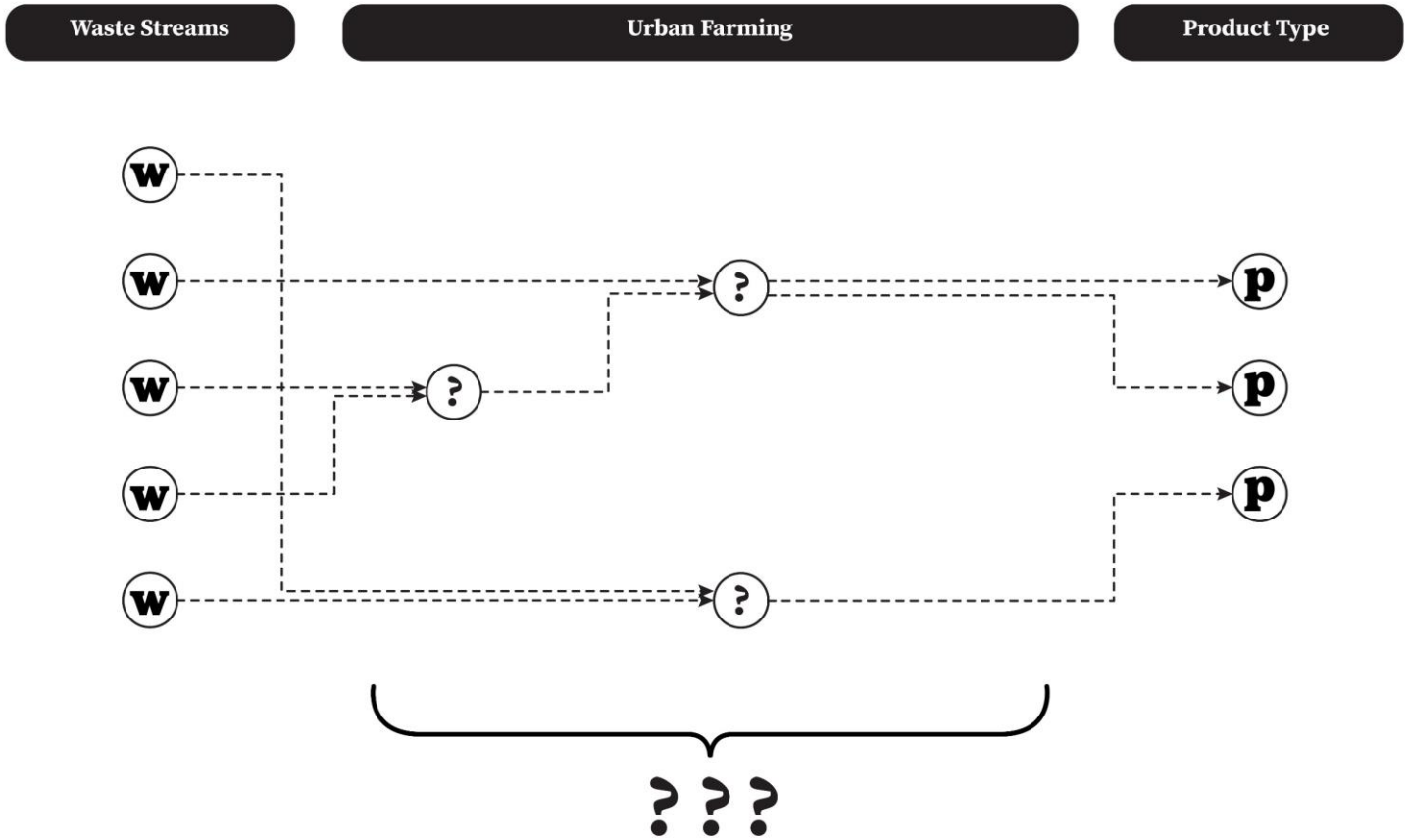
Earthworms

credit: Bunker https://cycloponics.co/galerie/
Fish https://www.worldwildlife.org/industries/farmed-salmon
Mushroom Smallhold https://www.smallhold.com/about
Worms https://www.filtsep.com/content/other/scottish-water-trials-earthworms-fleas-to-treat-wastewater

Different Systems



Exchange Hub



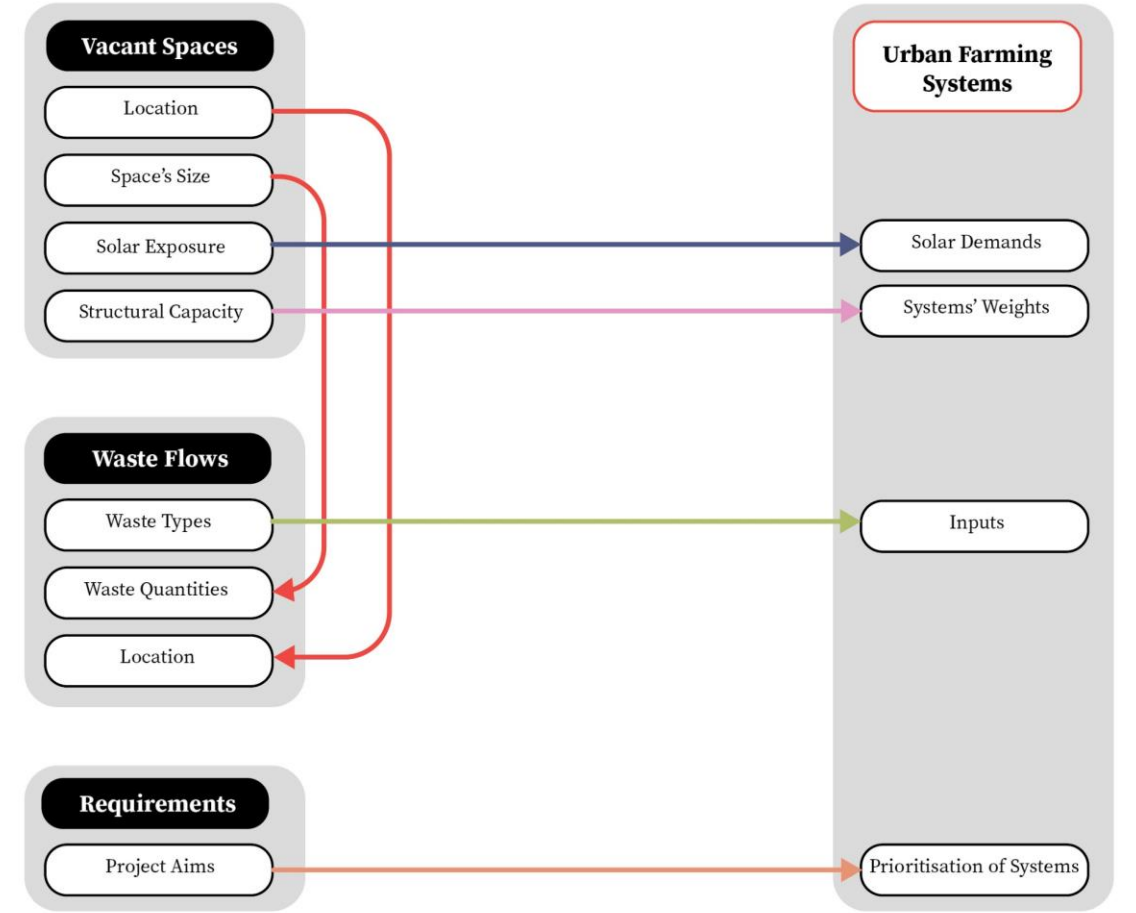
Database

Space	Waste	Supplement	Medium	Growing Technique	Design Characteristic	System Type	Main Product	Bi-Product
Rooftop	Food Waste	Fertilser	Soil	Compost	Fish Tank	Food Production	Small Crops	Heat
Facade	Coffee Waste	Nutrient Solution	Water	Spawning	Tank	Supplementary	Large Crops	Food Waste
Intermediate Floor	Other Waste	Calcium	Fish Tank Water	Aquaculture	Stacked System	Food Producing Supplementary	Mushrooms	Spent Mushroom Substrate
Ground Floor	CO2	Lime Bath*	Air	Raised Beds	Horizontal		Worms	Fertiliser
Basement	Rainwater		Food Waste	NFT	Vertical		Fish	Fish Tank Water
	Heat		Coffee Waste	Aeroponics	Modular Frame			
			Other Waste	EBB & Flow				
			Clay Balls	Gravity Trickle				
inputs				**system**			**outputs**	

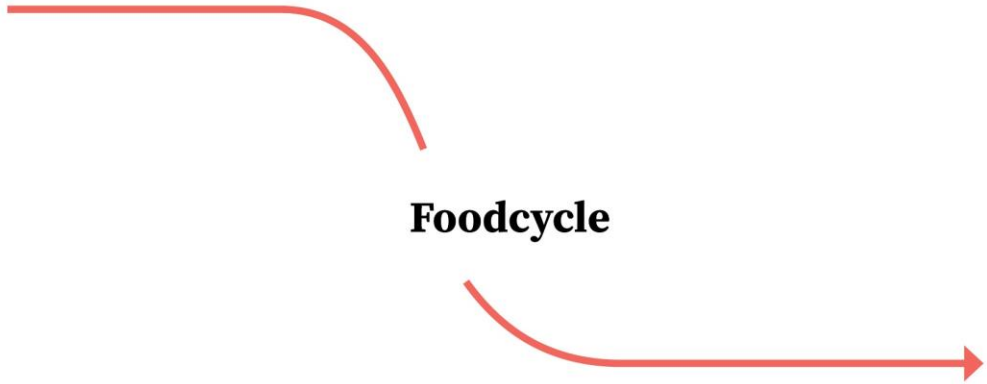
* Lime Bath is used for pasteurization of substrate.

- Vermiculture
- Mushroom
- Plant Factory
- Aquaculture
- Raised Bed
- Aeroponics
- Hydroponic - NFT
- Hydroponic - Water Culture
- Hydroponic - Media Bed

Rule Based Decision Making

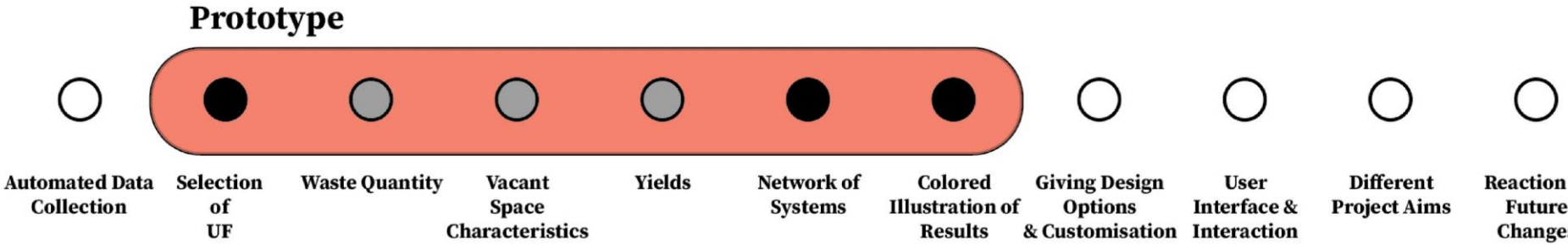


if .... then ...



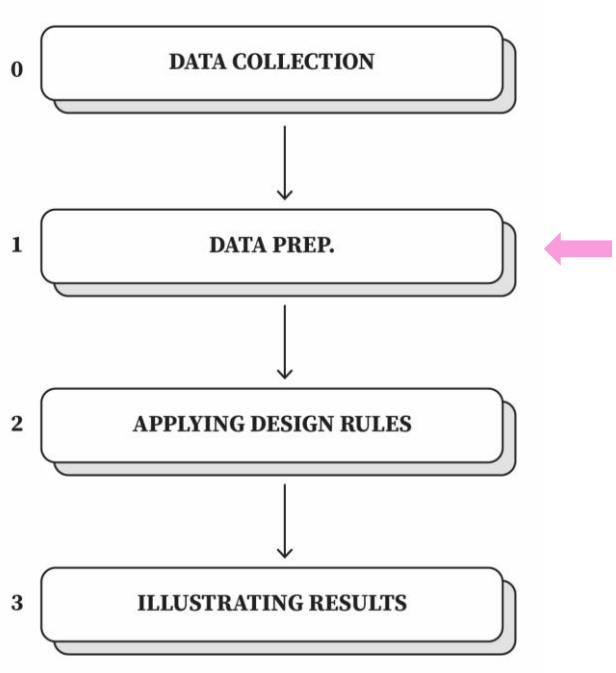
Aim / Scope
Data Flow
Design Rules
User - Tool Interaction
Design Process

Project Scope



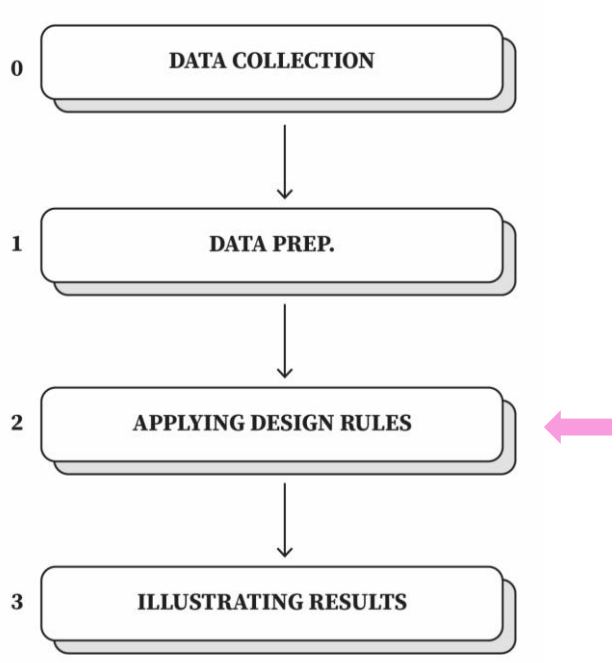
Included Simplified In theory

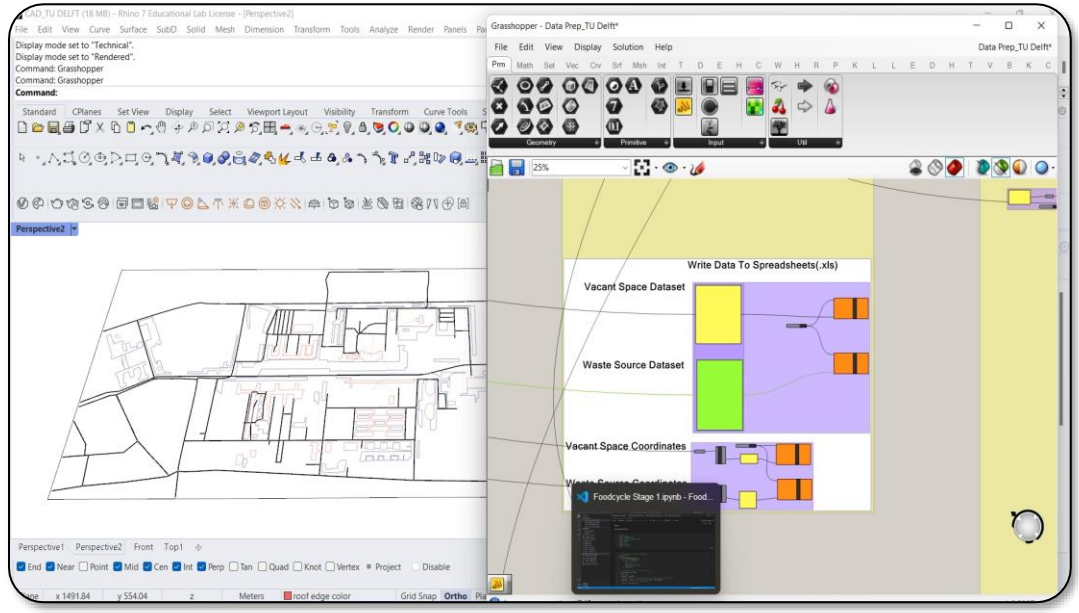
Decision Making Flow



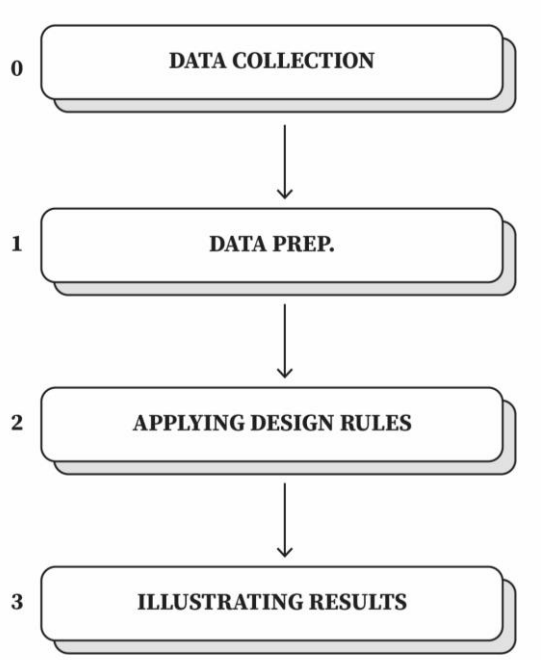

```
Welcome To FoodCycle!
```

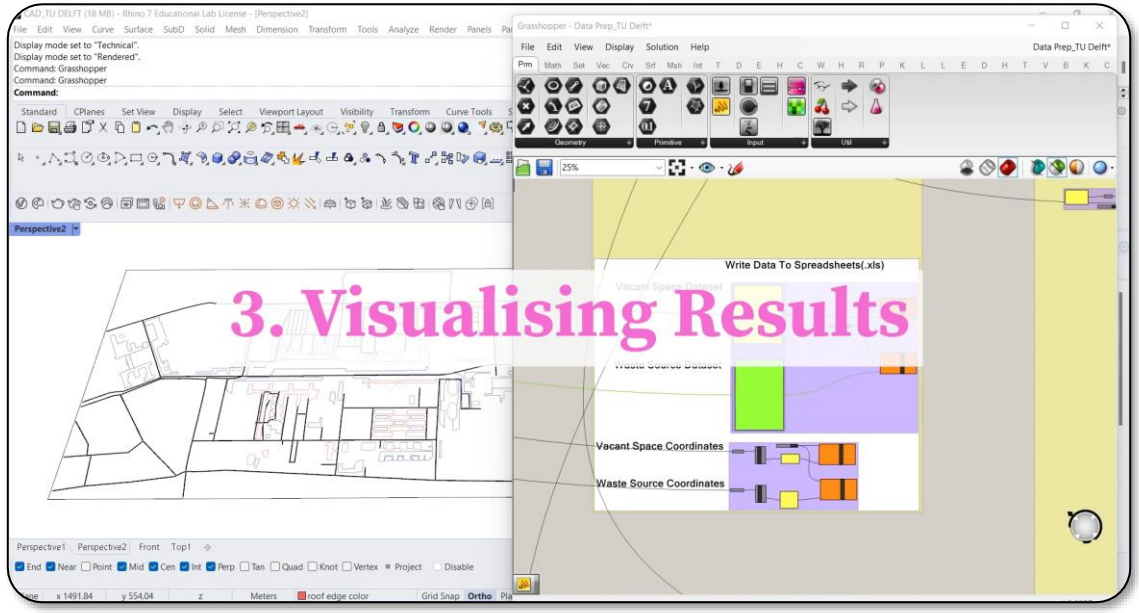
Decision Making Flow



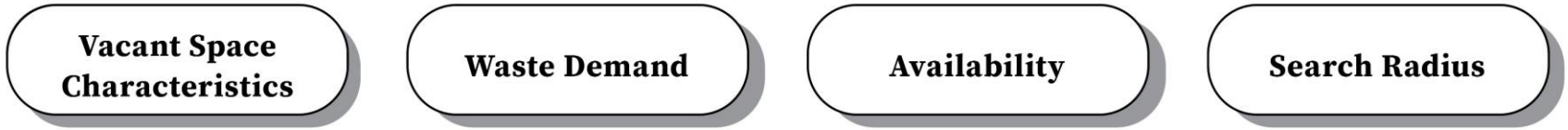


Decision Making Flow

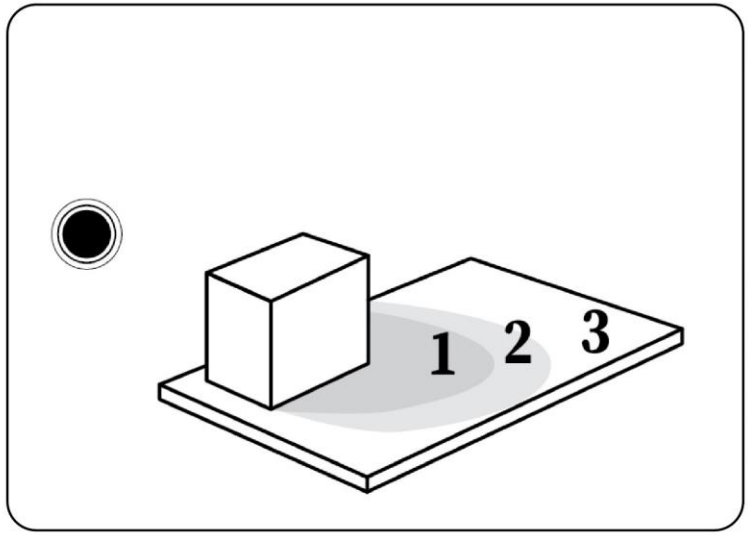




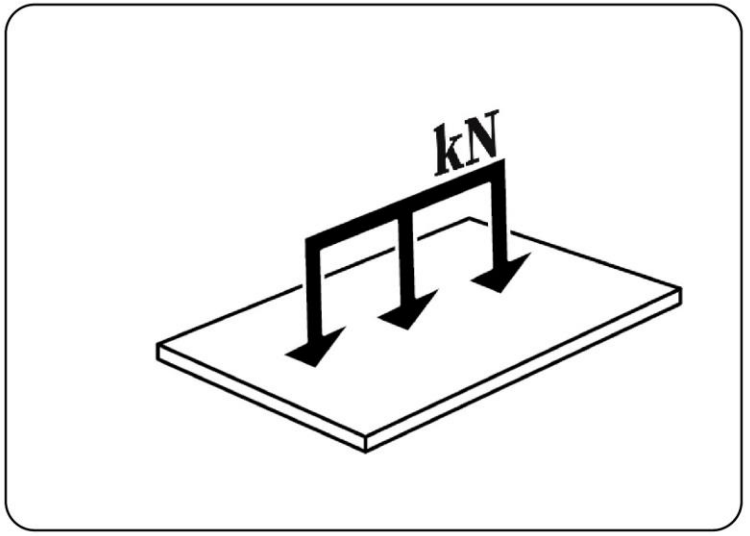
Design Rules



Vacant Space Characteristics

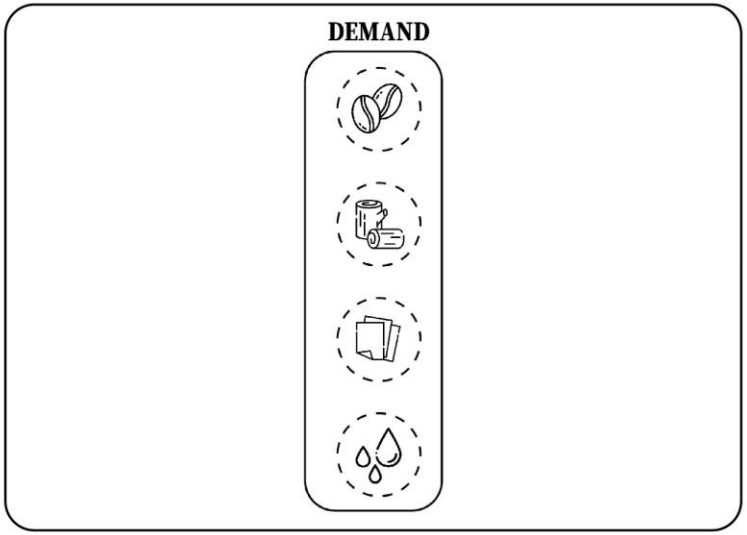


Solar Exposure

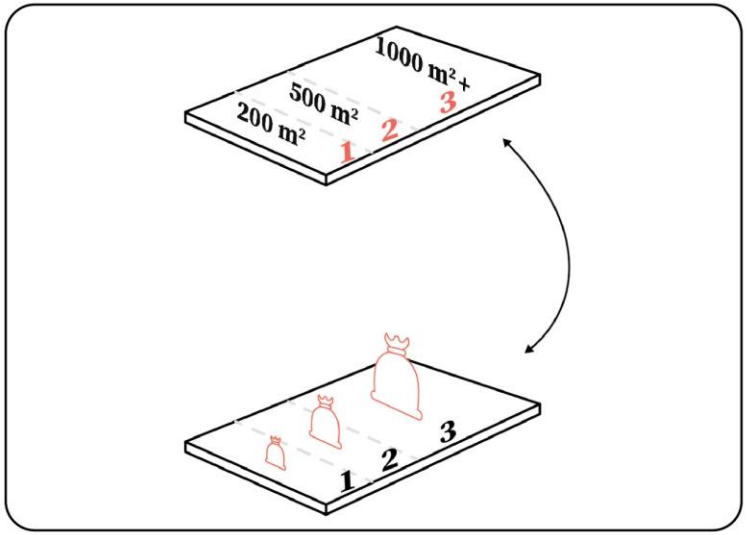


Structural Capacity

Waste Demands

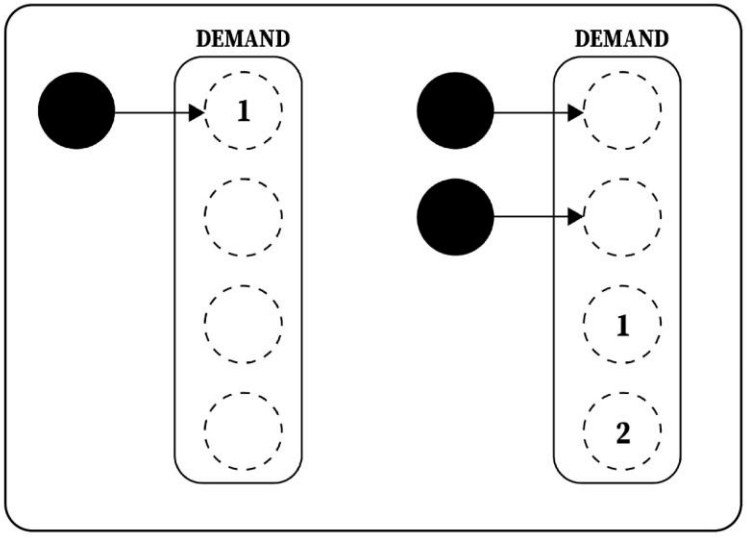


Demanded Waste Types

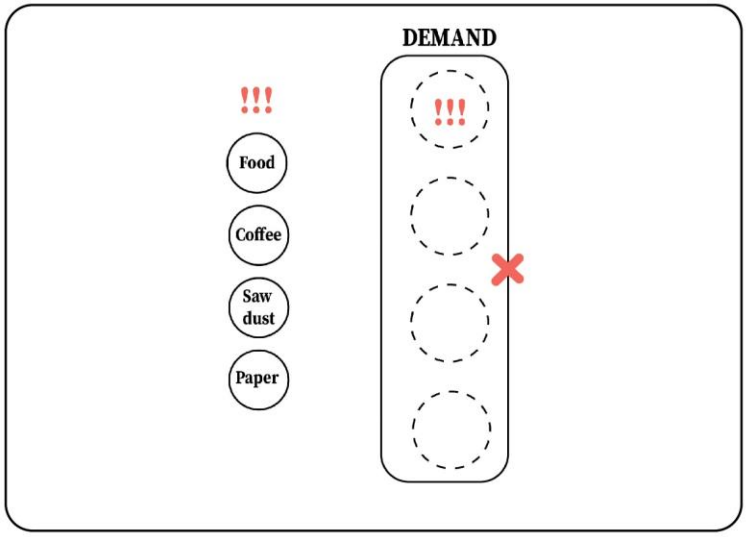


Demanded Waste Quantity

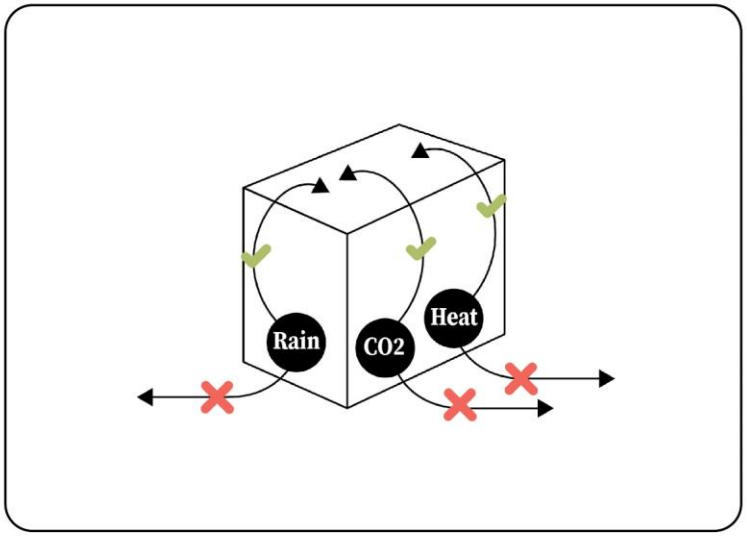
Waste Availability



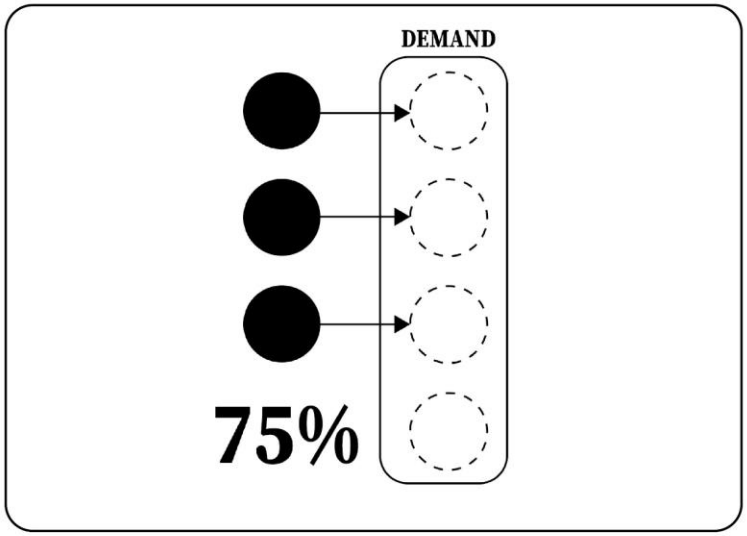
Found & Missing Items



Critical Items

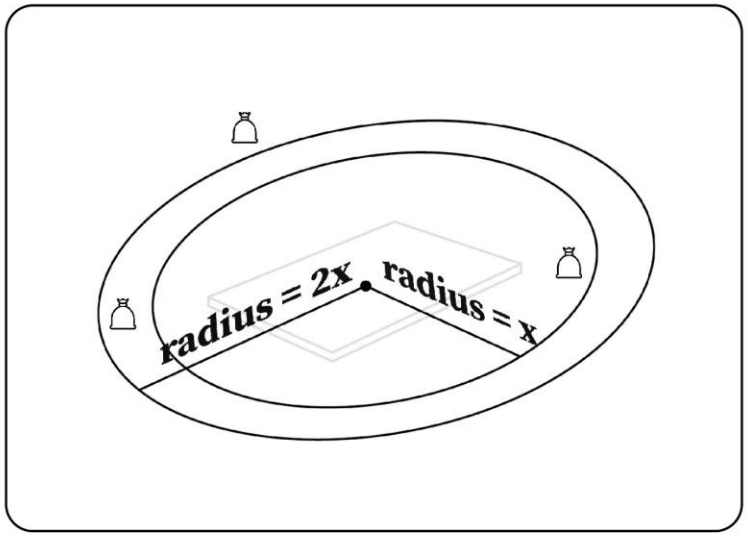


Non - Transferable Items



Symbiosis Rate

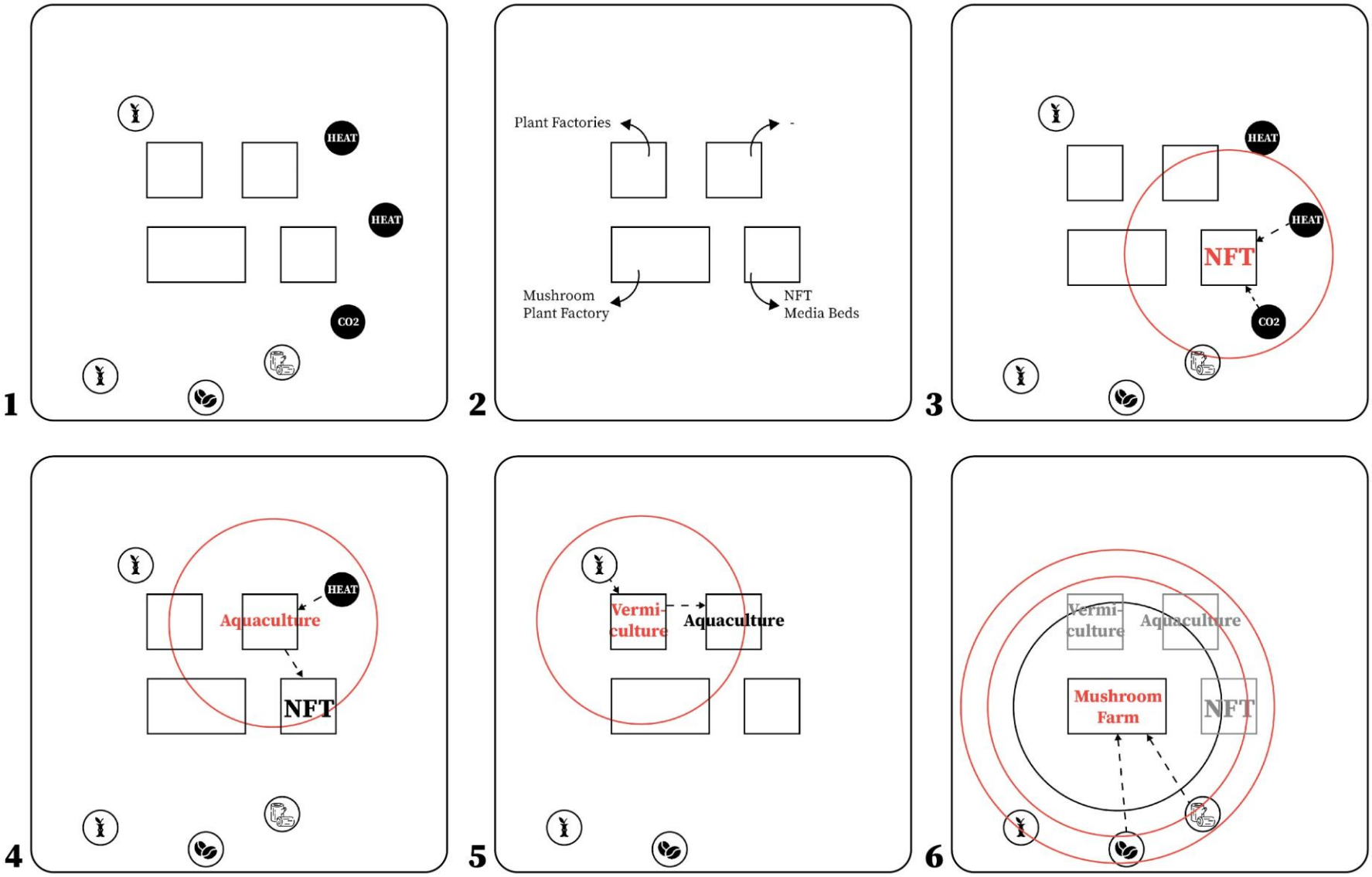
Search Radius



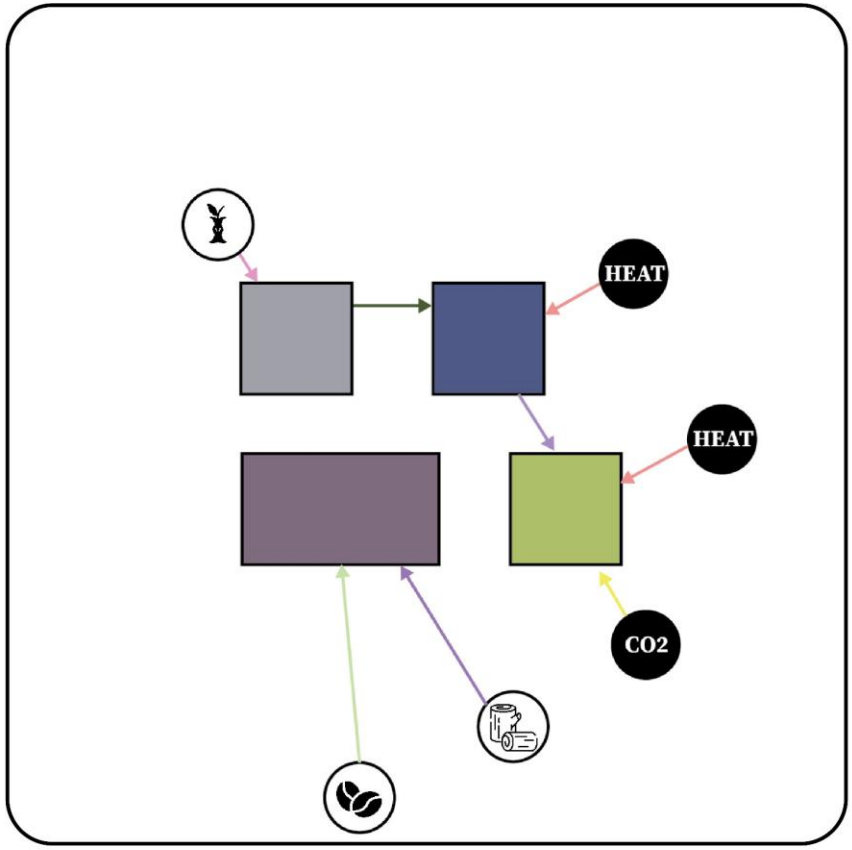
Minimum & Maximum Radius

How to make decisions?

Step By Step Decision Making



Illustrating Decisions



Food Waste (W1)
Sawdust (W2)
Paper (W3)
Coffee Waste (W4)
CO2 (W5)
Rainwater (W6)
Heat (W7)
N.D. Water (S2)
Fertiliser (S4)
Fish Food (S5)

Vermicompost (UF1)
Aquaculture (UF2)
Mushroom Farm (UF3)
NFT (UF4)
Mediabeds (UF5)
Raised Beds (UF6)
Water Culture (UF7)
Plant Factory (UF8)
Aeroponics (UF9)

Using Foodcycle

User - Tool Interaction
Design Process

How to Interact with Foodcycle?

Welcome To FoodCycle!

Please wait while we are restarting the kernels ...

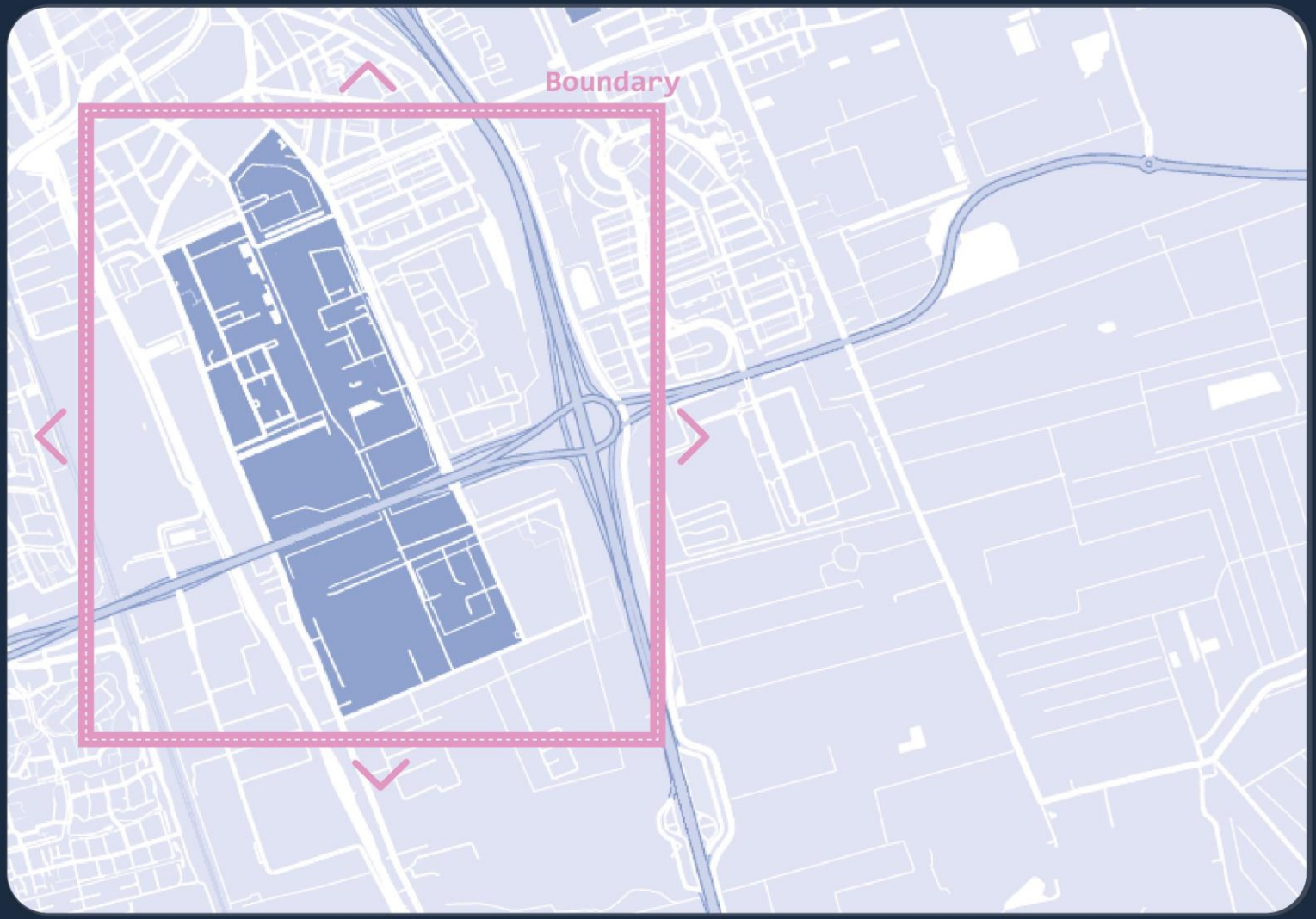
FoodCycle

Start New

Open File

Help Me

Site Selection



Location

TU Delft

Boundary

Tip! Drag Corners To Rseize Boundary Box

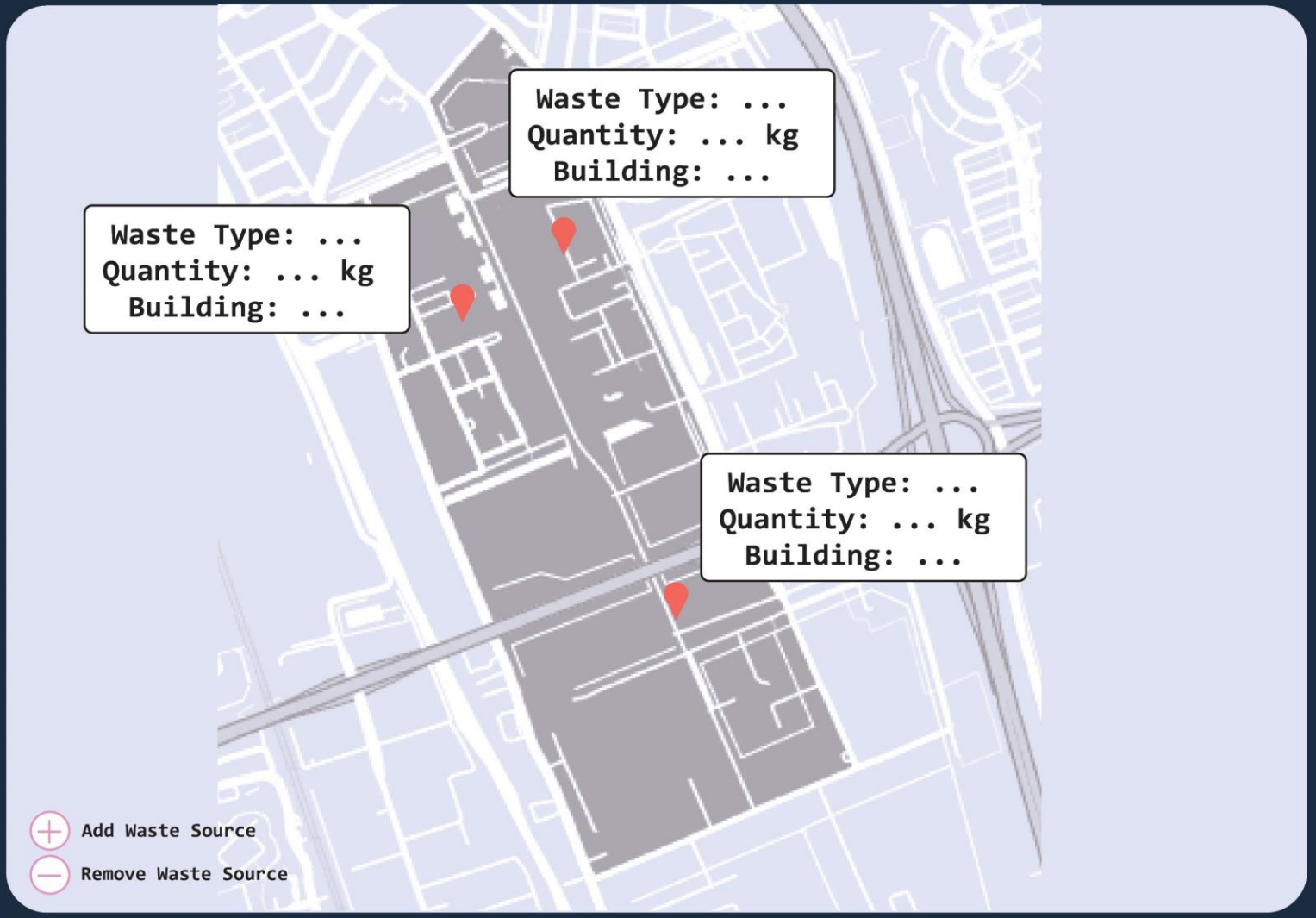
Coordinates :
x , y , z

Area : ... m2

Elevation Difference
: ... m

NEXT

Waste Flows Data



Include Waste Types:

- [x] Coffee Waste
- [x] Food Waste
- [x] Paper Waste
- [x] Sawdust
- [x] CO2
- [x] Excess Heat
- [x] Rainwater Harvesting

Tip! Drop Pin & Fill In The Details For Manual Input

Data Colection Method:

- [ ] GIS Data Import
- [x] Manual Input

NEXT

Vacant Space Data

Include Spaces For Farming:

- [x] Ground Floor
- [x] Roof Top
- [x] Indoor

Tip! Click on the areas to include

Data Colection Method:

- [x] GIS Data
- [ ] Drone Footage
- [x] Manual Input

NEXT

Design Questionnaire

Design Questionnaire

What is the aim of the project?

Questions 4/14

Research

Holistic Food Production

Maximum Productivity

Should all the waste sources be found for food production systems?

Both Critical and Non-Critical Items

Only Critical Items

How many missing resources is acceptable?

1

2

3

Should all the waste sources be found for food producing supplementary systems?

Both Critical and Non-Critical Items

Only Critical Items

Holistic Food Production

Uf systems are sorted according to ease of application in existing urban contexts.

All of the vacant spaces will be occupied based on the number of missing items even if there is not any found item.

Critical Items:

Resources which are a must for a system to function

Vermiculture: Food waste, sawdust, paper

NEXT

Design Questionnaire

hould all the waste sources be found for supplementary systems?

Questions 8/14

Both Critical and Non-Critical Items

Only Critical Items

How far can the waste sources be from vacant spaces?

100 [m]

Can this distance be increased if there are vacant spaces left?

No

Yes

What is the maximum distance waste sources can travel?

500 [m]

Food Production Systems:
Systems which only produce food including mushrooms, soft fruits and leafy greens.

Food Producing Supplementary Systems:
Systems which produce supplements in addition to food.

Supplementary Systems:
Systems which only produce supplementary items but no food items.

NEXT

Design Questionnaire

Can search radius be increased if there are vacant spaces left?

Questions 11/14

No

Yes!

How many times?

0

1

2

Is there a possibility to add infrastructure to transfer CO2, heat and Rainwater?

No

Yes!

Search Radius:
Search radius is the distance between each vacant space and waste sources around it.
Non Transferable Items:
CO2, Heat, Rainwater
These resources are only used if they are available in the same building as the vacant space.

NEXT

Design Questionnaire

How many steps should there be until it reaches the maximum value?

Questions 14/14

2

3

4

How Is there a possibility to add infrastructure to transfer CO2, heat and rainwater?

No

Yes!

Should all the vacant spaces be occupied even if there are not any found items?

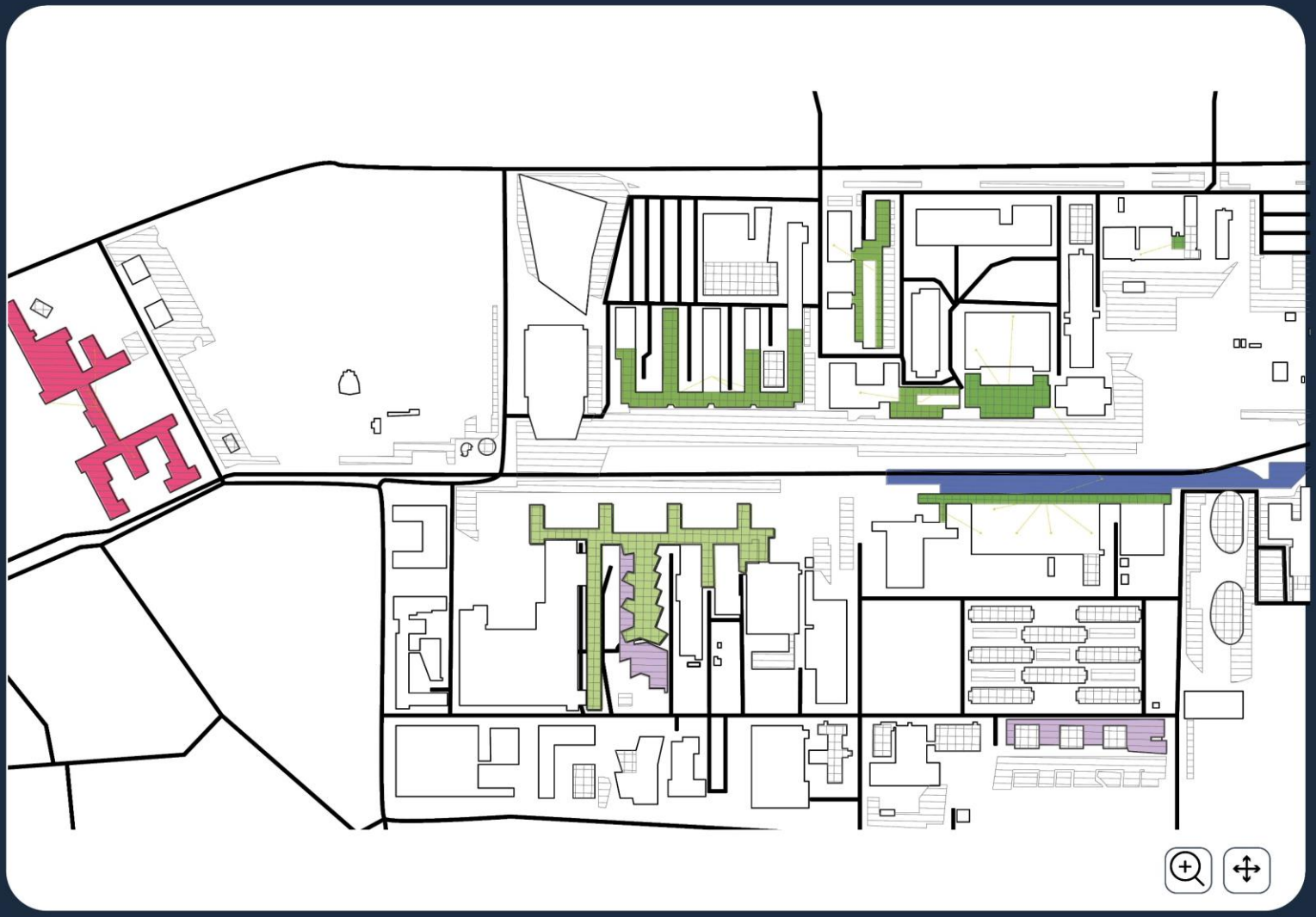
No

Yes!

Search Radius:
Search radius is the distance between each vacant space and waste sources around it.
Non Transferable Items:
CO2, Heat, Rainwater
These resources are only used if they are available in the same building as the vacant space.

NEXT

Designing



Initial Search Radius

Increased Search Radius

Increased Search Radius

0 500

Maximum 2 missing resources

Min. 1 found resource

Critical Items Cannot Be Supplied Externally

Average Symbiosis Rate:
... %

Number of Vacant Spaces:
... spaces

Number of Used Waste Sources:
... sources

NEXT

Designing

Initial Search Radius

Increased Search Radius

Increased Search Radius

0 500

Maximum 2 missing resources

Min. 1 found resource

Critical Items Cannot Be Supplied Externally

Average Symbiosis Rate:
... %

Number of Vacant Spaces:
... spaces

Number of Used Waste Sources:
... sources

NEXT

Designing

Initial Search Radius

Increased Search Radius

Increased Search Radius

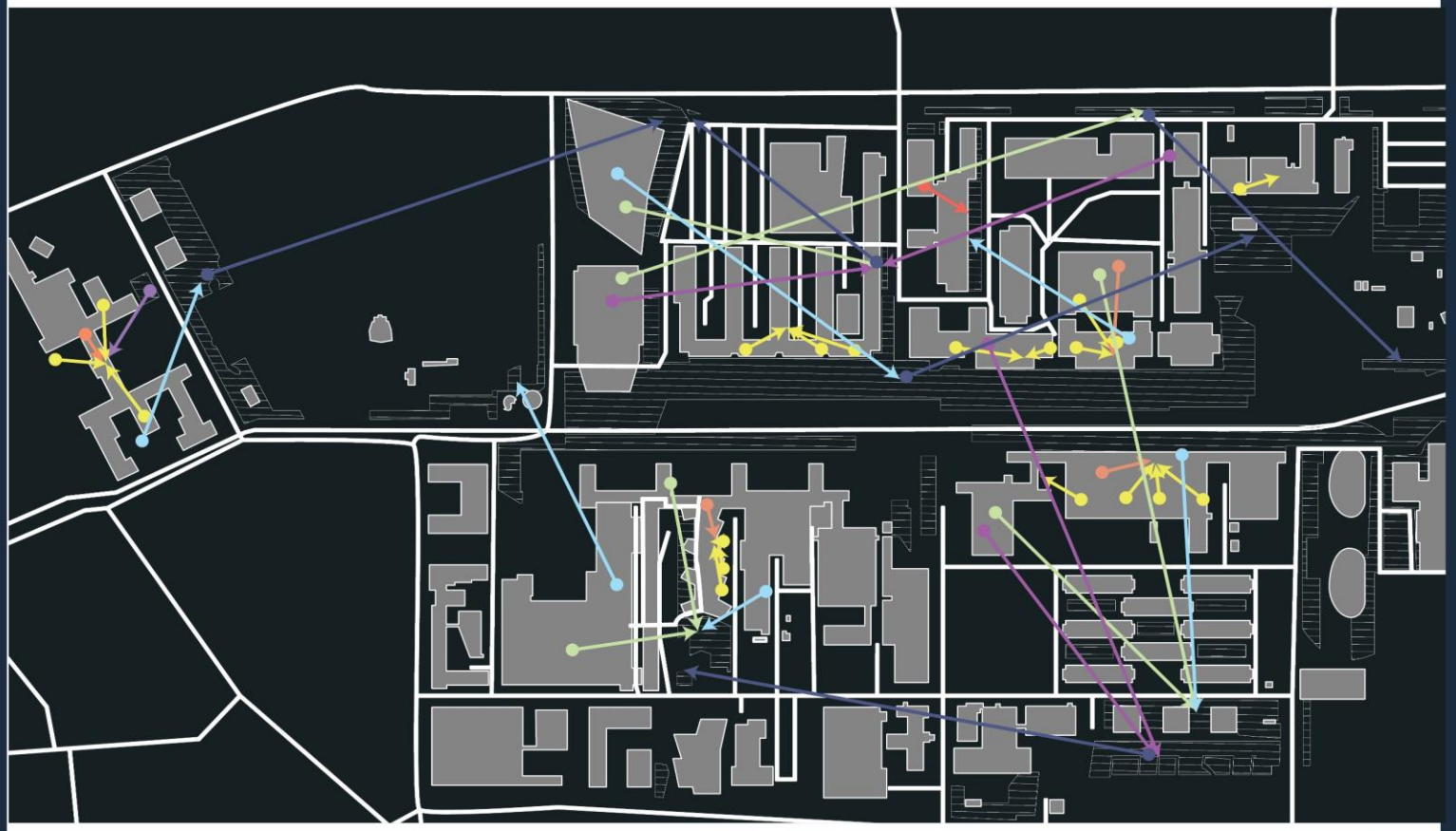
0 500

- [ ] Maximum 2 missing resources
- [ ] Min. 1 found resource
- [x] Critical Items Cannot Be Supplied Externally
- [x] Assign a system to every vacant space

Average Symbiosis Rate:	Number of Vacant Spaces:	Number of Used Waste Sources:
... %	... spaces	... sources

NEXT

Designing



Initial Search Radius

Increased Search Radius

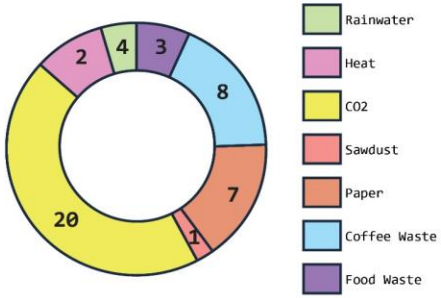
Increased Search Radius

0 500

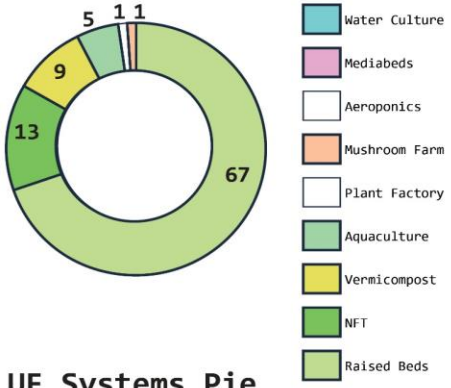
- [ ] Maximum 2 missing resources
- [ ] Min. 1 found resource
- [x] Critical Items Cannot Be Supplied Externally
- [x] Assign a system to every vacant space

Average Symbiosis Rate:	Number of Vacant Spaces:	Number of Used Waste Sources:
... %	... spaces	... sources

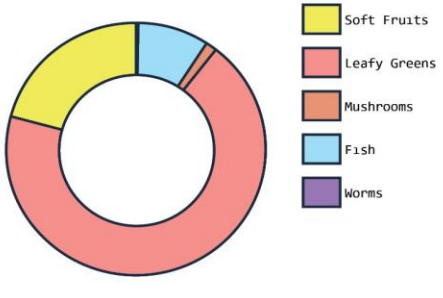
NEXT



Used Waste Types Pie Chart



UF Systems Pie Chart



Food Production Pie Chart

Enough Vegetables to Feed 72093 People (Daily)

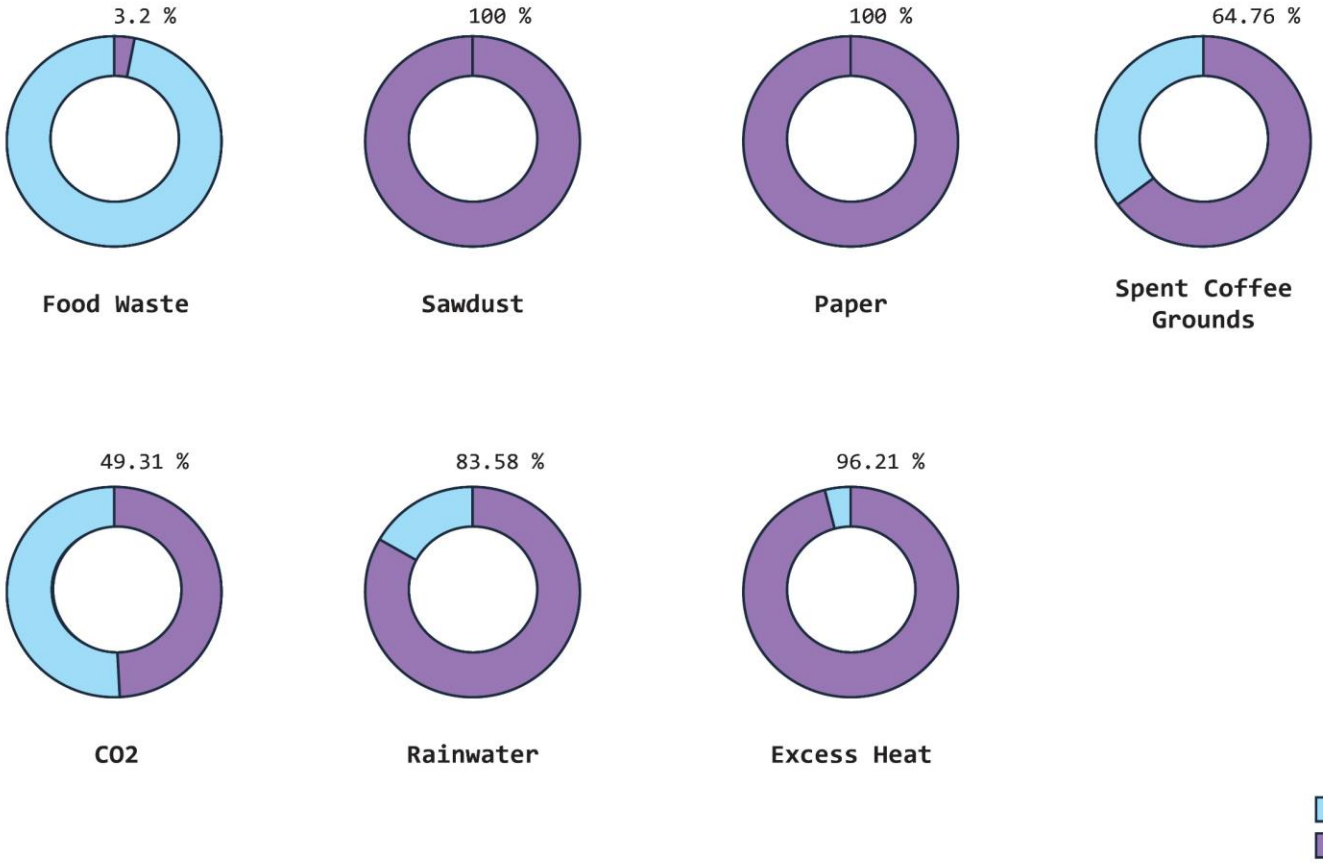
Delft Population : 101,030

250 gr Fruit & Veg

90 % of Delft Population

NEXT

Conclusions



Food Waste :
4237 / 131542
[kg/year]

Sawdust :
592000 / 592000
[kg/year]

Paper :
812601 / 812601
[kg/year]

Spent Coffee Ground :
13020 / 201040
[kg/year]

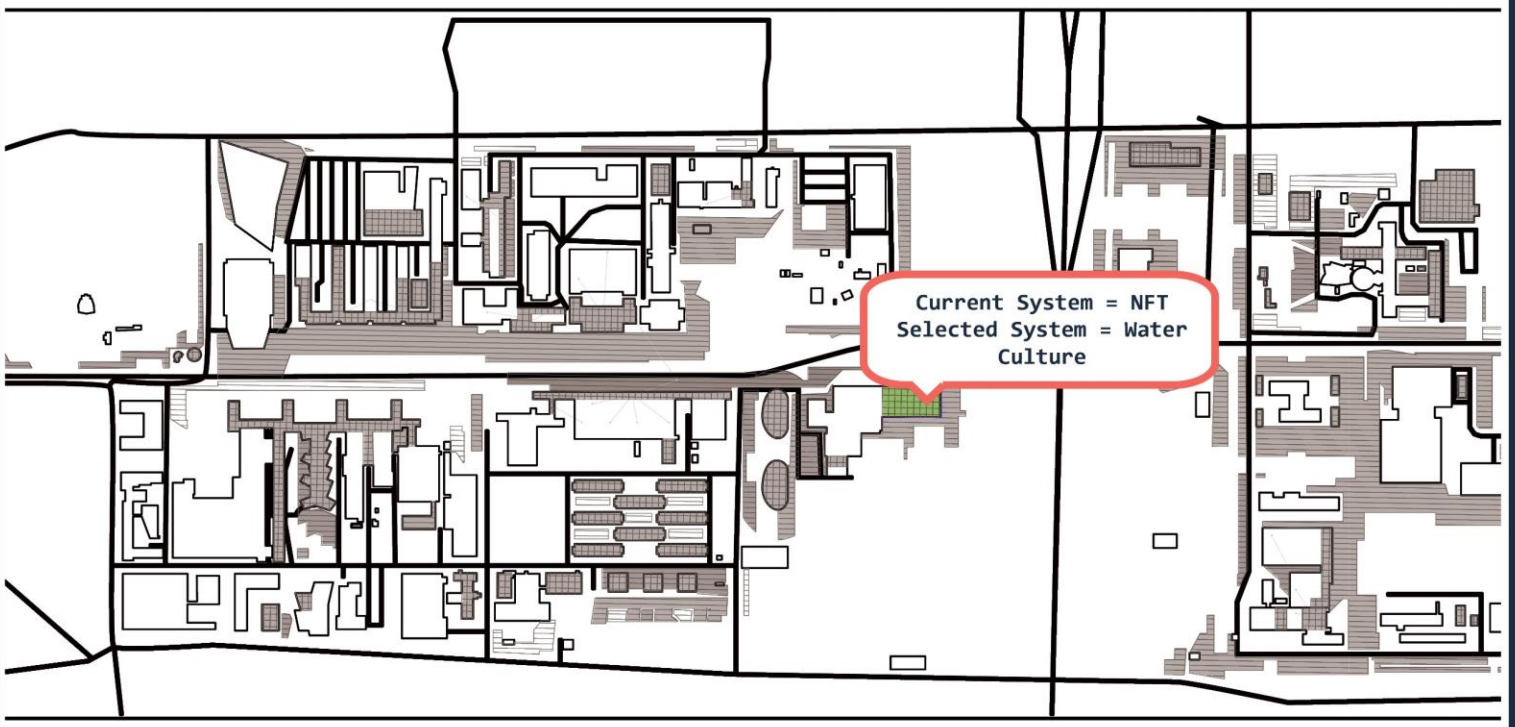
CO2 :
1962 / 3979
[kg/year]

Rainwater :
41050300 / 49116800
[L/year]

Excess Heat :
44000000 / 45732320
[kWh/year]

NEXT

Customisation



Change UF System

- [ ] Vermiculture
- [ ] Aquaculture
- [ ] Mushroom
- [x] NFT
- [ ] Mediabed
- [x] Water Culture
- [ ] Raised Bed
- [ ] Plant Factory
- [ ] Aeroponics

Warning! The system you picked is too heavy for a rooftop

Tip! Click on the system to chenge it

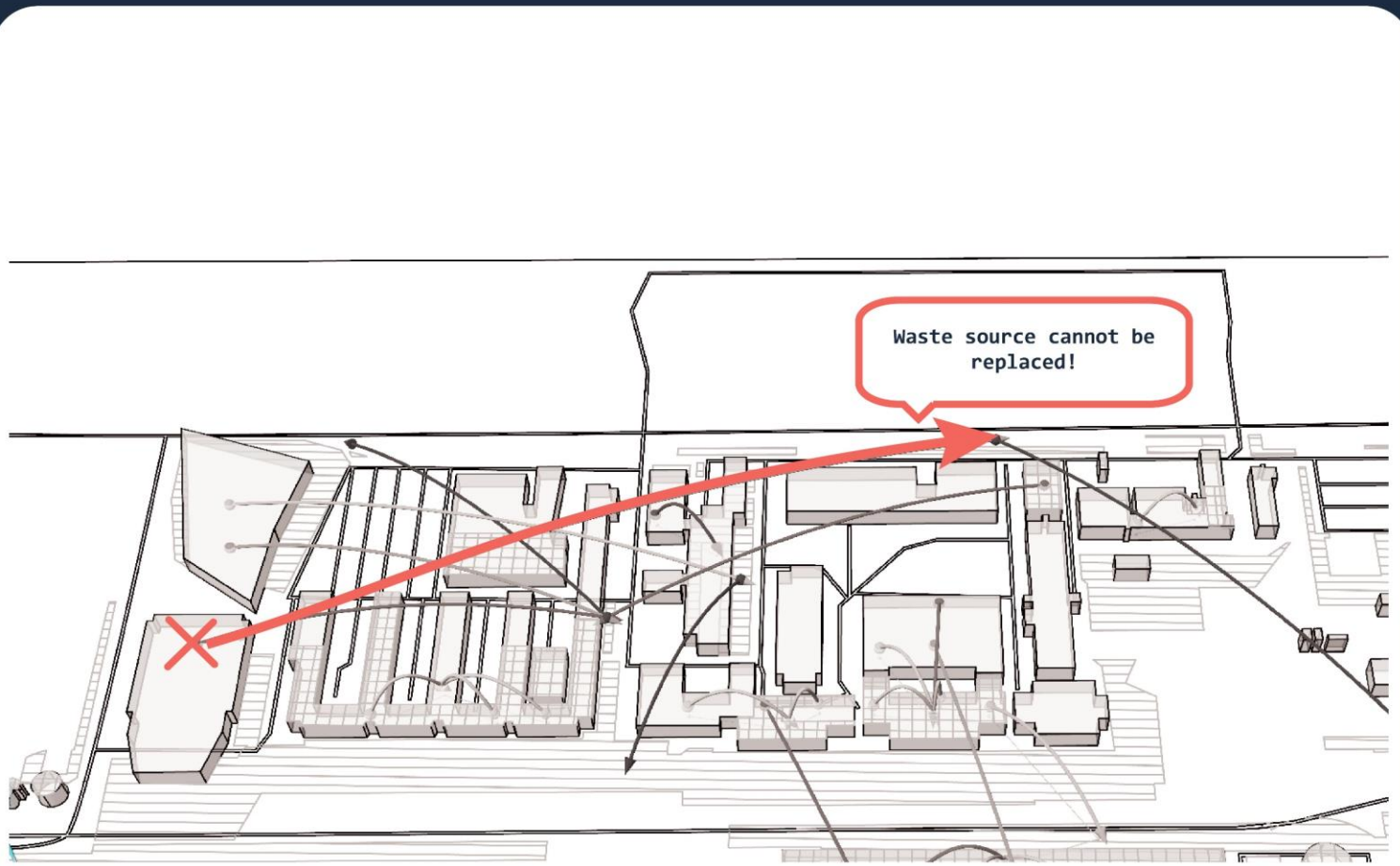
Average Symbiosis Percentage:
...% -> ...%

Food Yield :
... kg -> ...%

Number of Vacant Spaces:
... spaces ->... spaces

NEXT

Future Changes



Removing Waste Source

Warning! The waste source you removed provides a critical resource.
The productivity will be affected significantly!

Tip! Click on the node to remove it

NEXT

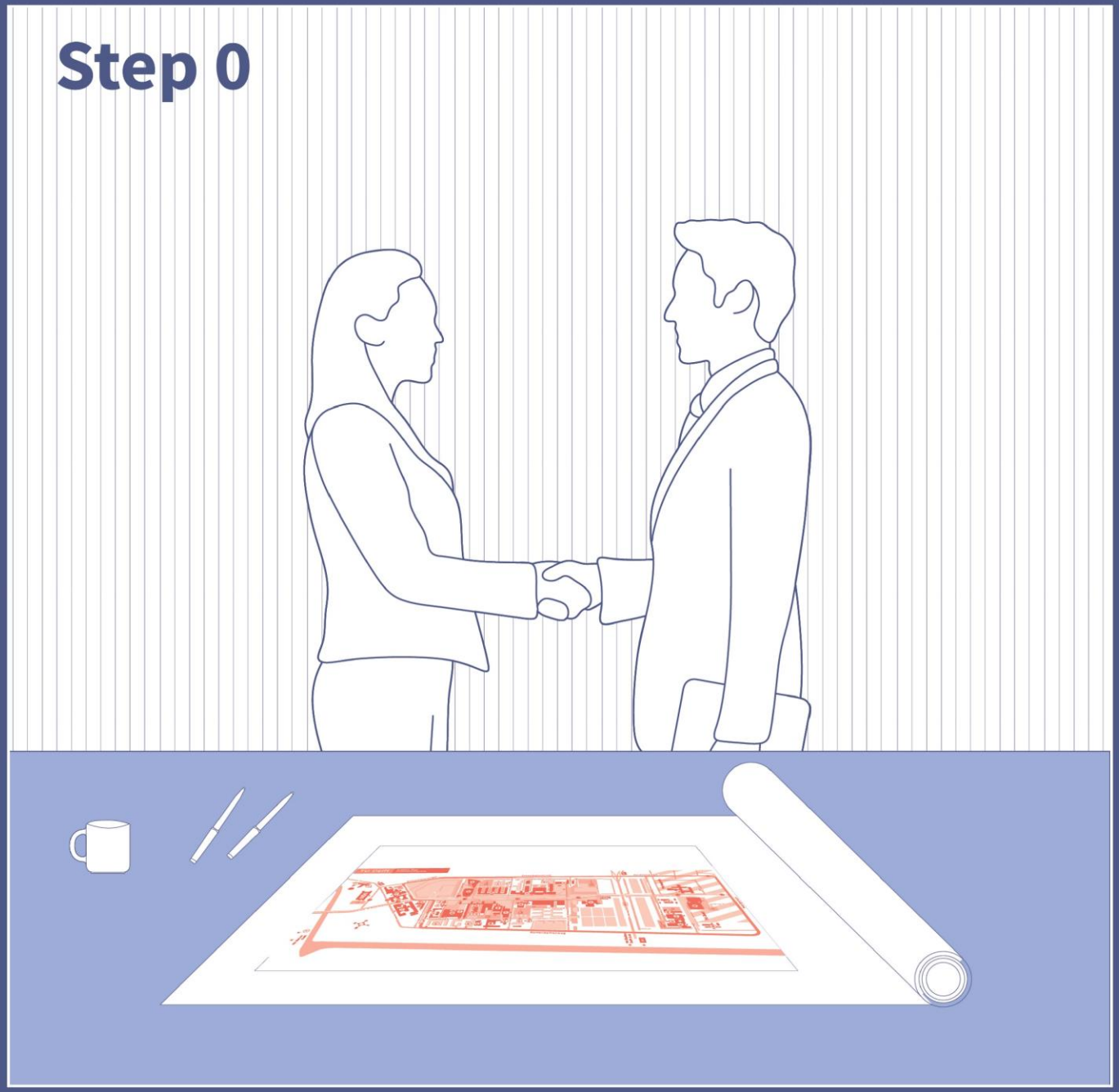
Average Symbiosis Percentage:
...% -> ...%

Food Yield :
... kg -> ...%

Number of Vacant Spaces:
... spaces ->... spaces

When to use Foodcycle?

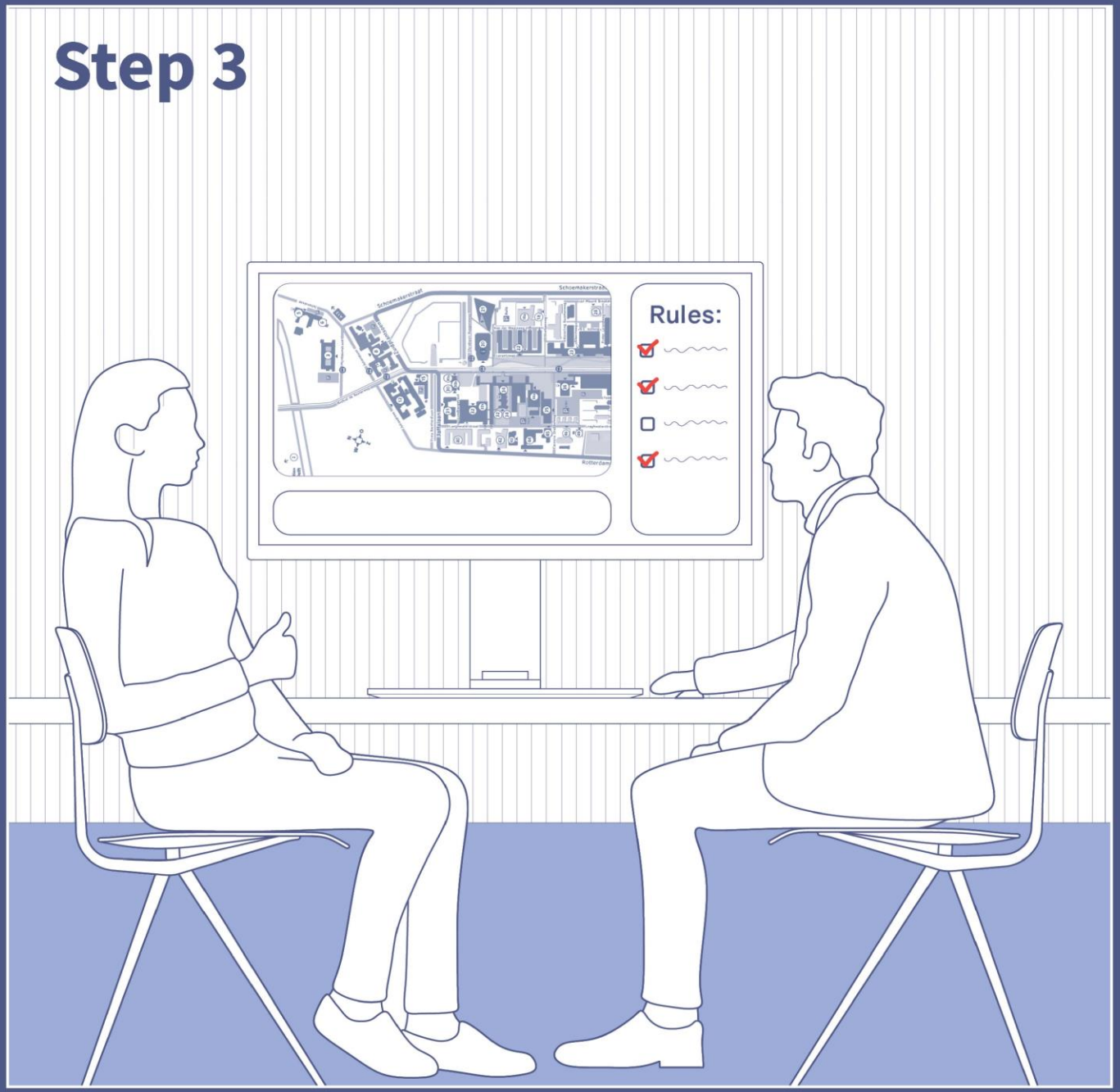
Step 0



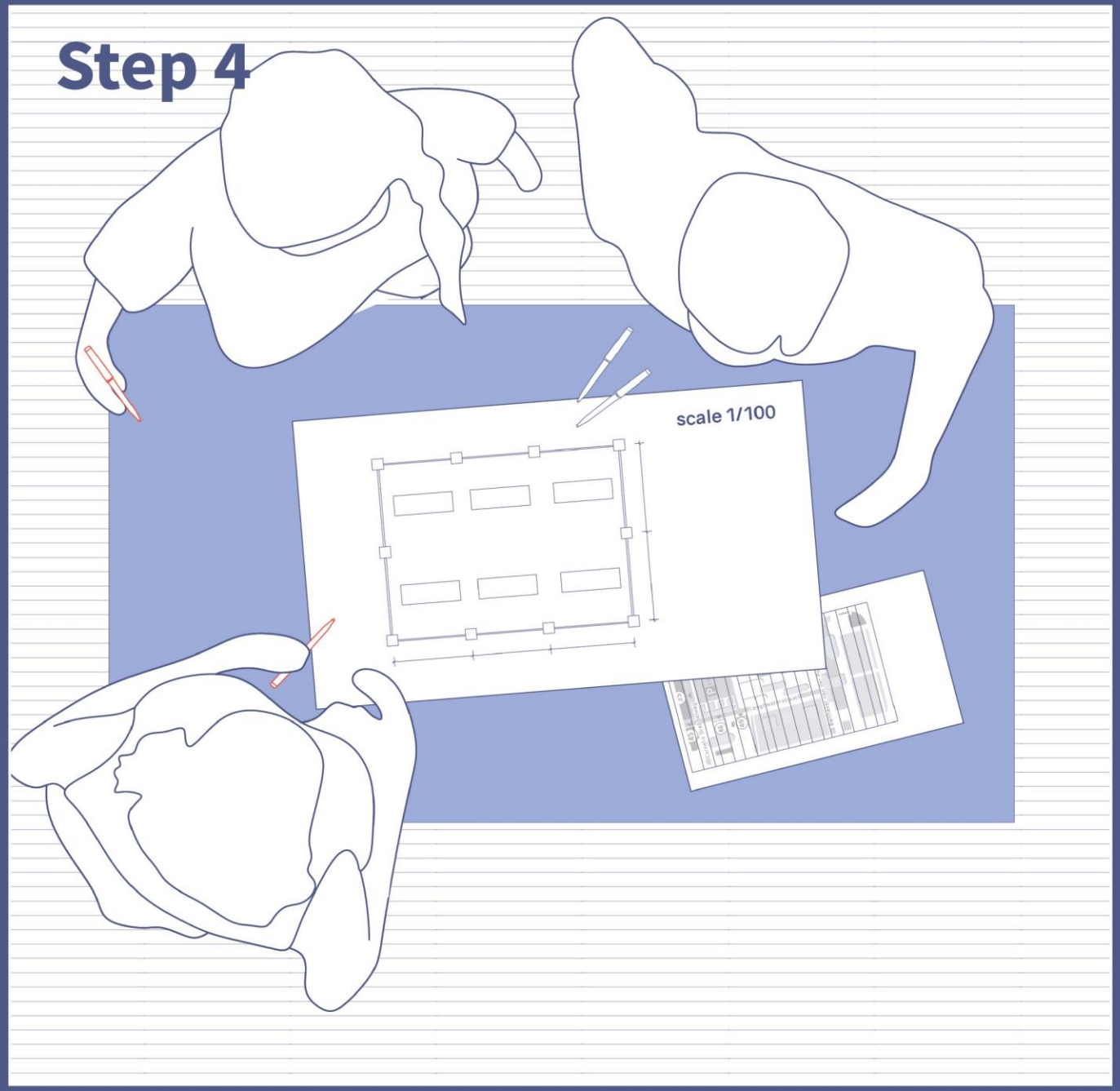
Step 1


Step 2
Foodcycle
new project

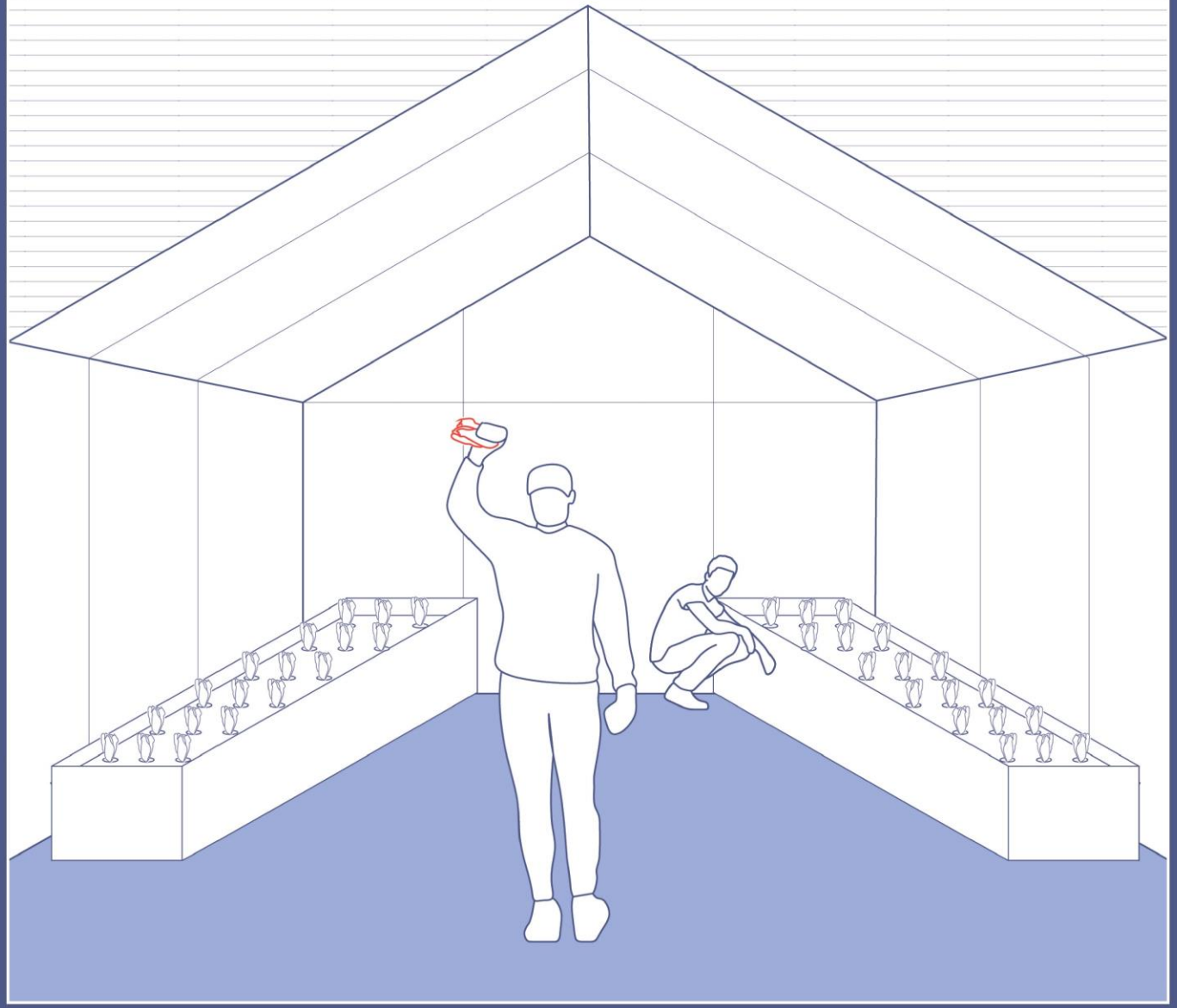
Step 3



Step 4



Step 5



the end ...

TU Delft Case Study

Vacant Spaces & Site Analysis
Waste Sources & Site Analysis
Rules For Tu Delft
Outcomes / Results
Waste Storyboard & Numerical Results
Impressions

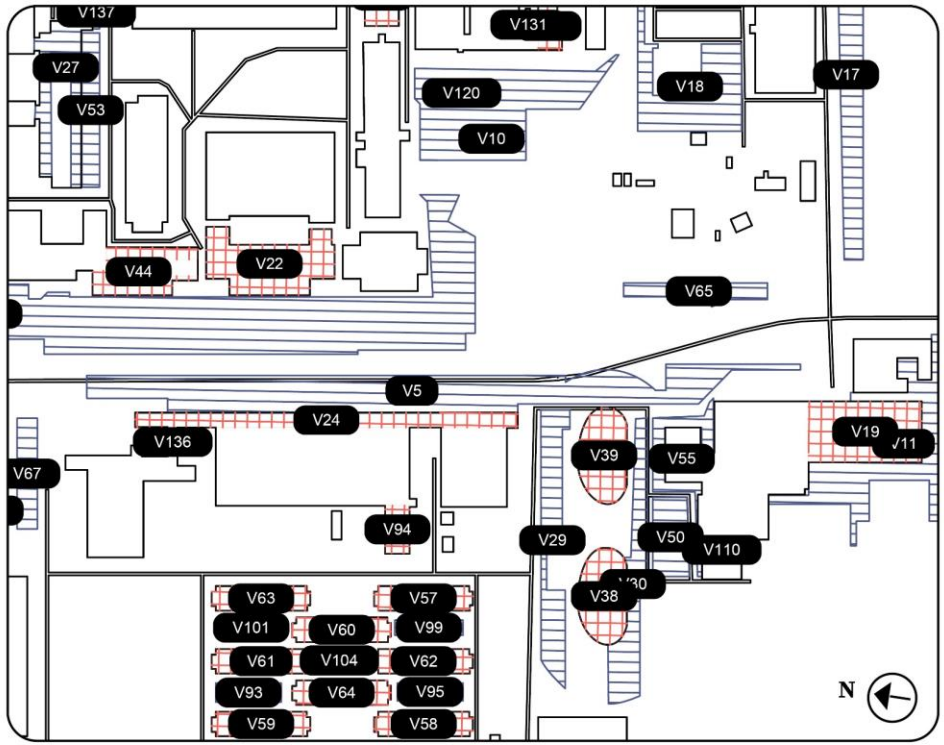
TU Delft Campus

N

Vacant Rooftop

Vacant Ground Floor

Available Spaces

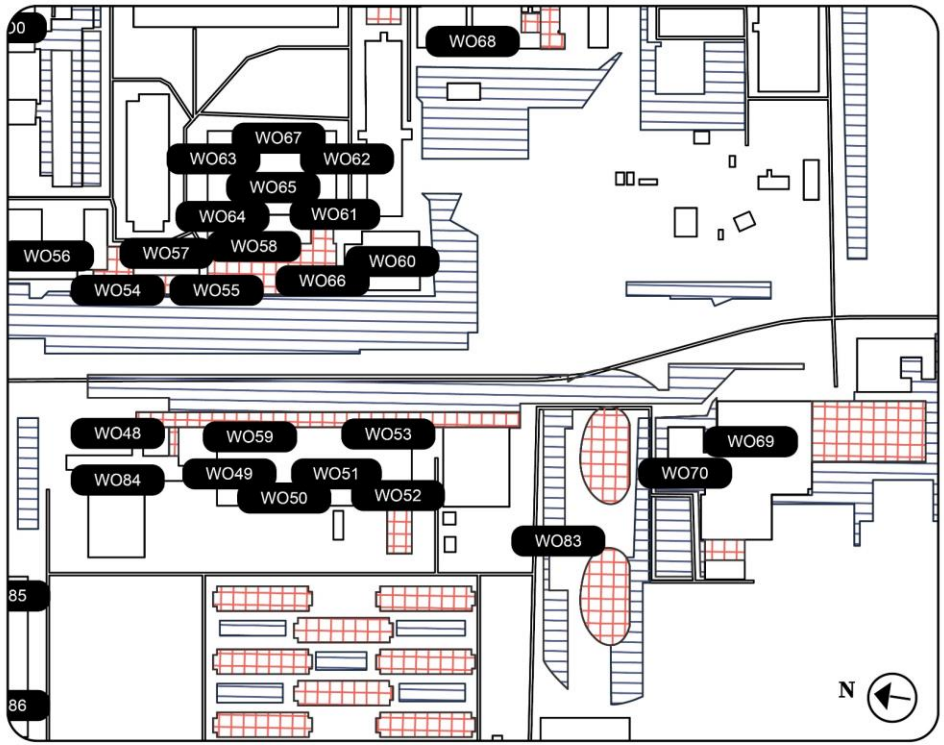


Identifier	Coordinates	Size	Building	Location	Orientation	Tag	Node Type
V94	{1180.528137, 402.278761, 12.0}	444	EEMCS2	roof	S	V94	vacant space
V95	{1200.66369, 302.439976, 0}	440	outside	outside	E	V95	vacant space

Vacant Rooftop

Vacant Ground Floor

Available Waste Sources



Identifier	Coordinates	Building	Type	Quantity	Tag	Node Type	Waste Type
WO84	{1008.117463, 432.481923, 0}	EEMCS2	W1	1257	WO84	waste	food
WO85	{938.062517, 361.587996, 0}	education	W5	148	WO85	waste	co2

Vacant Rooftop

Vacant Ground Floor

Design Rules (Stage 1 - 3)

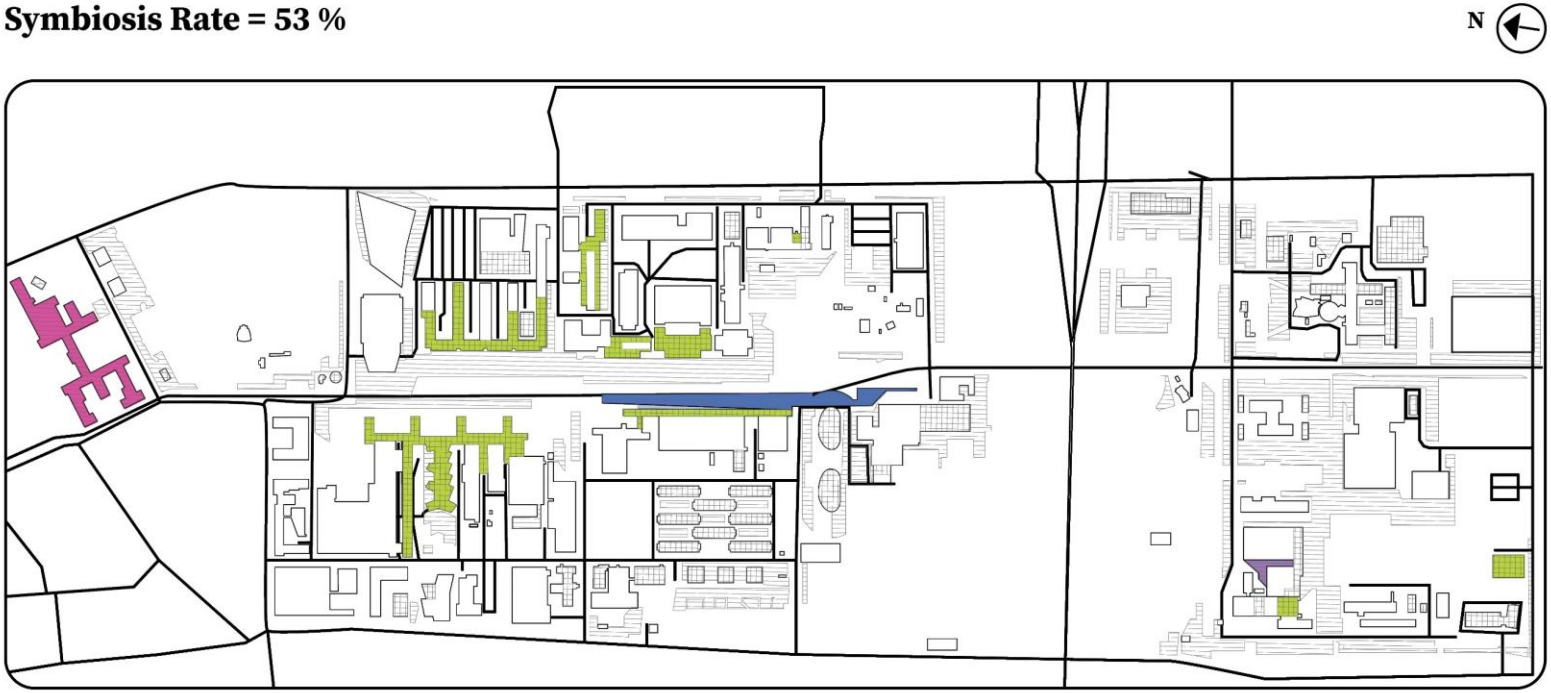
Availability	Search Radius
found items ≥ 1	100 meters
missing items ≤ 2	200 meters
critical items	500 meters
non - transferable	

Stage 1 Results

Radius 100 m

13 farms (4.3 hectares)

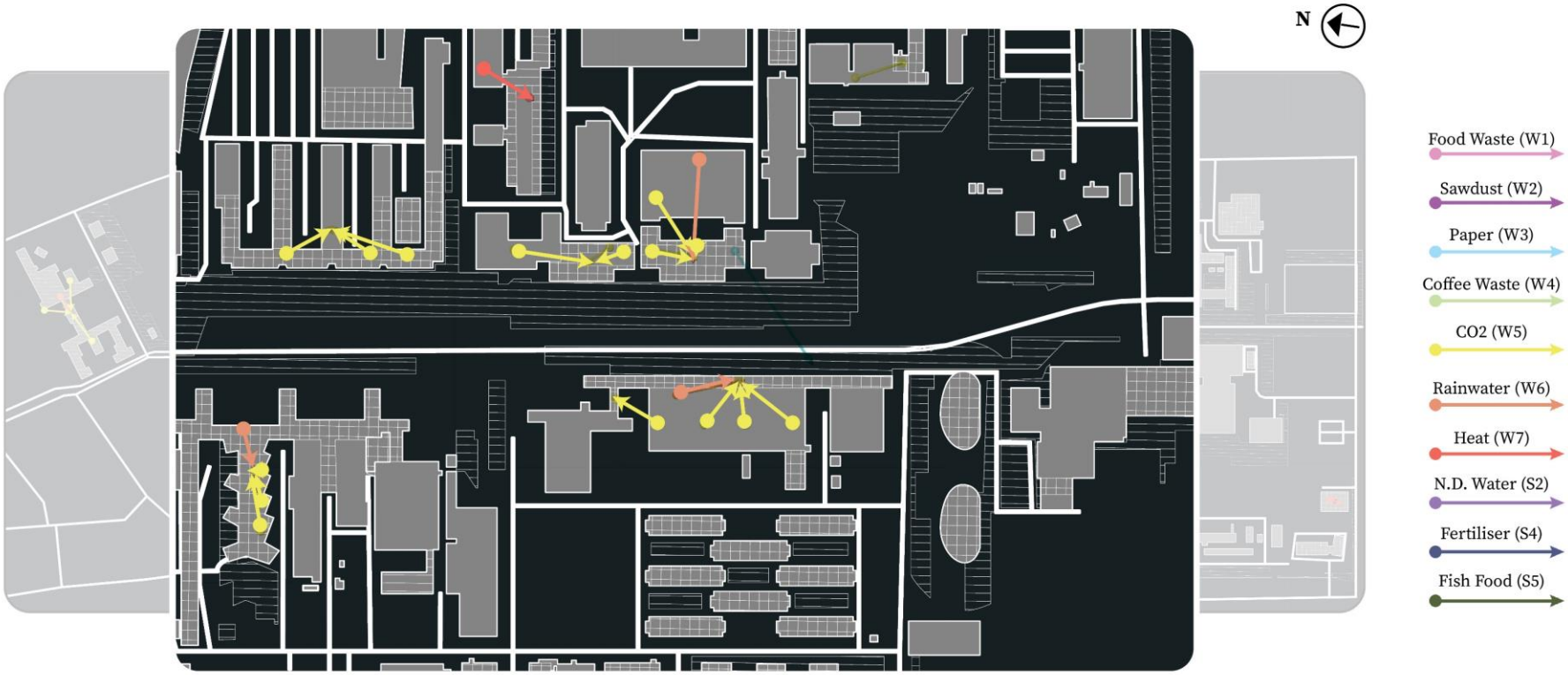
Symbiosis Rate = 53 %



Stage 1 Results

Radius 100 m

29 Used Waste Sources



Stage 2 Results

Radius 200 m

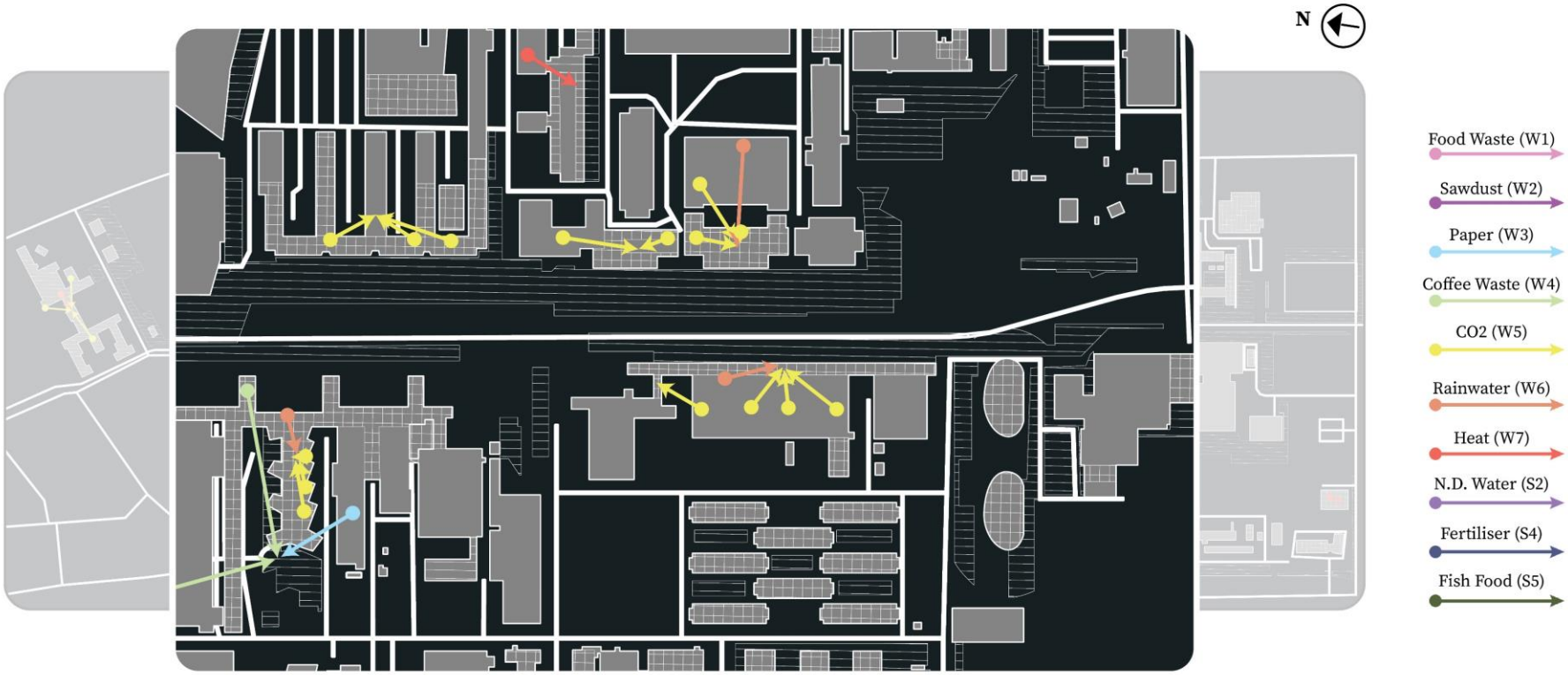
13 + 1 farms (4.3 + 0.2 hectares)

Symbiosis Rate = 50 %

Stage 2 Results

Radius 200 m

29 + 3 Used Waste Sources



Stage 3 Results

Radius 500 m

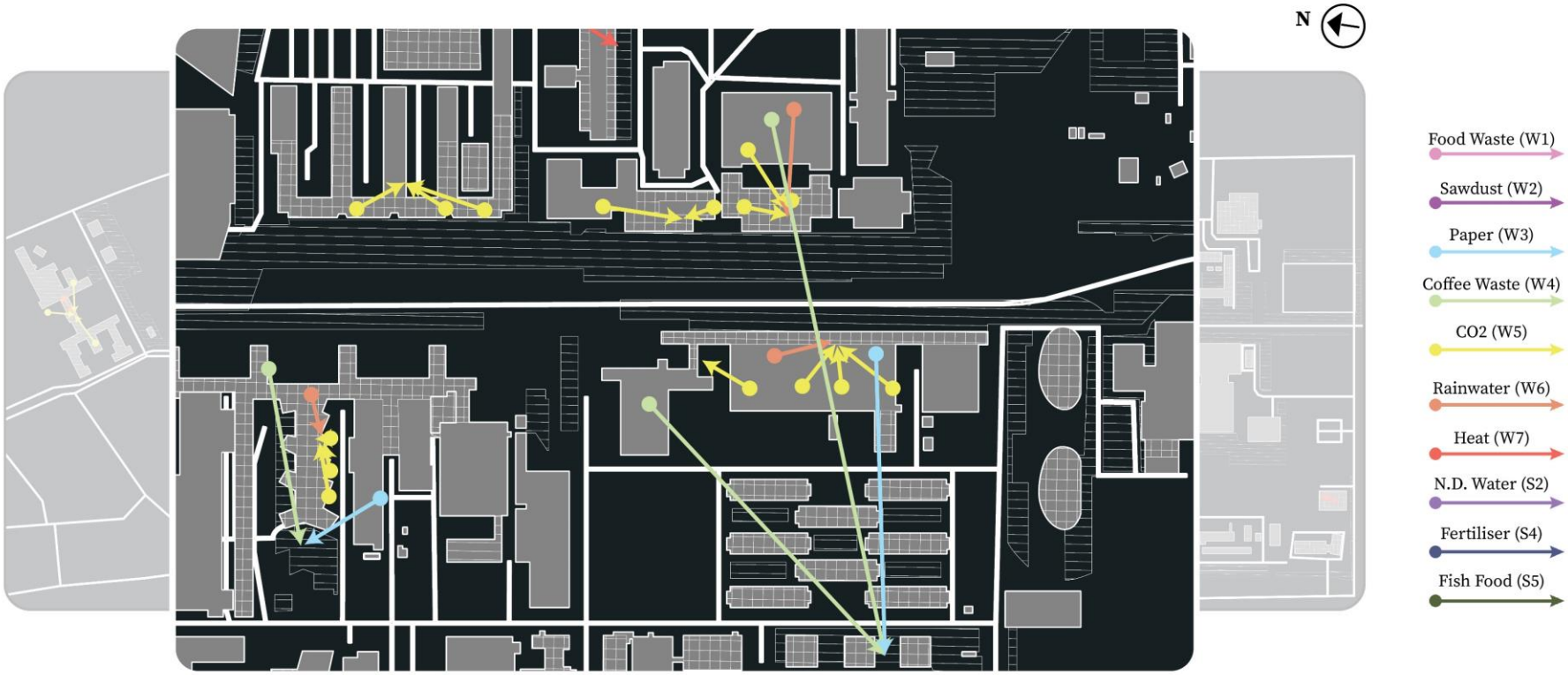
14 +1 farms (4.5 + 0.25 hectares)

Symbiosis Rate = 50 %

Stage 3 Results

Radius 500 m

33 + 3 Used Waste Sources



Design Rules (Stage 4)

Availability

found items ≥ 0

critical items

non - trasferable

Search Radius

500 meters

Stage 4 Results

Radius 500 m

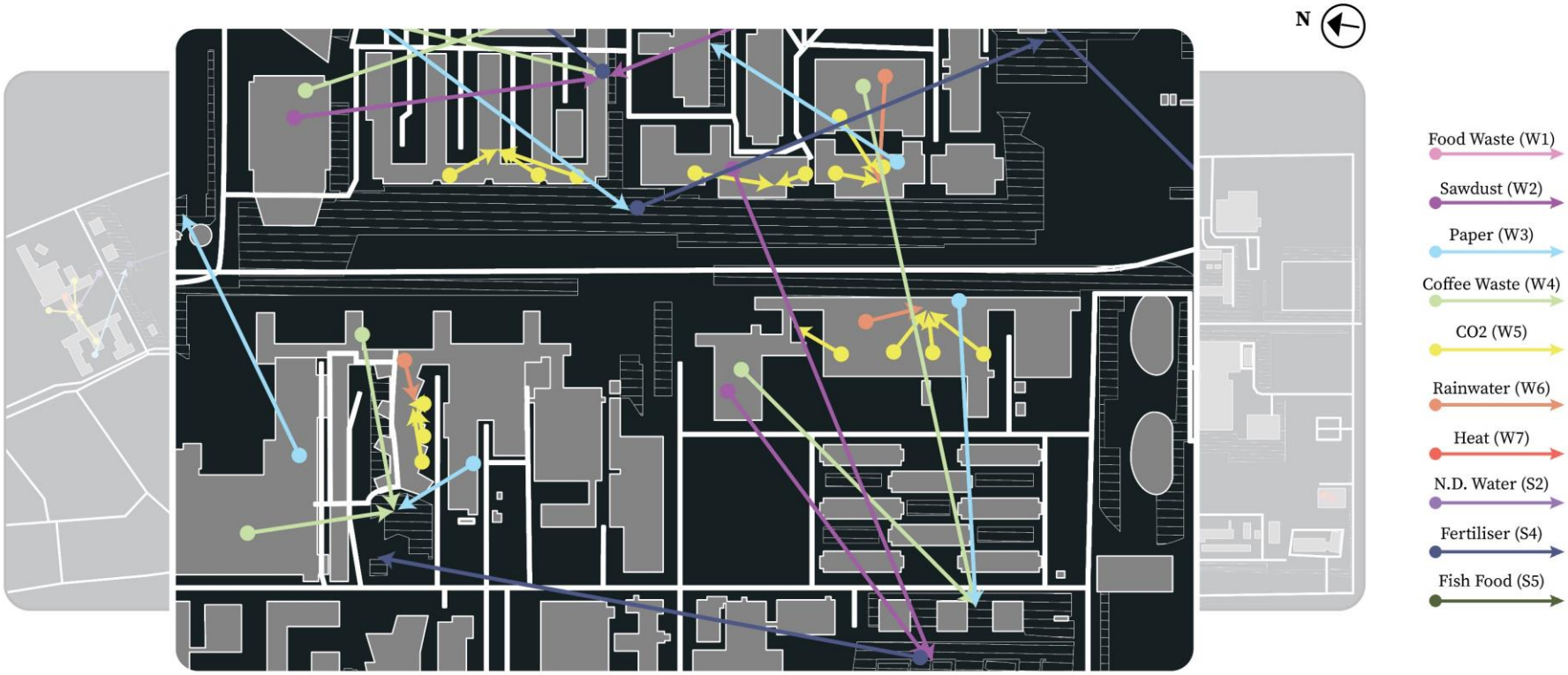
15 + 110 farms (4.75 + 17.4 hectares)

Symbiosis Rate = 17 %

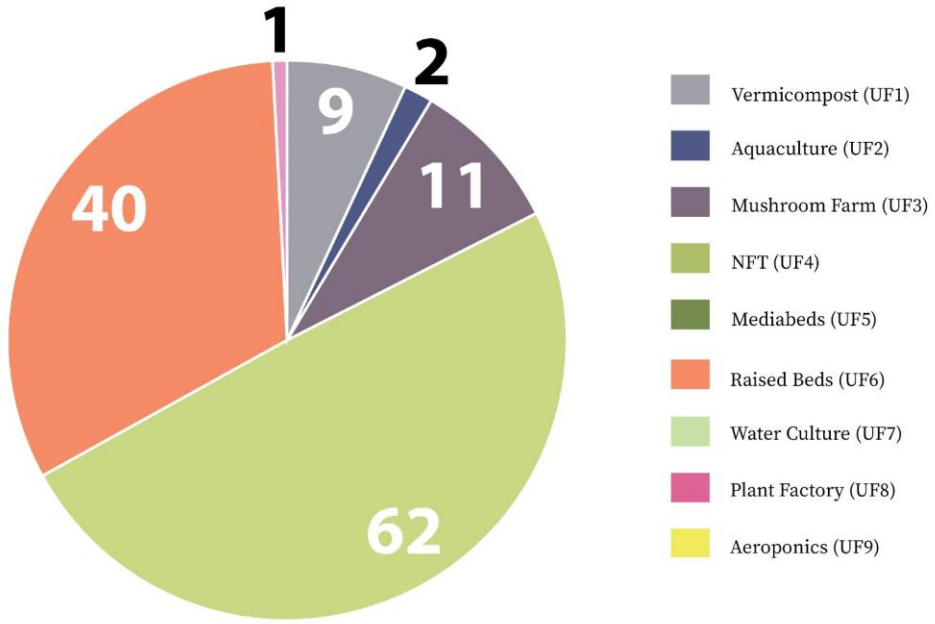
Stage 4 Results

Radius 500 m

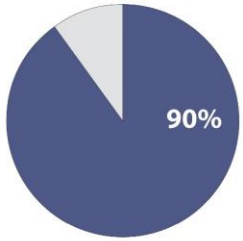
36 + 29 Used Waste Sources



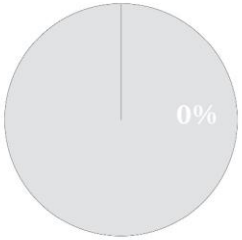
Assigned Urban Farming Systems



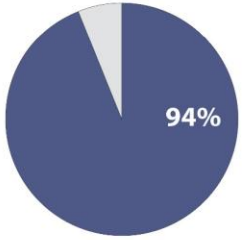
Waste Use Percentage



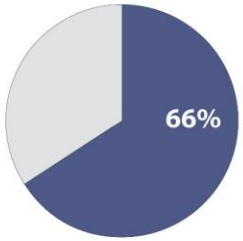
Food Waste (W1)



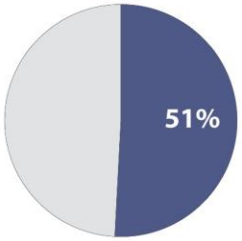
Sawdust (W2)



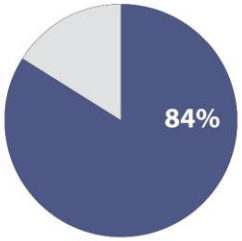
Paper (W3)



Coffee Waste (W4)



CO2 (W5)



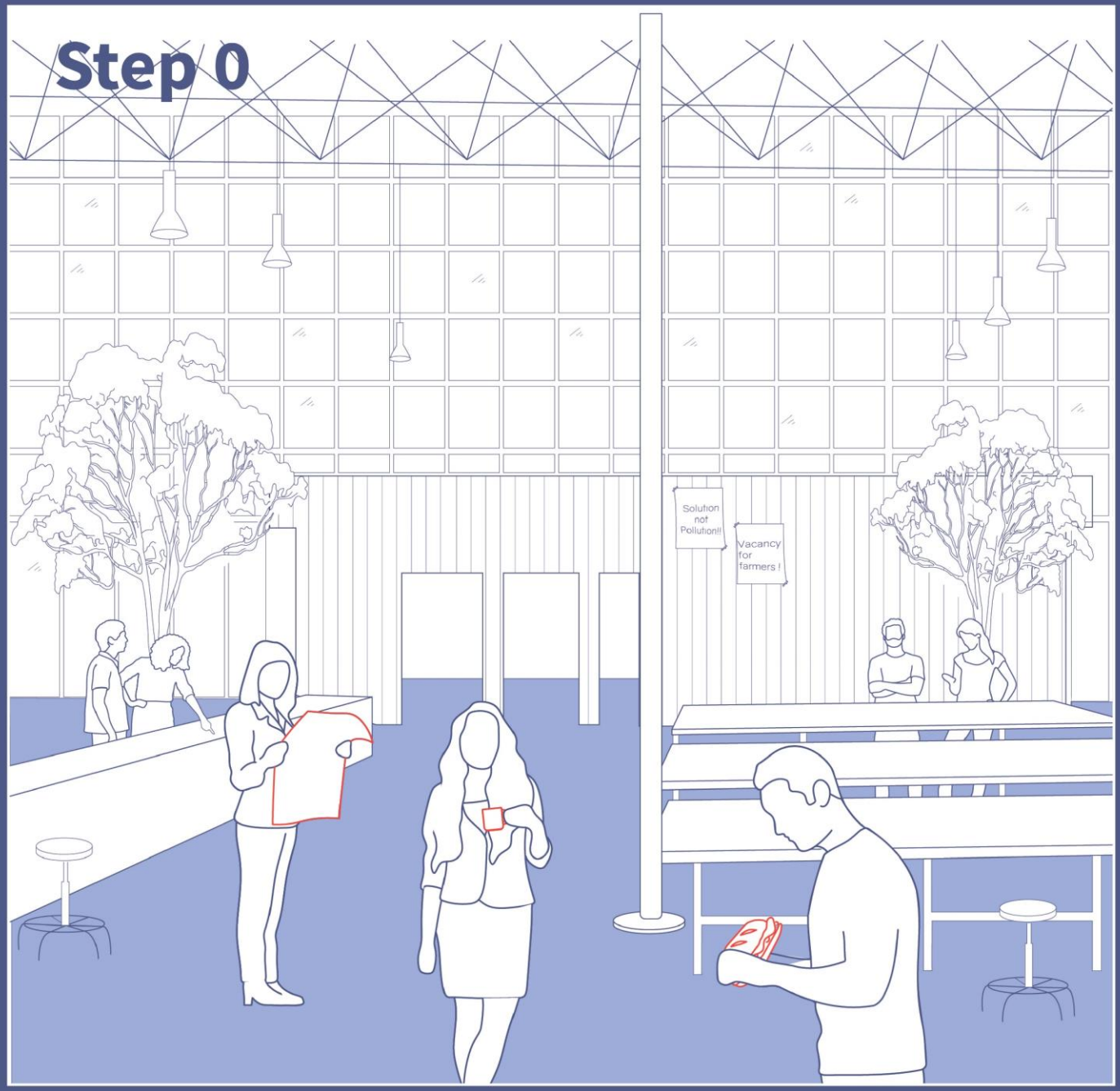
Rainwater (W6)

Residual Heat (W7)

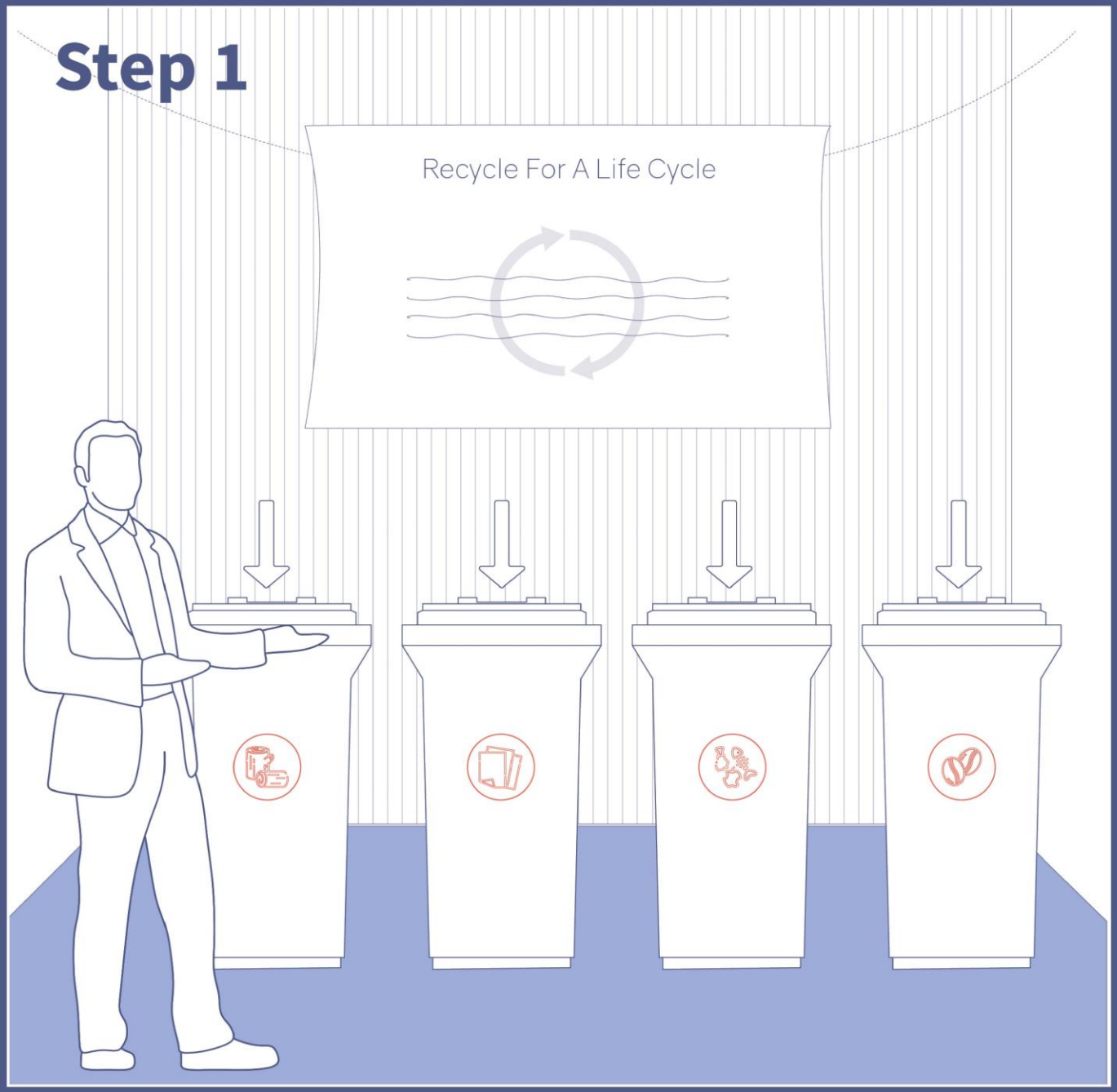
Not Used Waste

Used Waste

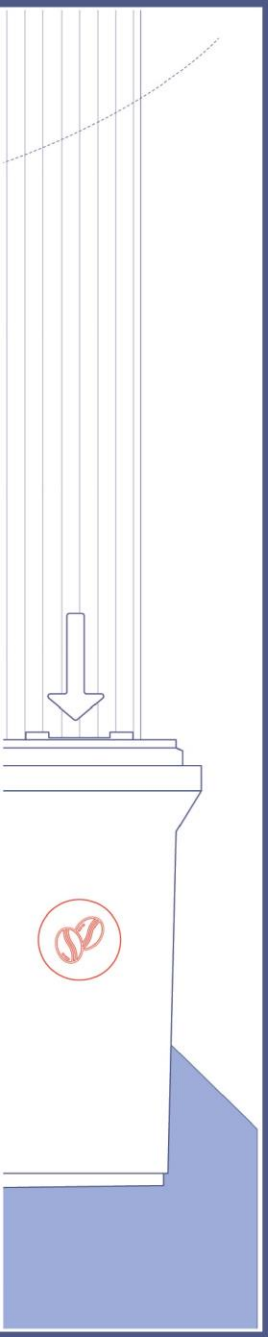
How to transfer waste?

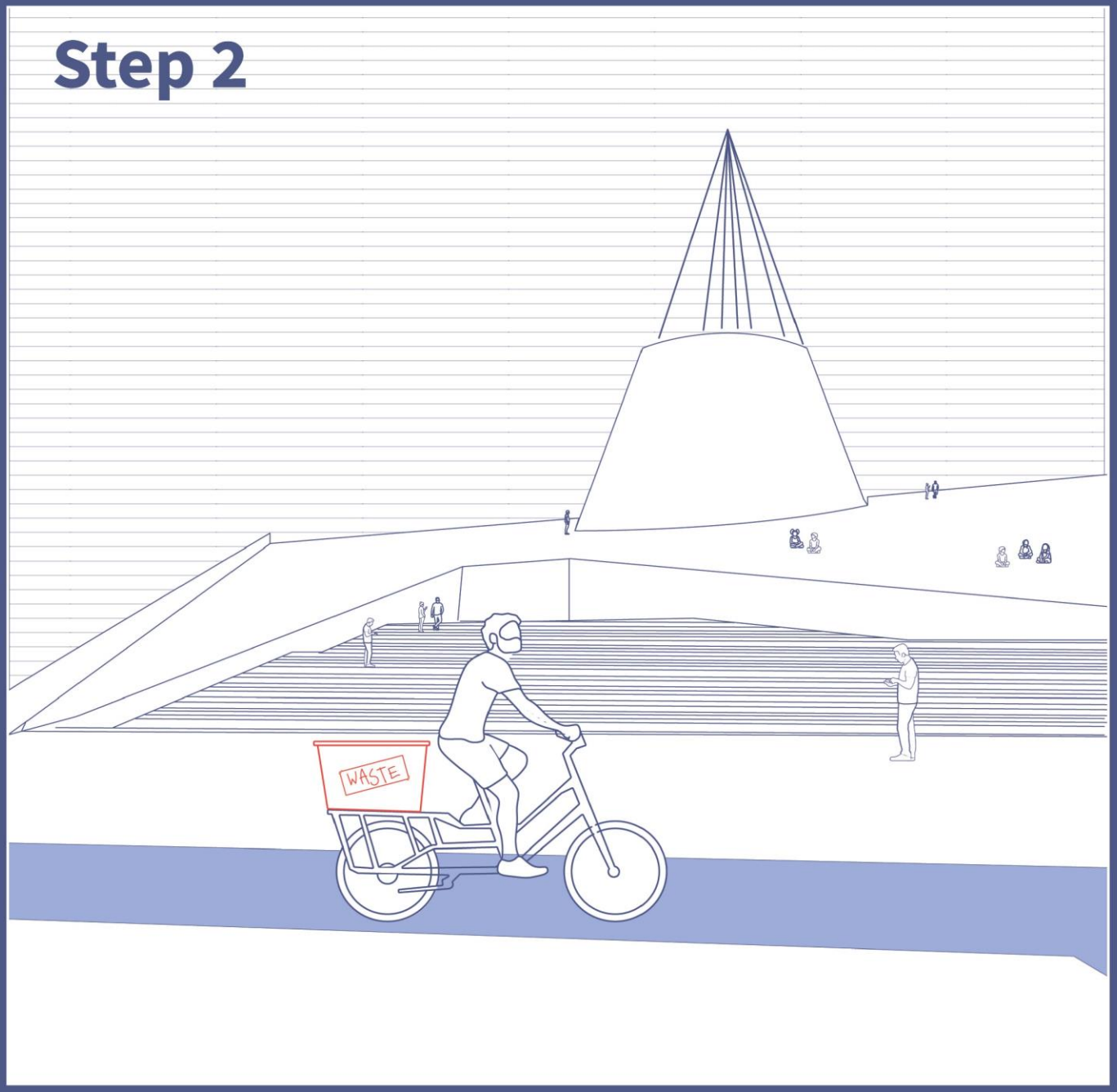

Step 0
Solution not Pollution!!
Vacancy for farmers !

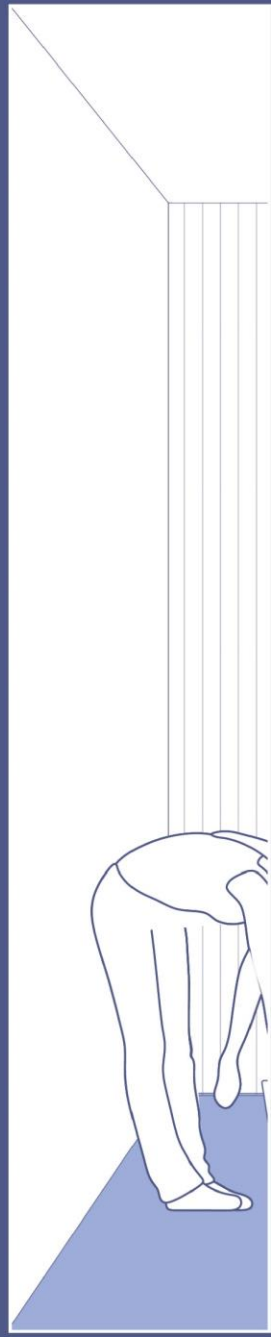
Step 1



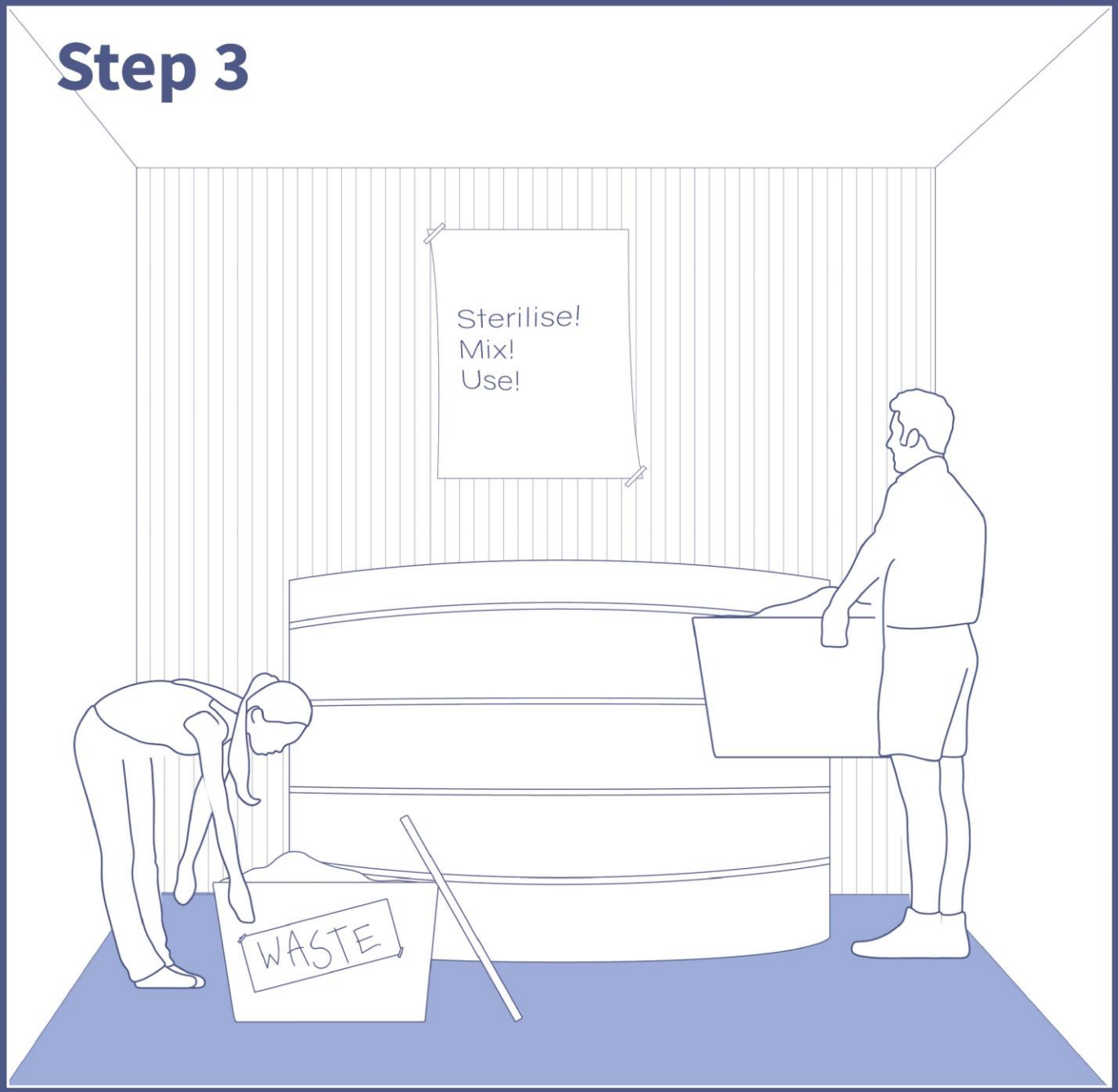
Step 2



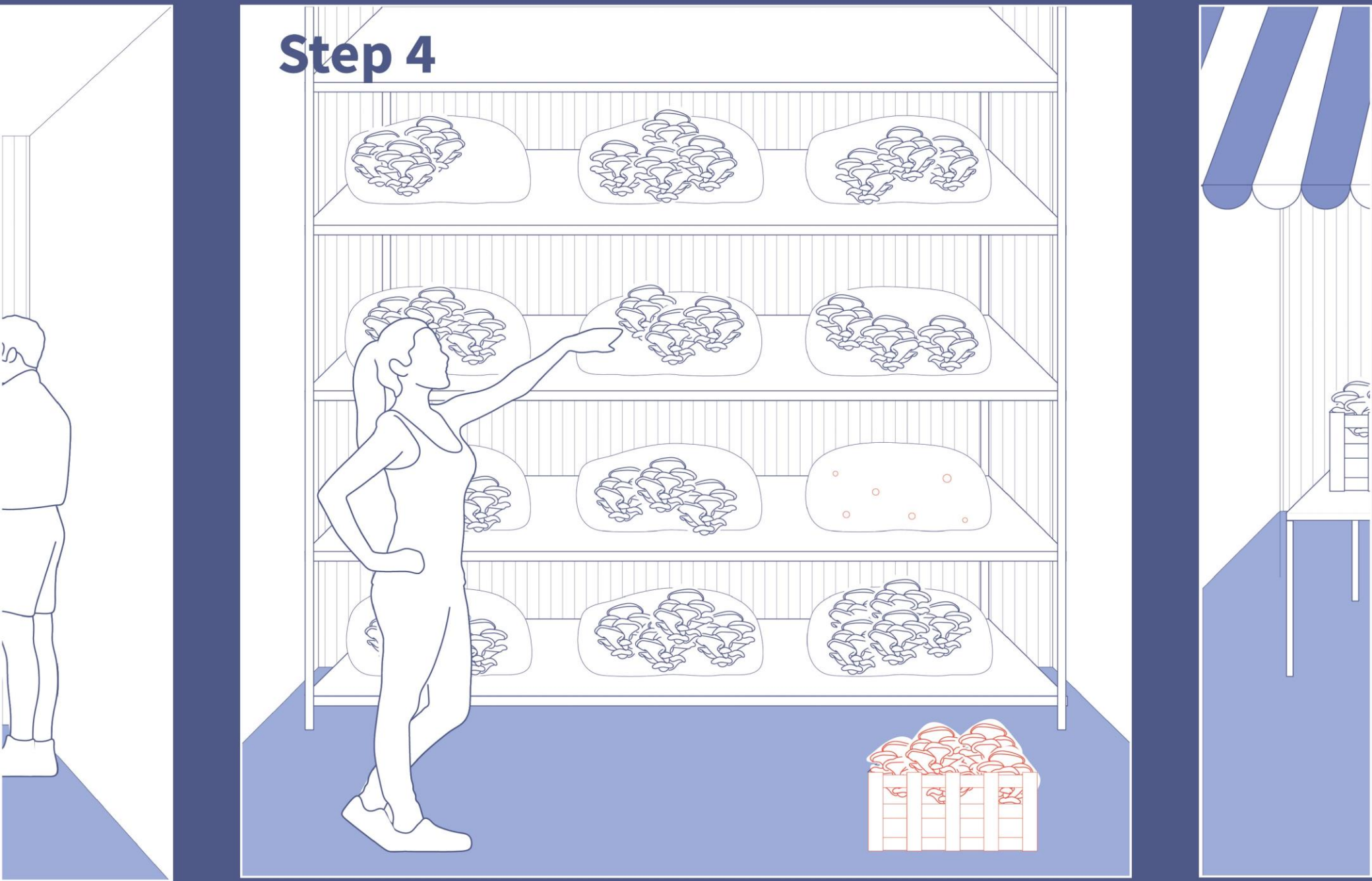


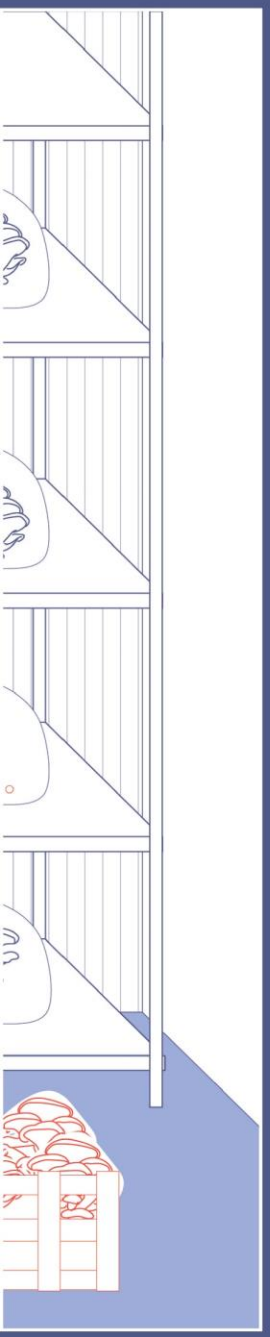


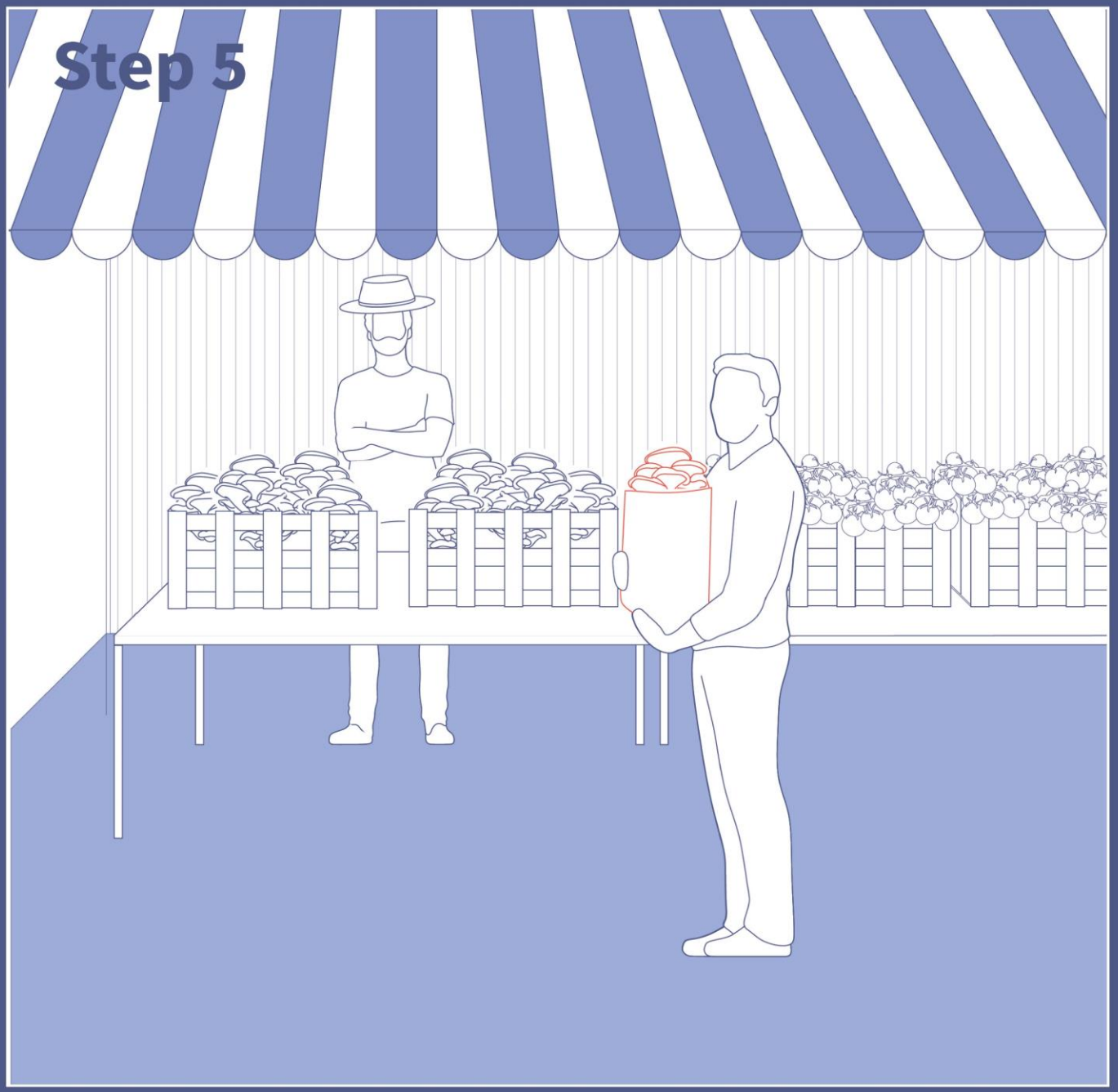
Step 3



Step 4

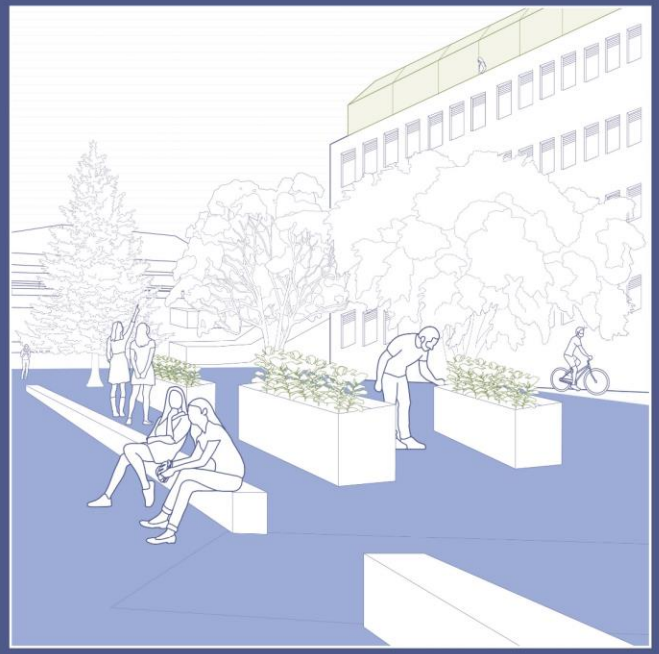


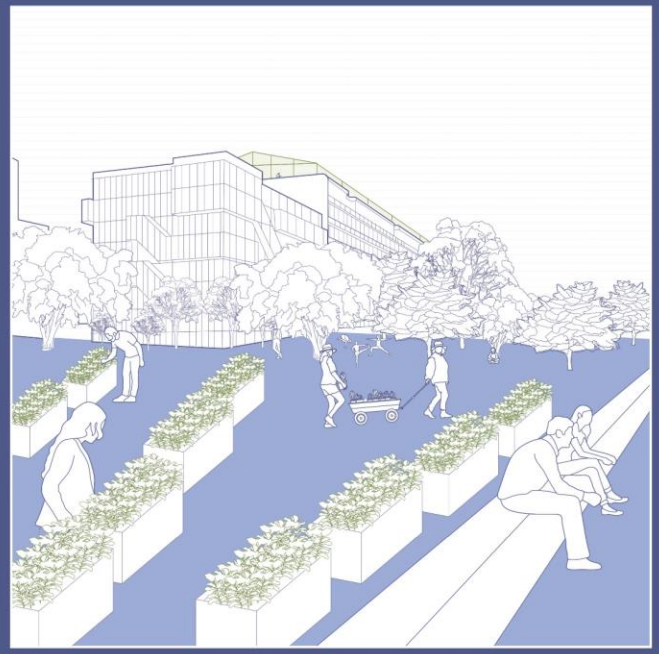


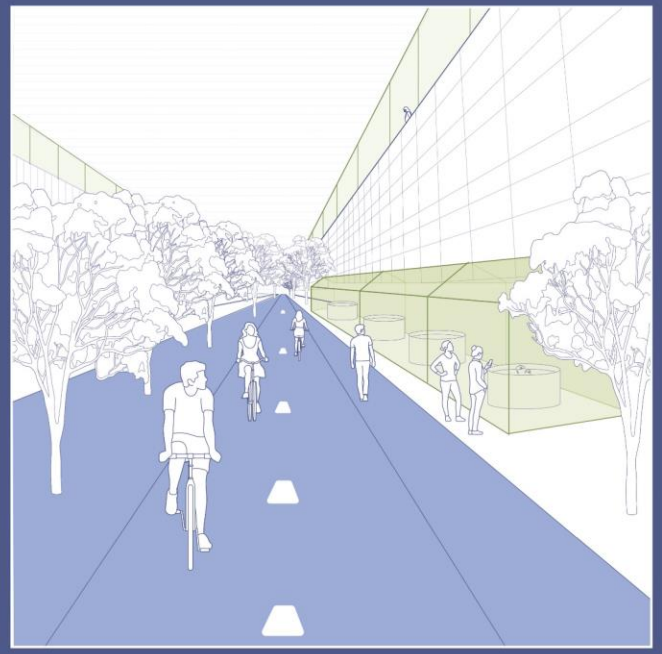


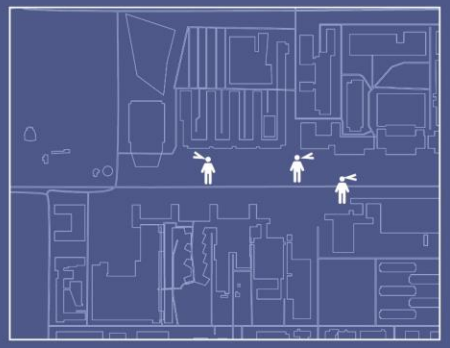
the end ...

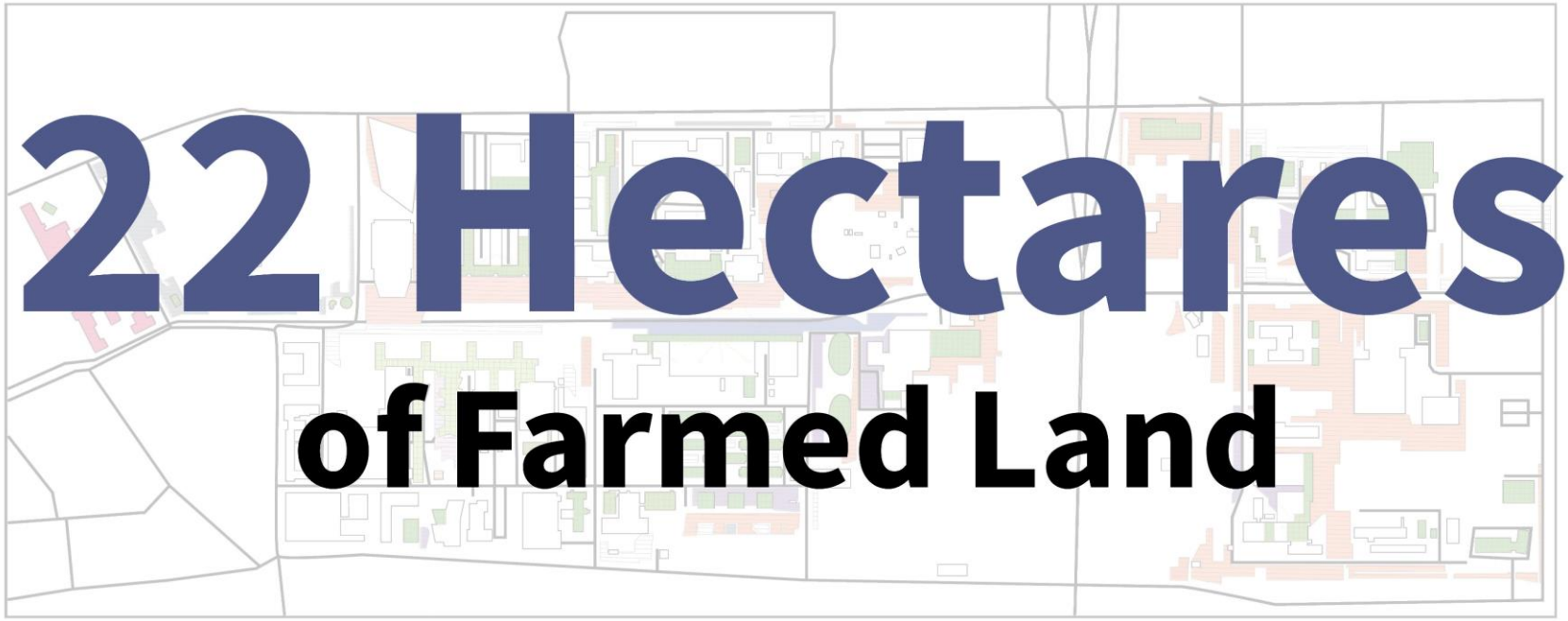
What is the potential of TU Delft Campus?





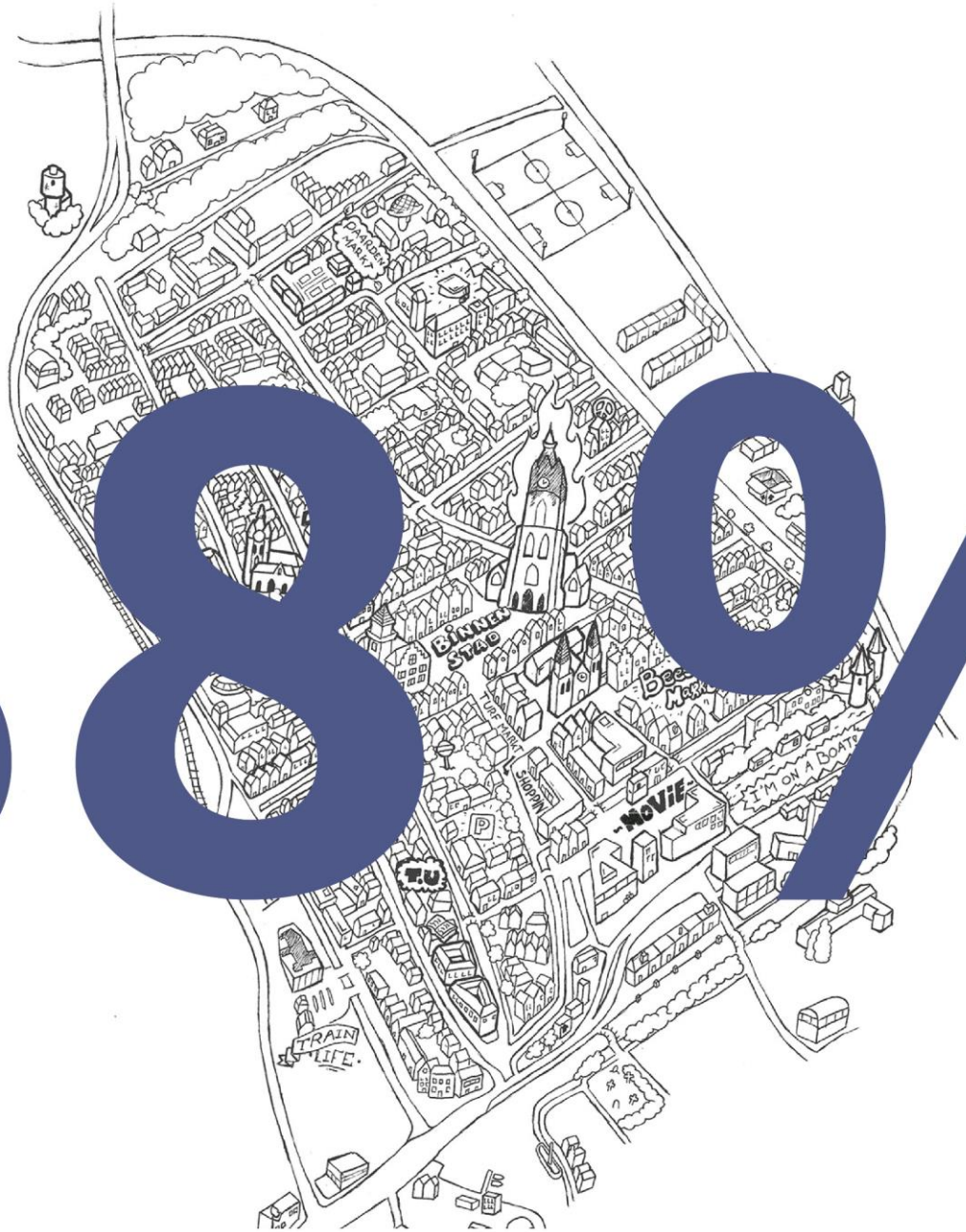





22 Hectares
of Farmed Land

23 Tonnes
of Leafy Greens

+ 4.8 tonnes of mushrooms
+ 346 kg fish
+ 3.1 tonnes soft fruits



88%

based on recommended 250 gr of fruits&veg consumption daily

Conclusions

SWOT
Comparison With Other Tools
Learnings

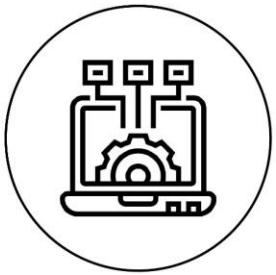
SWOT Analysis

Agritecture vs Delphy QMS vs Foodcycle

Features	Agritecture Designer	Delphy - QMS	Foodcycle
Energy calculations	+	+	-
Yield estimation	+	+	+
Profit estimation	+	+	-
Business plan	+	+	-
Comparison between models	+	+	+
Using waste as a resource	-	-	+
Building a network of farms	-	-	+
Suggests growing techniques	-	?	+
Suggesting farming systems	+	?	+
Designing for more than one space at once	-	-	+
Different project aims	+	?	-
Designing with a budget	+	?	-
Different crops to select	urban/peri urban/ rural	?	urban
Site	+	+	-
Different design stages	+	-	-
Includes ease of running the farm	+	-	-
Concept report	+	+	+
Advice regarding farm design	+	+	-
Climate control	-	+	-

Learnings

Urban Farming



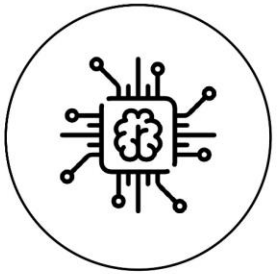
Thinking Methodologically

Waste Sources

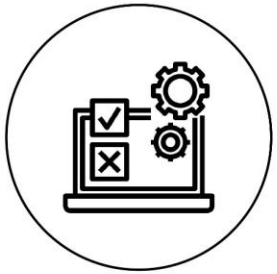
Datasets Influence

Further Improvements

Weaknesses



Automated Data Collection



More Tests

Optimisation

Thank you !!