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2050: The earth's population as estimated by the United Nations will be 9.2 billion people. In order to be able to sustain this population number and afford a further growth, humankind has to radically change the way we produce, process and consume food.

The current food production system abuses the natural environment in a multitude of ways. Ranging from soil deterioration to the draining of fossil fuel and the consequent CO_2 production and climate change effect, the issues that food production causes are complex and interconnected.

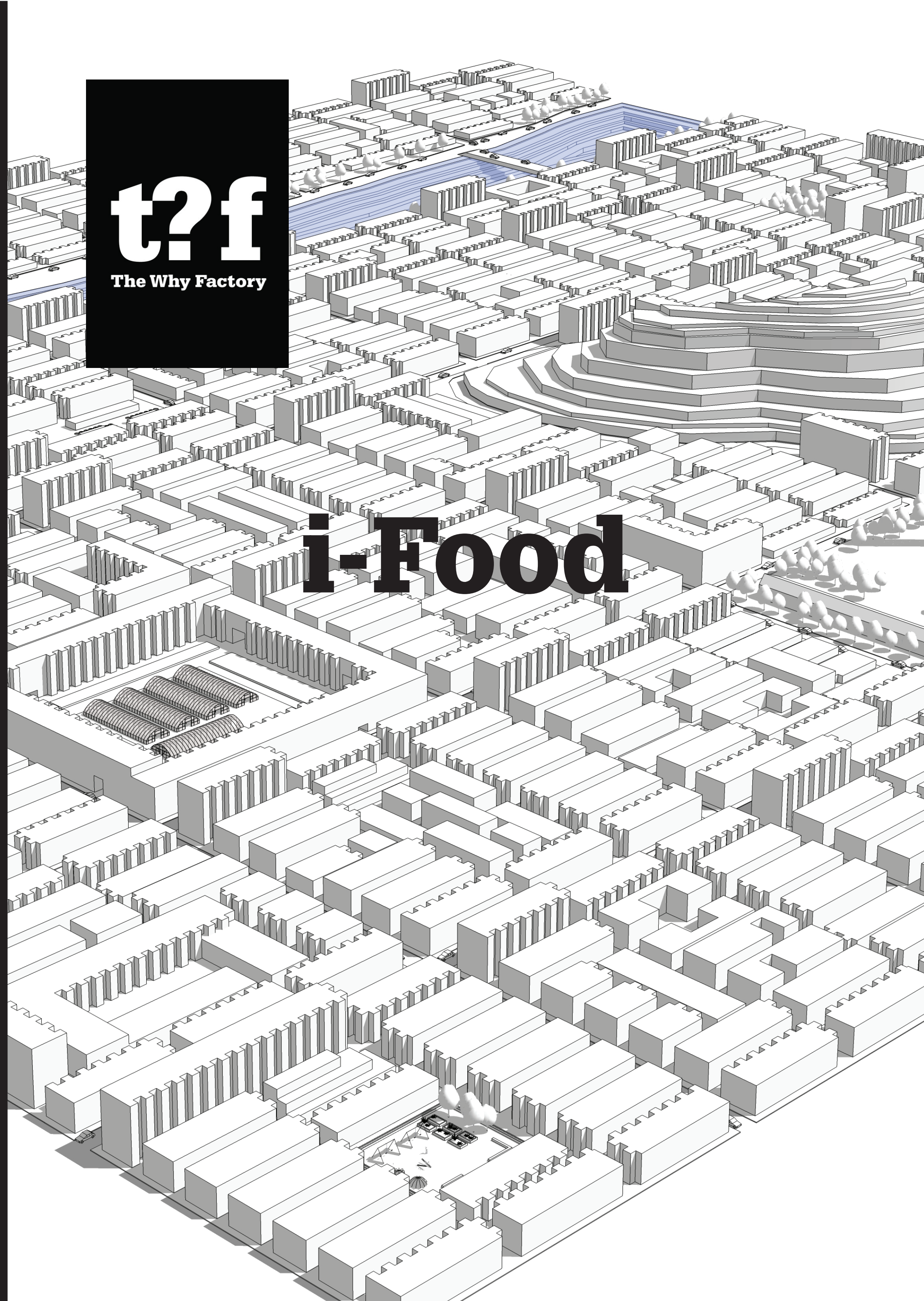
AgroCity is examining possible solutions to this series of challenges.

Looking into different approaches as sources of inspiration, AgroCity is revisiting old methods of agriculture and combines them with new technologies and innovation. Further into the food chain, other aspects are examined to some extend: food processing, storage, water and waste management are some examples.

In terms of design, AgroCity is using a bottom up approach, starting from the needs of one person. It illustrates how space efficiency increases when food production becomes collective. The result of this study is an optimum size of communities. This optimum size changes also according to the diet ingredients. Diet changes are also proposed, as an effort to assure a healthy, nutritionally dense diet in a much smaller space than we are used to.

AgroCity is organizing the different elements used throughout this new food chain into a "Toolbox". Using modular designs that can easily be combined with each other, AgroCity offers a catalogue of growing, processing and preserving units that can be added as "plug ins" to the dwelling units or other urban program. This way, even existing cities could be transformed into food production machines, by taking advantage of empty spaces.

AgroCity is attempting to be a highly sustainable, space efficient, "user friendly" alternative to the current food chain, giving back to the people the power to feed themselves and know what they eat.



Graduation Project

Tutors: Ulf Hackauf _ Huib Plomp _ Winy Maas
Student: Alexia Martha Symvoulidou

Year: 2011-2012

Contents:

0. Intro

2050: The earth's population as estimated by the United Nations will be 9.2 billion people. In order to be able to sustain this population number and afford a further growth, humankind has to radically change the way we produce, process and consume food.

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0. Intro _ Calculations Method

0.1. Calculations Method

Need (Kcal/day) / Ingredients (Kcal/Kg) = Food Eaten (Kg/day)

Food Eaten (Kg/day) X Waste (% (percentage)) = Food Produced (Kg/day)

365 days X Food Produced (Kg/day) / Yield (Kg/year) = Area/p.p. (m2/p.p.)

The calculations of the agricultural area needed per person can be done in different ways. AgroCity follows the method described on the diagram above, as part of the bottom up approach.
Starting by the calory needs of one person and dividing them with the calories per kg of food, the amount of food needed per day is the result.
There is though a certain percentage of food waste that can range from 50 to 20 percent, depending on the food production system and the food processing chain. This "waste factor" is multiplied by the amount of food needed per day, in order to show the total amount of food that needs to be produced, including food waste.
This total amount of food per day can then be multiplied by a whole year (365 days) to give the year-round per person need of food.
If we divide the amount of food that needs to be produced with the amount of food that we can get per square meter, per year (yield), then we end up with the square meters needed per capita to grow one's food.
This parts of this "equation" are further analysed on the following pages.

Contrary to the popular belief, a future without enough food for Earth's population is not a dystopia but an unavoidable situation. We need to change the way we produce food and/or the ingredients of our nutrition, in order to re-establish a balance of demand and supply in the food sector and Earth's resources in general.

We have to deal with the facts: meat demand is increasing, while meat is extremely space inefficient; the arable land is being reduced due to soil degradation and desertification; and the population keeps increasing. At some point, we won't be able to grow enough food.

On top of that, we are not just killing our only food source -Earth, that is- but also ourselves. The convenient, cheap, prepackaged, precooked meals that feed most of the world's developed countries, have caused a raise in a series of serious, food related health issues. And of course, as Carolyn Steel put it, "the price of our food does not reflect it's real cost" in terms of environmental degradation.

This chapter presents these facts in detail. The reason for that is, that educating producers and consumers on these facts can lead to people taking action and making more conscious food choices. This way, the much needed changes in our food production and consumption patterns might be done in a designed and organized way.

1. No Choice

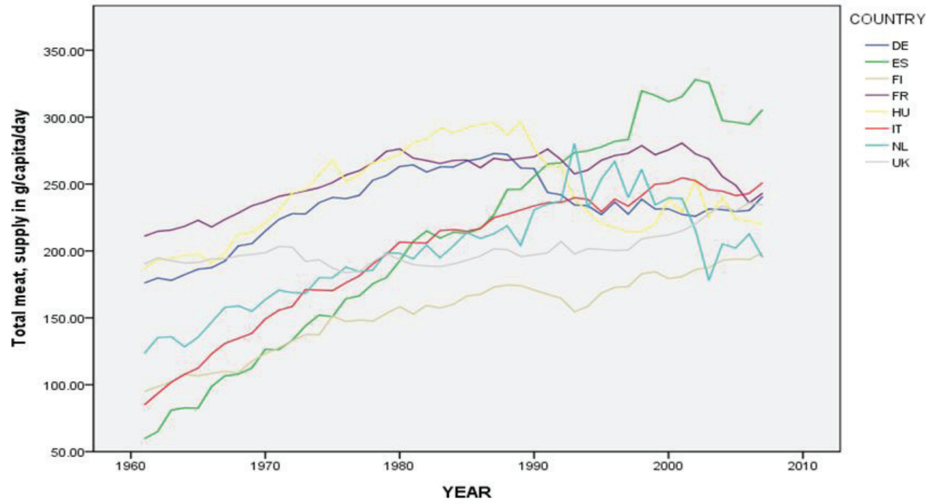
Why we will have to change the way we produce our food

1. No Choice !/ The need of Change

1.1. The increase of meat demand

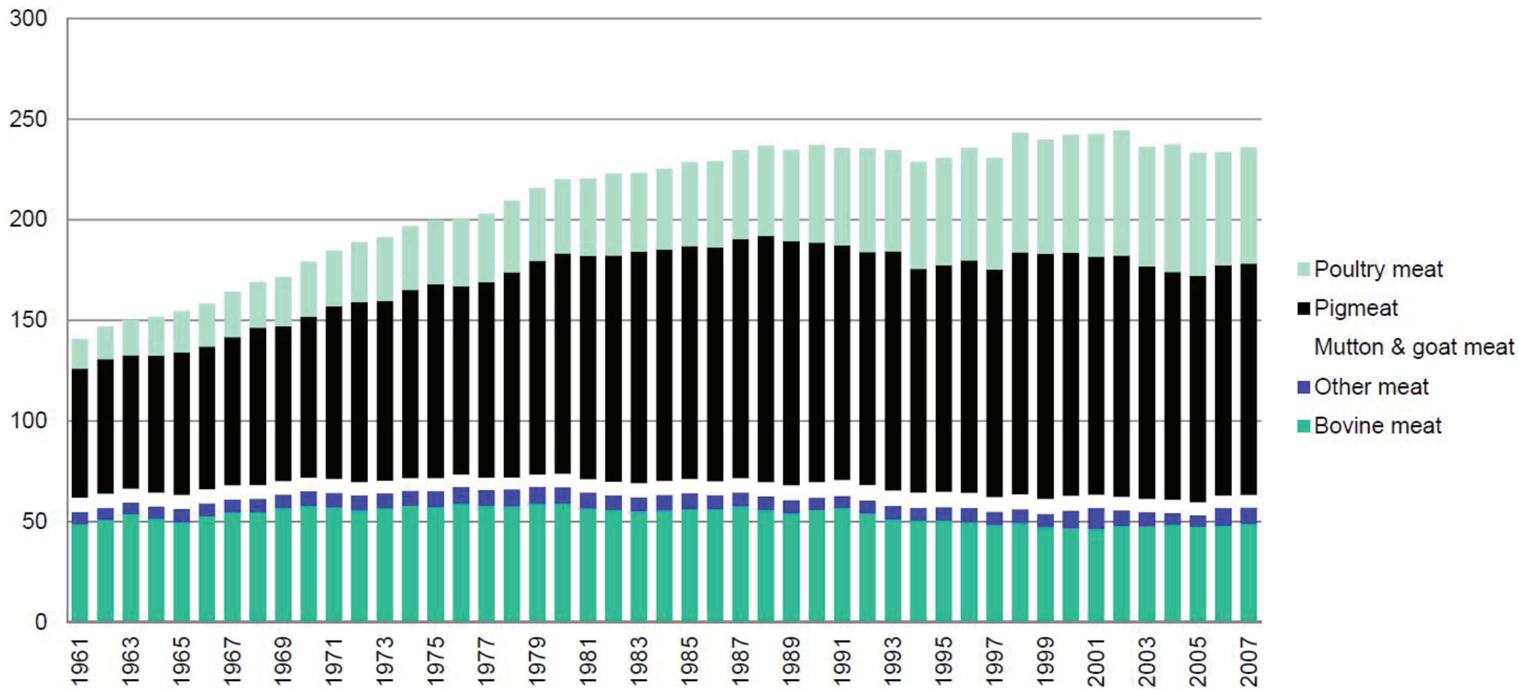
Meat Demand is increasing every year, as a sign of welfare, but the land required to cover a person's caloric needs with meat is many times bigger than the land needed to cover the same needs with plant based food.

More meat eaters means reduced space efficiency.



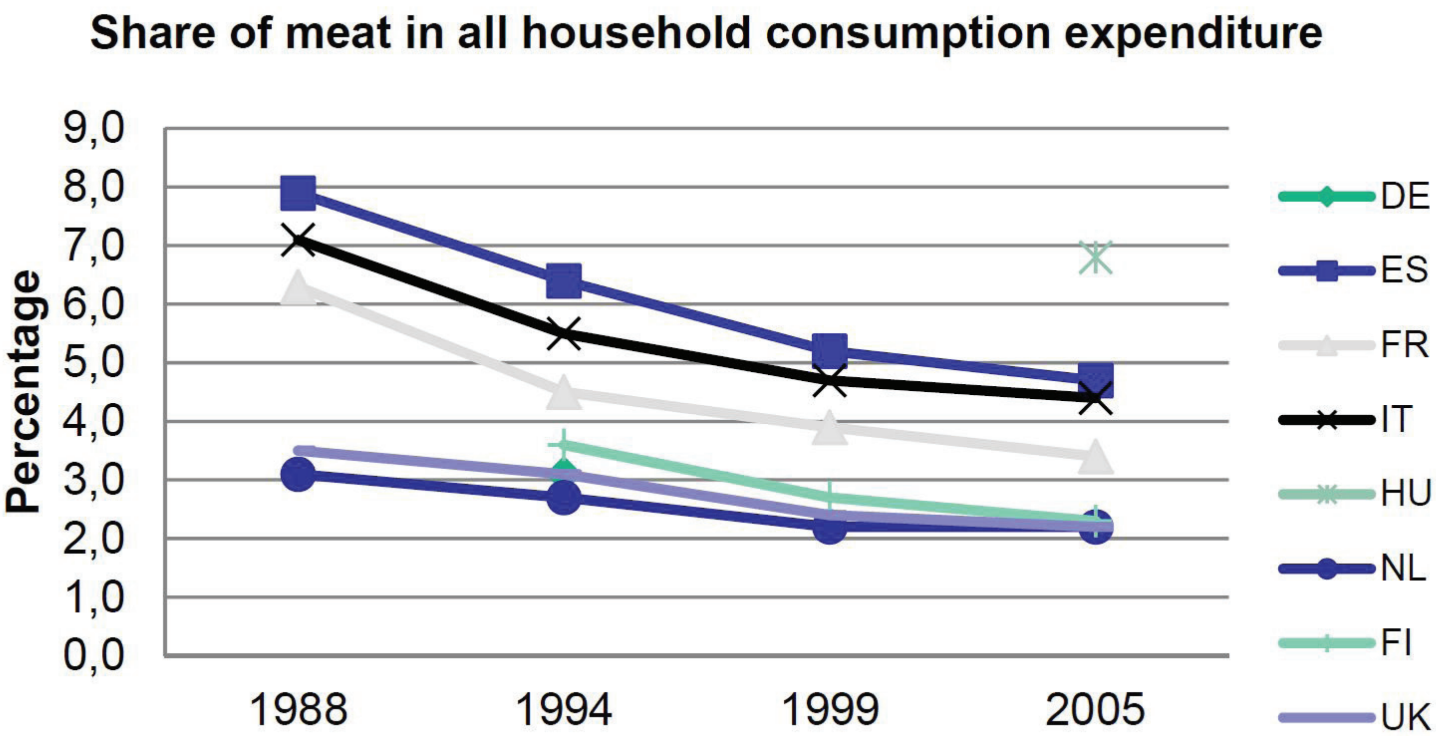
Right page:
Total meat consumption diagram in 8 EU countries.

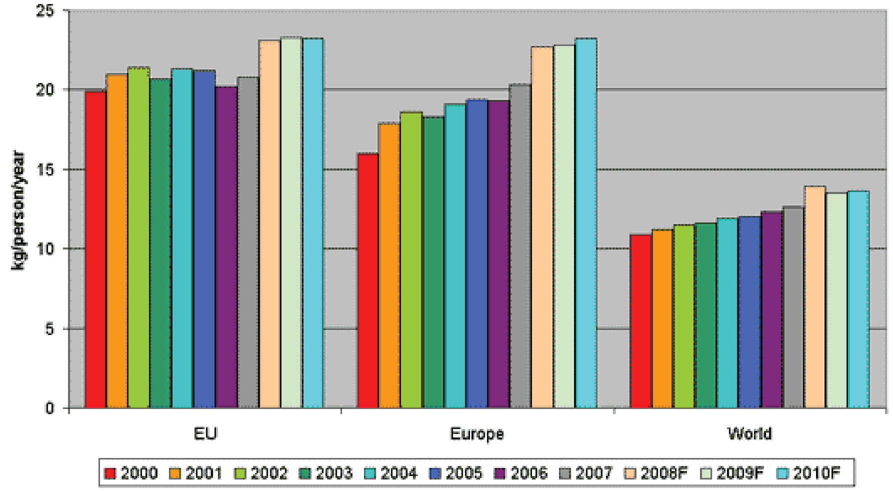
Trends – Per capita consumption
Per capita meat supply for group of 8 EU countries - Germany, France,
Italy, Spain, UK, Netherlands, Hungary, Finland - in g/capita/day



Graph source: "Main trends in meat consumption in Europe", Minna Kanerva, July 2011, University of Bremen.

Below:
Share of meat in all household consumption expenditure
Graph source: “Main trends in meat consumption in Europe”, Minna Kanerva, July 2011, University of Bremen.

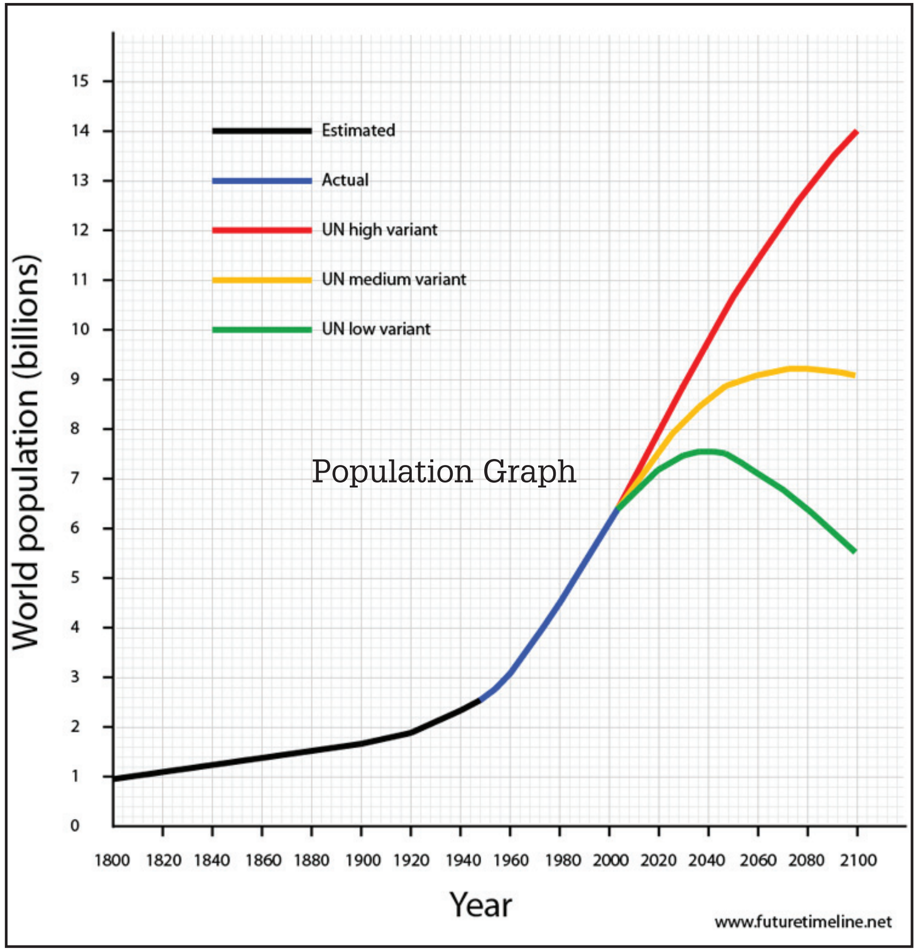




Per-capita poultry meat consumption in the EU and Europe compared to the global average (graph source: FAO)

1.2. The lack of arable land

In 2050 the earth will be inhabited by 9 billion inhabitants. Our arable land is not increasing though. On the other hand, it is getting reduced as cities and Mega- Cities expand.
Meat Demand is increasing every year, as a sign of welfare, but the land required to cover a person's caloric needs with meat is many times bigger than the land needed to cover the same needs with plant based food. More meat eaters means reduced space efficiency.

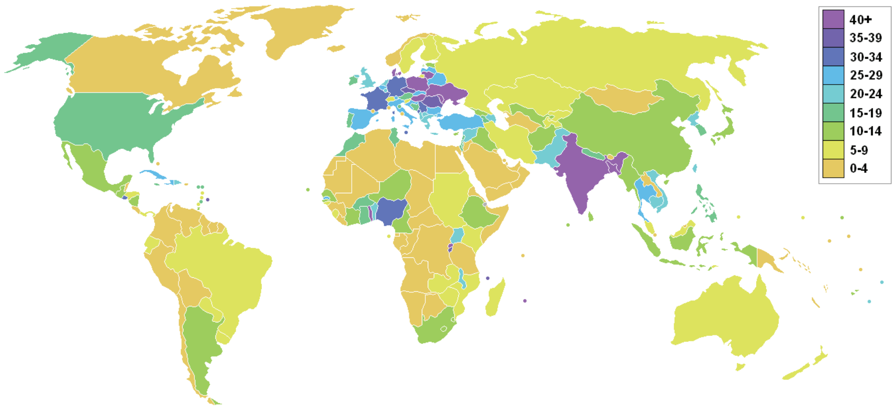


1. No Choice !/ The need of Change

Damages Caused by Current Food Production:

1.2.1. Desertification

Desertification is the degradation of arable land in dry lands and can be caused by different factors. The covering of the soil with vegetation can prevent desertification as the roots help maintain moisture and nutrients in the soil. The overgrazing that takes place in already fragile dry lands leads to desertification extremely fast, rendering the ecosystems useless both for cultivation and the maintenance of biodiversity.

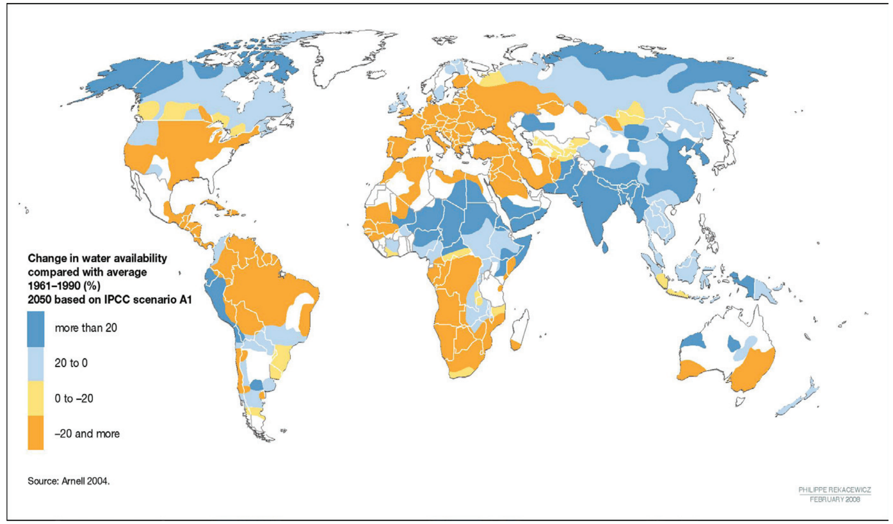


Arable Land Graph
Today

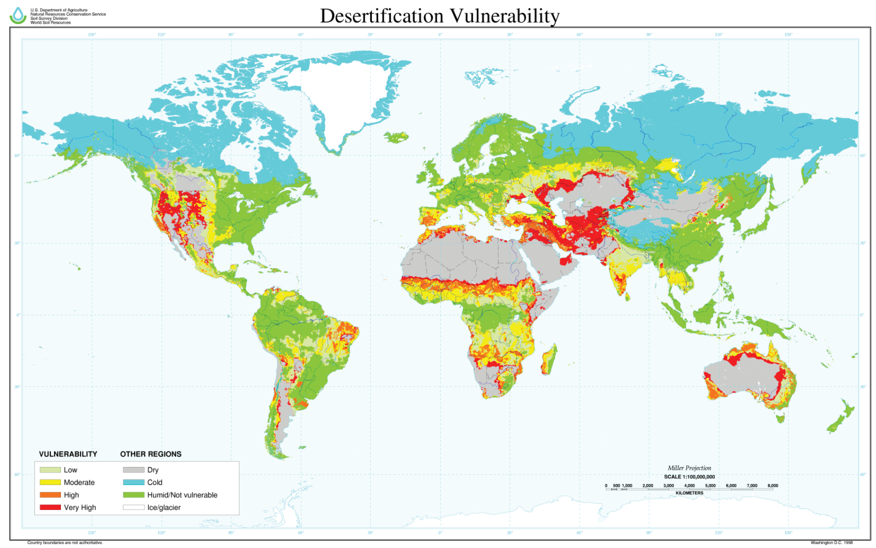
percentage by country

Graph sources:
Top and up right page: Philippe Rekacewicz
Bottom right page: U.S. Department of agriculture

1. No Choice !/ The need of Change



Desertification Estimations
2050

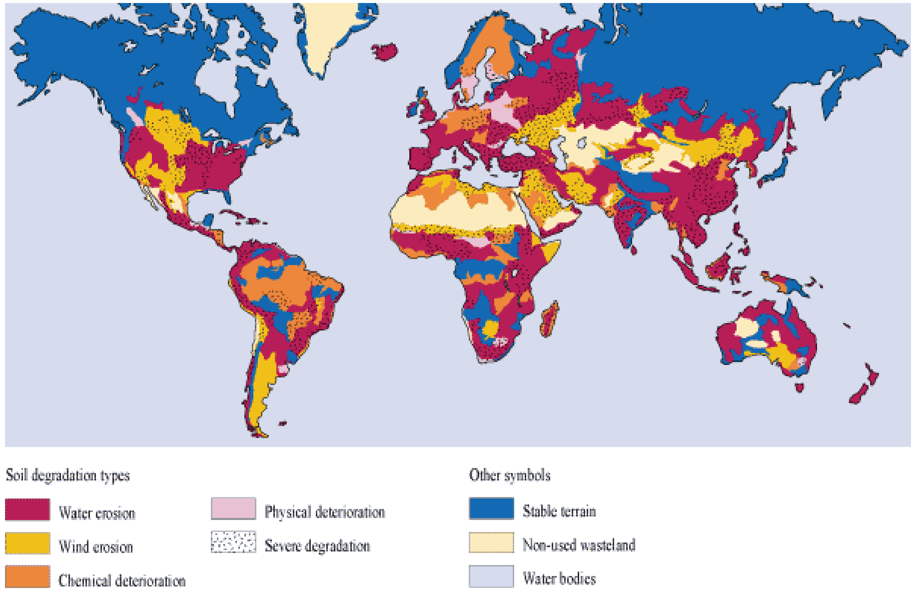


Global Desertification Vulnerability Map

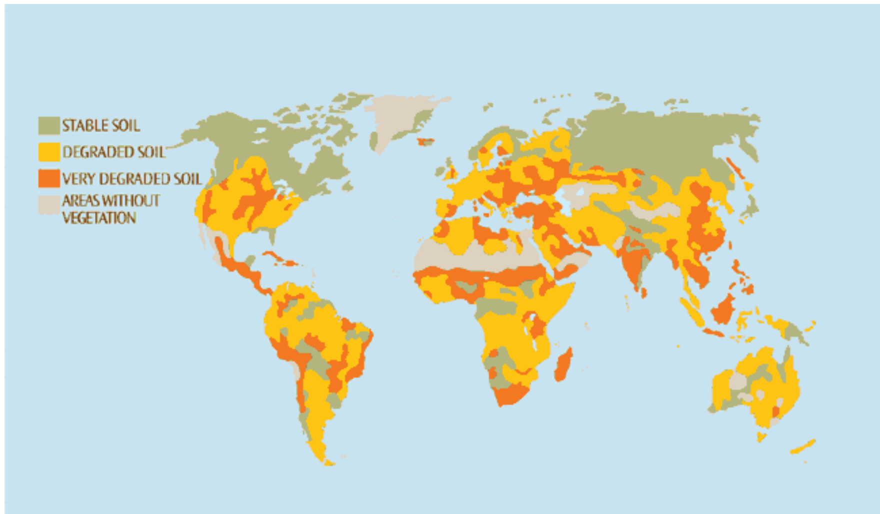
Damages Caused by Current Food Production:
1.2.2. Soil erosion / Degradation
"Land that is used for industrial agriculture generally experiences a significantly greater rate of erosion than that of land under natural vegetation, or land used for sustainable agricultural practices. This is true if tillage is used, which reduces vegetation cover on the surface of the soil and disturbs both soil structure and plant roots that would otherwise hold the soil in place. However, improved land use practices can limit erosion, using techniques such as terrace-building, no-till, and tree planting."
Wikipedia

Reference Image of Agriculture Related Erosion
(Limburg, NL)

1. No Choice !/ The need of Change



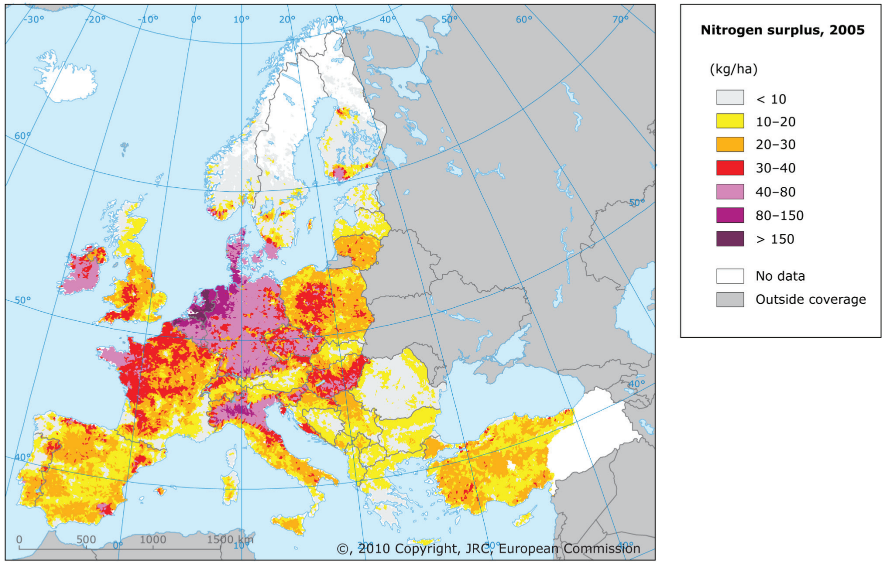
Types of Soil Degradation
Source: Natural resources conservation service, U.S. Department of agriculture



Soil Degradation
Source: The global education project
(http://www.theglobaleducationproject.org)

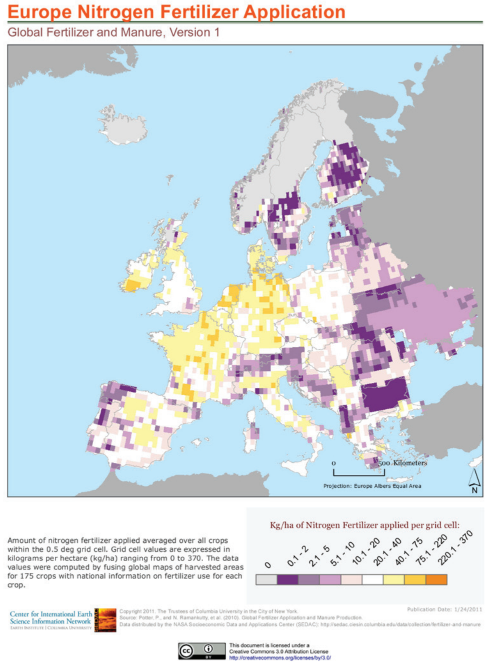
Damages Caused by Current Food Production:
1.2.3. Chemical Fertilizer Issues

-Depletion of natural minerals, as synthetic fertilizers do not replace the soil minerals depleted by crops
-Major ab-use of fossil fuels in order to produce chemical fertilizers
-Eutrophication of systems as fertilizers pass into water streams.

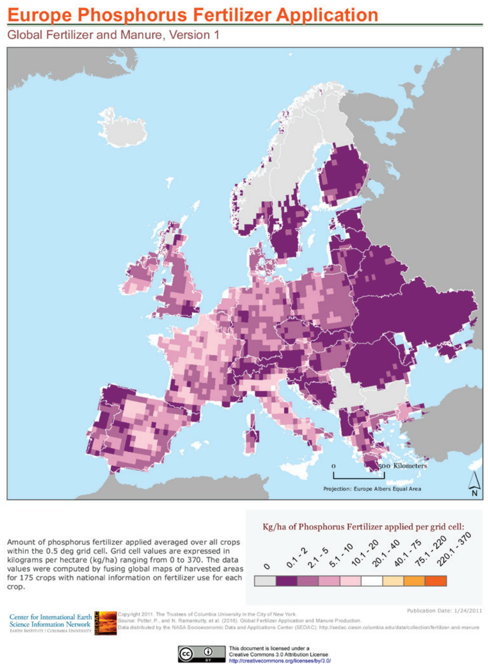


Estimated nitrogen surplus (the difference between inputs and uptake by crops, meat or milk production) for the year 2005 across Europe. Surplus nitrogen in the soil as a result of excessive application rates and/or low plant uptake can cause an increase in the mineralization of organic carbon, which in turn, leads to an increased depletion of carbon from soils.
Source: JRC: Bouraoui et al., 2009.

1. No Choice !/ The need of Change

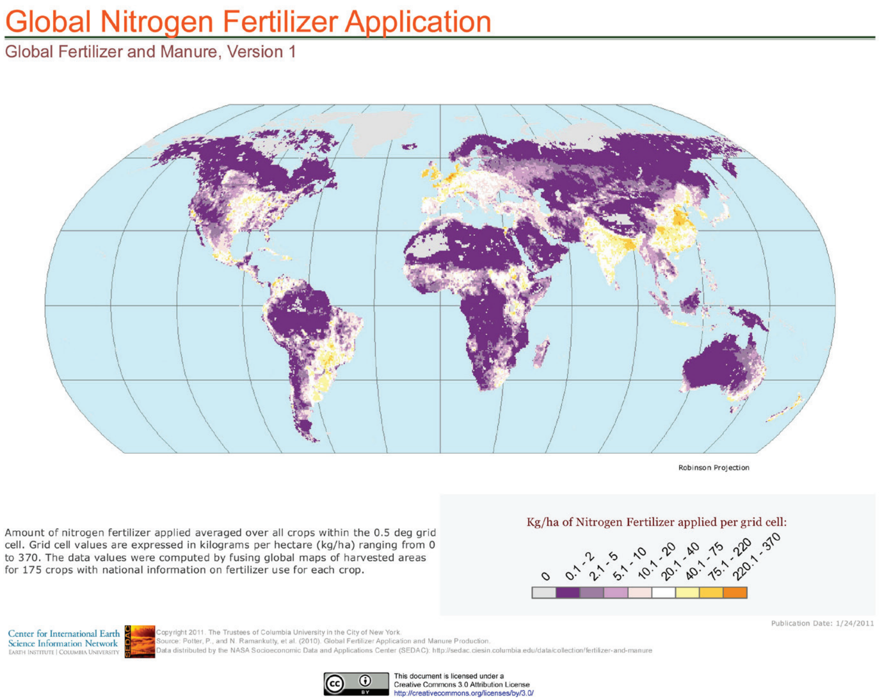


Nitrogen Fertilizer Use
(2010)
Source: Centre for International Earth Science Information Network



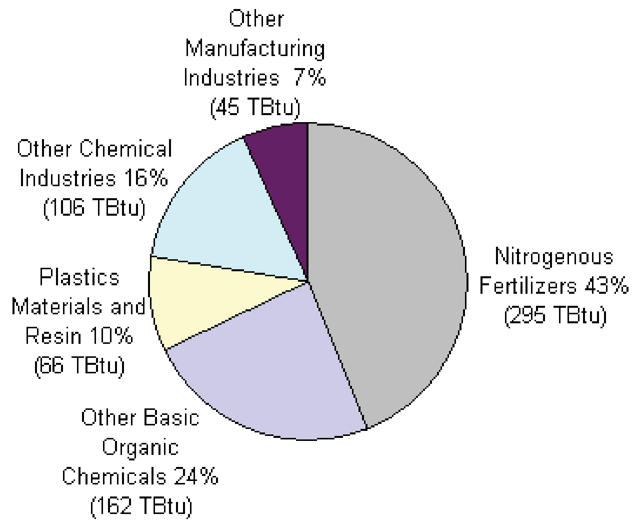
Phosphorus Fertilizer Use
(2010)
Source: Centre for International Earth Science Information Network

-Overfertilization, also called “fertilizer burn”, which is as dangerous for the crops as underfertilization

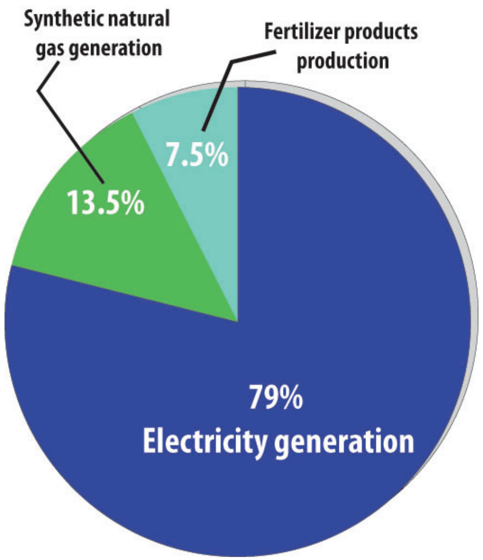


Global Nitrogen Fertilizer
Use
(2010)
Source: Centre for International Earth Science Information Network

-Ammonia used in synthetic fertilizers is produced currently using natural gas, which leads to a high energy consumption



Natural gas used as a feedstock by industry, 2002
Source; Enery Information Administration, 2002 Manufacturing Energy Consumption Survey



-As many ingredients of synthetic fertilizers come from mines, the resources are not infinite, thus the long term sustainability of the inorganic production of fertilizers is highly problematic.

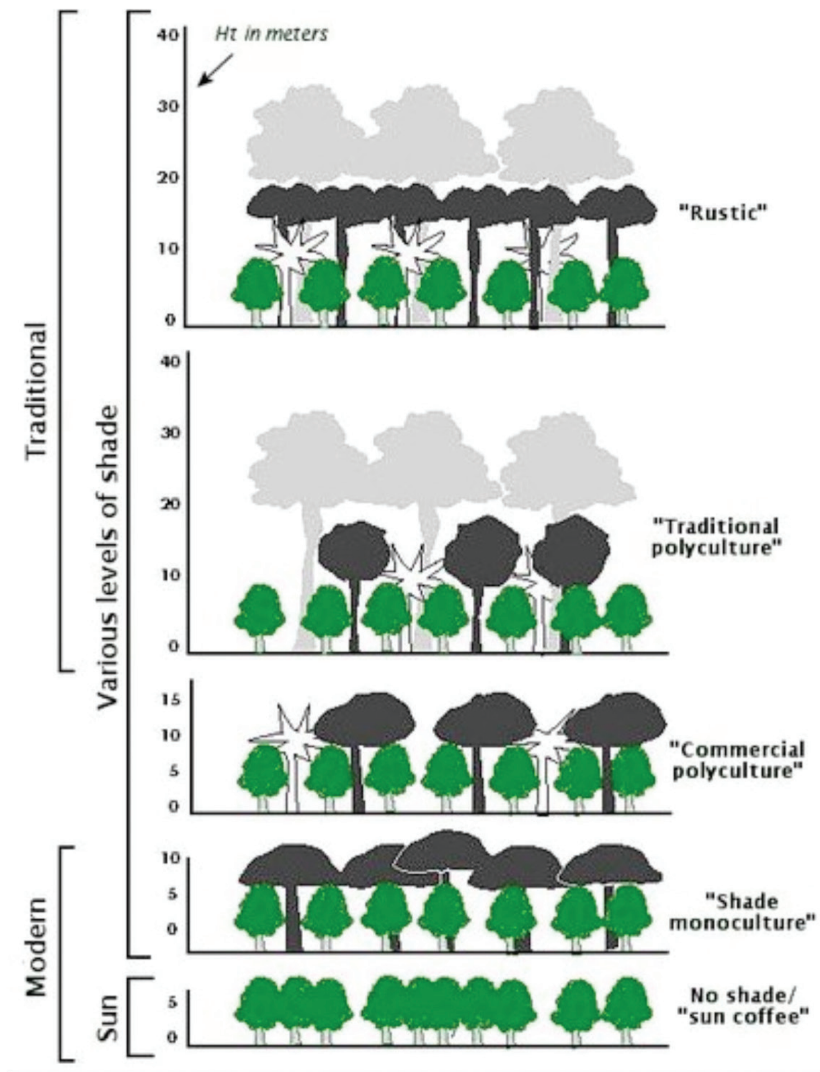
Lignite use: 7.5 percent is used to produce fertilizer products (anhydrous ammonia & ammonium sulfate)
Source: Lignite Energy Council

Damages Caused by Current Food Production:

1.2.4. Monoculture Issues

The term “monoculture” refers to the controlled and planed production of one type / variety of a plant or animal species. The problems that arise from monoculture in forestry have to do with the fact that all the trees have the same age and size, excluding from the ecosystem wildlife that depends on forest openings or dead trees to survive. This way biodiversity in greatly damaged. In terms of food crops like grains, as vast fields are planted with the same -most profitable, high yielding- variety, if one disease attacks these fields, food safety is then in great risk.
It has been proved that polyculture is beneficial not only in terms of biodiversity and food safety but also in terms of soil health, as it enriches it with micro nutrients and minerals, enhancing yields.

Forest in Japan: monoculture replaces variety



Polyculture - Monoculture
Source: Biodiversity Conservation in Traditional Coffee Systems of Mexico. Patricia Moguel, Victor Toledo 1999.

Once common varieties of vegetables and fruit have become a rare delicacy due to monoculture. (Heirloom gourmet grocery store, Munich)

1.3. Food Related Health Issues

The average European diet tends to become more and more homogenized. The same tends to happen to most countries of the developed world. Globalization of economy and markets has also led to a globalized diet . The year-round availability of any kind of food products is considered as a sign of welfare.

As mentioned in the paper "Globalisation of Indian Diets and the Transformation of Food Supply Systems" of 2004 by Pingali and Khwaja, "During the first stage, income-induced diet diversification, consumers move away

from inferior goods to superior foods and substitute some traditional staples, especially rice. In the second stage, diet globalisation, the influences of globalisation are much more marked with increased consumption of proteins, sugars and fats. Diet diversification has marked the process of transformation in food production systems."

With such as shift to a different diet, based on more processed food, loaded with calories with very poor nutritional value, the diet related health issues tend to increase.

Stressful lifestyle is another factor that leads to food related health issues. Grant Thornton's 2006 International Business Owners Survey (IBOS) "examined the stress levels of more than 7,000 business leaders in 30 countries... Stress levels around the world are rocketing, with more than half of executives worldwide saying they felt under greater stress last year than they did in 2004 and those in Asia's booming tiger economies feeling the greatest pressure.". Things are no better for the staff: "the State of Human resources survey by Kings College London and law firm Speechly Bircham (2011):The survey found that half of organisations surveyed have increased staff working hours but have failed to incorporate pay raises and bonuses have been withheld.". With such a tight schedule and salaries remaining the same, while food prices rise, society was led to a boom of food processing industries. As Barbara Kingslover mentions, when the women fought for their liberation, industry was there, ready to encourage them "go on, liberate. We will take care of food". It seemed like a blessing at the time, but gradually consumers lost control of where their food comes from and what it includes. In many cases , even half of the ingredients of TV meals and microwave dinners have a chemical name we do not recognize. Also, genetically modified ingredients are not required to be labelled by law, leaving the consumer no choice to avoid them.

Even if someone chooses to make the extra effort to cook a meal from scratch, the fresh produce available is very limited. Both Carolyn Steel and James Mc Williams mention that even though we can find many apples or bananas in our super markets, they all belong to the same variety, genetically modified or not- there is no easy way to know. Food diversity is lost in favour of high yields and year-round production.

Even the consumers who are willing to pay more to buy organic,

1. No Choice !/ The need of Change

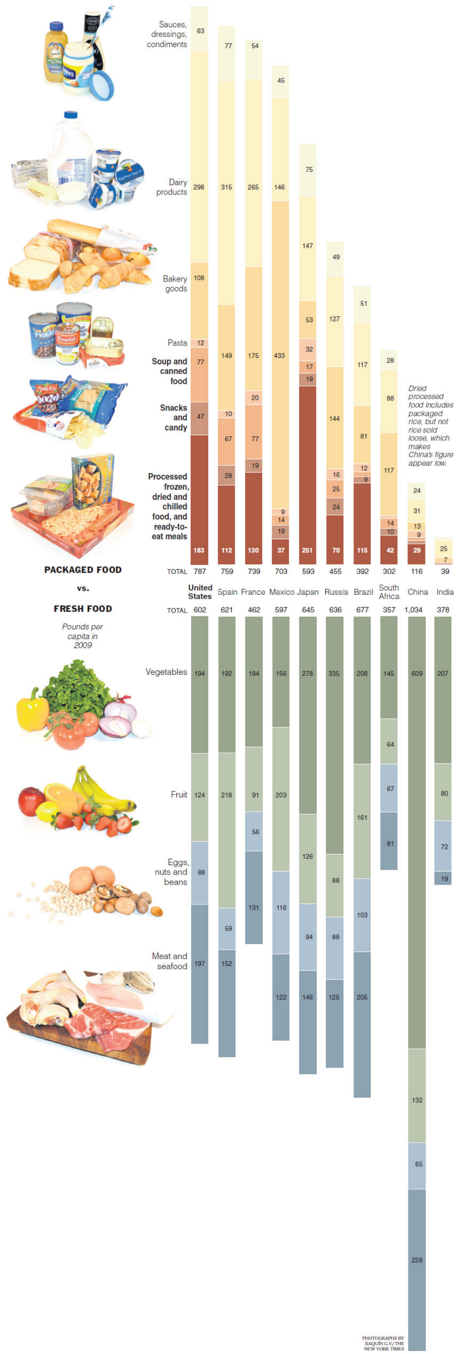
might be caught in a trap, as many small scale producers do not have the money an organic farming certificate requires, but are using much more health- and environment- friendly methods than the corporate food production chains that start to take advantage of the rising marketing value of the word "organic".

The food allergies or intolerances related to gluten and dairy products keep increasing, as a result -nutritionists say- of poorly informed or misguided consumers. Many food intolerances are a result of inadequate activity of an enzyme called diamine oxidase (DAO), necessary to digest histamine. "Our systems are being exposed to higher amounts of histamine than ever, thanks to our consumption of yeast-based foods, preserved meats and more servings of processed foods.", Dr. Albert Missbichler notes.

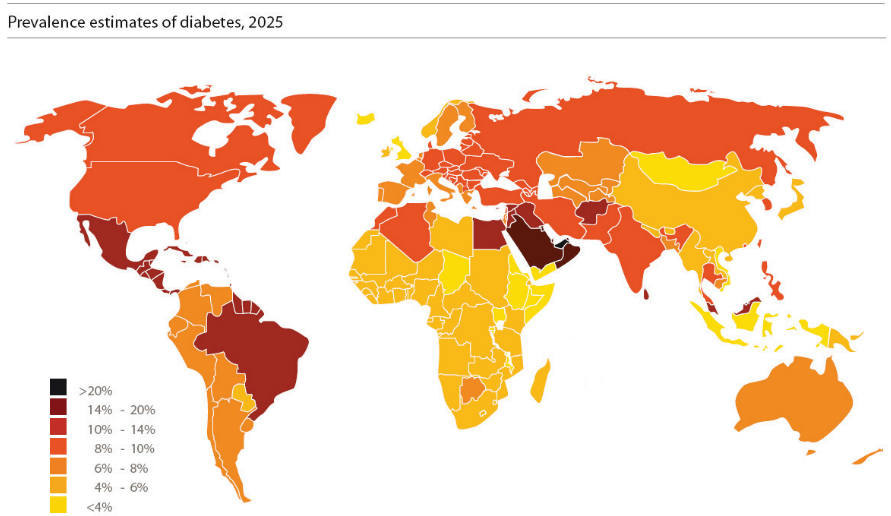
The same happens with diabetes. Pushed by corporate businesses, dietary guides lead consumers to believe that wheat and it's by products, along with cereal, should be as much as 1/3 of our everyday diet. This overconsumption leads often to obessity. Accordingly, there is a rise in diabetes, having a lot to do with all the added sugars in processed foods we are not aware of.

In order to prevent all these health issues, consumers need to be offered enough information sources, to be able to make conscious food choices. A labelling system that includes not only ingredients and additives, but also more details about the food production (for example, labels indicating genetic modification, hothouse crops etc) could be a good first step.

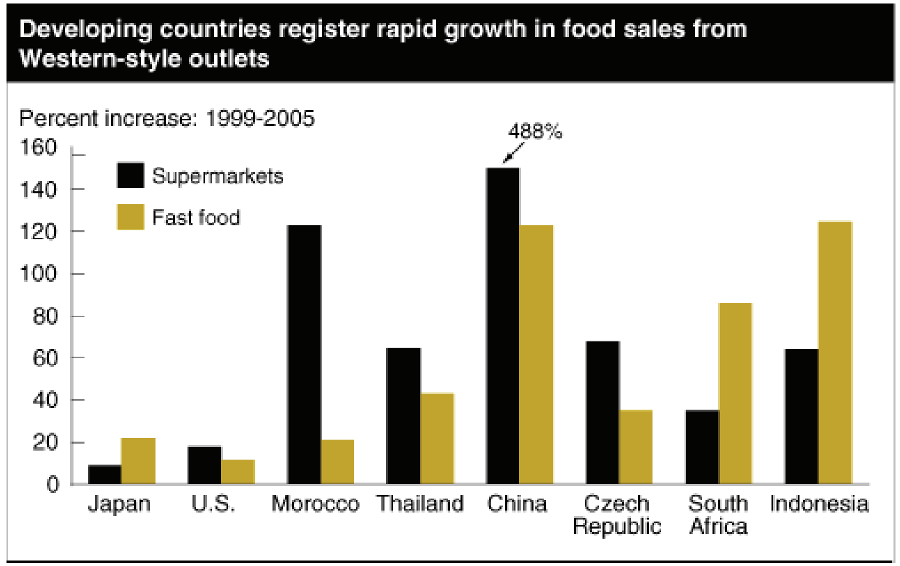
One way to raise food awareness, is to support people in cooking their own meals and even growing a part of their diet by themselves. This way, one comes to realize how complex ready-made meals are, how many components are in them and how little control the consumer has over the quality of these separate components. One could argue, that growing and processing one's own food is the most direct and safe way to ensure food safety and quality. But this is not the case nowadays. Our ancestor did indeed manage to produce their own food, but had all the experience needed to properly treat it to preserve it. This knowledge got forgotten by the individuals, as food industry took care of food production. This means that if people are to take food production back in their hands to all levels, relevant technical education needs to be offered, in order to ensure safety.



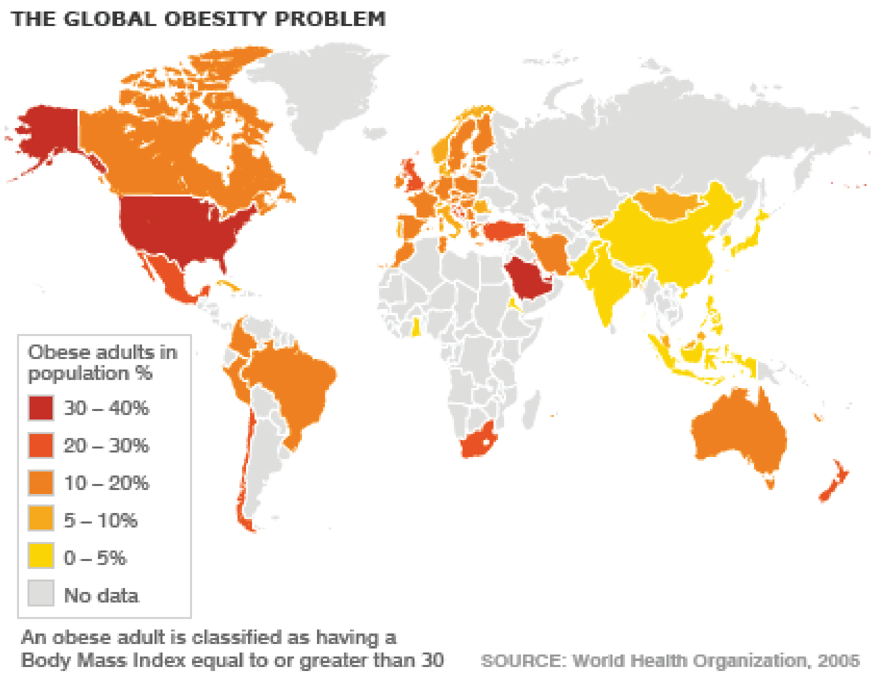
Processed VS Fresh Food
Consumption
Source: Euromonitor International
U.S.D.A. Economic Research Service



Expected Diabetes Rates (2025)
Source: Diabetes Atlas, third edition, International
Diabetes Federation



Western style food outlets taking over
Developing countries
Source: Euromonitor International



The Global Obesity Problem
Source: World Health Organization

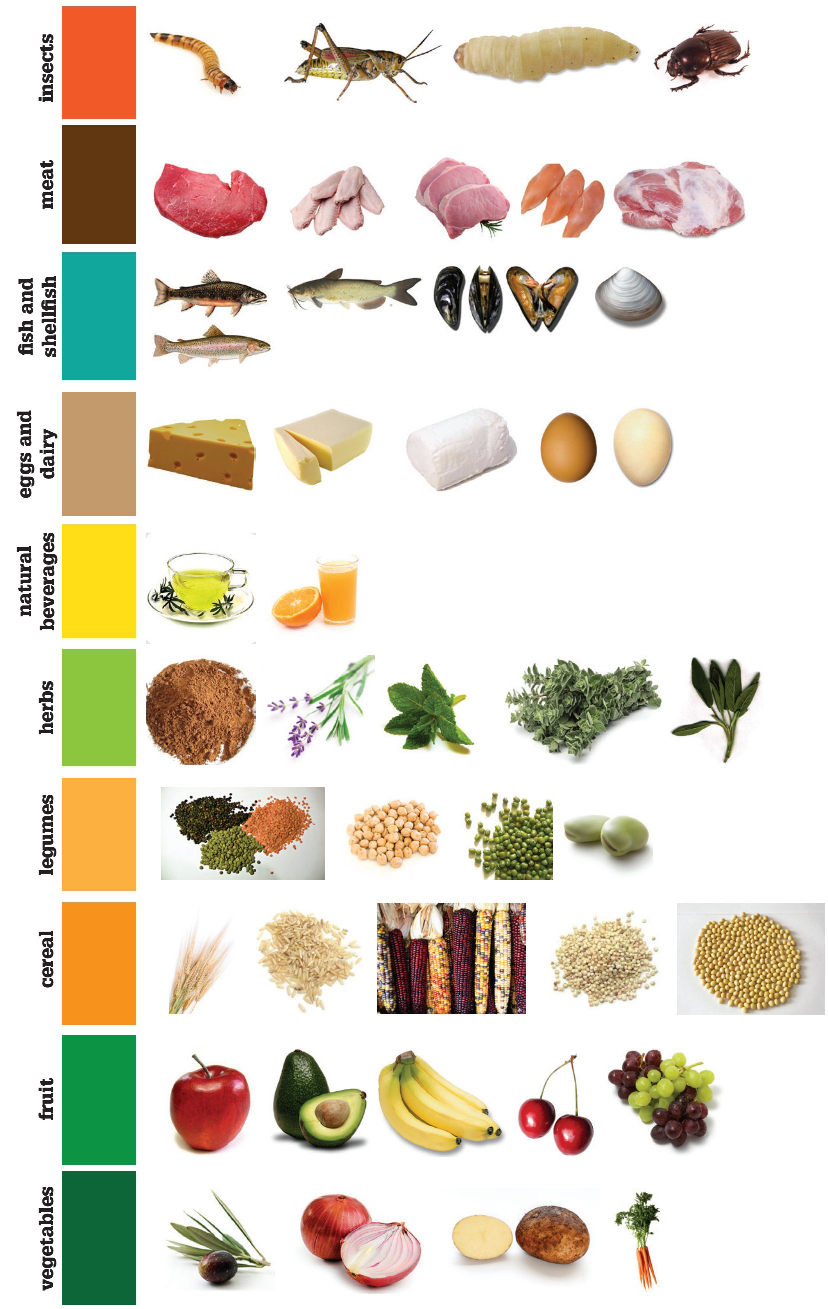
How would a city look if it were self sufficient when it comes to food?
How would it look if it used as little energy as possible for food production, storage and processing?
How should it look to make as much use as possible of water and natural light?
This chapter studies the potential of individual food production combined with farming within small communities, in order to achieve sustainable agriculture and a diverse, healthy diet.
The study leads to a toolbox of prefabricated modules for locally produced food and a set of rules and strategies to combine the modules to communities or cities.

2. Let's Share My Goat!

To what extend is collaboration in food production more efficient

2.1 Analysis of the diet

In order to deal with the complex issue of diets and nutrition, there is the need to brake the diet down to a limited number of main ingredients.
In this study, the categories used are :
-vegetables
-fruit
-cereal
-legumes
-herbs
-natural beverages
-eggs and dairy
-fish and shellfish
-meat
After interviews with experts in the university of Wageningen, one more category is added as a source of animal protein, and that category includes different types of insects (see chapter...).
From each of those categories, a selection was made based on characteristics that make certain foods more suitable for such an efficiency and health based experiment. The criteria of choice are:
-yields
-caloric value
-nutritional density
-popularity



Colour Coding Legend

2.1.1. Ingredients

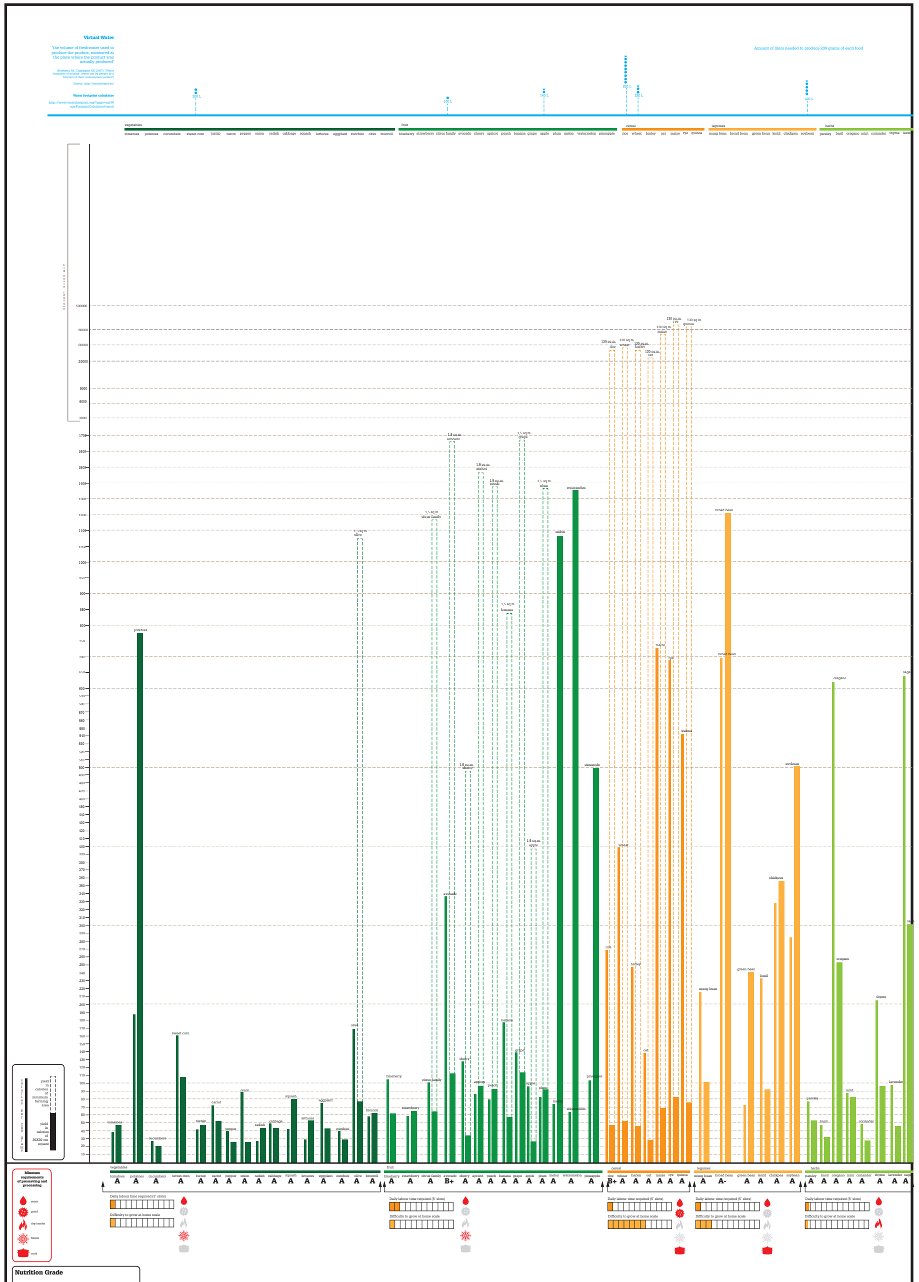


Diagram of Yields and Calories

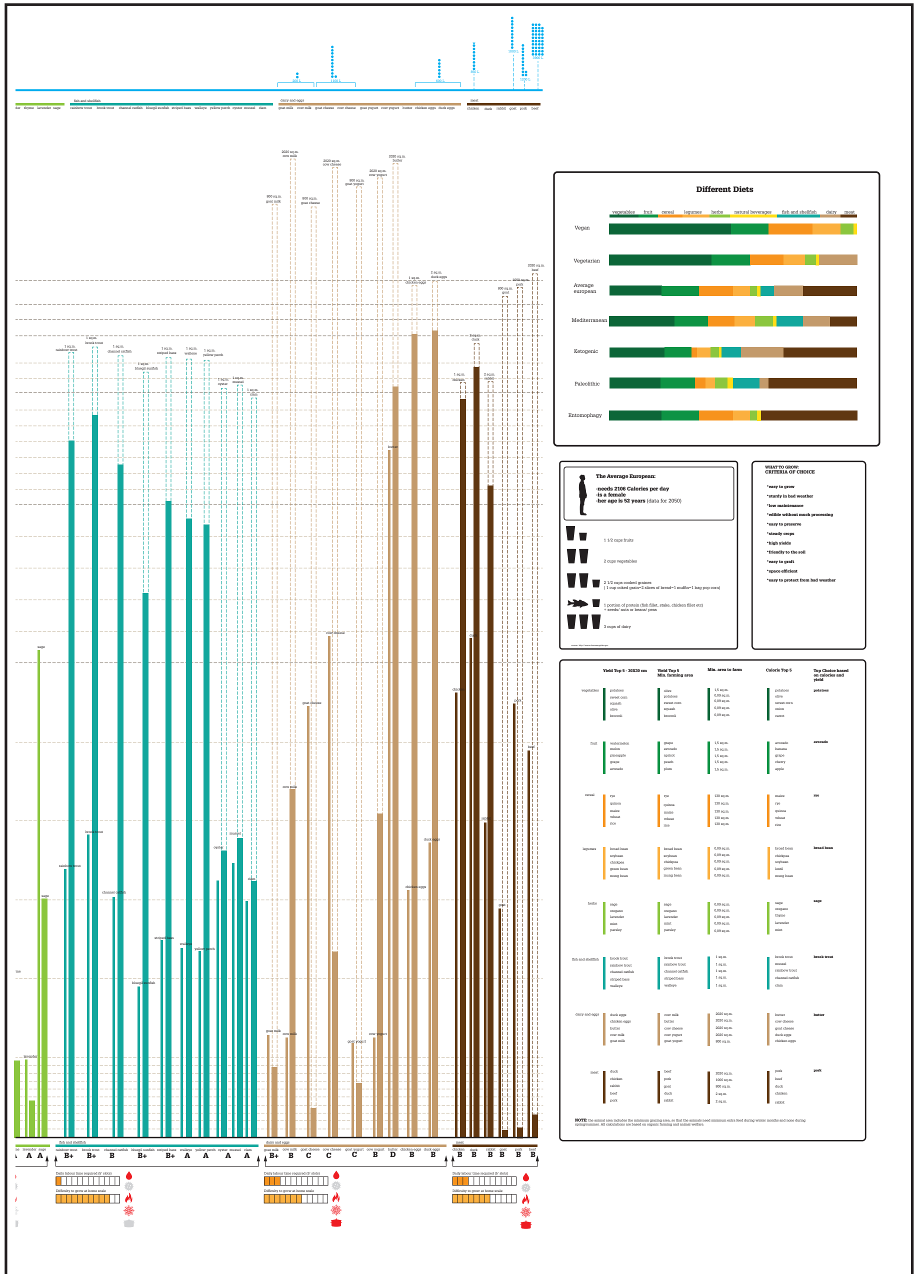


Diagram of Yields and Calories

Need / Ingredients = Food Eaten

Kcal/day — Kcal/Kg — Kg/day

Food Eaten X Waste = Food Produced

Kg/day — % (percentage) — Kg/day

365 days X Food Produced / Yield = Area/p.p.

Kg/day — Kg/year — m2/p.p.

Need: The Average European

0,95
males per female

age group / year	0-14	15-64
2020	15,5	64,3
2050	14,3	57

gender / average calories 2050	0-14 f	0-14 m	15-64 f	15-64 m
	1573,75	1783,75	1962,5	2558,75

consumers

1000000

Calories consumed per day by the Average European

2106,59

The Average European Calories are a result of the average calories of different age groups, according to what percentage of the population they are, as shown on the table above.

age group / year	65-79	80+
2020	14,4	5,8
2050	17,7	11

gender / average calories 2050	65-79 f	65-79 m	80+ f	80+ m
	1855	2215	1855	2215

producers

740400

Calories produced per day by the Each Average European Producer

2645,88

As certain age groups cannot take part to the food production (children, elderly, disabled people), the workforce has to produce enough food also for these groups, meaning they have to produce more calories than they need.

2110	/	Ingredients	=	Food Eaten
Kcal/day		Kcal/Kg		Kg/day

Food Eaten	X	Waste	=	Food Produced
Kg/day		% (percentage)		Kg/day

365 days	X	Food Produced	/	Yield	=	Area/p.p.
		Kg/day		Kg/year		m2/p.p.

2110	/	Ingredients	=	Food Eaten
Kcal/day		Kcal/Kg		Kg/day

Food Eaten	X	Waste	=	Food Produced
Kg/day		% (percentage)		Kg/day

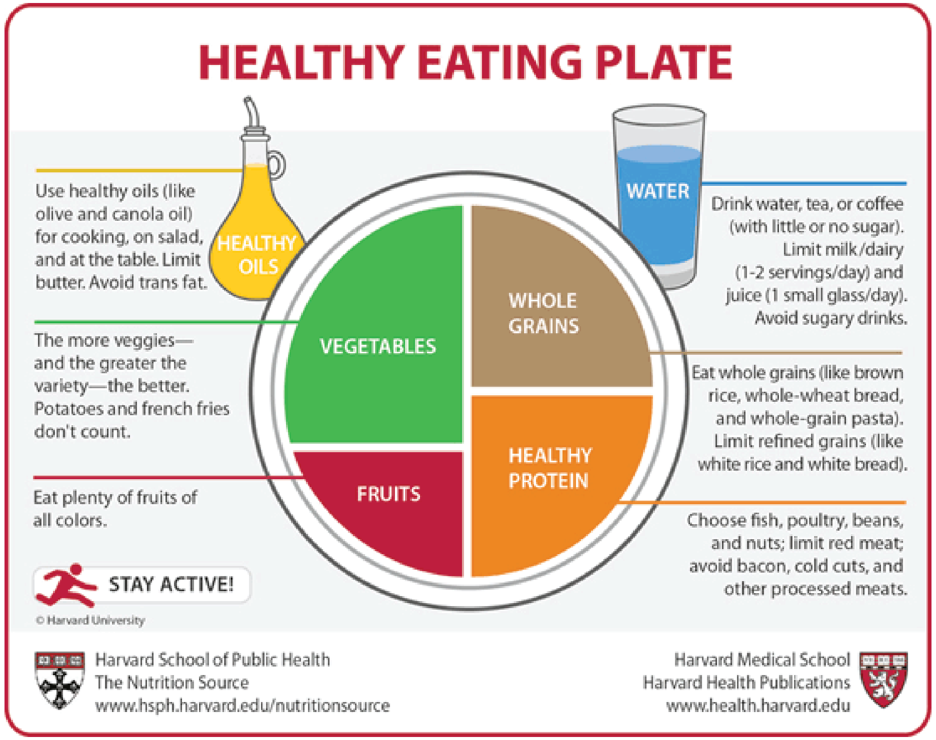
365 days	X	Food Produced	/	Yield	=	Area/p.p.
		Kg/day		Kg/year		m2/p.p.

Ingredients

This is a rather complex part of the equation, as we have to define the types of foods that are used to fulfil the caloric needs. As mentioned on chapter "2.1. The Analysis of the diet", we can brake the diet to food categories and use representative ingredients for each one of them, to do the necessary calculations.

But we need to define what percentage of each of those food categories takes part into each meal. This can be done with the help of nutritionists. World Health Organization and national health institutions (organizations and ministries) issue healthy eating guides that are renewed often. The research on food is ongoing, which means that the percentages of carbohydrates or protein that we need to take might fluctuate among countries or in the same country in different years. There are though some pillars of healthy eating which can be summarized into:
-lots of vegetables daily
-lots of fruit, especially the ones that are lower in fructose, like berries, daily
-whole grains as a source of carbohydrates and fibres, daily
-fish as a source of omega 3 acids and antioxidants
-legumes and protein rich seeds as sources of protein
-white meat preferably once a week or less
-dark meat once every two weeks or once a month (it varies according to climate, among other factors)
-dairy products and eggs as sources of protein and calcium. Depending on their fat content and the lactose intolerance common among adults, the form of dairy that one should consume can not be generalized.

And then, we need to choose a certain variety of ingredients that fall into the same food category. There are several reasons that variety is important:
-health issues: different fruits, for example, provide us with different nutrients
-food culture issues: we are used to eating different types of foods and a shift to our diet towards more healthy, unprocessed ingredients is already a big step to take. Thus, to make it more appealing, people need to be given the chance to discover that nature has a pleasing variety of different tastes to offer.
-food safety reasons: if there is only one variety of salad vegetables, for instance, and it is attacked by pests or a vegetable disease, then it will spread quickly, crops might fail and food safety is put at great risk.
-extended growing season: there are certain varieties of the same fruit or vegetable that reach maturity sooner or later from each other. By planting those different varieties, one can extend the growing period and the availability of fresh produce throughout the year.



Top:
A Harvard Medical School proposal of a healthy eating diagram.

Left:
Example of a diagram illustrating the percentage that each food category should take up into our diet.
This diagram shows different alternatives in each food category.

http://www.wellness-therapist-info.com

2110 / Ingredients = Food Eaten

Kcal/day | Kcal/Kg | Kg/day

Whole Foods
Vegetables
Fruit
Legumes
Seeds
Nuts
----
white meat
----
dark meat
----
insects

Food Eaten X Waste = Food Produced

Kg/day | % (percentage) | Kg/day

365 days X Food Produced / Yield = Area/p.p.

Kg/day | Kg/year | m2/p.p.

2110 / Ingredients = Food Eaten

Kcal/day | Kcal/Kg | Kg/day

Whole Foods
Vegetables
Fruit
Legumes
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Nuts
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white meat
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Kg/day | Kg/year | m2/p.p.

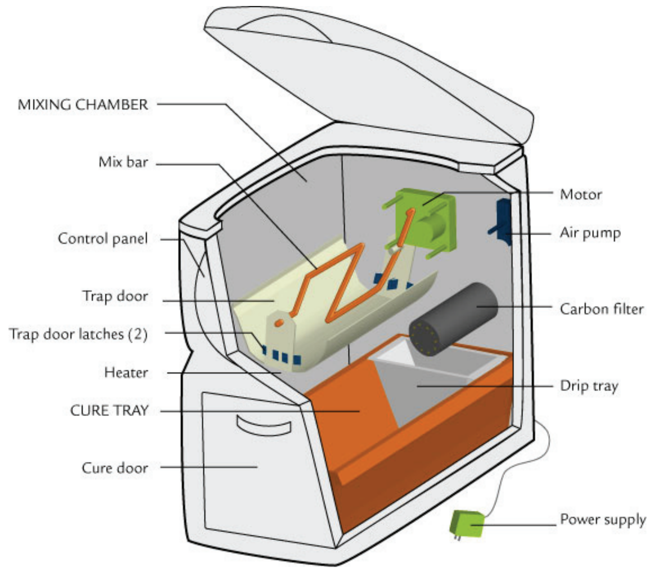
Waste

Food Waste as a term can be defined in different ways and there is no official definition. The reason for this, is the fact that some people do not consider food waste as waste, as it can be used in different applications (animal fodder and compost are good examples). Other people and organizations disagree on what food waste consists of: can canned food that has been expired be under the same umbrella with crops attacked by pests?

This issue is complex, but for the calculations of AgroCity, as food waste are considered the following:
-crops that fail due to bad weather or pests
-food that gets damaged during transportation from production to consumption
-food that expires before use
-household food waste.

The choices of food production, preservation and processing methods of Agro City are also influenced by the waste management issues. The bottom up approach can help to drastically reduce some categories of food waste:
-As crops are of much smaller scale than the current corporate agriculture fields, diseases and pests can be spotted and isolated faster and more efficiently.
-Production and consumption are very close. In many cases production happens in one's own dwelling unit. This way transportation of food is minimized, reducing also the transport induced food waste.
-Fresh, whole food is encouraged and packaged, processed meals are not the norm in AgroCity. This way, if a food expires, it can be composted without the package being a problem. Furthermore, the food production in AgroCity is calculated in such a way that over production of food should not be a problem.
-Household food waste is reduced in two ways: the first is meal planning according to one's own production or based on local production and seasonal eating. The second way is food preservation. Canning, drying and smoking of foods that give high yields in growing season saves them for winter consumption. The little food waste produced when cooking, like peels for example, can be composted.

2. Let's Share My Goat !/ Study on Collaboration in Food Production



NatureMill PRO Indoor Composter is an example of an indoor composter that can be used to treat household food waste.

A concept proposal by Philips about household waste treatment:
"A methane digester that converts bathroom waste solids and vegetable trimmings into methane gas that power a number of functions in the home such as the cooking range and the gas mantle lights. This digester is required to have a constant supply of water and waste material."

2110 / Ingredients = Food Eaten

Kcal/day — Kcal/Kg — Kg/day

Whole Foods
Vegetables
Fruit
Legumes
Seeds
Nuts
----
white meat
----
dark meat
----
insects

Food Eaten X 0.15 - 0.2* = Food Produced

Kg/day — % (percentage) *depending on the food category — Kg/day

365 days X Food Produced / Yield = Area/p.p.

Kg/day — Kg/year — m2/p.p.

2110 / Ingredients = Food Eaten

Kcal/day | Kcal/Kg | Kg/day

Whole Foods
Vegetables
Fruit
Legumes
Seeds
Nuts
----
white meat
----
dark meat
----
insects

Food Eaten X 0.15 - 0.2* = Food Produced

Kg/day | % (percentage) *depending on the food category | Kg/day

365 days X Food Produced / Yield = Area/p.p.

Kg/day | Kg/year | m2/p.p.


vegetables
fruit
cereal
legumes
herbs
natural beverages
fish and shellfish
dairy and eggs
meat
insects
NOTE: the bar indicates the percentage of GRAMS that comes from each group.
As vegetables have much less calories than meat for example, the bar would look very different if it showed percentage of calories that come from each group.
Vegetarian
Vegan
Ovo-Vegetarian
Lacto-Vegetarian
Ovo-Lacto-Vegetarian
Semi-Vegetarian
Non-Vegetarian
Fish
Chicken
Rabbit
Goat/sheep
Pork
Beef
Insects
White Meat + Rabbits+ Goats
White Meat + Rabbits+Goats+Pork
All Types of Meat
Legend
Community Size
1
2
4
8
16
32
64
total square meters:
increase of space efficiency:
labour time per person/ number of farmers:
Diet
Vegetarian
Vegan
Ovo-Vegetarian
Lacto-Vegetarian
Ovo-Lacto-Vegetarian
Semi-Vegetarian
Non-Vegetarian
Fish
Chicken
Rabbit
Goat/sheep
Pork
Beef
Insects
White meat + rabbits + goats
White meat + rabbits + goats + pork
All Types of Meat

vegetables
fruit
cereal
legumes
herbs
natural beverages
fish and shellfish
dairy and eggs
meat
insects
NOTE: the bar indicates the percentage of GRAMS that comes from each group.
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Vegetarian
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Semi-Vegetarian
Non-Vegetarian
Fish
Chicken
Rabbit
Goat/sheep
Pork
Beef
Insects
White Meat + Rabbits+ Goats
White Meat + Rabbits+Goats+Pork
All Types of Meat
Legend
Diet
Community Size
1
2
4
8
16
32
64
total square meters:
increase of space efficiency:
labour time per person/ number of farmers:
One Type of Meat
Mixed Types of Meat
White meat + rabbits + goats
White meat + rabbits + goats + pork
All Types of Meat

In order to achieve food production within the city, the most space efficient diet ingredients need to be grown, with the most space efficient techniques.

If agriculture could be shrunken enough to fit within a “residential footprint”, then the city could keep it’s urban character, while benefiting from the advantages of having food production within it.

Efficiency, though, cannot be the only goal when it comes to food. Health, variety, and the pleasure that food offers should not be neglected. AgroCity excludes particular ingredients that are not space efficient or sustainable -like beef and pork- but offers innovative alternatives.

The recommended diet of AgroCity is a healthy diet that offers all types of valuable nutrients, but not always from the sources we are used to. Protein rich seeds and insects replace animal proteins and different types of algae and berries provide a wide variety of antioxidants and micronutrients. Food changes but it remains pleasing.

By choosing a healthy and sustainable diet, not only are consumers expected to experience wellbeing, but also Earth’s resources and biodiversity are protected.

3.Make it Feasible, Make it Work!

How new ingredients and technologies increase space efficiency

2110 / Ingredients = Food Eaten

Kcal/day — Kcal/Kg — Kg/day

Whole Foods
Vegetables
Fruit
Legumes
Seeds
Nuts
----
white meat
----
dark meat
----
insects

Food Eaten X 0.15 - 0.2* = Food Produced

Kg/day — % (percentage) *depending on the food category — Kg/day

365 days X Food Produced / Yield = Area/p.p.

Kg/day efficient ingredients — Kg/year — m2/p.p.

3.1. Efficient ingredients

As the graphs show animals are not space efficient when it comes to food production. There are certain exceptions to this rule though, having to do with the size of the animals raised, as well as the energy and water they need.
Goats, rabbits, chicken and fish are much preferred to cows and pigs, not only because they require much less grazing space, but also because some of them offer very nutritional food products , other than their meat, namely eggs and milk. In addition, the CO2 emissions produced by goats are much less compared to cow emissions.
An example of low energy use is mushroom farming, as mushrooms can be grown indoors and need minimal light. Snails are another example of space efficient animals that can be also grown indoors and need a brief time to reach a size that qualifies them as a meal. A more radical approach when it comes to ingredients, having to do with a change of diet, is the strategy of promoting entomophagy (the practice of eating insects) to the western world, as insects are an incredibly space efficient animal protein source.

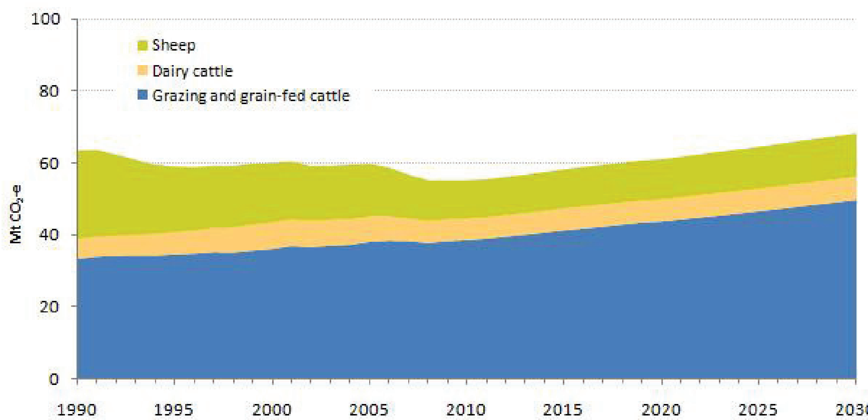


Diagram Comparing CO2 emissions

Comparison of feed consumption efficiency

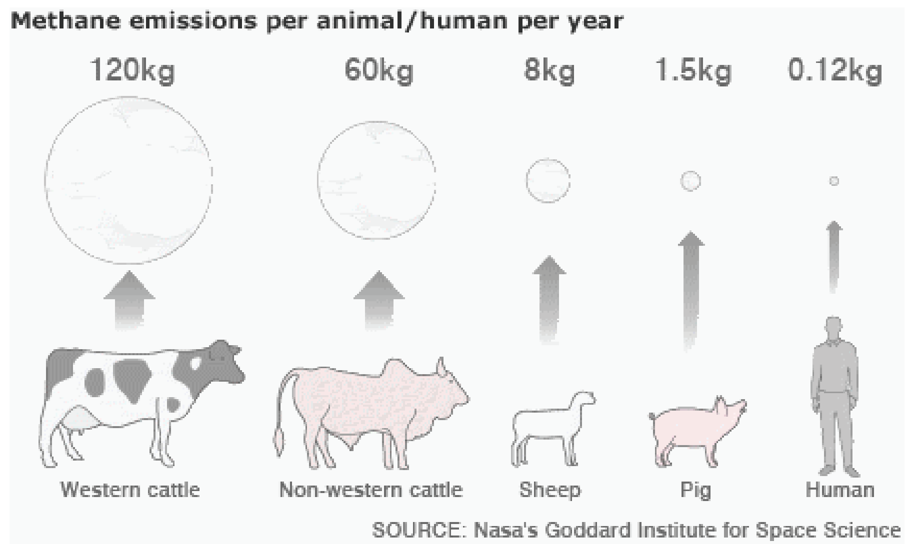


Diagram Comparing CO2 emissions

3.1.1. Entomophagy
The practice of using insects as a source of food.

It might seem strange for Europeans and North Americans to eat insects, as it has not been part of our culture. The rest of the world though enjoys this protein and fibre rich ingredient and has learned to prepare insects in many different ways. As children grow to like foods like legumes or coffee, that they were intimidated by as toddlers, so can the western civilization adapt to entomophagy. And even enjoy it.

In the article "Entomophagy: Using Insects As A Food Source"* there is a list of insects commonly eaten in different parts of the globe:
"Africa: In Africa, popular insects to eat include termites, grasshoppers, caterpillars, beetles, ants, and locusts. Termites are often eaten raw or fried,

3. Make it Feasible, Make it Work ! / Towards a Better Diet

or are made into a cooking oil. Grasshoppers, caterpillars, and young beetles are fried and ants are eaten either raw or ground-up into a paste. Locusts are typically boiled and salted prior to eating.
Asia: All over Asia, the giant waterbug, which is gathered by farmers at night near water sources, is roasted whole and eaten as a delicacy. Meanwhile, in Korea, fried locusts are popular as a food source and in the Philippines, many insects including ants, beetles, crickets, grasshoppers, katydids, locusts, and larvae from the dragonfly are fried or boiled prior to eating. In Papua New Guinea, chefs typically prepare insect grubs either roasted or boiled to serve as a main meal.
Australia. Home to many large colonies of termites, some of which have termites as long as three inches in length, Australians favor these insects and prefer to fry them prior to eating.
Mexico and South America: In Mexico, grasshoppers are a popular food source especially when fried prior to eating. Fried grasshoppers are also canned commercially and sold in supermarkets and local grocery stores. The agave worm is also a popular insect to eat, whether swallowed whole in a preserved state in a bottle of tequila or eaten cooked inside of a tortilla. In Columbia, South America many insects are eaten including ants, termites and palm grubs. Insects are often cooked prior to eating or are used as ingredients in recipes."

Even the most hesitant ones might reflect on this option a bit more, if they consider the fact that we do already eat insects. On the on-line page of FDA (U.S. Food and Drugs Administration) there is an extended list of "of natural or unavoidable defects in foods that present no health hazards for humans.". Insects are of course included.

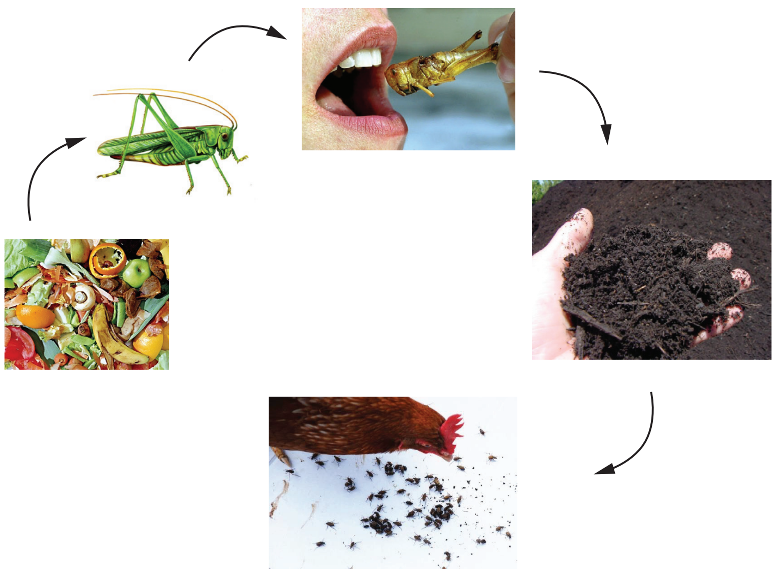
But why put the effort to incorporate such a strange ingredient in our diets? There are major benefits is switching our source of protein from meat to insects.

Advantages of Entomophagy

*nutritional value: insects are rich in protein but also fibre
*insects are abundant and environmentally sustainable
*farming and harvesting insects takes very little
- -water
- -transport fuel
- -space
- -"livestock" food ...compared to livestock, grains and even vegetables.

* http://www.essortment.com/entomophagy-using-insects-food-source-22027.html

Entomophagy Cycles



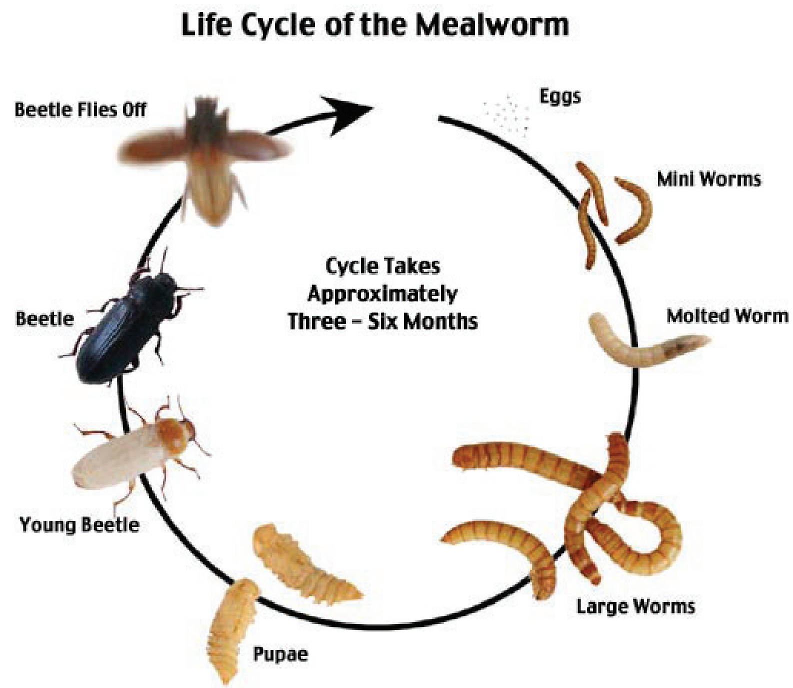
Cycles

vegetable waste → insects → human food/ animal feed → sewage waste/ manure → insects

Insect Waste Cycles:

The sustainable aspect of insect farming can be explained if we look into Waste Cycles.
Insects can be raised on compost and food waste. If raised on this kind of waste, they can be safely consumed by humans.
But insects can also be raised on human and animal manure. In this case they can be fed to animals, but not to humans. Chickens and fish particularly enjoy them and are greatly benefited by their nutritional value.
This means that insects do not only require very little space to be raised, but also reduce waste produced in other parts of the food cycle.

3. Make it Feasible, Make it Work ! / Towards a Better Diet



How to raise mealworms. An example of insect farming at home.

Mealworms are maybe the easiest insect to raise at home. It is important to know their life cycle and separate insects that are in different life stages from one another. The reason for that is that the larger worms might eat the younger worms and beetles will eat pupae. This is mostly the case when there is not enough food or the “insect farm” is overcrowded.
Three clear containers are enough for the three main stages of a beetle’s life: one for the eggs and the mini worms, one for the large worms and one for the beetles. Each time an insect changes life stages, it moves to another container. Of course, this happens at the same time for larger groups of insects.
The bedding used for mealworms is usually some kind of grain: oats, corn meal, wheat bran can be used. This is also the main food of the insects. Additionally a source of moisture needs to be put in the container. Carrots and potatoes are good choices. They need to be replaced once they start to mold.
Moisture is very important as mealworms will cannibalize in the absence of it.
It is good to take out of the container any dead or deformed worms and beetles, as they will be eaten by the rest of the insects. This has not been proven to be a health hazard, but it is important for animal welfare, it prevents insect infections and keeps the containers odour-free.

Insects Cooked in Different Ways

Insects can be used for consumption:

*cooked, like regular meat
*dried, grinded and used as our
*as a protein supplement for foods (the protein is extracted from the insects and used as an additive to any food)

Entomophagists say that different have not only different texture, but also different taste. The table illustrates how different nutritional values can be among different species.

Risks of Entomophagy:

As with any other food, there is the risk of allergies when consuming insects. Also it is important to make sure that the insects that are being consumed are not toxic. This is why it is wise to make sure that the insects are included in an “edible insects” list. Ingesting chemicals is another danger of entomophagy, as insects feed often from plants that have been treated with chemicals. Parasites might also have infected insects, but this is not considered a pathogenic factor, if insects are cooked before consumption.

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Nutritional Value of Various Insects per 100 grams

Data collected from *The Food Insects Newsletter*, July 1996 (Vol. 9, No. 2, ed. by Florence V. Dunkel, Montana State University) and *Bugs In the System*, by May Berenbaum

Insect	Protein (g)	Fat (g)	Carbohydrate	Calcium (mg)	Iron (mg)
Giant Water Beetle	19.8	8.3	2.1	43.5	13.6
Red Ant	13.9	3.5	2.9	47.8	5.7
Silk Worm Pupae	9.6	5.6	2.3	41.7	1.8
Dung Beetle	17.2	4.3	.2	30.9	7.7
Cricket	12.9	5.5	5.1	75.8	9.5
Grasshopper	20.6	6.1	3.9	35.2	5.0
Grasshopper	14.3	3.3	2.2	27.5	3.0
June Beetle	13.4	1.4	2.9	22.6	6.0
Caterpillar	28.2	N/A	N/A	N/A	35.5
Caterpillar	9.7	N/A	N/A	N/A	1.9
Termite	14.2	N/A	N/A	N/A	35.5
Weevil	6.7	N/A	N/A	N/A	13.1
Beef (Lean Ground)	27.4	N/A	N/A	N/A	3.5
Fish (Broiled Cod)	28.5	N/A	N/A	N/A	1.0

Insect Recipes
(http://minilivestock.org/recipes/)

Insect Flour

Insect flour is any insects that are ground to a power-like consistency. It's versatile and can be made with any insect and used in virtually any recipe as a flavourful ingredient or nutritional supplement. In addition to protein, insects also contain vitamins and minerals. Different insects contain different levels of nutrients.
Oven-baked Method:

1. To begin, spread your cleaned insects out on a foil-lined baking sheet (to learn how to prepare insects, please refer to "FARM" page).
2. Set your oven 200 degrees and dry insects for approximately 1-3 hours (the larger the quantity, the longer the baking). Periodically stir mealworms around tray to ensure even drying. Keep an eye on the insects to make sure they do not burn.
3. Test to see if the insects are ready, take a kitchen utensil and crush one of the insects. When the insects are fairly brittle and crush easily, that means they are done baking.
4. Take your dried insects and grind until fine or the consistency of wheat germ. Try using a mortar and pestle, a food processor or coffee grinder. Set aside or place in the refrigerator until ready to cook with.

3. Make it Feasible, Make it Work ! / Towards a Better Diet

Insect Recipes
(http://wildernesschilde.blogspot.com)

Mealworm Chocolate Chip Cookies

Ingredients:
1 1/2 cups almond flour
1/8 tsp baking soda
few shakes of salt
5 Tbsp melted butter
3 Tbsp honey
2 tsp vanilla extract
1/3 cup or more chocolate chips
gently roasted mealworms* (as many or few as you'd like)

1. Preheat the oven to 350 degrees.
2. Mix your dry ingredients together in a bowl. In a separate bowl mix your wet ingredients together and add them to the dry ingredients. Fold in your chocolate chips and mealworms.
3. Drop spoonfuls of dough onto a parchment-lined cookie sheet and bake for 10-13 minutes.

*Note: When preparing mealworms for recipes, they should be frozen at least a day or more, then gently toasted in the oven or in a dry pan on low heat, until slightly browned (as if you're toasting nuts.) Don't heat too quickly. They pop!

Bellow is the advertisement text of “Don Burgito, Prehespanic Snackeria”. It is a good example of how insects can become part of the European and American food culture, if presented in the right manner to the public.
Don Burgito offers a variety of dishes with different types of insects and in it’s press release does also mention the ecological aspect of choosing to eat insects as a protei source.

“No, you’re not buggin’…yet. Don Bugito offers edible (yes, edible) insects, inspired by pre-Hispanic and contemporary Mexican cuisine. Insects are a valuable source of protein in many cultures throughout the world, and we feel like the US is finally ready to try these tasty critters, through food that is as delicious as it is innovative. Don Bugito uses locally sourced ingredients (including the insects) and fresh flavors to create amazing dishes that simply happen to have an unexpected ingredient. For those of you interested to know, insects not only offer an insanely high source of protein, but also come from production methods that are more ecologically-friendly than many other food sources. For the rest of you, we just make great food!”

Prof. Arnold van Huis,Personal Chair, Professor Tropical Entomology

Interview with Prof. Arnold van Huis, by A. Symvoulidou
29/11/2011, Wageningen University, Laboratory of Entomology

My first question would be about the food crisis. I have been reading about different kinds of causes that include the lack of water or plant diseases that spread globally really fast even tsunami or the nuclear crisis in Japan… And my question is, is it really a crisis that will affect Europe soon? And by "soon", I mean in how many years? And also, what are the first signs that we are going to see in our everyday life, so that we realize that something is going really wrong?

If we talk about the food crisis, I would say more "meat crisis" maybe, and the point is that at the moment 70% of all the agricultural land is used for livestock, so with a growing world population from 7 to 9 billion more or less in 2050, but also because of –let's say- the increasing welfare, people start to eat more meat. So the expectation is that the meat demand will more or less double in the next, let's say, 30-40 years. And then you need another planet. So we are going to have a crisis. And also food prices are already increasing worldwide. And that's because, let's say, the production lacks behind –more or less- the population increase. In the past the production really increased tremendously. But that is going to lever off, so we will have their (? Probably the African countries') problem as well. And if you look at the feed industry –the feed for animals and for fish- then that is reliant for a large part on fish meat and fish oil which is by catch from the oceans but also that is going to diminish very quickly. So that's becoming also far to expensive, so we need alternatives. That's the whole idea.

I know that you are pro-entomophagy and also I read this article of yours "The six-legged meat of the future" that I found very interesting and I know that so far we have alternative methods of producing things like aquaculture –when you combine fish and crops to save footprint- but I

know that this still are not efficient enough for the future crisis that we are awaiting somehow. So could you elaborate a bit on entomophagy? I know that so far the good thing about insects is that they are very high in protein and very low in fat. That's as far as I managed to get from the articles. If you want to elaborate a bit…

Well, there are two things: you can consider insects as food for humans –and that's what we call "entomophagy"- but you can also consider insects as feed for animals and for fish. So those are two different things. Of course in the tropics everybody eats insects, that's quite common, but in Europe and United States and Russia, they don't. So there I think the prospect of using insects as feed for animals and for fish, that is well, the first option that we have. And insects can be reared in rather small units –factories, you could call it- but the challenge is of course, how can we produce that much insects in order to be able to use that as feed, because in the industry, in the feed industry, is really looking for alternatives because of this fish meat and fish oil problem and because of soya, which is an important ingredient but also becoming very very expensive. So they are really looking for alternatives, but they would like to have large quantities. So then we have to think about how can we rear those insects in factories. And another big advantage of the insects is that you can rear them on organic waste, organic waste products. One of them is manure. Manure is a tremendous problem especially in the Netherlands that we import a lot of feed, produce the animals and then export the meat again, but we are left with all the manure. So how can you get rid of this manure and at the same time have high quality proteins for the fish and for the livestock industry? And I think there we have a lot of potential, a lot of possibilities. There are already several companies also in the Netherlands, who are pursuing this idea. There are also several companies in the world who are trying to look at this. But I think this has tremendous promise. That is when we talk about insects as feed. Insects as food: well, there are numerous benefits. First of all, it has the same nutritional quality than normal meat –it depends of course what kind of insect you are going to take, because there are 1800 different species that we can use- but that requires of course a kind of psychological change in the European thinking and eating culture and also in the United States, but nutritionally it's equivalent to the meat that we know, the conventional meat. It has other advantages, like green house gas production is much less with edible insects. Insects are cold-blooded, which means they don't need feed to make body heat, it's not necessary. They adjust to environmental temperatures. And I think animal welfare is also less a problem, because they are used to being huge quantities together. It's only the psychological problem that we have to face. There are also several possibilities. First of all you can eat insects as they are, just removing the legs or the wings.

So, without cooking even you mean. Raw?

No, you have always to prepare them. So at the moment what we sell in the Netherlands, they are freeze dried, but you still have to do some preparation for the insects.

For health reasons I guess.

For health reasons, but also, I mean, normal meat, you don't eat it just like that, you also prepare it, so with insects it's just the same. But there is also the possibility that you can say "well, people don't want to see the insect", so you can grind them. That's another possibility. Dry them and grind them, make a kind of flour which you can use or add to all kinds of products. And the other, ultimate, possibility is –and that's what we are doing here, at our laboratory- we rear insects in waste streams and then we try to extract the proteins from the insect. So then you have of course a product which is not recognizable at all. It doesn't resemble any insect at all. So that's another possiblitiy. So we have three avenues to tackle this problem of psychology.

I saw that you have also collaborated with a chef and a team of students –cooking students- is that right? Who created different kinds of recipes. I just found images on the internet, not the real article, so I don't know how the people who tasted these foods reacted. Were they positive, were they more willing to try? So is this really a way to bring the public to start tasting insects?

Well, in 2008 there was a large food fare in Amsterdam and we have been there. And thousands of people have tasted the insects. Well, first of all people are a bit resistant, but I have the impression, if they have tasted it once there is no problem anymore and they will take it the second time. We are currently preparing a cooking book, I think it will be announced the 12th of April, if I am not mistaken, next year, and there are quite a number of recipes in the cooking book. And we also have invited important people in the Netherlands, who are in favor of this change in food culture. So we hope this is one of the ways to overcome that psychological barrier.

And one more question about the insects: you said that they can feed on manure, so could it lead to really closed cycles of energy? Because we know that we already use manure to produce methane or in compost facilities combine these kinds of things. So could they really use such a big part, that they could be a significant part of closed cycles, or would it be a small percentage?

Well, I have to be a bit careful, when I say manure, then it only means for feed. Because I think it's very difficult to rear insects on manure and then feed them to people also. So there we are talking really about different kinds

of waste streams. Just an example: if you take cooking industry, they also have waste which is safe. There you can also rear insects. But also the sugar beet factories, the apple industry, they all have waste streams which are safe to use. So if we are talking about waste, it's not that it's contaminated waste or something. So we have to be careful with that. But closed cycles, I think there are lots of waste streams in the Netherlands, so if you can use them profitably to turn that into protein either for animals or for human food, then okay.

I saw in your papers' list –I don't have any contact with this field but- I saw some words reappearing and they were about pest management and I see again the words "traditional" and "innovation" combined. And I know that you visit Africa often and some of your papers are also about African countries. So, what I was thinking is, can we use all these years of experience that we have with agriculture, like traditional agriculture, with very few means, and by adding innovation and our new view that we have now through technology, and again with little means, to manage and have a very efficient pest control? And eco-friendly as well?

Well, there are several examples especially with grasshoppers that are pest in agriculture, that you can use those grasshoppers as feed or as food. So those examples exist in a few countries, but we should remember that in the tropics the entomophagy is mainly because of the harvesting in nature. So it's not because they rear the insects. So it's a seasonal product, because they depend on certain trees or certain plants. So if you really want to promote this thing, you have to do something different. Then you have to rear the insects. And that's what's happening in countries like Laos and Thailand where there are a lot of domestic farms, where they farm the crickets, for either domestic consumption or for sale at the market. The advantage of the tropics is that insects are cold-blooded and if you take Netherlands at the moment, it's almost too cold for the insects to grow, so you need to provide heat in order to rear them, while in the tropics of course that's different, because you have high temperatures. So it's much easier in the tropics to rear those insects, than in temperate zones, especially in winter time. So there is certainly a possibility of rearing those insects in the tropics and then sending them to Europe for consumption, animal feed or human food. So those are certainly possibilities. But harvesting from nature, I don't know whether you can harvest unlimited from nature. I think there are limits to it, although we are not quite sure how that works. But I have one PhD student in Laos who is working in this case of river ants. River ants, the pupae, are very popular food in Southeast Asia, so he is looking at how much can we harvest from nature, in order not to threaten the population of river ants. And those river ants are interesting because they are also biological control against pests. So you can do both things: you can use them as biological control and at the same time you can eat them. So there are several possibilities.

But now that you mentioned about the Netherlands, that we would need extra heat in order to rear the insects here, then it starts already raising some questions. And we had all the benefits so far, but already I can imagine people asking "But if we need energy consumption for that, why would I choose it?". I guess that the energy that you need in order to rare some insects is much less than the impact that you have on the environment for instance from the cows and the CO2 footprint. Is that the case?

Yes, that is certainly the case. What one of our students did, he looked at the green house gases and of course that turned out quite favorably for the insects in comparison to the conventional livestock, but what did he more do, and he is currently engaged in this research, that's to look at the lifecycle analysis and ecological footprint. So he is then looking at energy, you know, what kind of energy do you use, how much water do you use, all kind of ingredients that you use, what is the ecological footprint of that. So he is trying to combine all that and I hope this publication will be out in half a year time.

You mentioned before that there are companies already in the Netherlands who are trying to engage in entomophagy. Could you mention some names?

Yes, in fact there are three –maybe four- but three companies at least who are working on this. They are combined in a kind of organization –united rearing companies of the Netherlands or something- and that is one company who only rears mealworms, there is one that is rearing all kinds of insects, there is one that only rears locusts. And they deliver that to a kind of wholesaler and they are freeze dried and they are available in about 18 outlets in the Netherlands.*

One more question about that: If we wanted to raise insects in our own houses, could we do it?

Yes, there is even one publication or several publications by a Japanese and a Canadian group that look at the space shuttles, because if you go at another planet, let's say in your own time you are in space, what kind of protein do you take? So they have made a kind of, I call it "reactor", because to take a cow on a space flight is a bit too difficult, even chickens will be difficult, but insects is certainly a possibility. So they have devised something, the size I think of this room (a room around 3 by 5 meters) to produce larvae of beetles and this room will be sufficient to feed almost 100 people with proteins. So, it only indicates that you don't need that much space.

And about the long term impact that entomophagy could have on our health? More or less we know that it's safe because of all the other population that eat insects like Asians or Africans. Is that right? There are no concerns?

There should always be concerns but as far as we can see if you rear them hygienically, there shouldn't be any problem. So all the cases that we know about pathogen and contamination are about the not safe handling of those insects. So if you handle them safely I don't see a problem for human health. But of course we have to be careful. We are also looking at allergies for example, those kinds of things. So this is still under investigation. But if you see how much research has been done on normal food and we are at the beginning of entomophagy, then there is still quite a lot to study. But we are certainly taking this very seriously. Of course if you rear insects in huge numbers you get also problems, that we have in normal livestock, like diseases, which could happen as not a problem for humans but as a problem to rear them. You could have a virus or whatever… But I think with insects we have some more possibilities. Like, if you take only crickets, we have a number of species that we can use so we are not dependent on one species like cows but we have a number of cricket species that we can use so we have some more, I think, alternatives.

I have one last question. Like I told you, now my project is about trying to bring the grow of food into the city, so I have done quite an extensive study on the space that each species of food needs, and cows and pigs of course need huge amounts of space. So one idea would be to replace cows and pigs and these kinds of things with insects. But the question is, first of all could we really replace all our protein that we take so far just with insect protein? Or would we still need some variety for instance from chickens or rabbits that take also less space?

No, I don't think so, because the insects are absolutely comparable to all kind of meat. It could be of course of interest to not only take one species of insect but to have several to keep the variety. But with insects it is absolutely possible, taken into account that we have 1800 species to play with. Of course some of those are really tropical species but there are quite some candidates that can be used. And they all have different nutritional composition. It also depends a little bit on what they are reared on, because that also influences the nutritional composition, the chemical composition of the insect. But I think we have possibilities enough to make a variation in the diet.

I have one more question. It's about veganism and vegetarianism. What do you think? Because these are too movements that have been very controversial so far. And the question is that if you think that if we all became vegetarians at some point, if this would help the environment in the end or not, because there are all these theories that also the amount of energy that we would need to grow all the different species of vegetables in the Netherlands for instance, where the weather is not good enough, still it's not environmental friendly. Do you agree with that or…?

Well, there are several ways to deal with this meat crisis. Of course one of the ways is "don't eat meat every day of the week", that is one possibility.

And I am certainly not saying that insects are the only alternative that we have, there are certainly more alternatives. But I think insects could absolutely be a very good replacement for meat. I think it depends a little bit on what kind of motives a vegetarian would refuse to eat meat. If it is for environmental reasons, then there is not much reason not to eat insects. If you do it for the environment or if you do it for animal welfare, also in animal welfare I think there are less problems with insects, although we are very careful with it because I am certain that insects also can experience pain and those kinds of things so we have to be careful there. But it depends. If vegetarians say “we don’t eat meat because it’s murder”, then they will also not eat insects.

I think we have more than enough to reflect on, thank you.

*The insect farmers’ group that Prof. van Huis refers to is Venik. It is the trade association that brings together growers who farm insects for human consumption. More information is available at: http://www.venik.nl/

These are the logos of the Netherlands based companies that work with Venik and offer insects suitable for human consumptions.
The insects are sold either live or freeze dried and there is some variety available, including: mealworms, locusts, crickets, buffalo worms, red runner roaches.

Venik: http://www.venik.nl/
Kreca: http://www.kreca.com/
van de Ven: http://www.insectenkwekerij.nl/
Meertens: http://www.mik-meertens.nl/Welkom.html
Ruig: http://www.ruig.nl/

Traditional Fish Farming

3.1.2. Fish Farming

Fish is one of the last sources of food that man keeps "hunting". Even though there is a significant number of fish farms around the globe, many species of fish are depleted by overfishing. As Cecile Adams mentions in his article "What's better, farm-raised salmon or wild?" (2009), "the number of cod today is something like one percent of what it was in the 1960s [...] The Atlantic bluefin tuna has been reduced to about 15 percent of preindustrial numbers [...] In a 2006 paper, researchers led by Boris Worm of Canada's Dalhousie University reported that 30 percent of world fisheries had collapsed, with catches falling below 10 percent of the original yield. They projected the remaining commercial fish species would be exhausted by mid-century."

James Mc Williams in his 2009 book "Just Food: Where Locavores Get It Wrong and How We Can Truly Eat Responsibly" gives a good example on how to make the right fish choice both for the consumer and the environment "When a Bostonian chooses sustainably raised farmed fish send from Alabama instead of endangered cod caught with a beam trawl and processed a few miles away, she adheres to the hub-and-spoke logic." Mc Williams makes the point that as population rates increase, and technology allows fishermen to catch great amounts of fish to supply the market, nature does not have enough time to recover.

Farm raised fish will have to be the future, if we want to give to the

planet the chance to regenerate. It There are many ways to raise fish and some of them are successfully combined with other types of agriculture. Aquaponics (the combination of aquaculture and horticulture) is one example.

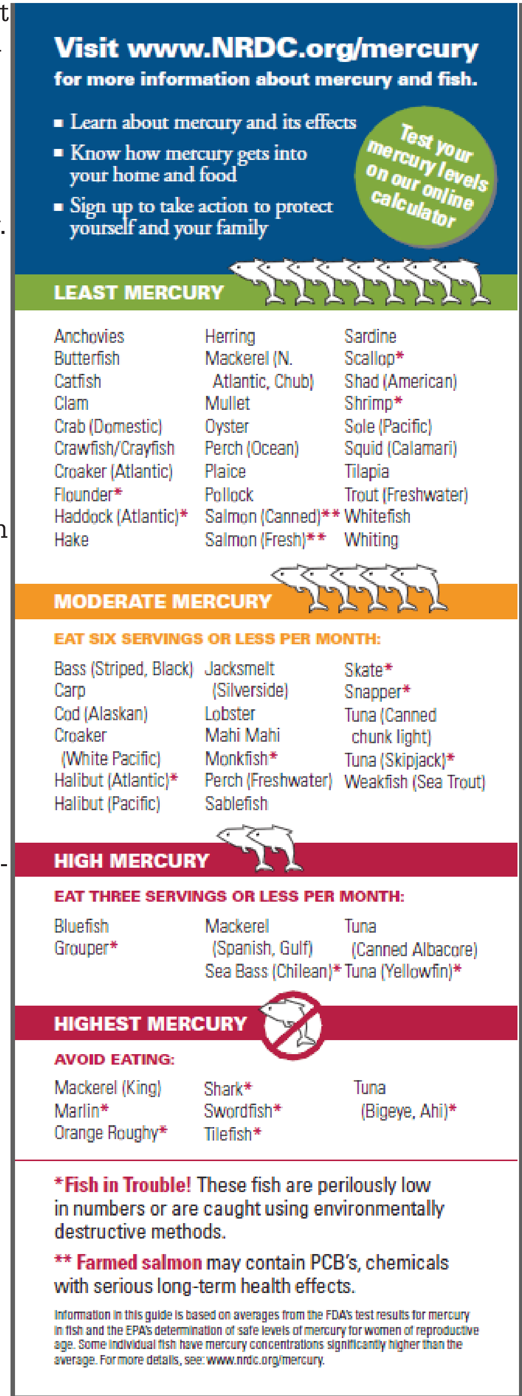
"CleanFish" (http://www.cleanfish.com) is an example of how fish farming in a smaller, artisan scale can provide the market with healthy, sustainably raised fish. As the trade organisation declares "CleanFish works closely with its producers. Next generation practices are already in the works, from raising fish in polycultures, to wetlands filtration systems to experimental deepwater aquapods for raising shrimp without additional feed."

The risk of mercury poisoning:

This guide from NRDC indicates fish that are high in mercury and their frequent consumption could cause mercury poisoning.

As the fish size increases, the build up of mercury is usually higher due to biomagnification.

In farmed fish that do not come in contact with waste waters of coal-burning power plants or chlorine production factories the mercury traces are insignificant.



3.1.3. Fungiculture (Mushroom Farming)

Mushrooms are an already popular source of food around the world, and for good reason. As Winston Craig writes at http://www.vegetarian-nutrition.info, mushrooms have a unique combination of nutrients. They are very low in calories and very low in sodium and fat. Around 8 to 10 percent of their dry weight is fibre. As AgroCity aims for space efficiency, it might seem that mushrooms, that have so low calories, are not efficient, as we need to eat a lot to cover our daily calory needs. But mushrooms are very nutrients dense.

According to Dr. Craig, mushrooms are “excellent source of potassium, a mineral that helps lower elevated blood pressure and reduces the risk of stroke. One medium portabella mushroom has even more potassium than a banana or a glass of orange juice. One serving of mushrooms also provides about 20 to 40 percent of the daily value of copper, a mineral that has cardio-protective properties.

Mushrooms are a rich source of riboflavin, niacin, and selenium. Selenium is an antioxidant that works with vitamin E to protect cells from the damaging effects of free radicals. Male health professionals who consumed twice the recommended daily intake of selenium cut their risk of prostate cancer by 65 percent.”

Growing methods:

There are three main methods of growing mushrooms:
-Indoors, on compost beds
-Indoors on straw/sawdust filled bags or larger balls
-Outdoors, on logs

The easiest medium to use to grow a crop for one’s personal needs are the straw balls. Nowadays one can buy a straw bag and just by watering it every now and then, can have a crop. But these bags have already been prepared in some food industry, while one could learn to follow all the fungiculture steps at home, from scratch.

According to www.hobbyfarms.com, the steps that all types of fungi farms need to follow, are:
-Inoculation: Mushroom growers don’t use spores to directly start growth in the beds. Instead they use small pieces of a juvenile mushroom mycelium known as spawn. The mycelium spawn is stirred up, broken apart and mixed into the growing medium to inoculate it.
-Cultivation: Once the medium is inoculated, the grower will control the environment to encourage maximum mycelial growth. This control may include slightly cooler temperatures and increased carbon dioxide levels in bed cultivation.
-Casing: A layer of organic material, usually treated peat moss, is spread onto the tops of the mature beds. The casing material perhaps represents a layer of leaf mold on top of the soil. The mycelium doesn’t actually colonize the casing in the same way as the growing medium underneath, but the moist and nutrient-free casing makes a good launching area for fruiting bodies to form.
-Harvest: If you’re growing in conventional beds, you’ll see mushrooms start to pop up about three weeks after casing. Similar time frames accompany other culturing methods.

Free range snail farming, snail caviar and snails cooked with herbs

3.1.4. Heliciculture (Snail Farming)

There are many varieties of edible snails and people have been enjoying them around the world since ancient times. One snail contains 7 calories, 33% fat, 7% carbs, 60% protein. This makes snails a good protein source. They are a space efficient alternative to meat and on the other hand, they have a more "meaty" texture than insects.

They are a sustainable food ingredient, as long as they are farmed in areas that have enough humidity. According to http://www.snailfacts.net, they will happily eat vegetables such as apples, artichokes, beans, cabbage, cauliflower, ripe cherries, citrus, kale, lettuce, potatoes, and tomatoes. They can also eat cooked vegetables, but it should be ensured that leftover foods

3. Make it Feasible, Make it Work ! / Towards a Better Diet

get discarded, so that they do not rot.

In order to raise snails, long greenhouses are a good type of enclosure, as they ensure humidity. In countries with favouring climates long tubes can also be used outdoors. Snails require at least 5 cm of soil as a bedding material, and it needs to be changed from time to time to ensure that it has not become unsanitary, as snails eat and digest it. It is also important that there is adequate drainage, as snails can get drown in too much water. A combination of compost, CaCO3 at pH7, clay, and peat, that is rich in magnesium and calcium is a good example of soil mixture. This type of mixtures encourage snail growth.

An interesting article at http://www.frenchentree.com presents how Béatrice and Pierre Fouquet that own a snail farm in France raise their snails. They have planted radishes in the greenhouse that houses their snails. Radishes are not only food for the snails, but also a hiding place for them, that offers shade and holds extra moisture.

Animal welfare is an important factor in snail farms, not only because of ethical reasons, but also because snails are sensitive to a number of external nuisance. Some factors that can reduce growth are: irregular feedings, temperature, moisture, stress, and population density,vibration, light, noise, and unsanitary conditions.

Nowadays snails are killed by being thrown into boiling water. This is actually a much faster death than the traditional preparation. In previous decades snails were smothered in salt and vinegar and left to ooze to death. This was done for sanitary reasons. Vinegar and salt are still used to clean snails after they have been killed.

3.1.5. Bees

(to add: health benefits of honey, pollination benefits, space requirements)

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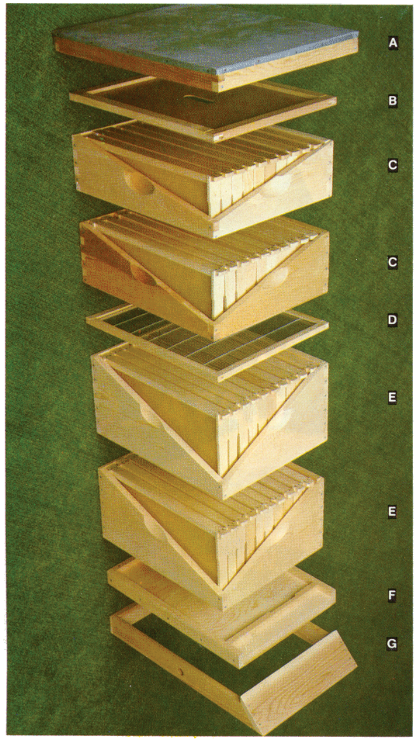


The modern bee hive is like a highly efficient multistoried factory with each "story" having a specific function. These "stories" work together to provide a home for bees and a honey factory for the beekeeper.

A) Hive Cover — telescoping cover "telescopes" over the sides of the top super to protect the hive. Galvanized covering.

B) Inner Cover — Creates a dead air space for insulation from heat and cold.

C) Shallow Supers — For "surplus" honey storage. Bees store their extra honey in these for the beekeeper to take. 6⅝", 5 11/16" supers, or even hive bodies may be used.

D) Queen Excluder — Keeps the queen bee in the brood chambers as she is too large to pass through the excluder.

E) Hive Bodies — "Brood Chambers" are the bee's living quarters. Queen lays eggs in these chambers and brood is raised. Honey is also stored for the bees' food.

F) Bottom Board — Forms the floor of the hive. Shown with wooden entrance reducer in place to keep mice and some cold out during winter.

G) Hive Stand — Supports the hive off the ground to keep hive bottom dry and insulate hive.

Successful beekeeping means easy manipulation of the frames of brood and honey to provide a "surplus" of honey beyond that needed by the bees to live on and rear their replacements. It is this "surplus" that the beekeeper removes and markets.

Components of the Hive

Up: The components of a traditional bee hive
Left: The Philips Design Probes Concept of The Urban Bee Hive

2110	/	Ingredients	=	Food Eaten
Kcal/day		Kcal/Kg		Kg/day

Whole Foods
Vegetables
Fruit
Legumes
Seeds
Nuts
----
white meat
----
dark meat
----
insects

Food Eaten	X	0.15 - 0.2*	=	Food Produced
Kg/day		% (percentage) *depending on the food category		Kg/day

365 days	X	Food Produced	/	Yield	=	Area/p.p.
		Kg/day insects, fish, mushrooms, snails, honey		Kg/year		m2/p.p.

2110 / Ingredients = Food Eaten

Kcal/day | Kcal/Kg | Kg/day

Whole Foods
Vegetables
Fruit
Legumes
Seeds
Nuts
----
white meat
----
dark meat
----
insects

Food Eaten X 0.15 - 0.2* = Food Produced

Kg/day | % (percentage) *depending on the food category | Kg/day

365 days X Food Produced / Yield = Area/p.p.

Food Produced: Kg/day
insects, fish, mushrooms, snails, honey

Yield: Kg/year

Area/p.p.: m2/p.p.

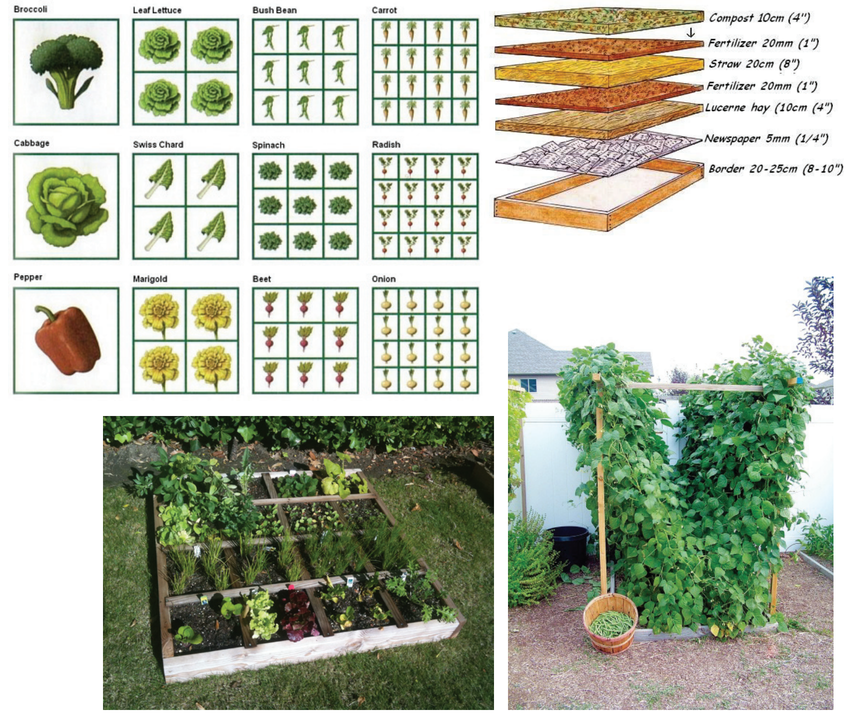
3.2. Efficient Growing Methods

Apart from choosing the more space efficient food sources (namely fruit and vegetable and less animal products), there are others ways to minimize the space needed to grow our food.
As the corporate food growing methods have proven disadvantages, this research looks into a different approach, starting from the basic methods used intuitively and based on experience by small scale farmers.

John Jeavons systematized and updated a wide range of traditional methods used to take advantage of small growing areas and named this system of rules "biointensive method".

A similar method, making use of minimum spaces, mostly in family gardens, is Square Foot Gardening. The term started becoming popular after it was used by Mel Bartholomew, who spread the technique through books and video series.
There is also a strategy called "aquaculture", that combines the growing of vegetables and the raising of fish at the same footprint, saving both space and resources. The same principles can be applied to the combined farming of different kinds of vegetables and animal species.

Square Foot Gardening



3.2.1. Square Foot Gardening

*less work load
*all the advantages of no-dig gardening and raised bed gardening:
-loose soil
-water savings
-no need for fertilizers
*very little weeding as the beneficial plants make use of all the space
*easy combination with covers and cages (even green-house covers) due to the small scale

Yields	Mid range yield (kg)	Spacing (m)	Maximum height and spread (m)	First Fruit (years)	Number per hectare	Yield (tonnes per hectare)
Tree Layer						
Apple (M26)	41	4	4	3-4	625	25.6
Pear (Quince A)	30	5	7	3-6	400	12.0
Plum (St Julien A)	32.5	4.5	4.5	3-6	494	16.0
Cherry (Colt fan)	10	4	2.5 and 5.5		625	6.3
Shrub Layer						
Raspberries	2.5	1	2 * 1	3-4	10000	25.0
Blackcurrants	4	1.8	1.8	3-6	3086	12.3
Gooseberry	4	1.5	1.5	3-6	4444	17.8

Source: Whitefield 2002

Biointensive Method Sample Yields Table

3.2.2. Bio Intensive Method

(to add: difference of biointensive method and square foot gardening)

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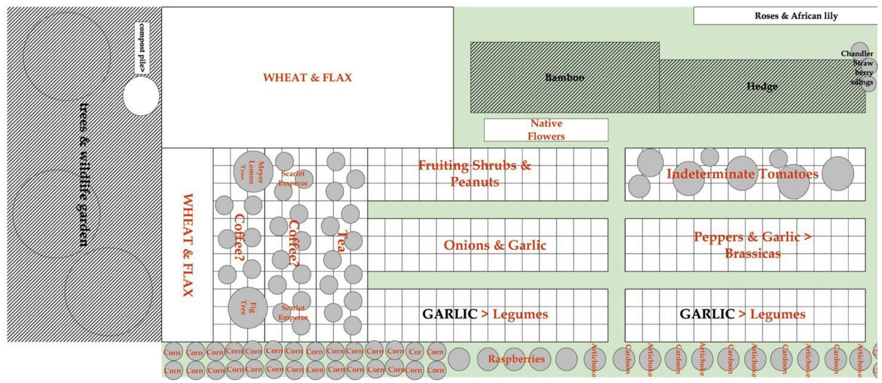
Biointensive Mini Farm



Biointensive Method Layout Example Diagram

Interview with Eldert van Henten

Professor of Agricultural Biosystems, Engineering,
Head of Farm Technology Group, Senior scientist at PRI
Wageningen UR Greenhouse Horticulture

-Food crisis versus energy crisis: How energy efficient can a greenhouse be? In northern countries, how much additional heating and/or lighting is needed to sustain crops during winter?

Currently the average use of natural gas in the Netherlands is 45m3/m2.year greenhouse which amounts to 4.5x109 m3/year. This amount is no longer considered acceptable by Dutch government and society and therefore the horticultural sector is put under pressure to reduce the use of natural gas. Clearly, natural gas is a limited resource. The targets for 2020 is that a considerable area of Dutch production should be energy neutral and a considerable portion should not use any fossil energy anymore. This is possible without doubt. Lighting is needed when you want to produce year round. Without lighting a lower production will be achieved during a shorter growing period. It depends on your business model whether this is acceptable or not. If you go further up north additional lighting becomes really necessary, but this is not the case in the Netherlands. Yes, it helps, for sure.

-Local eating: The "local eating" movement believes in eating localy to reduce the green house gas emissions produced by the transportation of food. There are, though, other studies that prove that it is the way we grow food that produces much more green house gases and wastes energy, and that growing foods in their natural environment/ climate and THEN transporting them, is much more efficient. What is your view on that matter?

Oh dear, I don't know the figures behind these observations, but I think both are right depending on the product. Currently, production in the Netherlands produces quite some CO2 and I think this exceeds CO2 production of trans-

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port. Yet, I recall a discussion on production of roses in The Netherlands and Kenia and I think this still favoured the Netherlands. But may be the source of this information was not fully 'independent'. We need some research on this. A LCA would give much insight. But there is more. Think of food security. If your food comes from a location that is politically instable, what happens when the mood changes? Think of food safety. Though production in the Netherlands is not fully clean, I am quite sure that the use of chemicals in many other countries is quite substantial. So, I think for this question we need to balance quite a lot of issues. Interesting stuff!

-Robotics: In your papers the words "robotics" and "automatic harvesting" re-appear often. How much labour time do you think that the automization of harvesting could save? Do you think that we could reach one point, at which we could grow our own food and still have time to keep our day job, by using these kind of robots? Do you estimate that they could be used in many scales? (minimal, "urban farming" to maximal, vast grain fields)

That is definitely an interesting question. Labour is currently the number 1 cost factor in horticultural production with roughly 35%. Energy costs amount to 20-25%. There is a strong demand for human labour, yet in the Netherlands no one wants to work in greenhouses. That is not strange. I read in the papers last week that currently in China 50% of the people are living in the city and will definitely not contribute to agricultural production anymore. In the Netherlands the labour volume in agriculture declined from roughly 30% in 1900 to below 3% today. So, less and less people have to provide for a growing population. That is a challenge and robotics and automation are one way to address this issue.

About growing our own food. Yes, I think it is possible. Then, I don't think many robots are needed, because growing your own food does not require a whole day.What you then do is distribute the work over many more people which the relieves the above mentioned problem of labour scarcity. In fact I heard that in Cuba this approach has successfully been implemented. There urban horticulture provides 50% of the food for Havana city and in the rural land is even up to 90 to 100%. But you definitely need a change in attitude of the consumer. Currently consumer hardly know how their food is produced and being a farmer is not considered to be a prestigious job. May be this changes in future.

Concerning scale size. That is my ambition. Currently the idea in agriculture is that machines require large scalesizes. I am not in favour of that. I think we also should develop technology that can be used in small scales. Also sharing of machines in a collaborative structure might help.

-Greenhouses: What are the latest innovations concerning green house

technology? How easy is it to sustain a green house? What are the estimated set-up and functional costs of a green house? What is the smallest crop/ vegetable garden size that it would make sense to use an automated green house set up for?

Sensing of plant responses, energy saving measures, automation, mechanization, decision support.

A blank greenhouse structure costs roughly 50 euro per m2. Depending on technical bells and whistles the overall price can go up to 100-200 and even 300 euro per m2

The best size is hard to tell. Current trend is of scale enlargement. Current average size is 1.5 to 2 ha. But I recall that some 15% of the growers currently account for 50% of the production area in the Netherlands. But that is not a law. I remember I was looking after a small greenhouse for my sister a couple of years ago, in an urban environment, covering some 6 m2 and obtained quite a nice production of tomatoes without much technology and spending much time on it every day. So it all depends on the business model. Who is willing to do what and for how much money and effort. As long as people expect their food to come from the supermarket in all sorts, shapes, sizes and pre-processed AND for low cost, the current trend in greenhouse horticulture will definitely continue.

-Greenhouse in the City: What impact do you believe it would have to a city's natural climate if vegetable food production came INTO the city, protected by green houses? Do you imagine a temperature rise, for example?

No, I don't expect much impact. There may be some light interference. Urban horticulture is an interesting issue because you can integrate the use of the different resources like energy and water. Yet, it may be a challenge to achieve sufficient productivity.

-Future: By 2050, how far do you think the green house will have gone? Could you describe your vision of the green house of the future? How "green" could it be? Could it use alternative energy sources? Could it produce much higher yields on the same surface due to innovation? Could it control itself the temperature/ humidity and readjust without the need of frequent checks?

There is a tendency towards more green greenhouses for sure and this will continue. Greenhouse crop production is a very effective way to produce large amounts of food and this is needed in the future. Yes, alternative energy sources need to be and will be used. More efficient use and storage of solar energy and alternative energy sources like geothermal energy, cluster-

3. Make it Feasible, Make it Work ! / Towards a Better Diet

ing of users and producers etc. Yes, productivity still increases. It is not so long ago that a grower would be proud of 45 kg tomatoes per m2. In a high-tech environment productions up to 100 kg have been achieved. Greenhouse offer the opportunity to push production higher than would ever be possible in open cultivation. Yes, greenhouses are currently already fully automated when it comes to cimate management. Yet, the grower interferes quite a lot as an expert. The current trend is to support and replace the grower more and more using knowledge based support and control systems. But this needs more time.

Interview with Eldert van Henten

"About growing our own food. Yes, I think it is possible. Then, I don't think many robots are needed, because growing your own food does not require a whole day.What you then do is distribute the work over many more people which the relieves the above mentioned problem of labour scarcity. In fact... that **in Cuba** this approach has successfully been implemented. There **urban horticulture provides 50% of the food for Havana city and in the rural land is even up to 90 to 100%.**"

Havana

728.26 km2

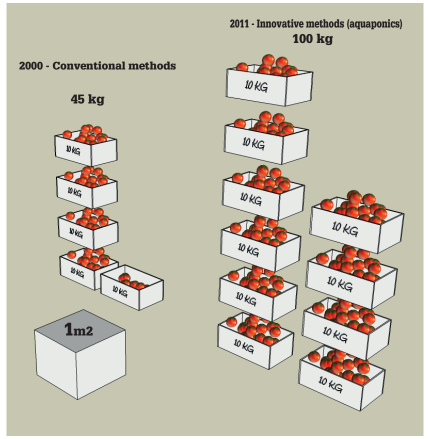
2.1 million inhabitants

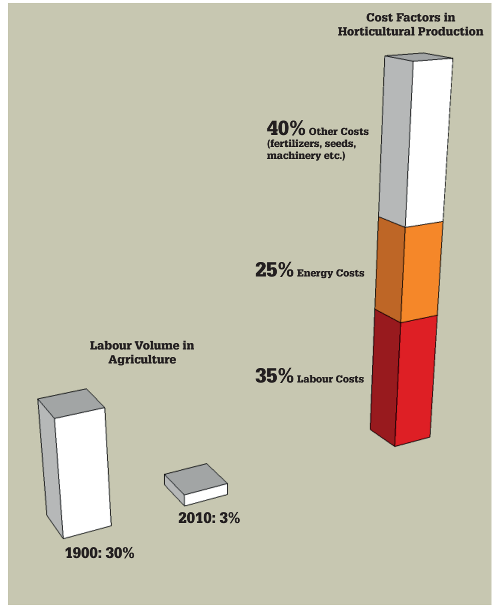
"**Organopónicos** are a system of **urban organic gardens** in Cuba. They often consist of low-level concrete walls filled with organic matter and soil, with lines of drip irrigation laid on the surface of the growing media. Organopónicos provide access to job opportunities, a fresh food supply to the community, neighborhood improvement and beautification of urban areas.

Organopónicos first arose as **a community response to lack of food security** after the collapse of the Soviet Union. They are publicly functioning in terms of ownership, access and management, but heavily subsidized and supported by the Cuban government. "

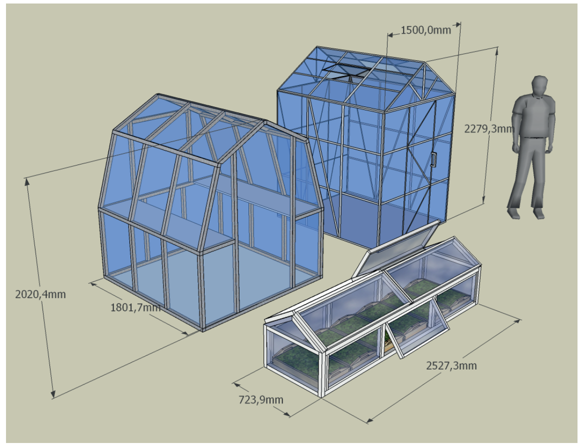
Wikipedia

Interview with Eldert van Henten





Interview with Eldert van Henten



"A blank greenhouse structure costs roughly **50 euro per m2**. Depending on technical bells and whistles the overall price can go up to 100-200 and even 300 euro per m2"

"...in an urban environment, **covering some 6 m2 and obtained quite a nice production of tomatoes without much technology and spending much time on it every day.** So it all depends on the business model. Who is willing to do what and for how much money and effort."

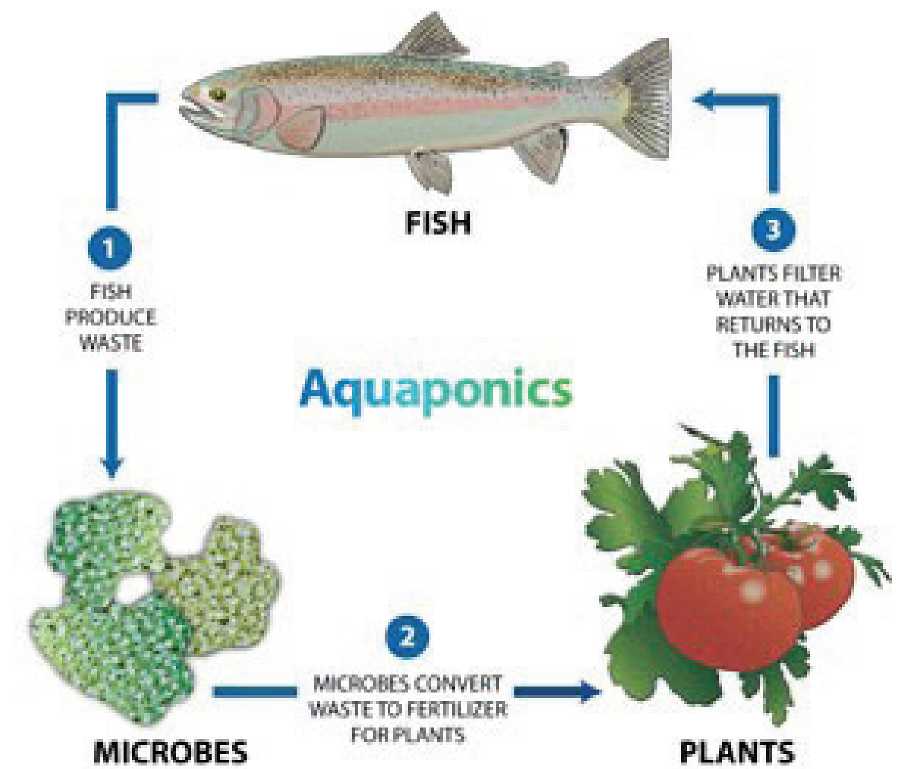
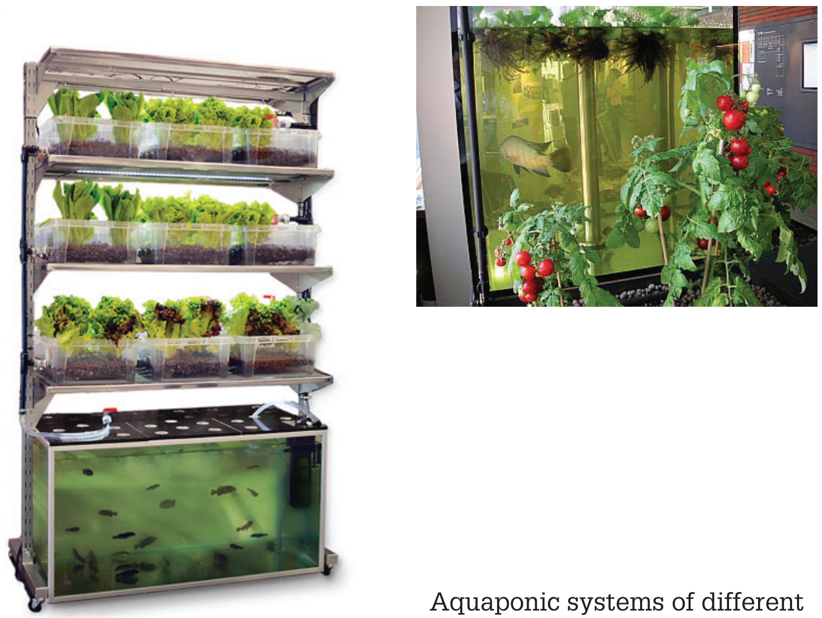


Diagram of Aquaponics Mechanism

3.2.3. Aquaponics

*the water is used very efficiently to grow two crops - fish & plants
*zero environmental impact - no nutrient-rich waste-water discharge
*two crops from the one input - the fish feed entering the system supports the growth of both fish and plants
*small footprint/high density - because of their compact nature, facilities may be located very close to the end users (restaurants, green grocers, food manufacturers, public) in a variety of locations (country, city)

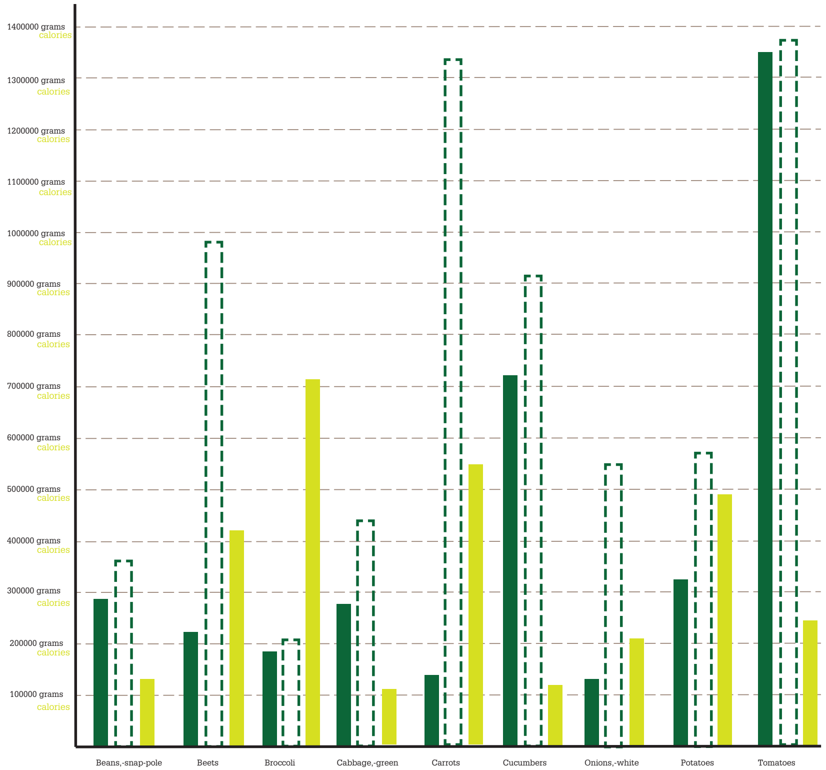
3. Make it Feasible, Make it Work ! / Towards a Better Diet



Aquaponic systems of different scales

Why hydroponic farming ?

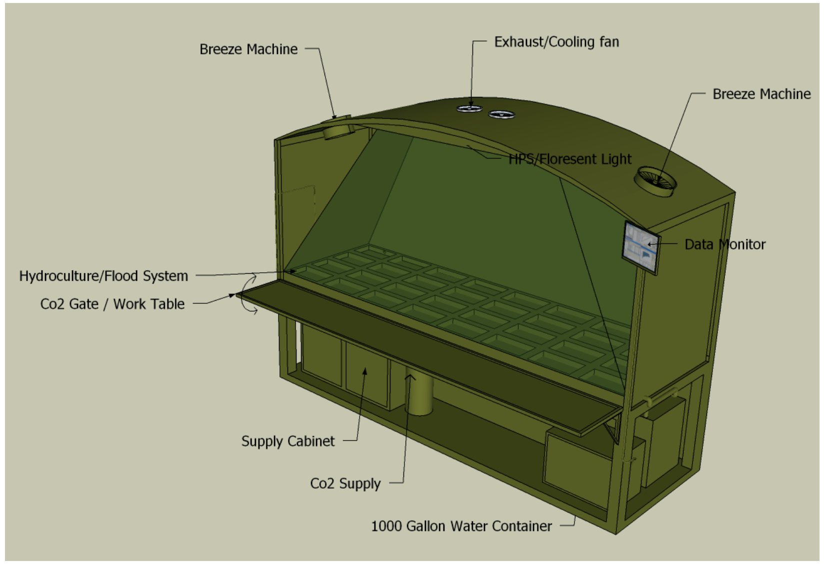
	Conventional Farming Yield per 10 square meters/ per year (crop* n. of crops)	Hydroponic Farming Yield per 10 square meters/ per year	Calories per gram	Caloric output of 10 square meters	Number of portions (1/3 of daily caloric intake: 700 Kcal)
Beans,-snap-pole	58000 grams X 5 = 290000 grams	375000 grams	0,35 Kcal	131250 Kcal	187
Beets	45000 grams X 5 = 225000 grams	982000 grams	0,43 Kcal	422260 Kcal	603
Broccoli	45000 grams X 4 = 180000 grams	204000 grams	0,35 Kcal	71400 Kcal	102
Cabbage,-green	68000 grams X 4 = 272000 grams	427000 grams	0,25 Kcal	106750 Kcal	152
Carrots	34000 grams X 4 = 136000 grams	1339000 grams	0,41 Kcal	548990 Kcal	784
Cucumbers	181400 grams X 4 = 725600 grams	903000 grams	0,12 Kcal	108360 Kcal	154
Onions,-white	45000 grams X 3 = 135000 grams	556000 grams	0,39 Kcal	216840 Kcal	309
Potatoes	108000 grams X 3 = 324000 grams	570000 grams	0,86 Kcal	490200 Kcal	700
Tomatoes	453000 grams X 3 = 1359000 grams	1364000 grams	0,18 Kcal	245520 Kcal	350
				Average: 260174 Kcal	Average: 371



3.2.4. Hydroponics

As not all types of vegetables and fruit can be combined with aquaponics, hydroponics is the next best solution, as it offers much higher yields than regular farming. It also saves resources (namely, water and a great amount of fertilizers)

http://www.androidworld.com/prod26.htm



1. yields of hydroponic crops can be 100 times as high as that of field grown crops.

2. Hydroponic or greenhouse production of vegetable crops will provide a more reliable source of food due to its year round growing season and lower susceptability to bad weather and pest damage.

3. Low quality and therefore low cost land can be used for hydroponics since the soil is not used. Since the government owns lots of land, the land cost should be almost nothing.

4. Facilities could be constructed in center cities. That would save on transportation costs between the growing facilities and the market. Unemployed people could be hired to pick and pack the harvest.

2110 / Ingredients = Food Eaten

Kcal/day | Kcal/Kg | Kg/day

Whole Foods
Vegetables
Fruit
Legumes
Seeds
Nuts
----
white meat
----
dark meat
----
insects

Food Eaten X 0.15 - 0.2* = Food Produced

Kg/day | % (percentage) *depending on the food category | Kg/day

365 days X Food Produced / Yield = Area/p.p.

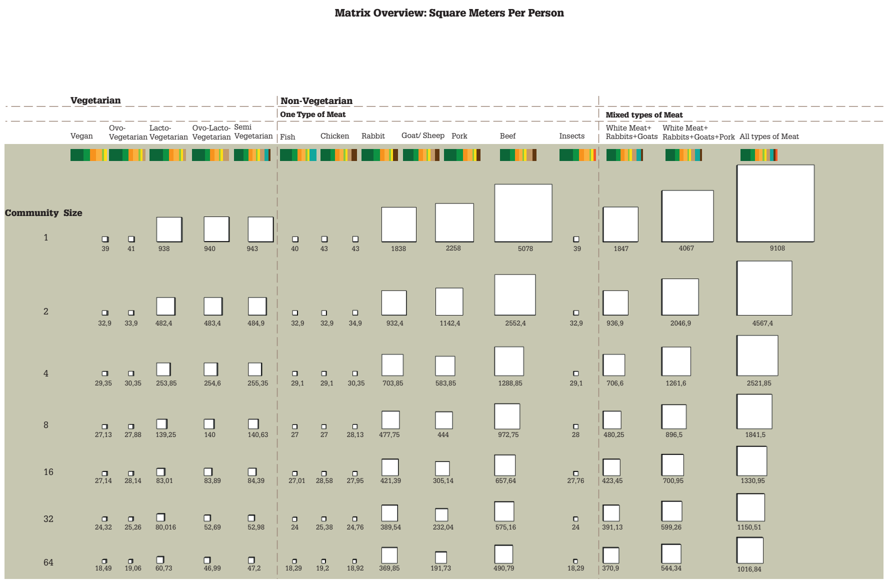
Food Produced: Kg/day
insects, fish, mushrooms, snails, honey

Yield: Kg/year

Area/p.p.: m2/p.p.

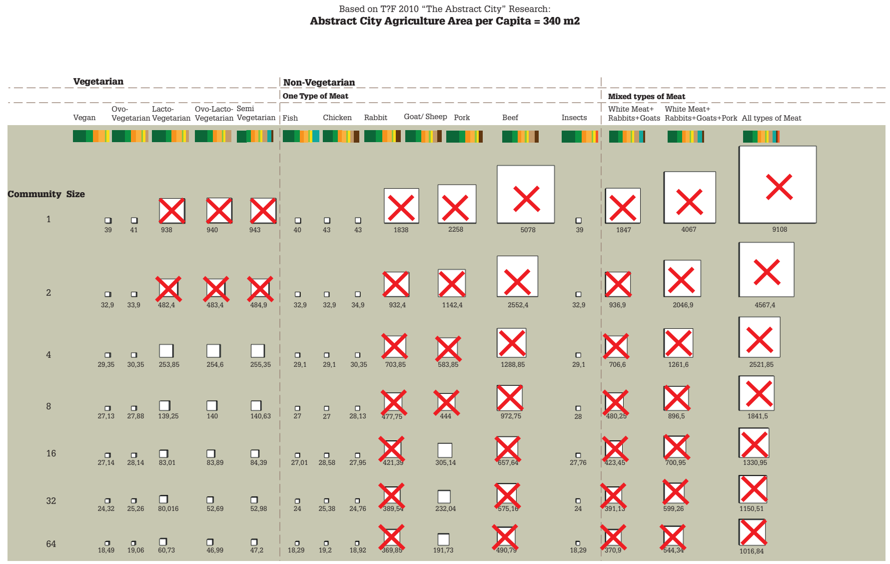
3.3. Size Limit

In order to define the maximum size of the agriculture production area, a study is made, comparing the average agricultural area per person as is today with the residential area per person. If agriculture could be shrunken enough to fit within a "residential footprint", then the city could keep it's urban character, while benefitting from the advantages of having food production within it.



Square meters per person

3. Make it Feasible, Make it Work ! / Towards a Better Diet



Square meters per person/ Agriculture

Square meters per person/ Residential

3.4. Optimized Foodprints

Choosing a healthy, space efficient diet

List of Diet Options	vegetables	fruit	cereal	legumes	fish and shellfish	dairy and eggs	meat	Insects	TOTAL FOODPRINT	
Diet 1										
Percentage in Diet	0,5	0,2	0,1	0,2	Not Included	Not Included	Not Included	Not Included		
Average Foodprint	179,5	251,6	168,8	73					672,9	
Optimized Foodprint	14	7	110	13,4					144,4	
Diet 2										
Percentage in Diet	0,4	0,2	0,05	0,1	Not Included	Not Included	Not Included	0,25		
Average Foodprint	143,6	251,6	84,4	36,5				17,75	533,85	517,1
Optimized Foodprint	11,2	7	55	6,7				17,75	79,9	63,15
Diet 3										
Percentage in Diet	0,5	0,2	Not Included	0,1	0,1	Not Included	Not Included	0,1		
Average Foodprint	179,5	251,6		36,5	12,9			7,1	487,6	481,5
Optimized Foodprint	14	7		6,7	6			7,1	40,8	34,7
Diet 4										
Percentage in Diet	0,5	0,2	Not Included	0,1	0,1	0,1	Not Included	Not Included		
Average Foodprint	179,5	251,6		36,5	12,9	160			640,5	
Optimized Foodprint	14	7		6,7	6	0,6			34,3	
Diet 5	0,6	0,2	Not Included	0,2	Not Included	Not Included	Not Included	Not Included		
Percentage in Diet	215,4	251,6		73					540	
Average Foodprint	16,8	7		13,4					37,2	
Optimized Foodprint										
Diet 6										
Percentage in Diet	0,45	0,15	0,1	0,1	0,1	0,05	0,05	Not Included		
Average Foodprint	161,55	188,7	168,8	36,5	12,9	80	80		728,45	2328,45
Optimized Foodprint	12,6	5,25	110	6,7	6	0,3	0,3		141,15	1741,15
Average Foodprint	359	1258	1688	365	129	1600	1600	71		
Optimized Foodprint*	28	35	1100	67	60	6	6	71		
*foodprint based on a diet based on the most space efficient and nutrient dense crops						Note 1: 965m2 is the average, but this means 2 goats--> min surface 1600 m2				In this column the whole animal and the grazing land is included. So this is the realistic foodprint.
						Note 2: Optimized option includes eggs but not milk				In this column the reproduction of insects is taken into account, so this is the realistic foodprint.

FOOD

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Production

FOOD

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Production

Processing

FOOD

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Production

Processing

Consumption

FOOD

Production

Processing

Consumption

-Desertification

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FOOD

Production

-Desertification
-Monoculture

Processing

Consumption

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FOOD

Production

Processing

Consumption

-Desertification
-Monoculture
-Abuse of chemical fertilizers

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FOOD

Production

Processing

Consumption

-Desertification
-Monoculture
-Abuse of chemical fertilizers
-Soil erosion/ degradation

FOOD

Production | Processing | Consumption

Production

-Desertification
-Monoculture
-Abuse of chemical fertilizers
-Soil erosion/ degradation
-GMOs/ hormones/ antibiotics

Processing

Consumption

FOOD

Production

-Desertification
-Monoculture
-Abuse of chemical fertilizers
-Soil erosion/ degradation
-GMOs/ hormones/ antibiotics

Processing

-Processed foods=Great energy waste

Consumption

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FOOD

Production

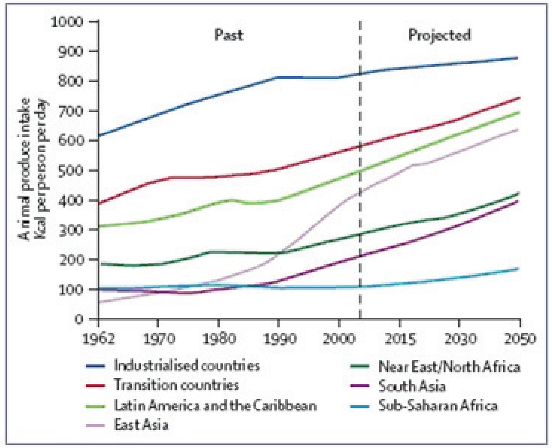
-Desertification
-Monoculture
-Abuse of chemical fertilizers
-Soil erosion/ degradation
-GMOs/ hormones/ antibiotics

Processing

-Processed foods=Great energy waste

Consumption

-Increased meat consumption



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FOOD

Production

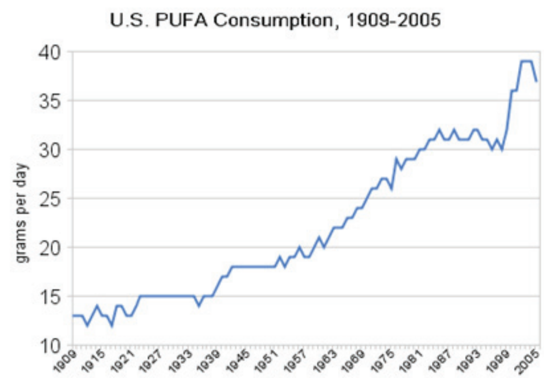
-Desertification
-Monoculture
-Abuse of chemical fertilizers
-Soil erosion/ degradation
-GMOs/ hormones/ antibiotics

Processing

-Processed foods=Great energy waste

Consumption

-Increased meat consumption
-Increased consumption of processed foods



FOOD

Production

-Desertification
-Monoculture
-Abuse of chemical fertilizers
-Soil erosion/ degradation
-GMOs/ hormones/ antibiotics

Processing

-Processed foods=Great energy waste

Consumption

-Increased meat consumption
-Increased consumption of processed foods
-Unhealthy food choices=Overloaded health system

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Exploration of efficient ways of food production with the goal of food autarky.

Exploration of **energy and space** efficient ways of **environmental friendly and healthy** food production, **by the individual and the community,** with the goal of food autarky.

Exploration of **energy and space** efficient ways of **environmental friendly and healthy** food production, **by the individual and the community,** with the goal of food autarky.

- Innovative food production methods

- Rethink food ingredients

- Improved diet (space - environment - health)

-Passive microclimate system (no extra energy)

-No artificial lighting/ heating/ cooling for food growth

-User friendly

-Mass-production friendly

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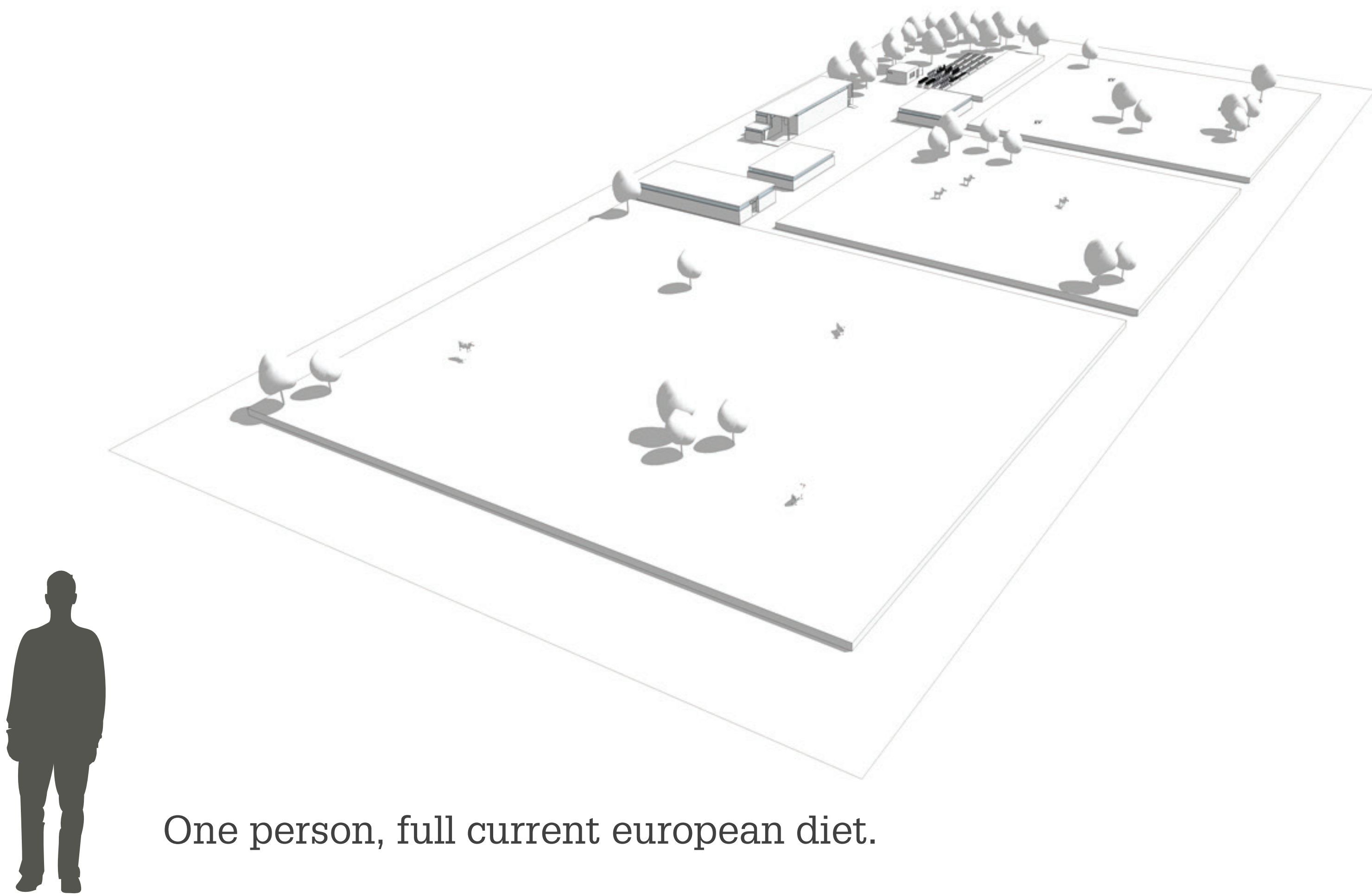
Agro-City

? Collaboration = Efficiency ?



One person, full current european diet.

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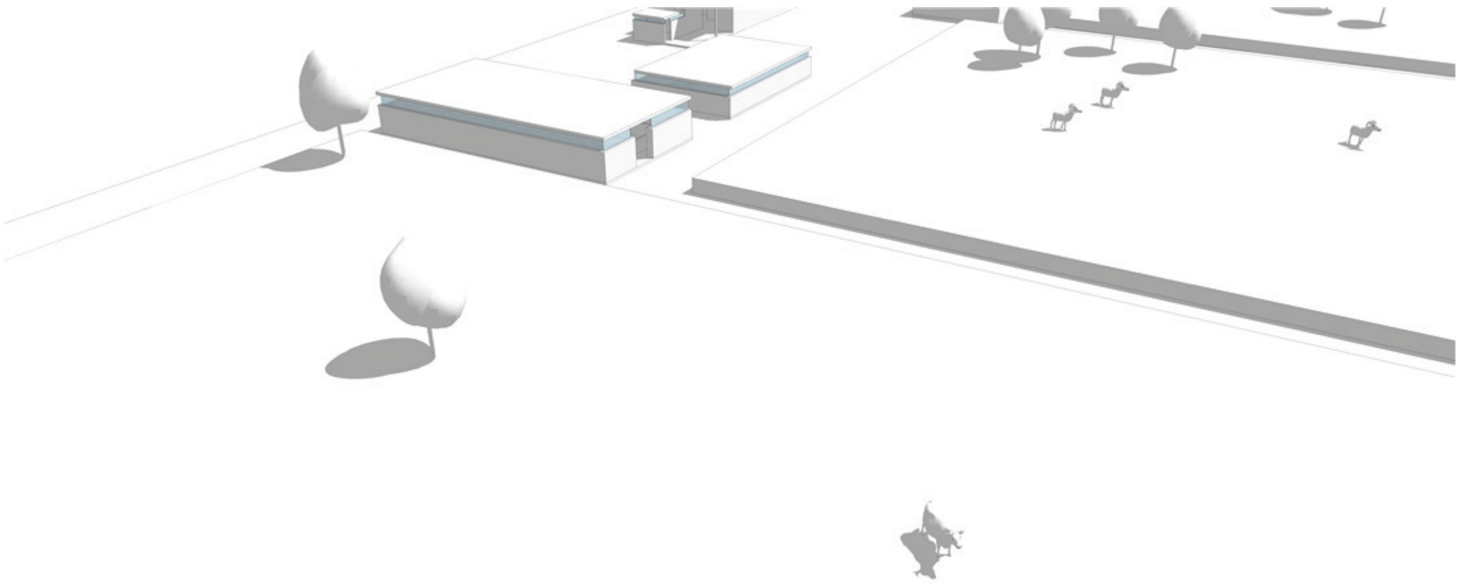

Organic, grass fed beef requires 1200 m2 per cow.

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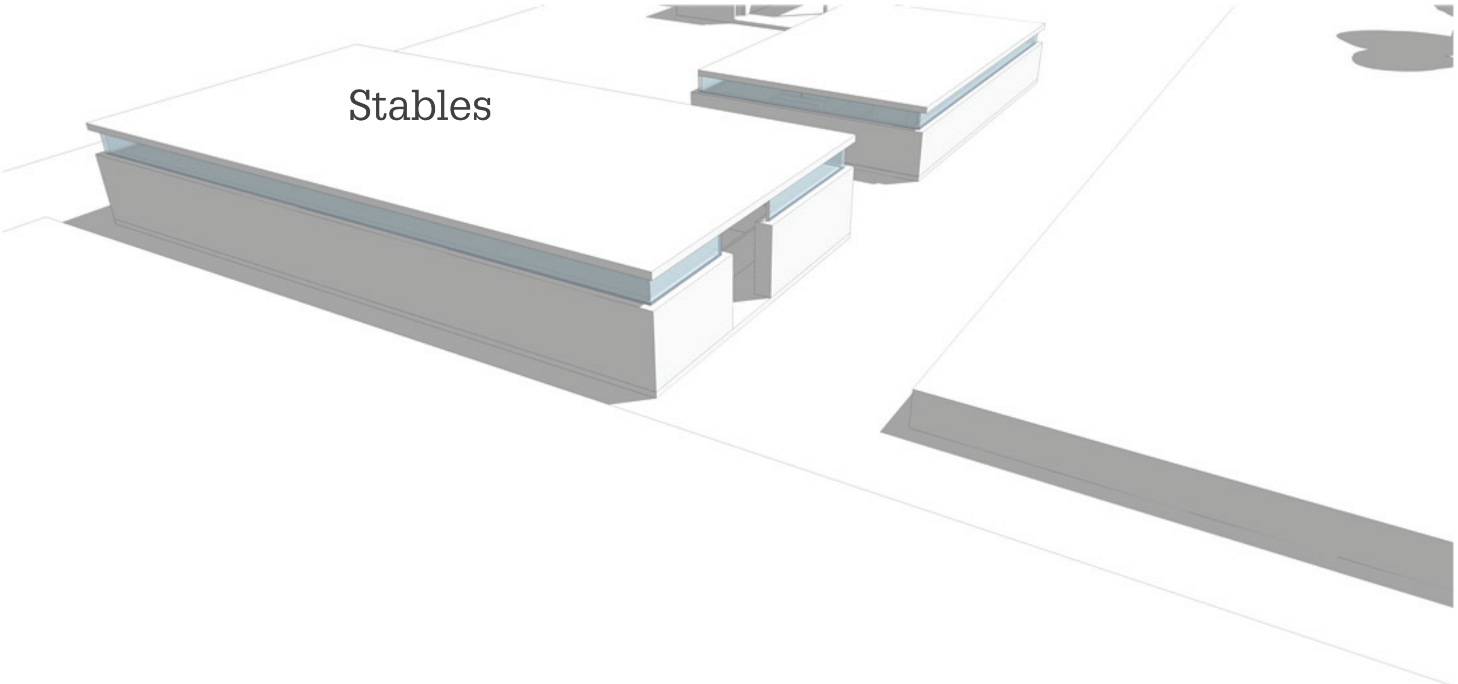

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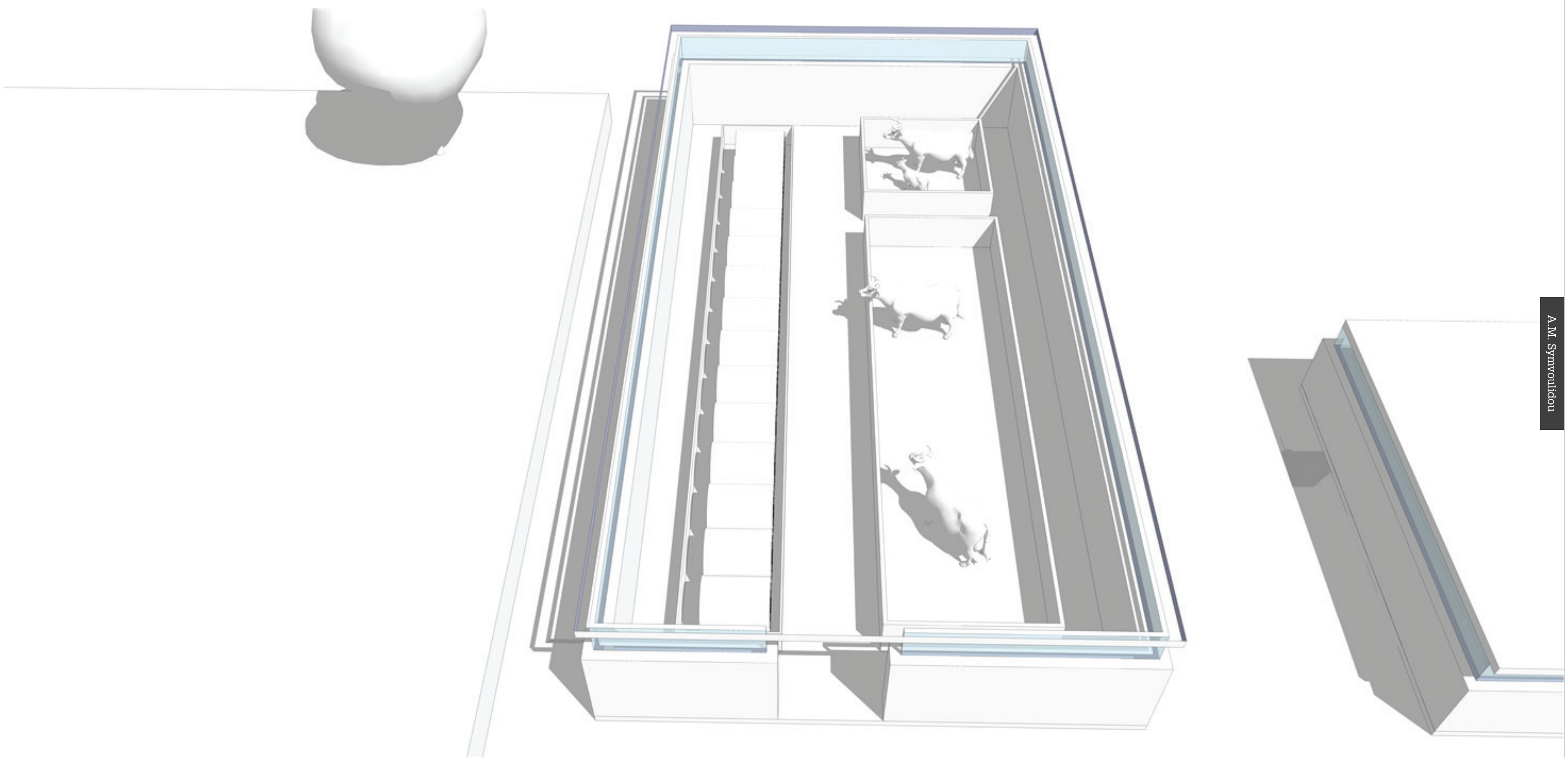

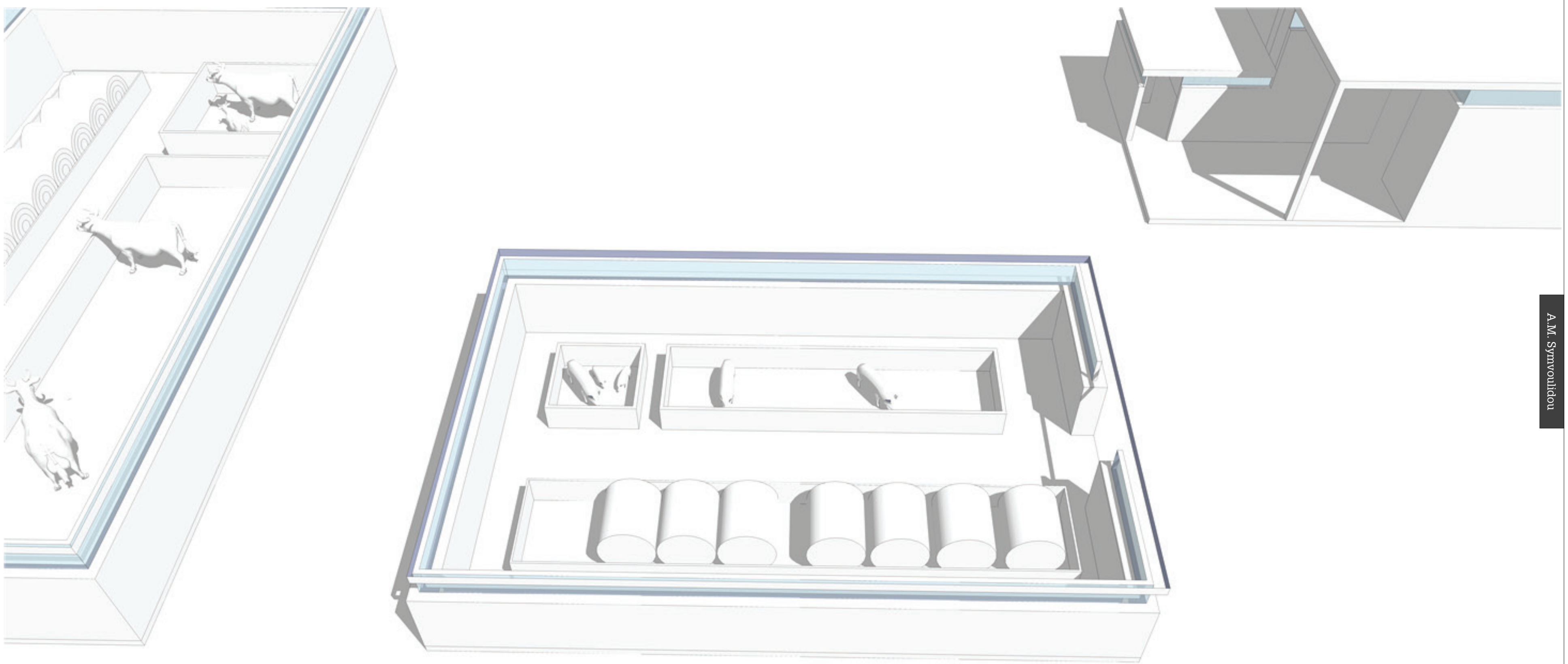

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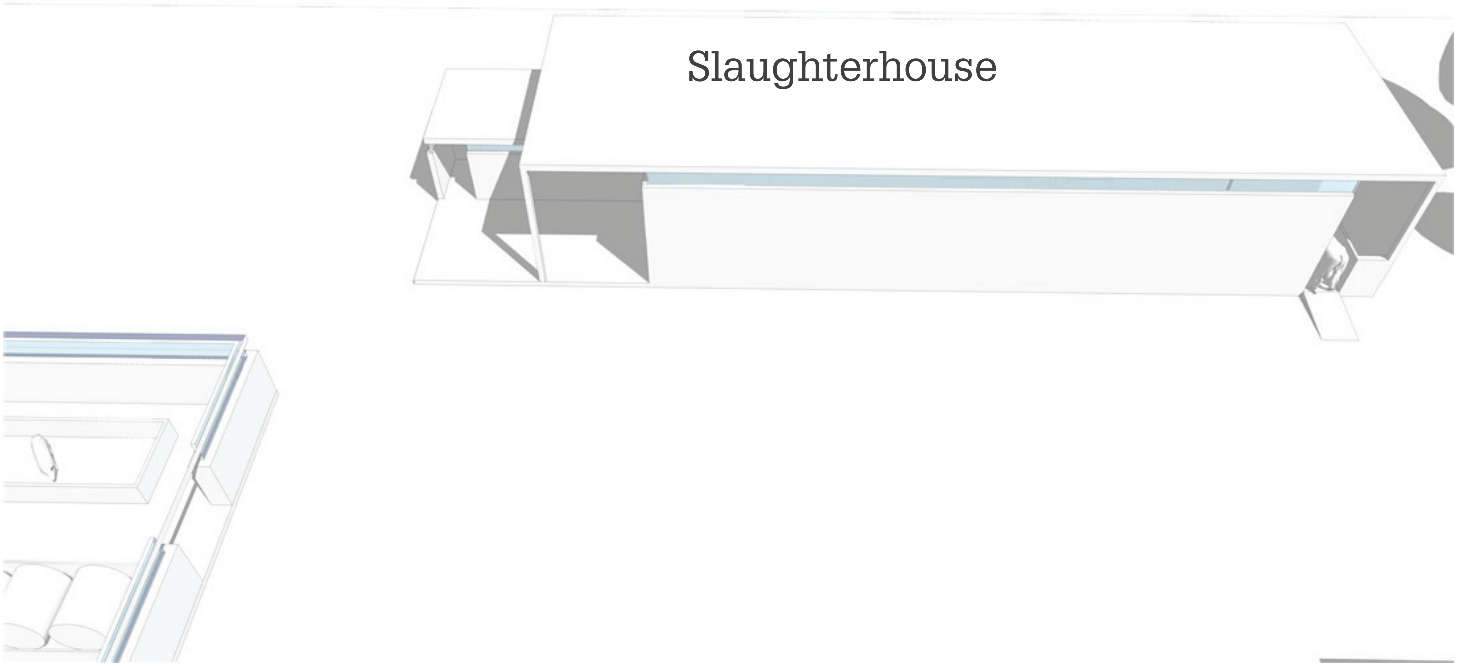

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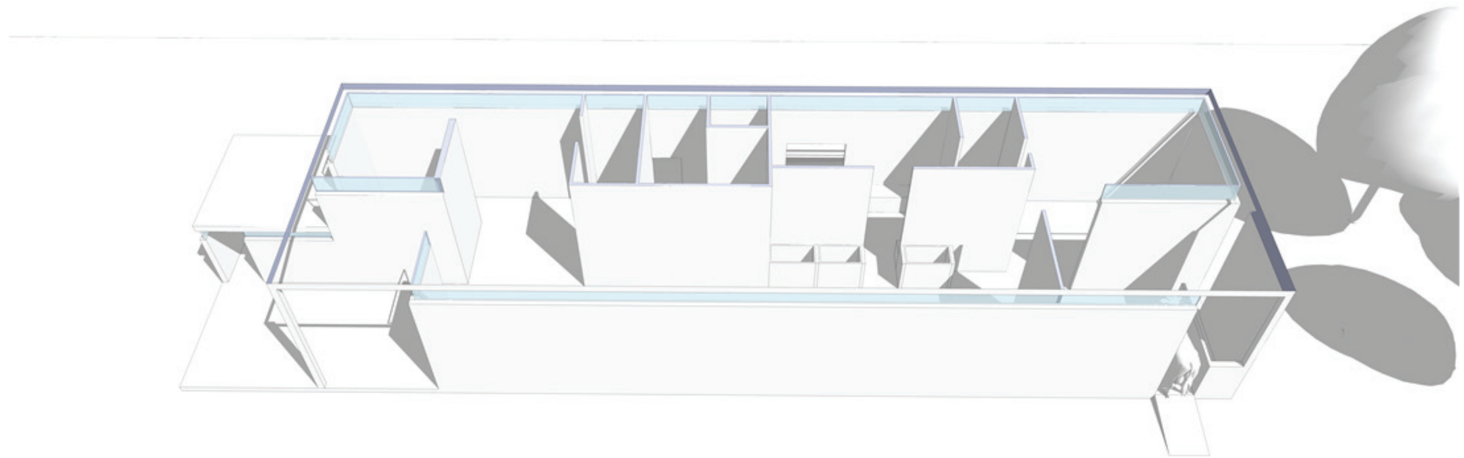
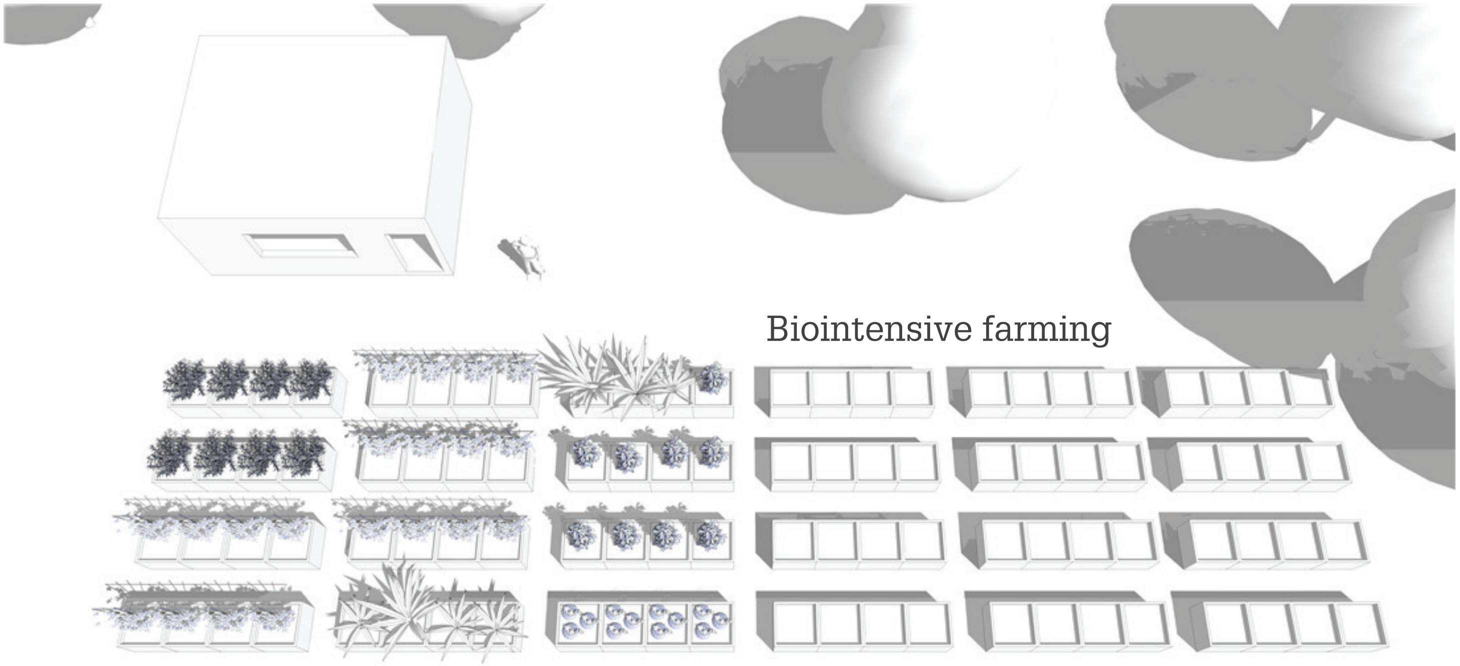
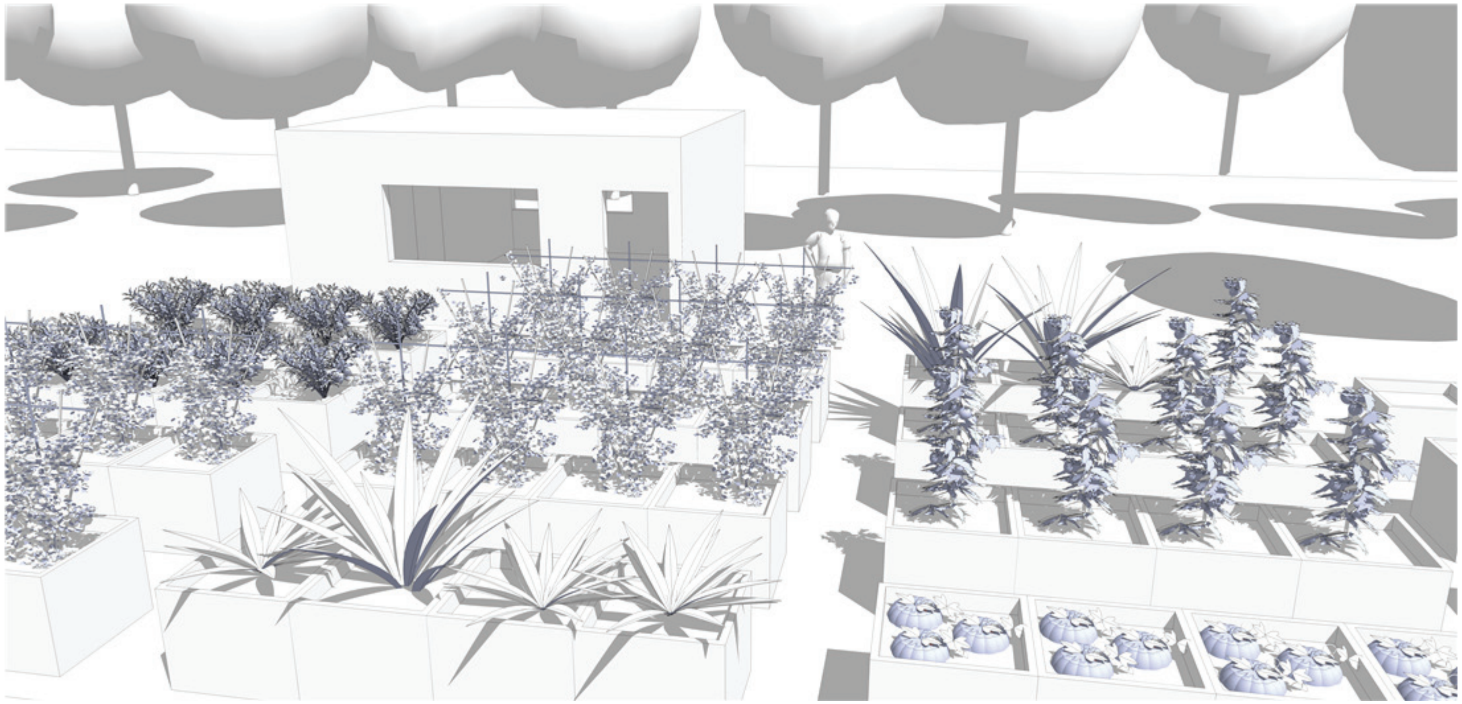
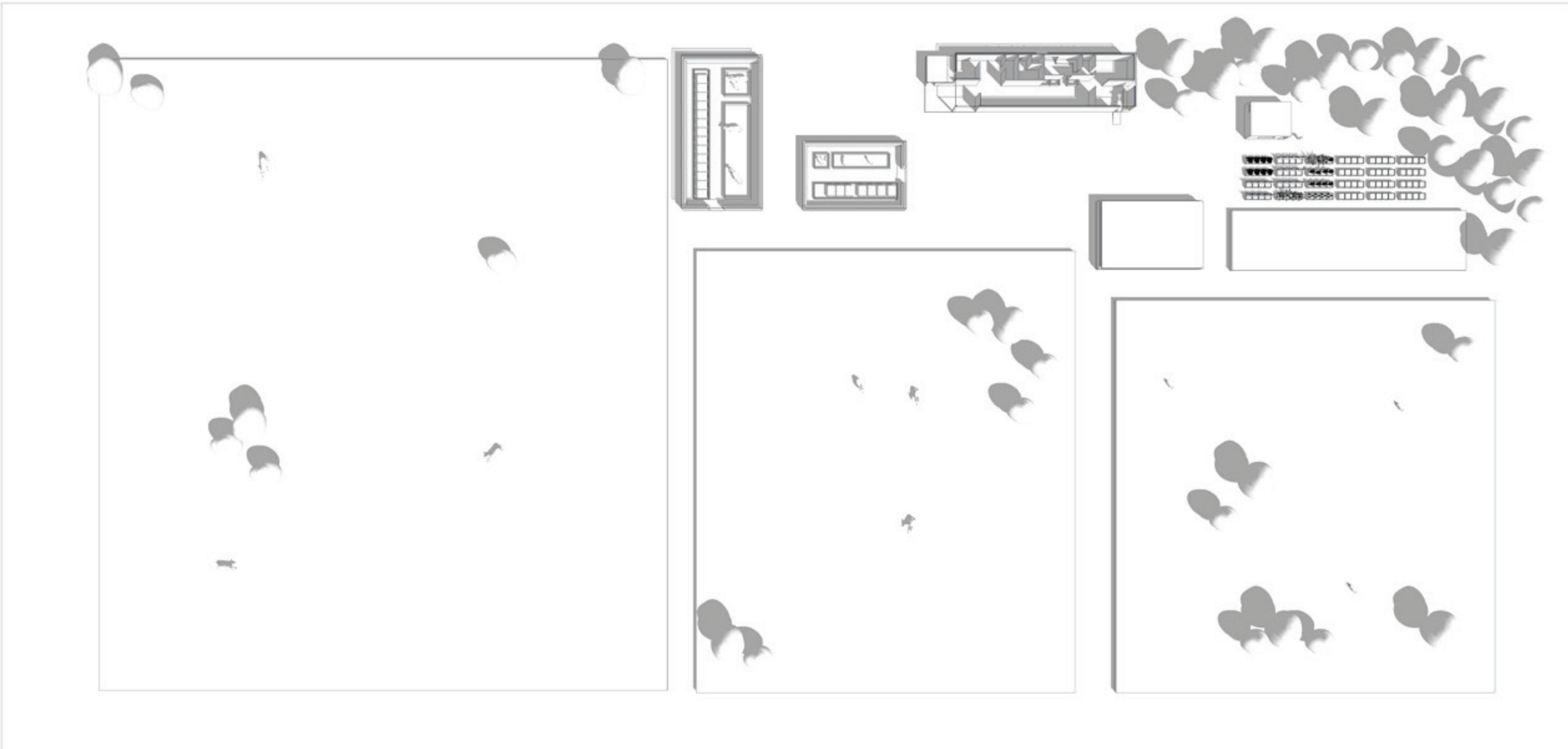


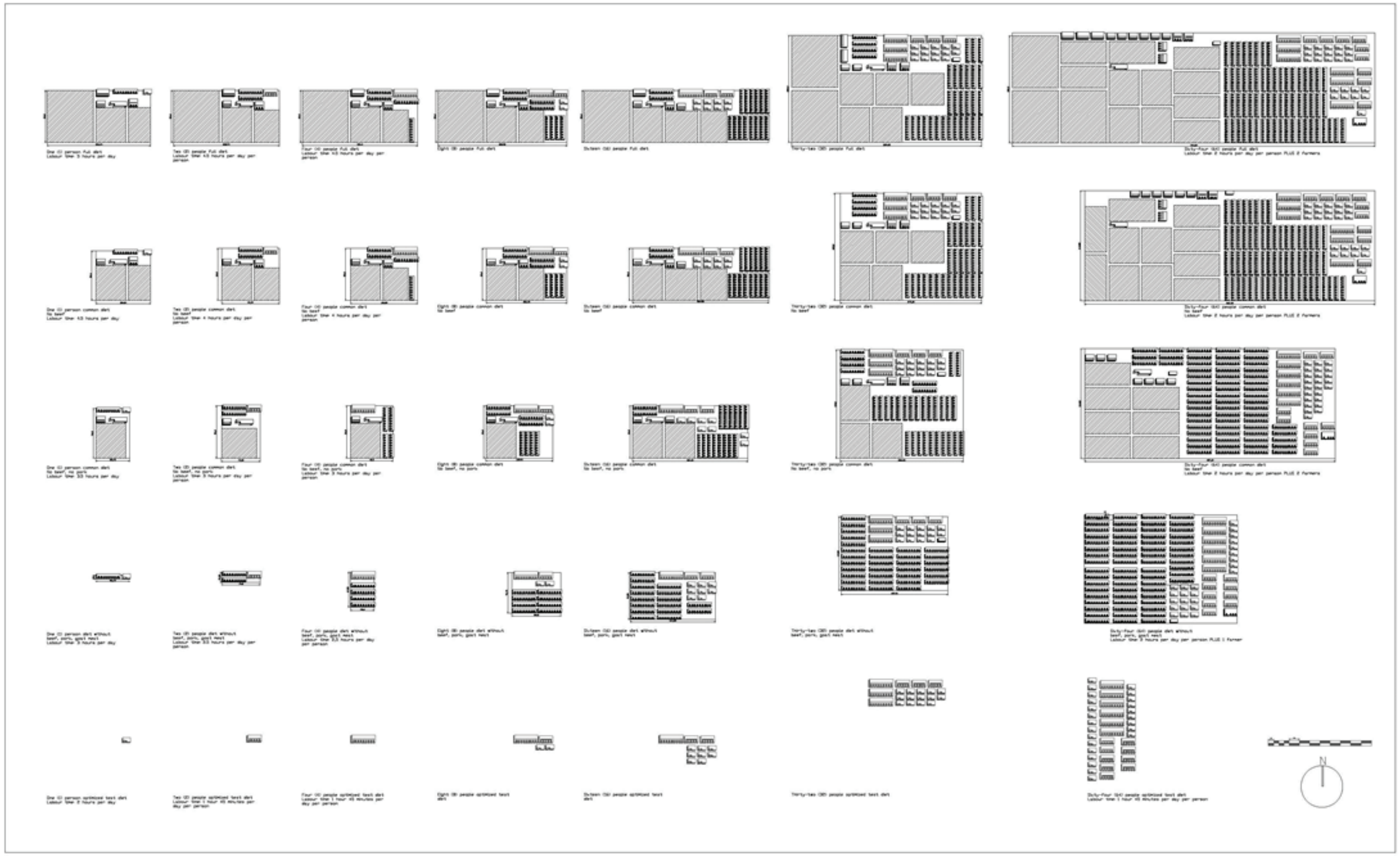

Fruit Trees
Fruit Trees


Biointensive farming





Collaboration effect on different diets



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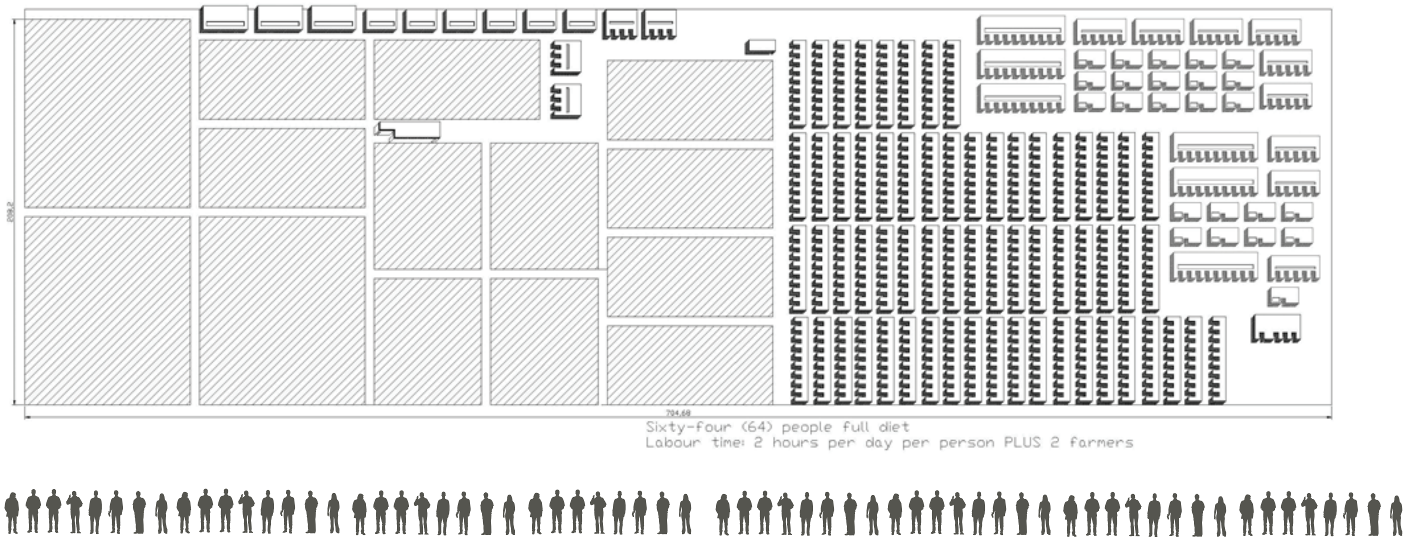

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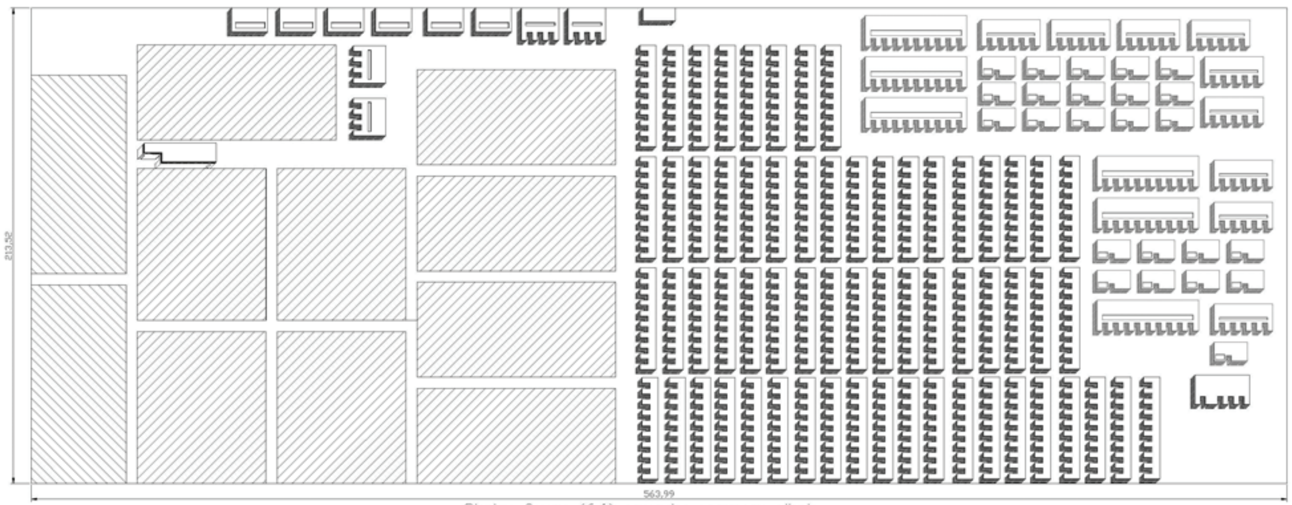

Sixty-four (64) people common diet
No beef
Labour time: 2 hours per day per person PLUS 2 farmers

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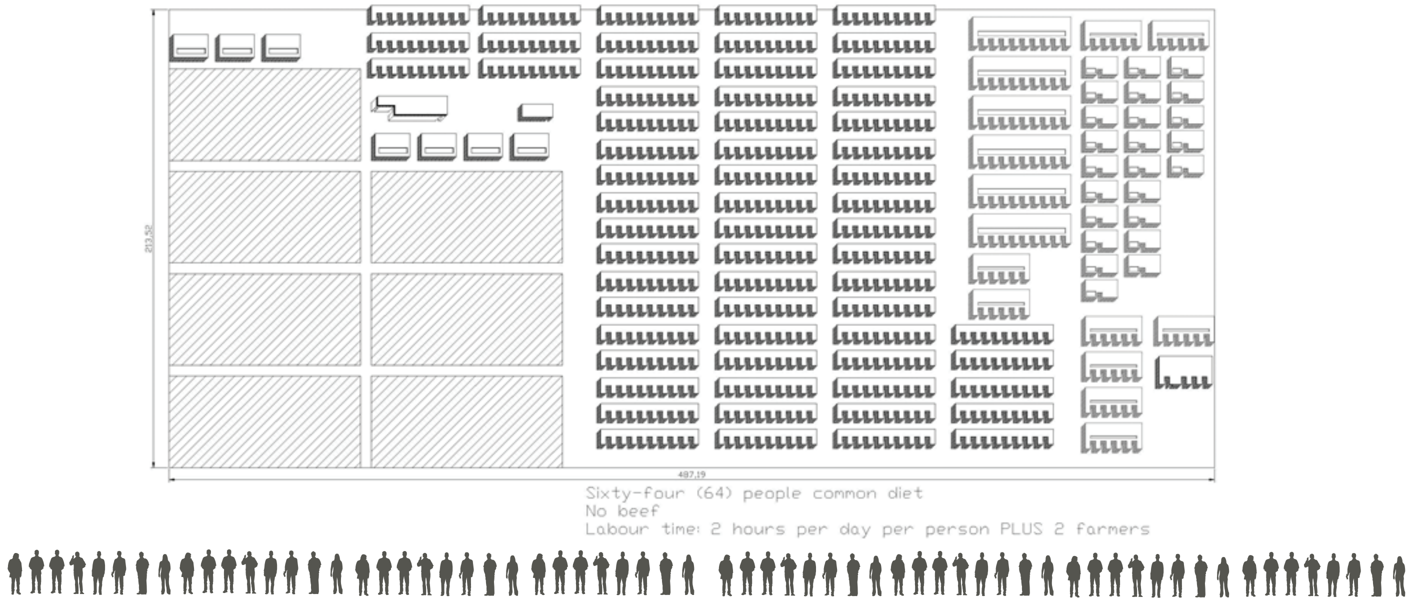

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Sixty-four (64) people diet without
beef, pork, goat meat
Labour time: 2 hours per day per person PLUS 1 farmer

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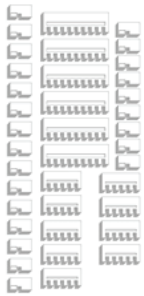

Sixty-four (64) people optimized test diet
Labour time: 1 hour 45 minutes per day per person

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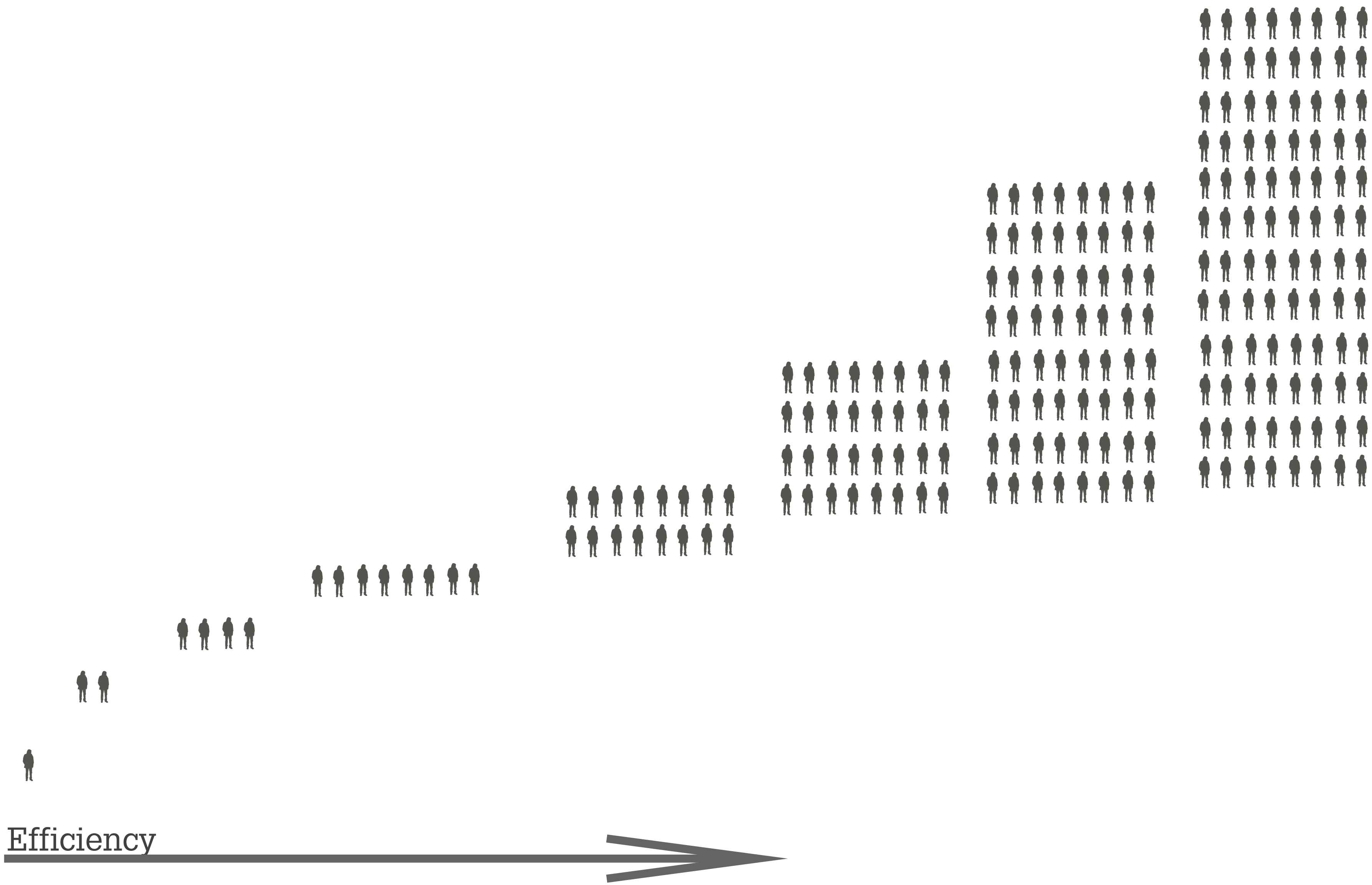

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+

Space efficiency

Food variety

Time efficiency

-

Efficincy limited to animal based diets

A full -animal including- diet is not feasible for less than 4 people

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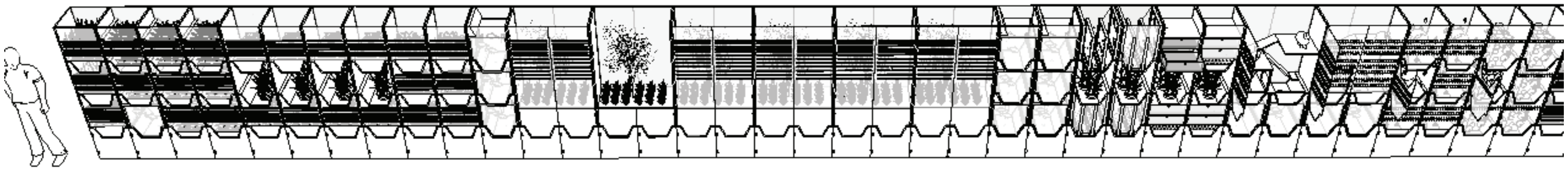
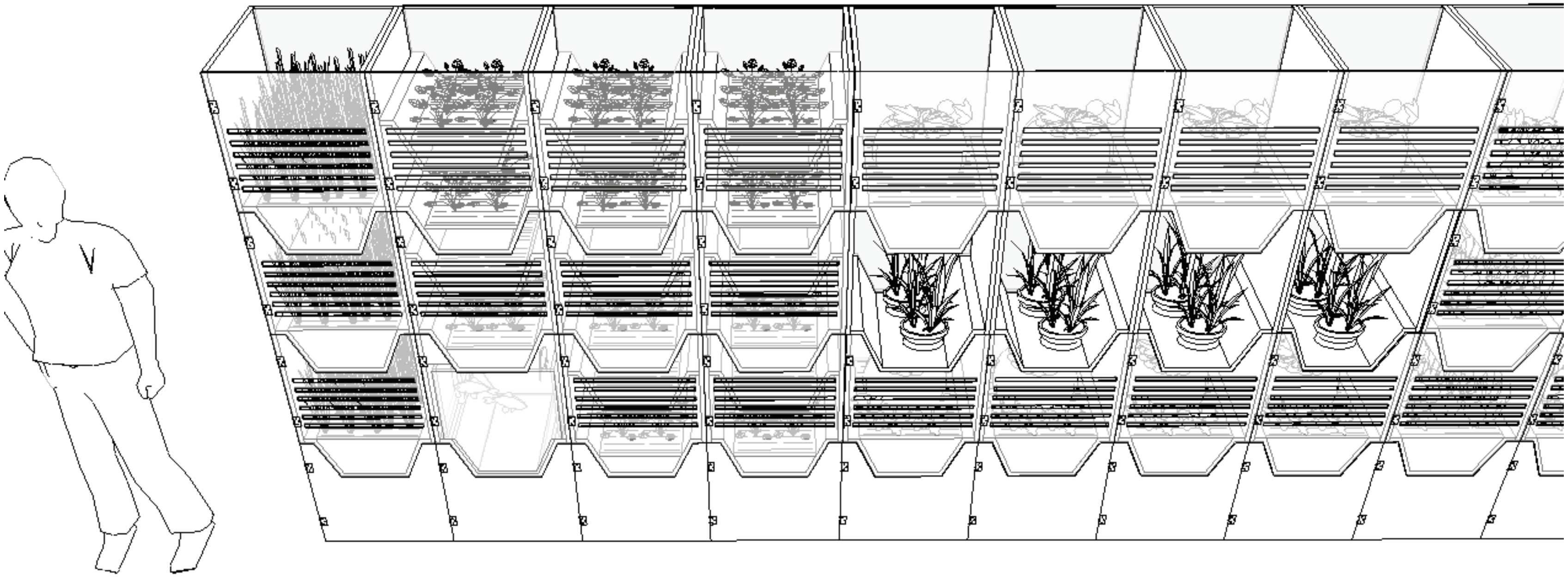
The i-Crates

This is the total number of crates needed to produce food for one person.





i-Crates fall into a grid of 60 X 60 X 60 cm.

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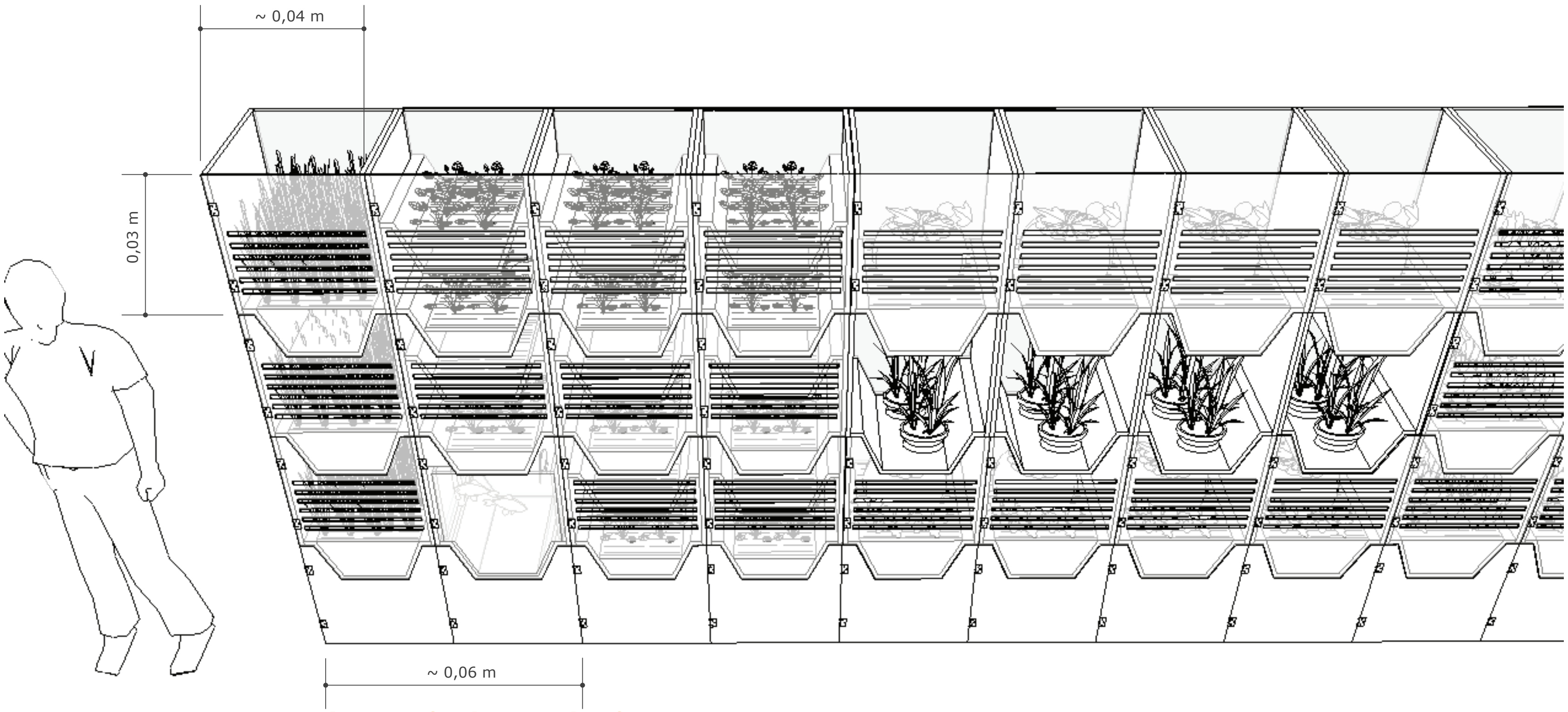

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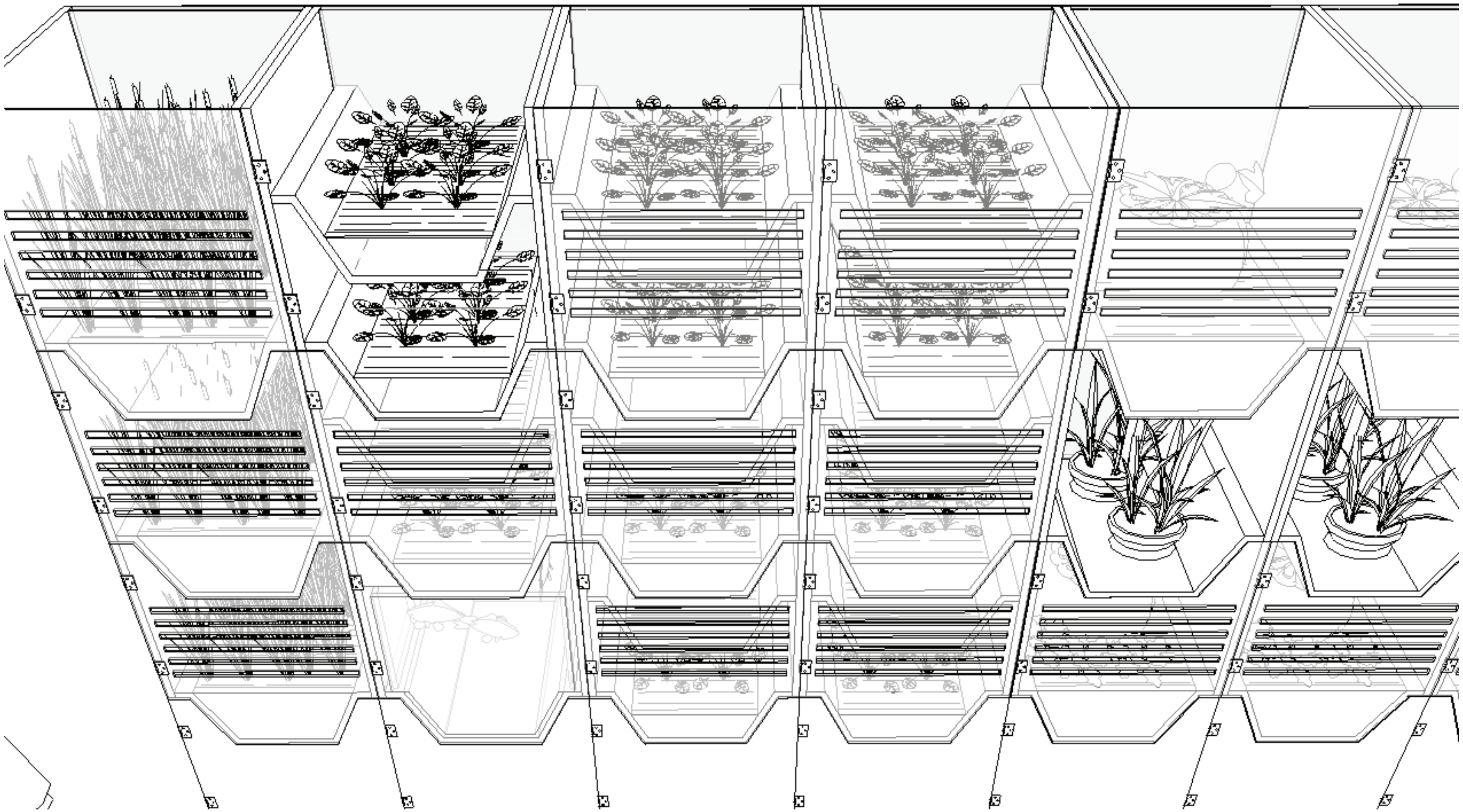

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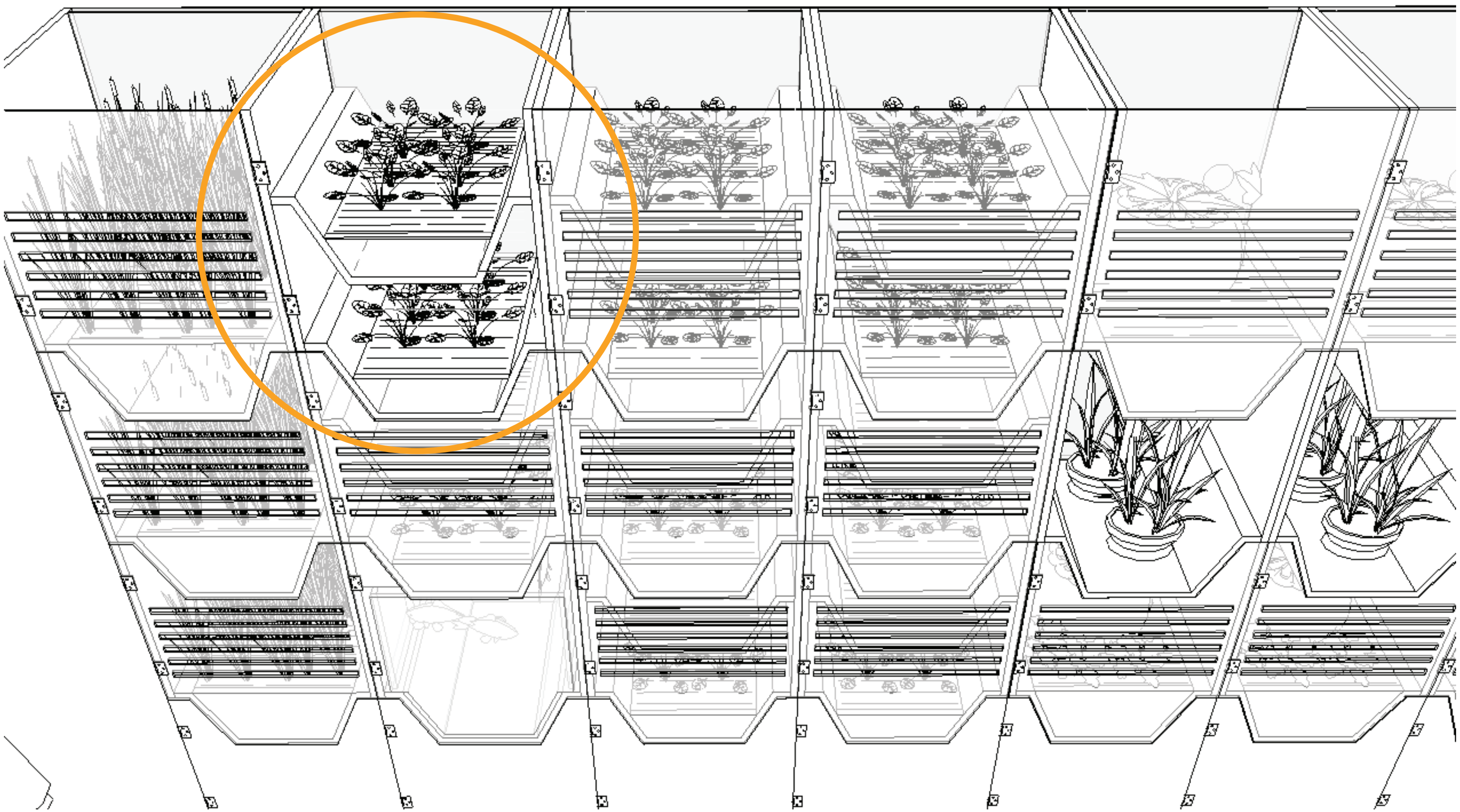
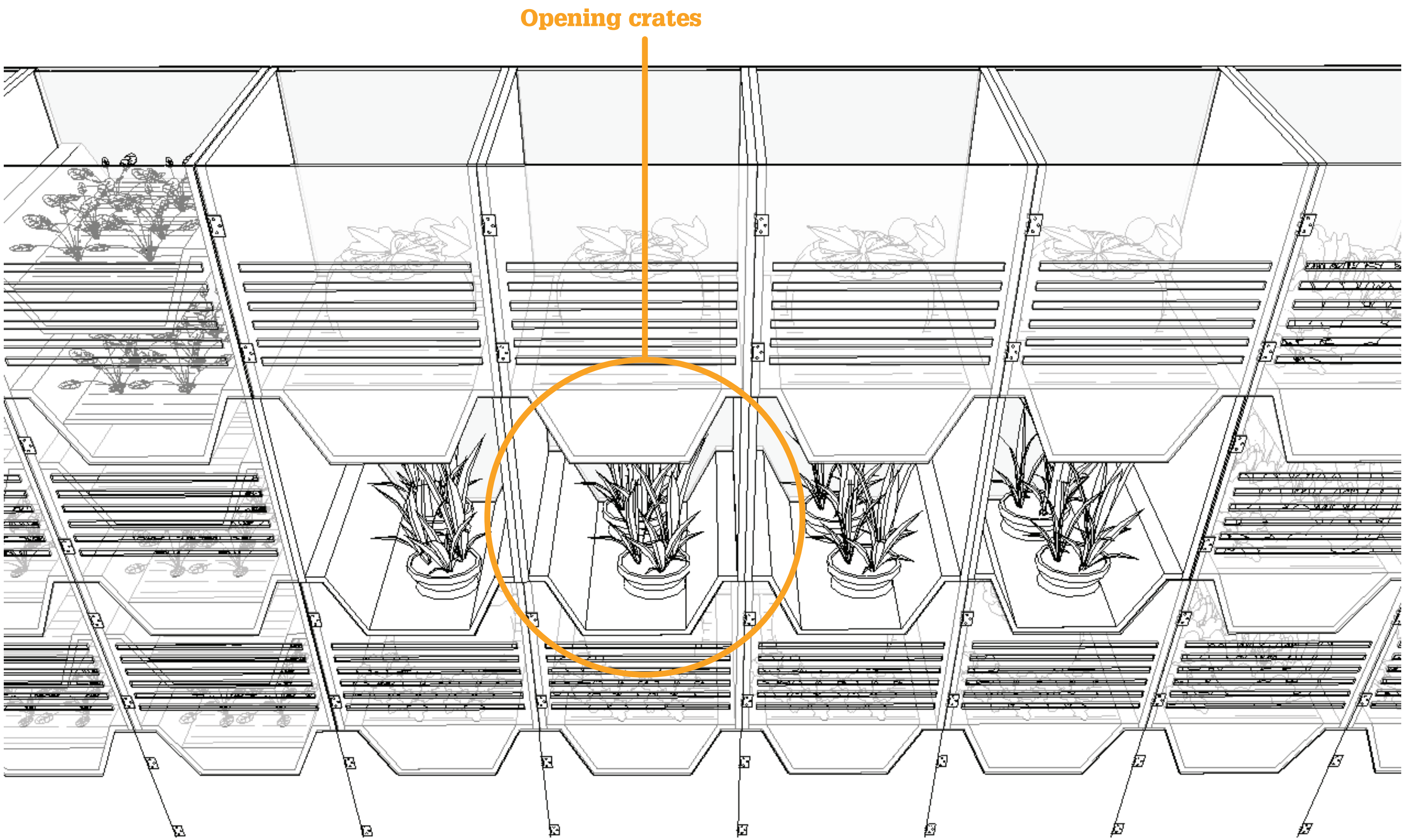
Sprouting trays/ Small root plants trays




Double production on a standard foodprint.
Additional sprouting tray



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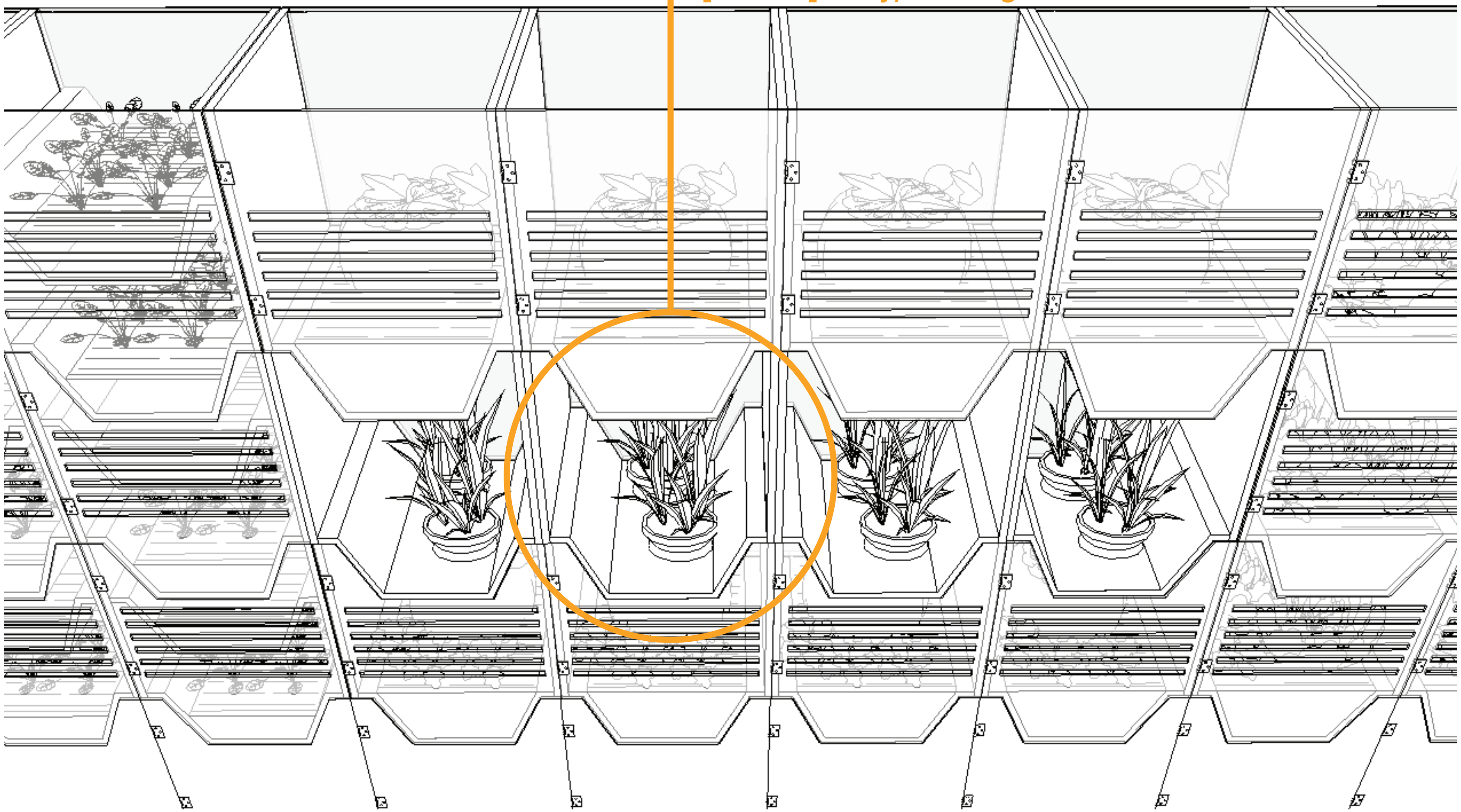
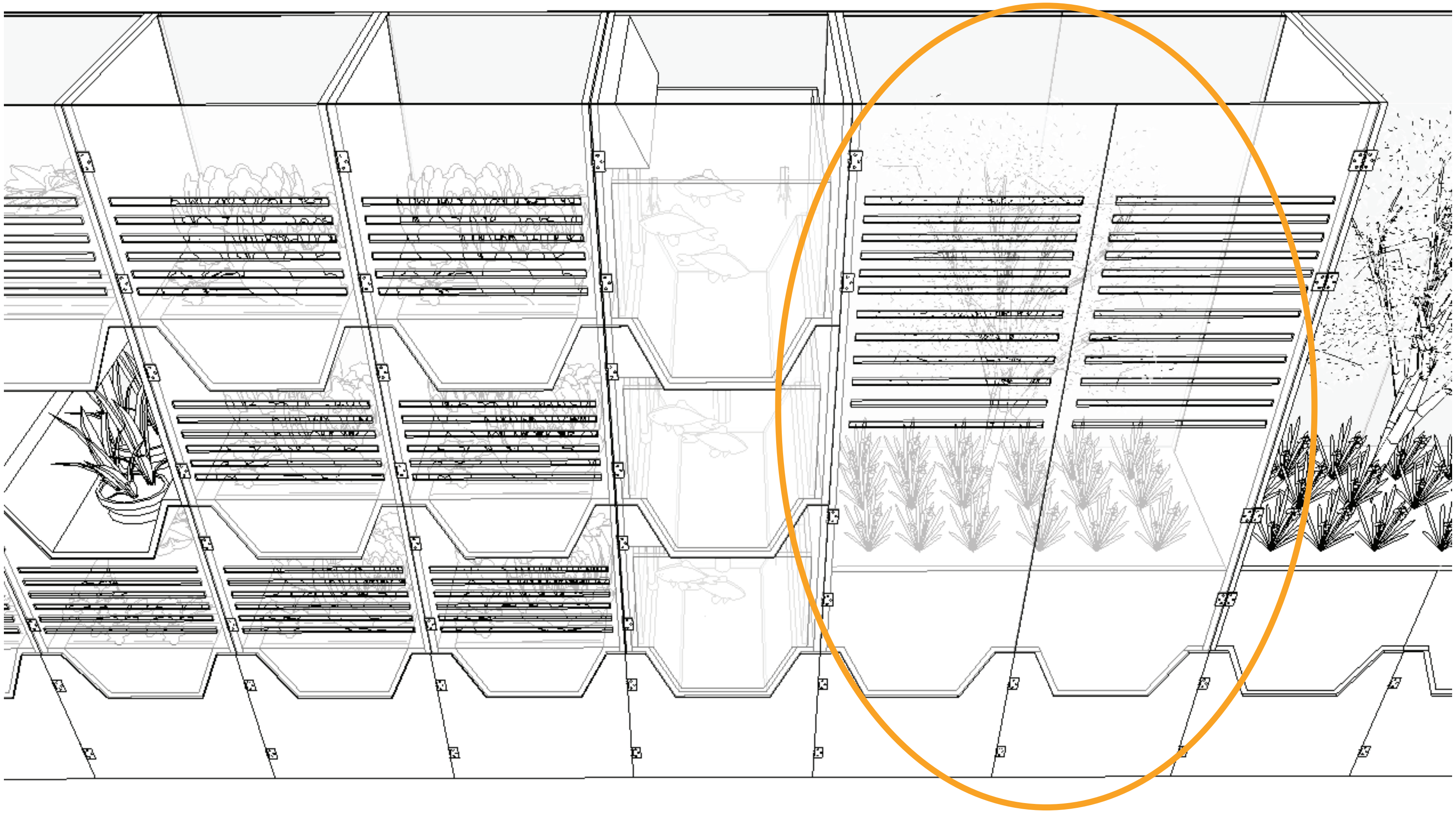
These crates work as windows. They open completely, allowing fresh air in.

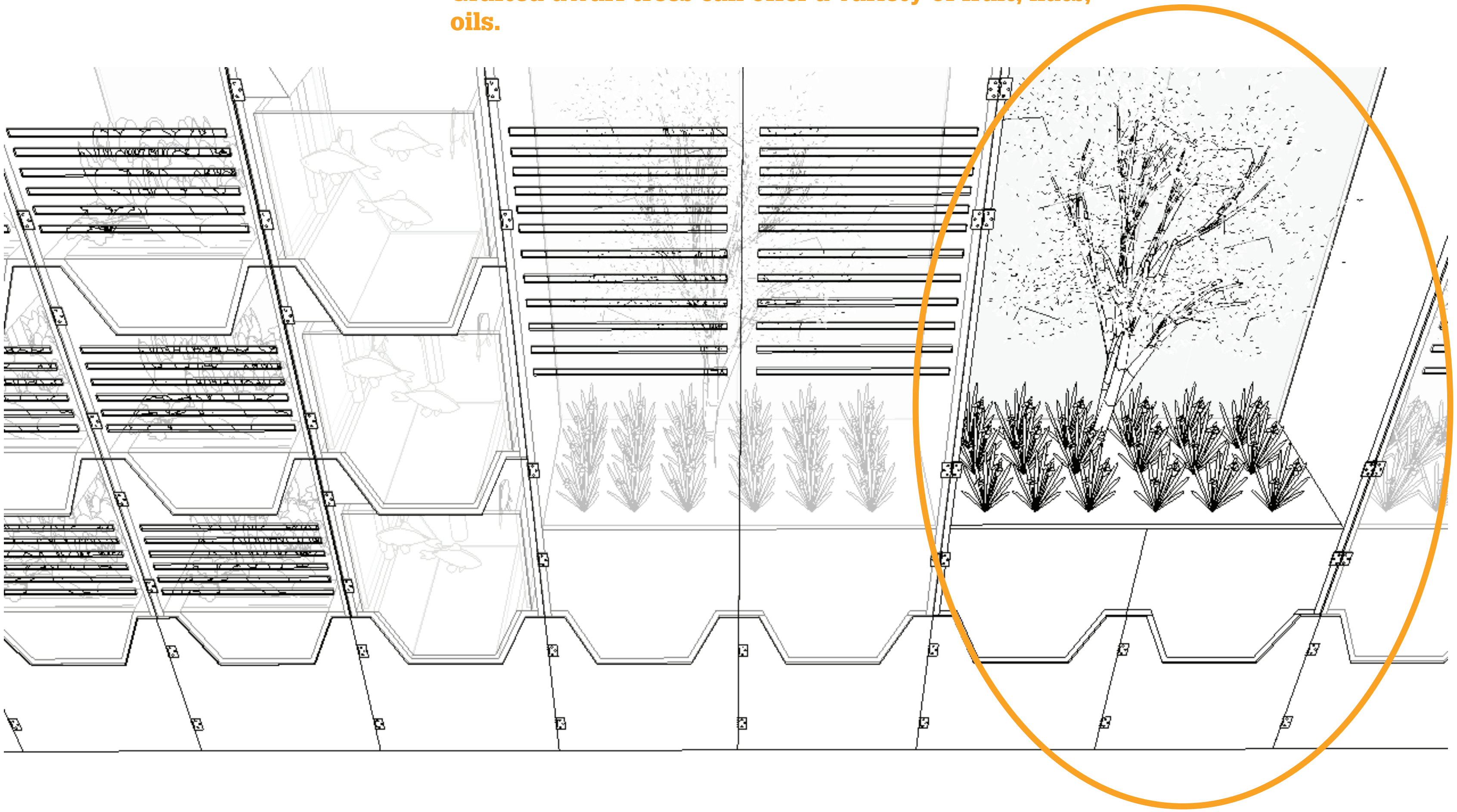


They can also accommodate pots with hardy plants, like agave succulents.

These full-height crates can accommodate larger/ taller plants.



Grafted dwarf trees can offer a variety of fruit, nuts, oils.



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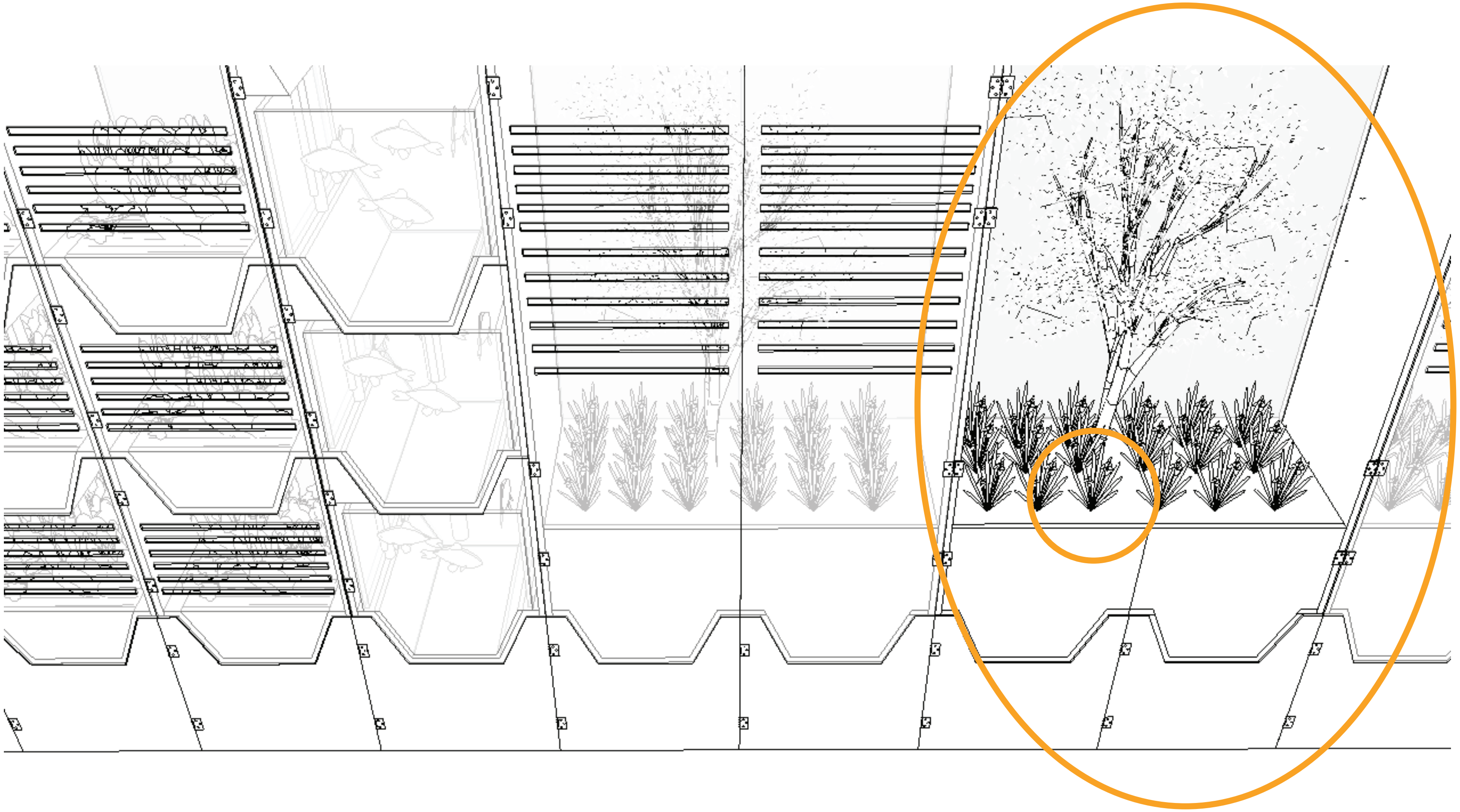
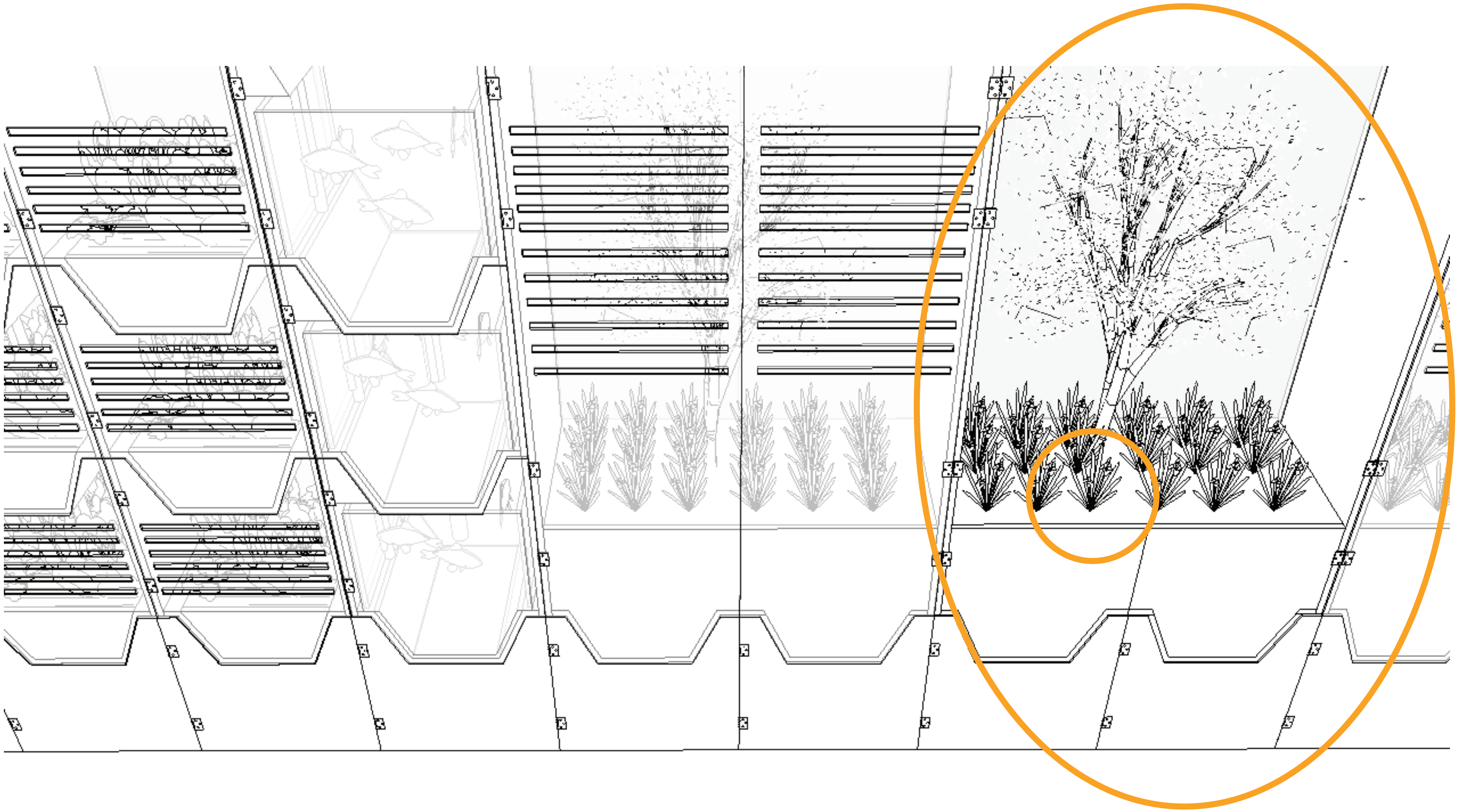
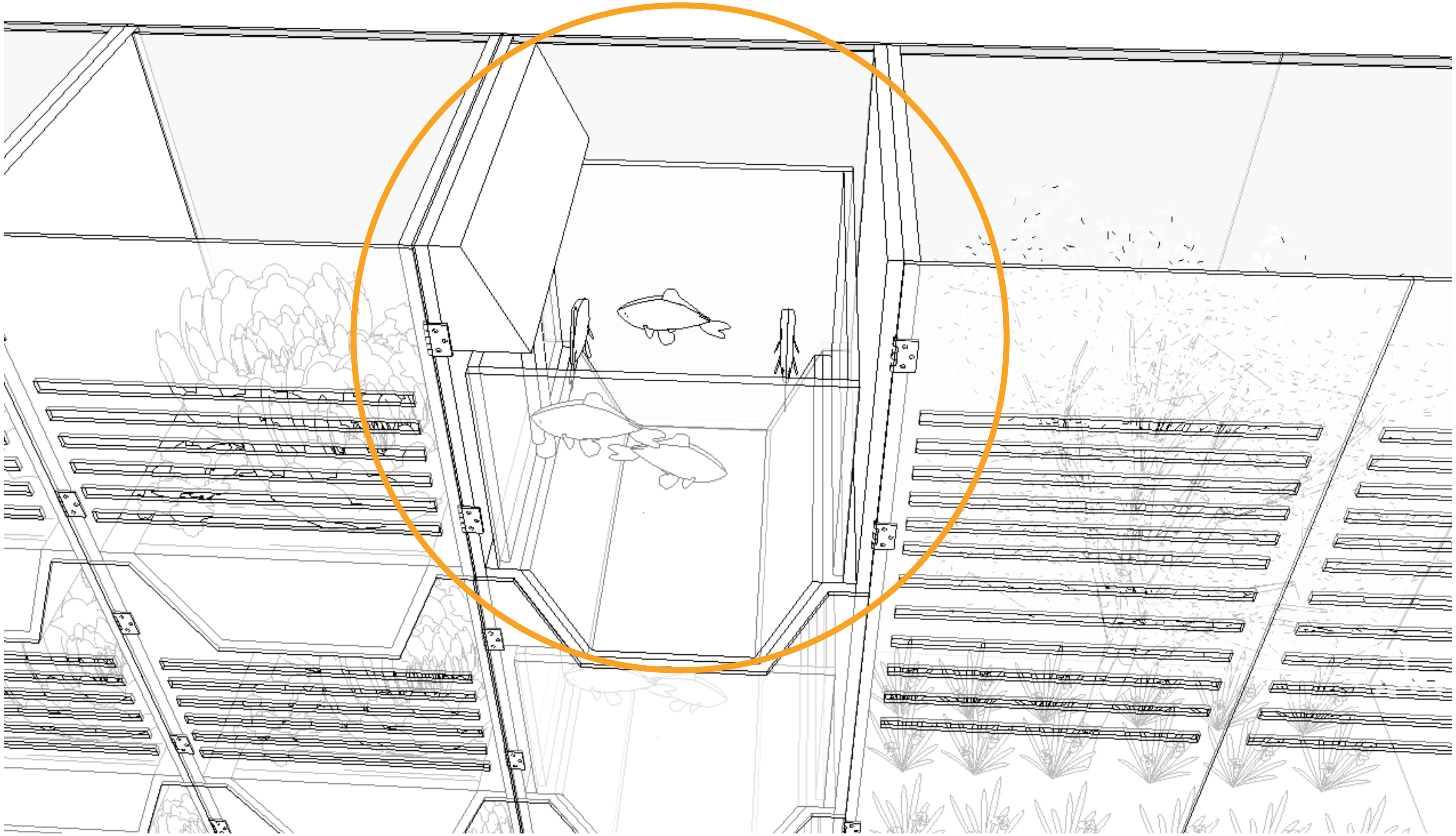


To maximize production, INTERCROPPING is used.



This means growing smaller plants on the free ground area.

introducing... AQUAPONICS



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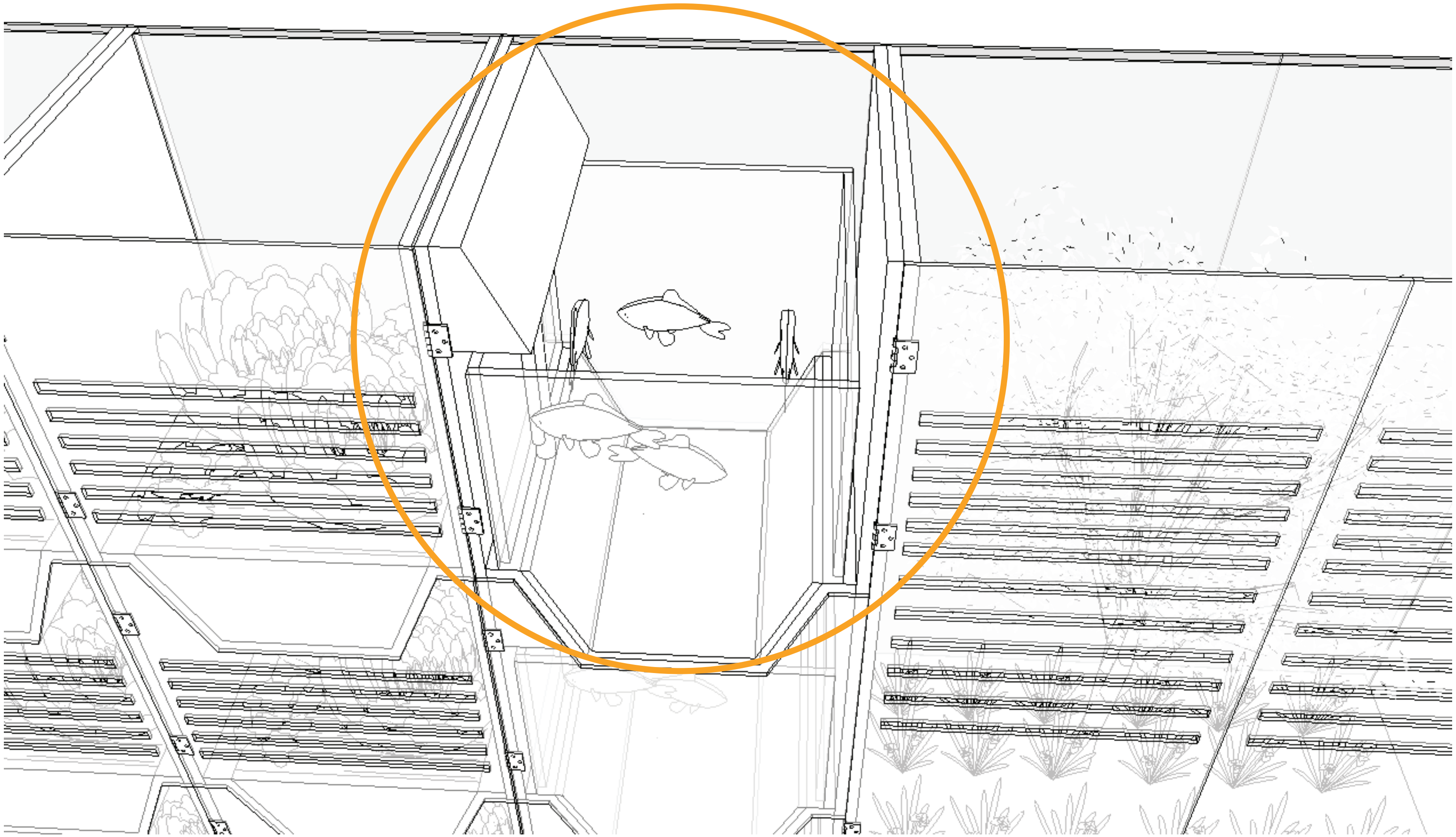
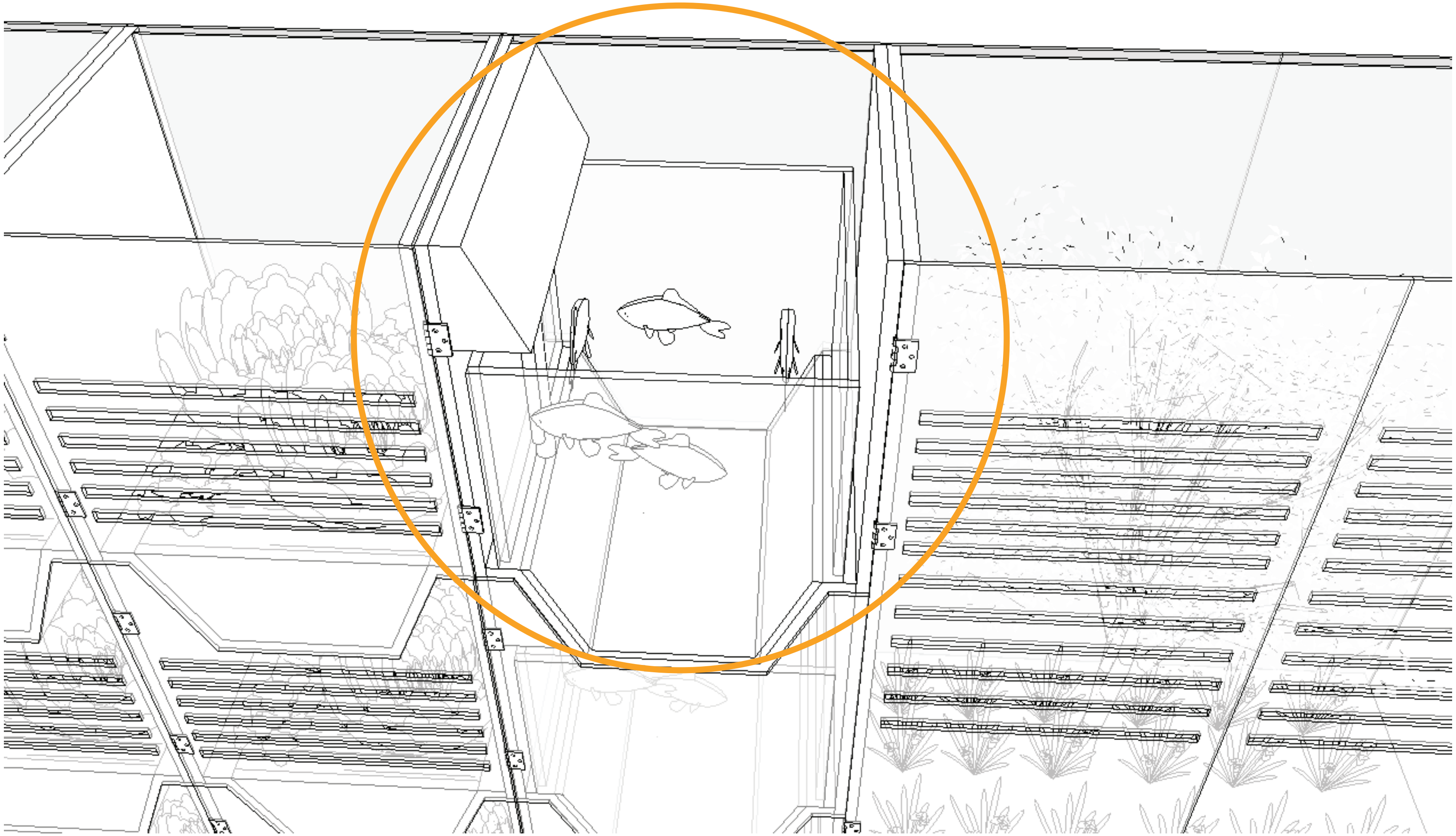
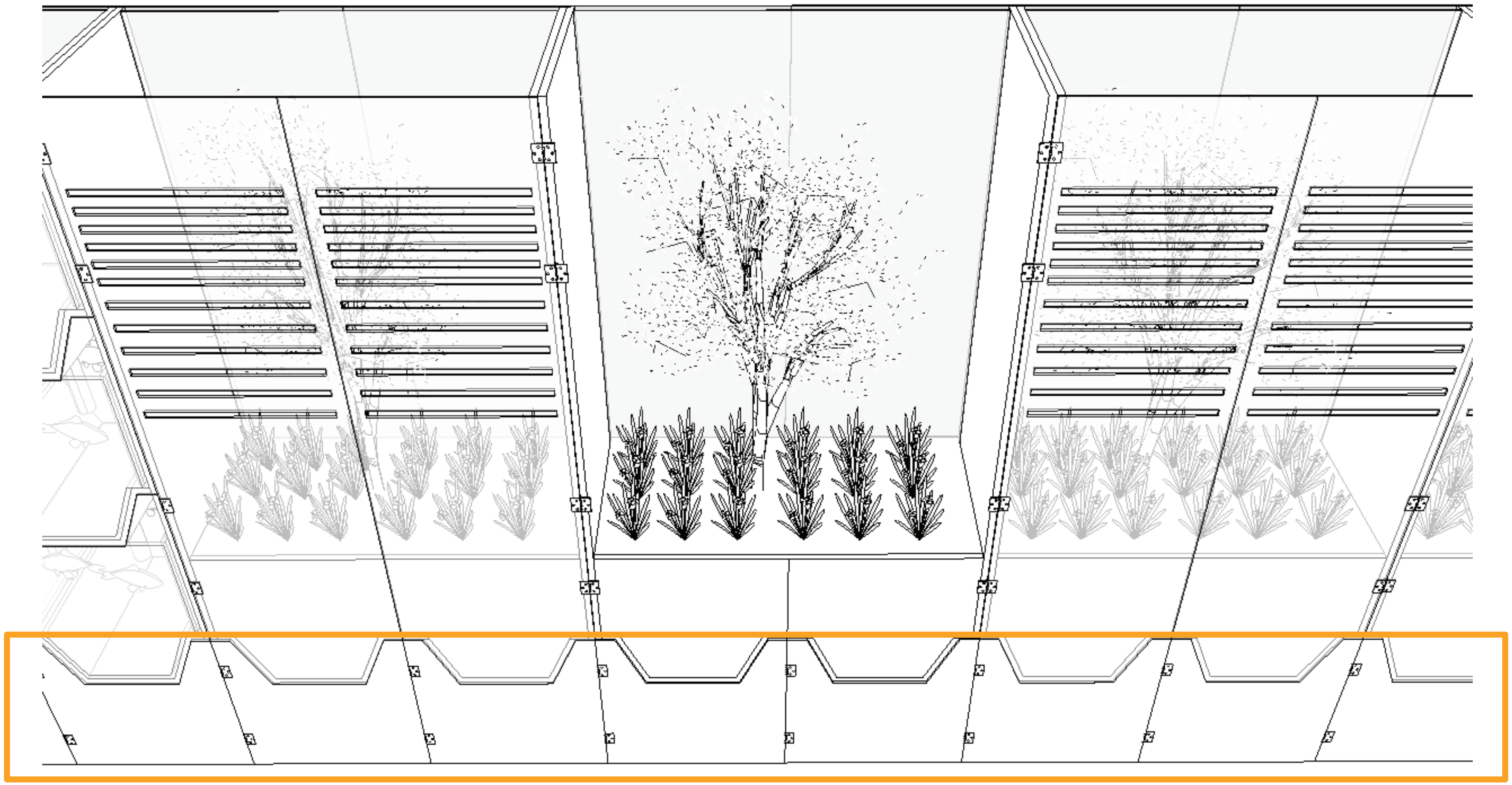
The fish "manure" is a natural fertilizer for plants.



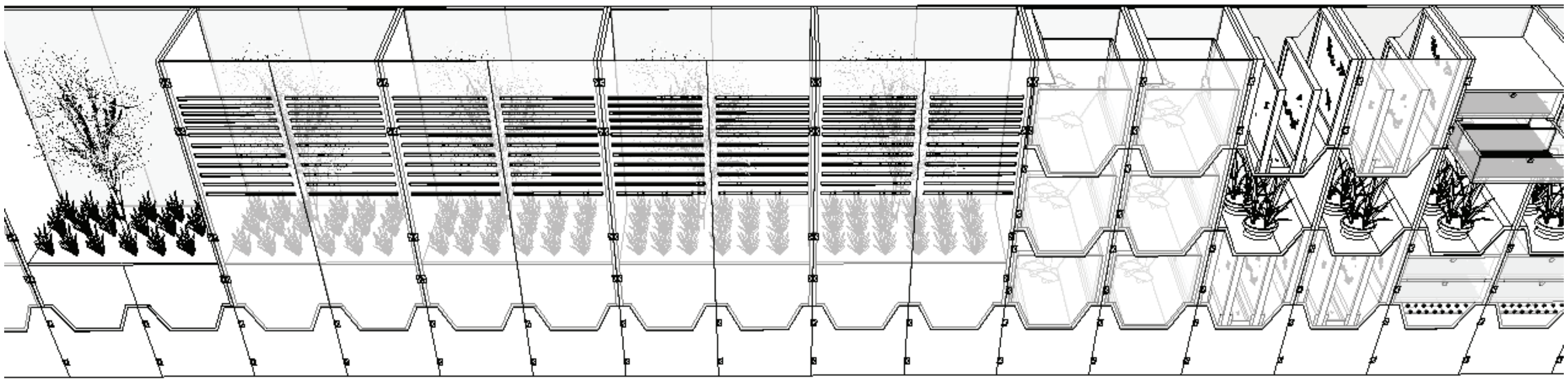
By using water cycles that take the water from fish tanks to plants, fertilization and water purification take place.



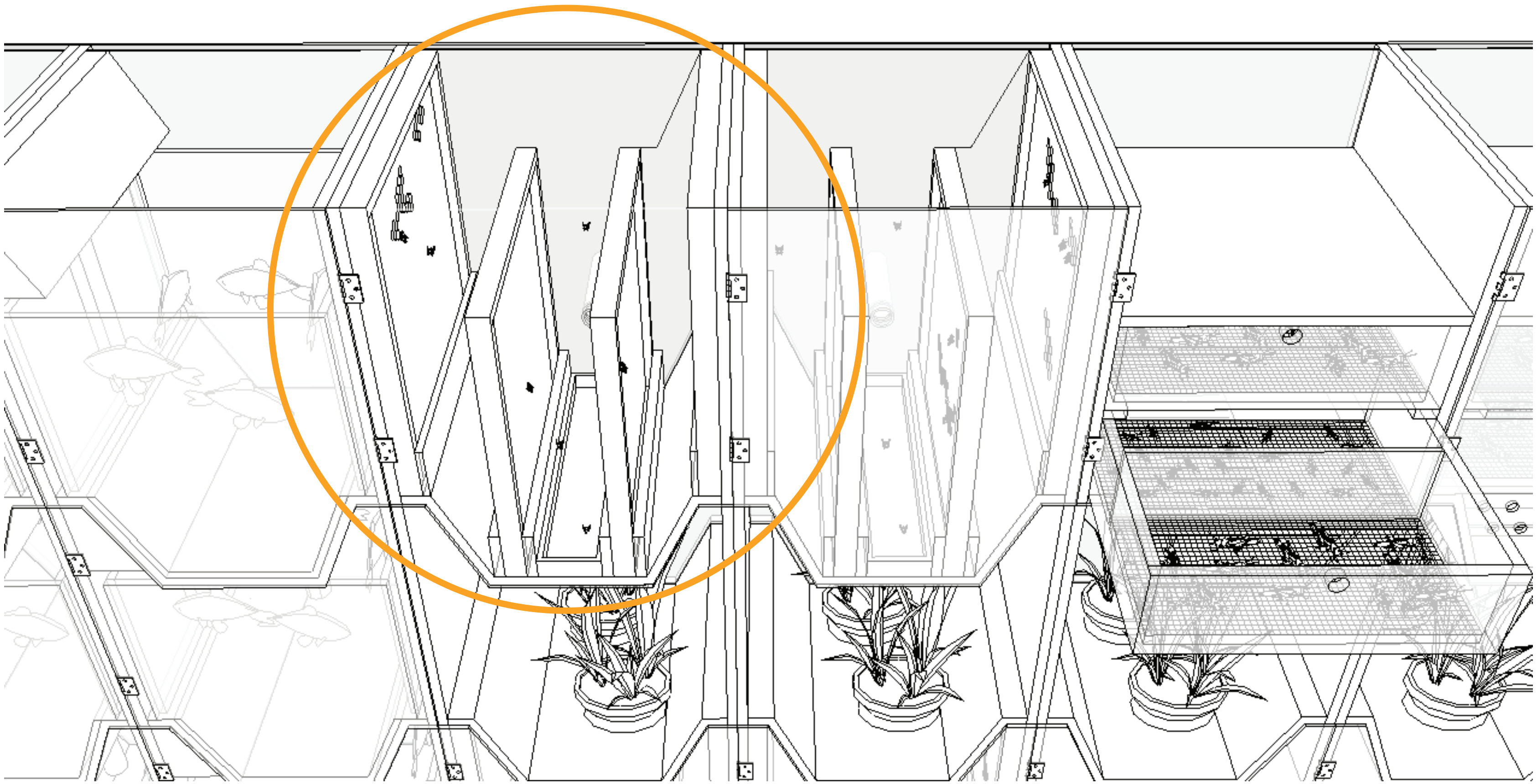


The bottom crates are used to accommodate parts of the aquaponics system, such as water pumps.

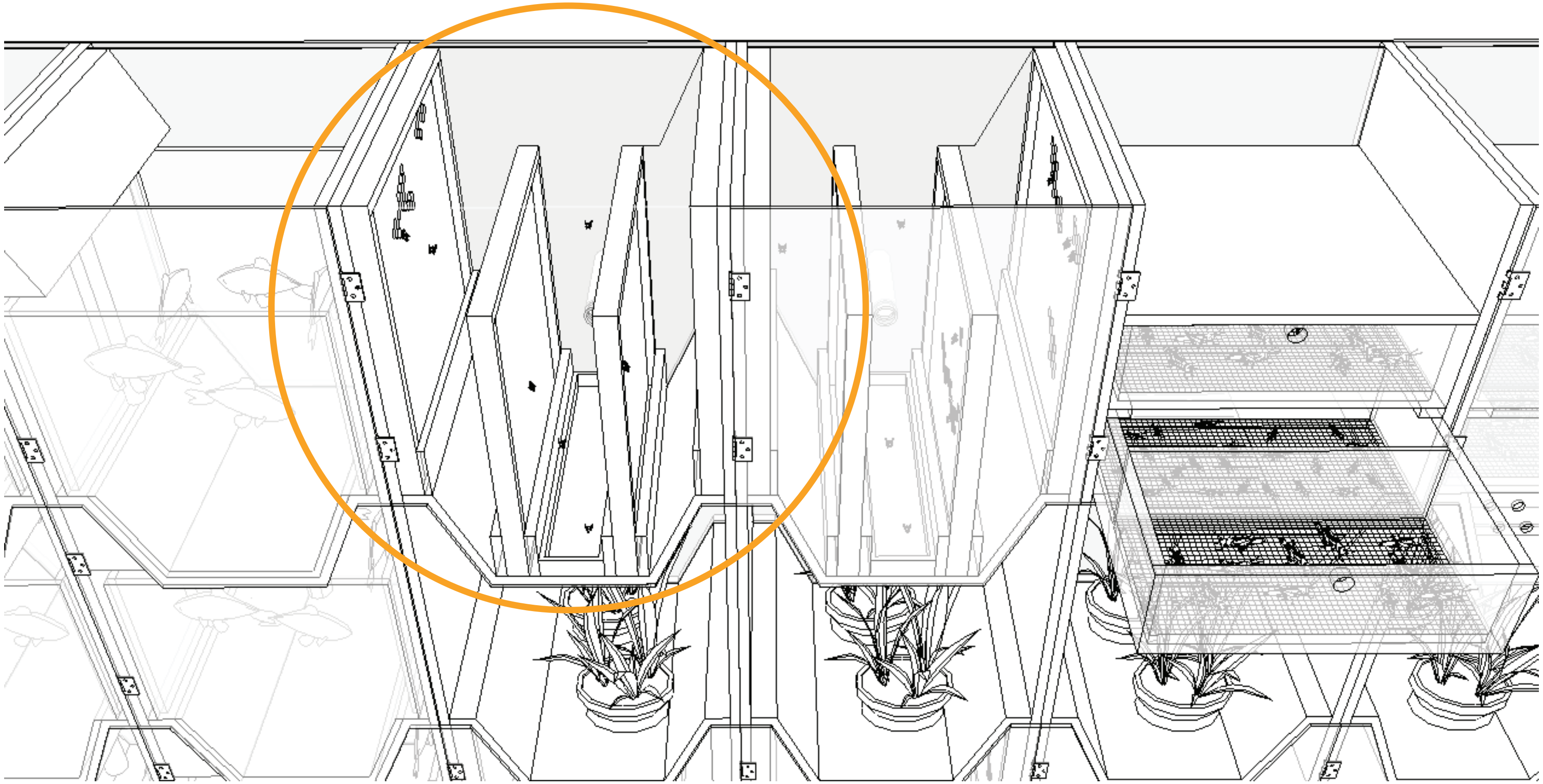
Apart from plants, animals are also accommodated in the crates.



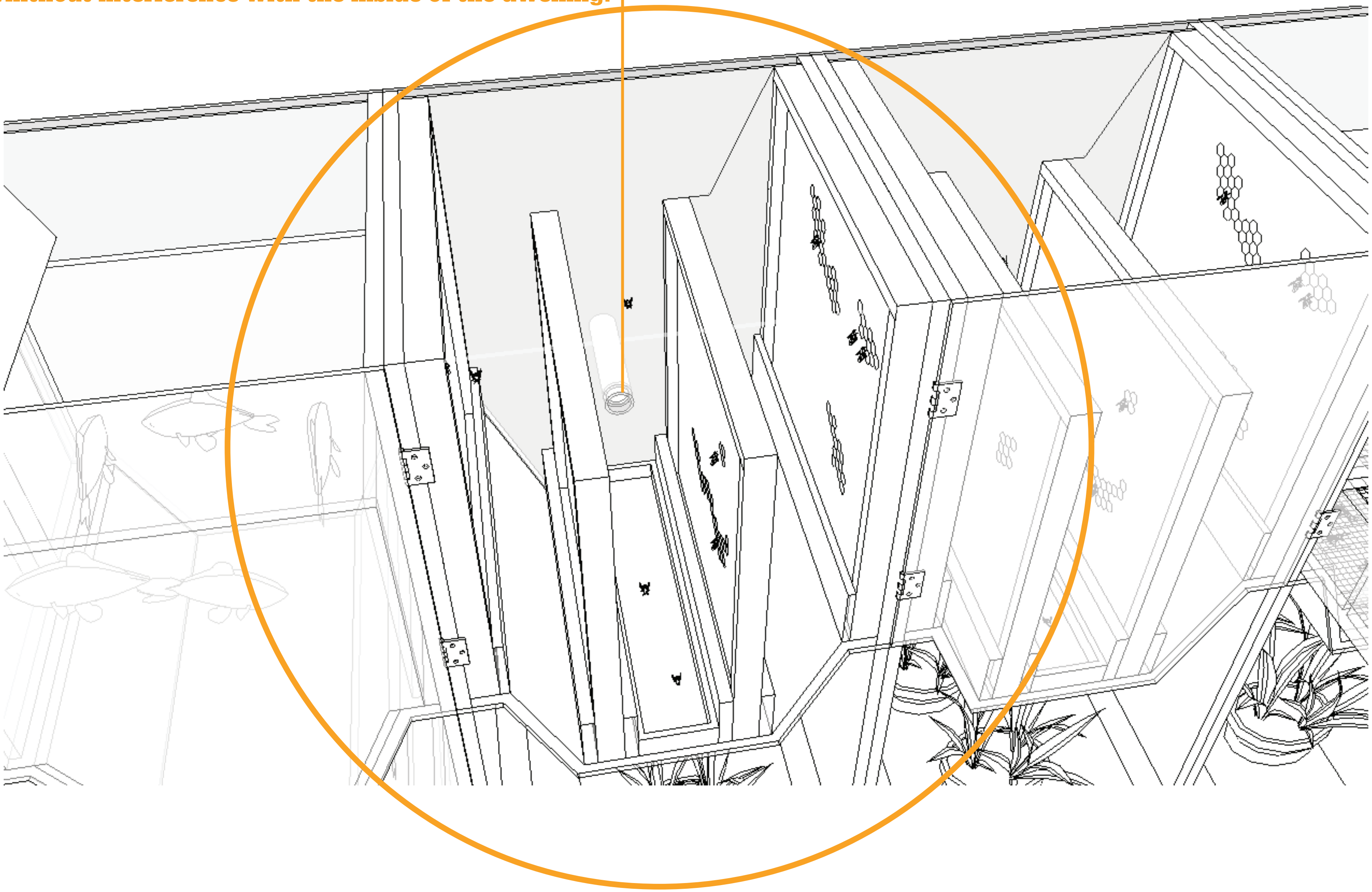
Bee hives



The hives are an adapted version of the traditional wooden panels.



The plexiglass pipe allows the bees to enter the crate, whithout interference with the inside of the dwelling.



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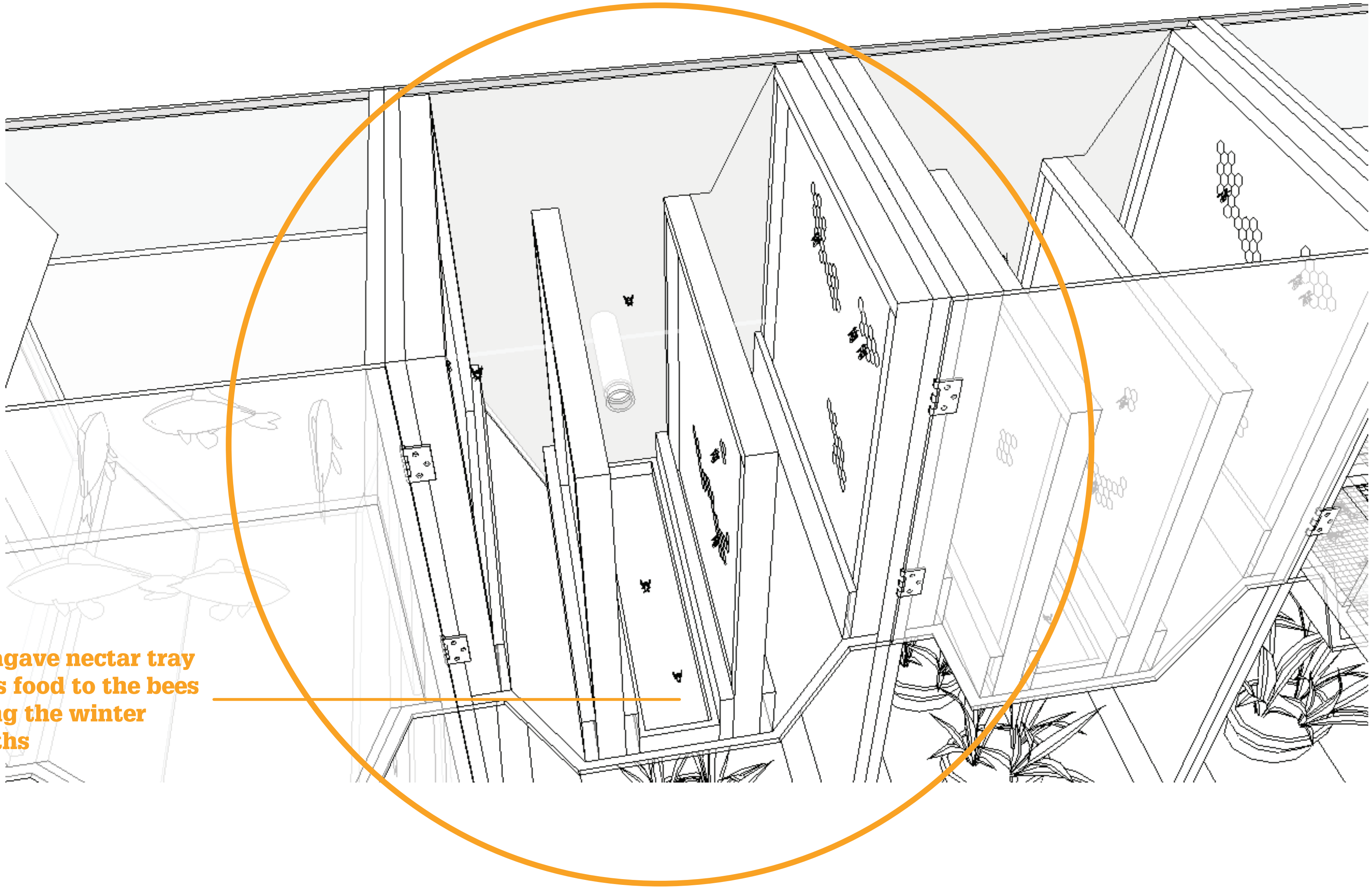

The agave nectar tray offers food to the bees during the winter months

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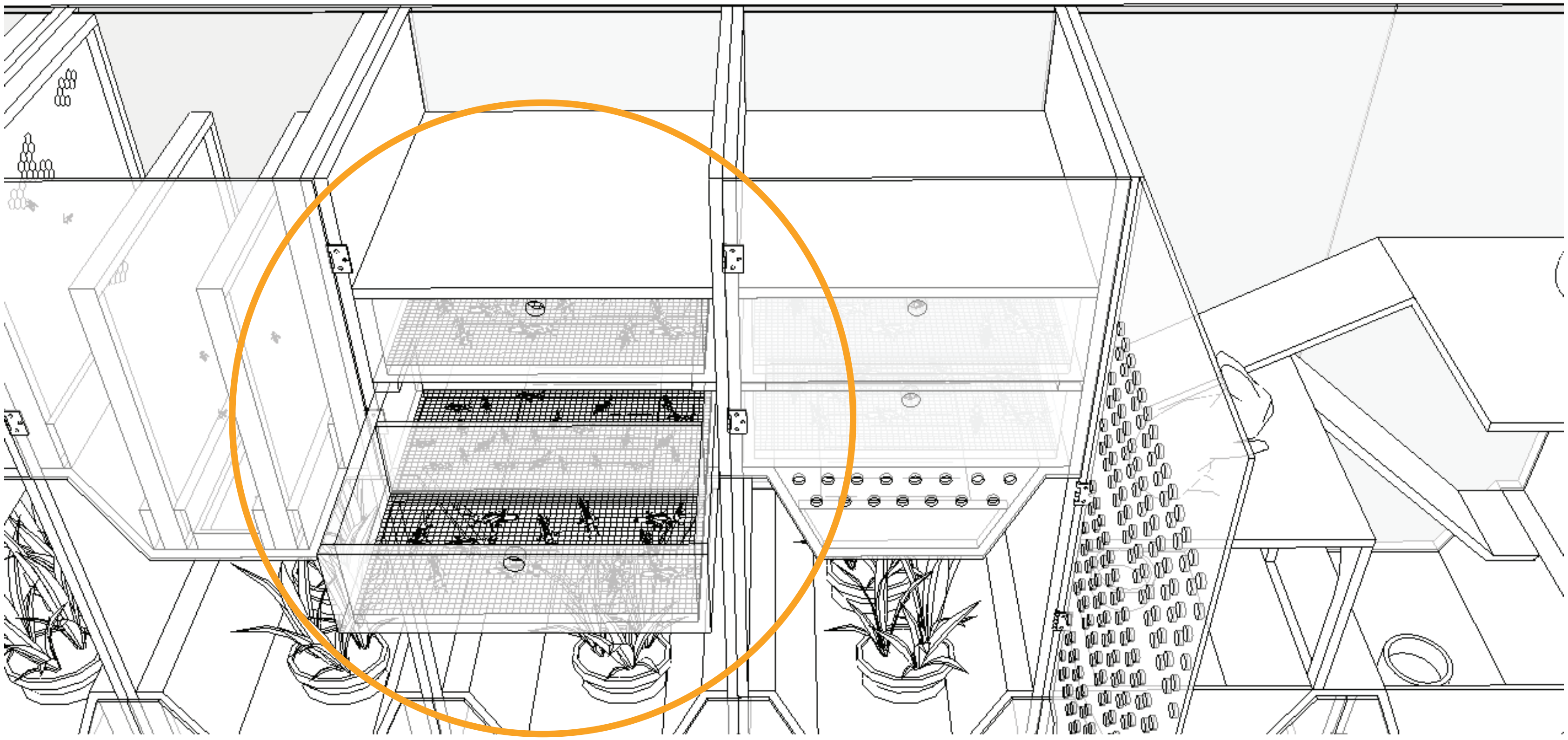
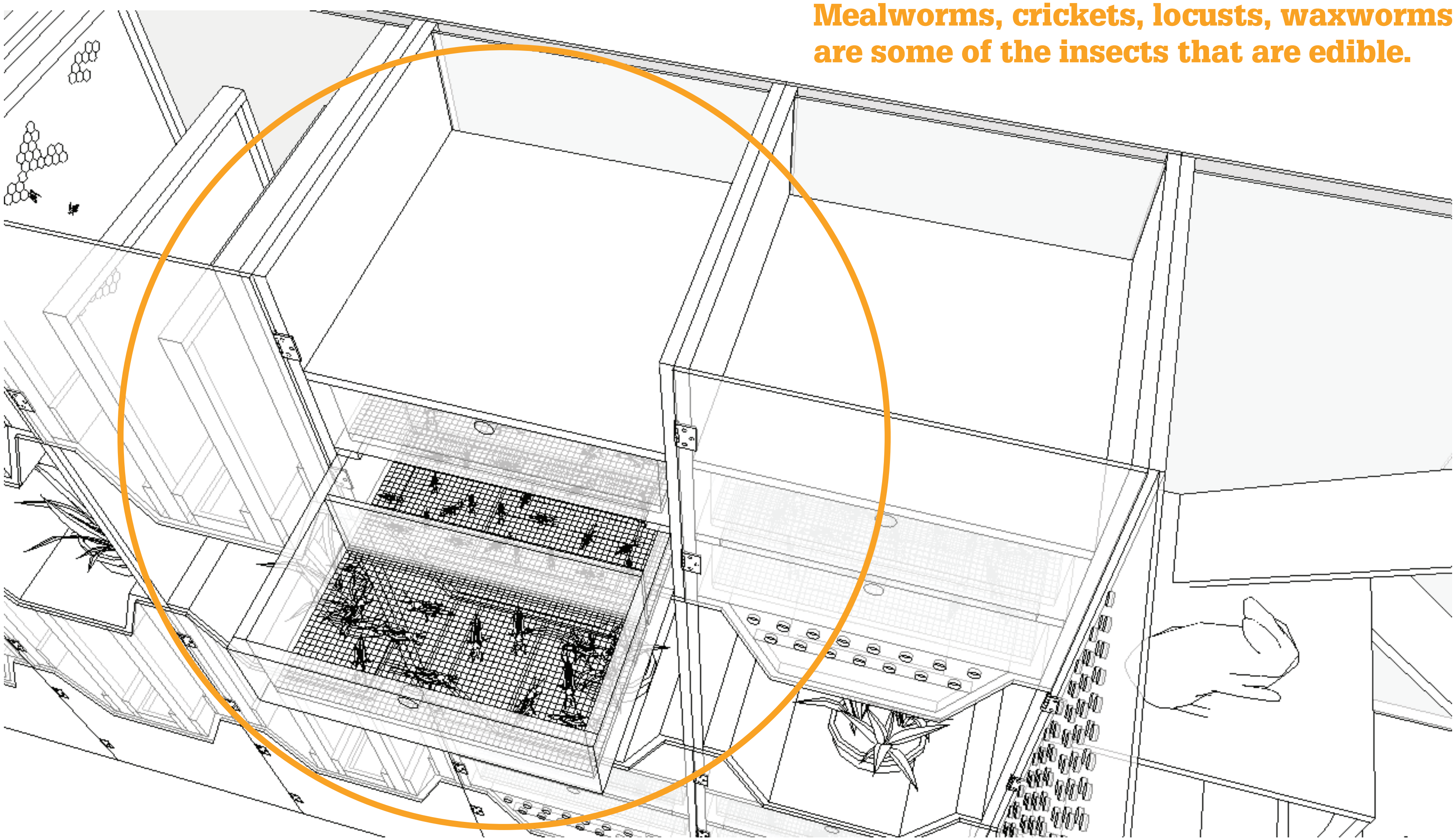
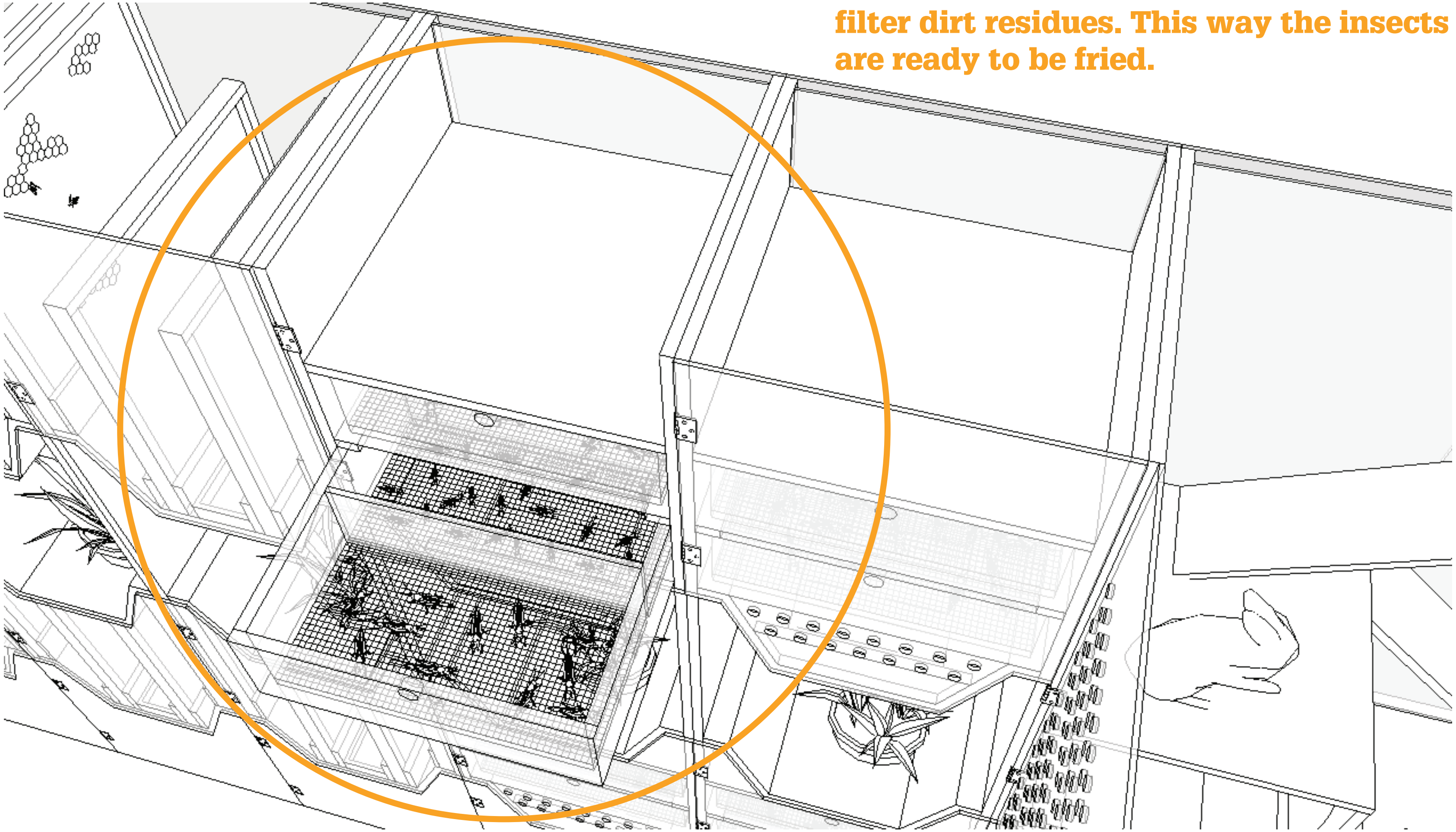
Insect Crate





Mealworms, crickets, locusts, waxworms are some of the insects that are edible.

The wire mesh at the bottom is used to filter dirt residues. This way the insects are ready to be fried.



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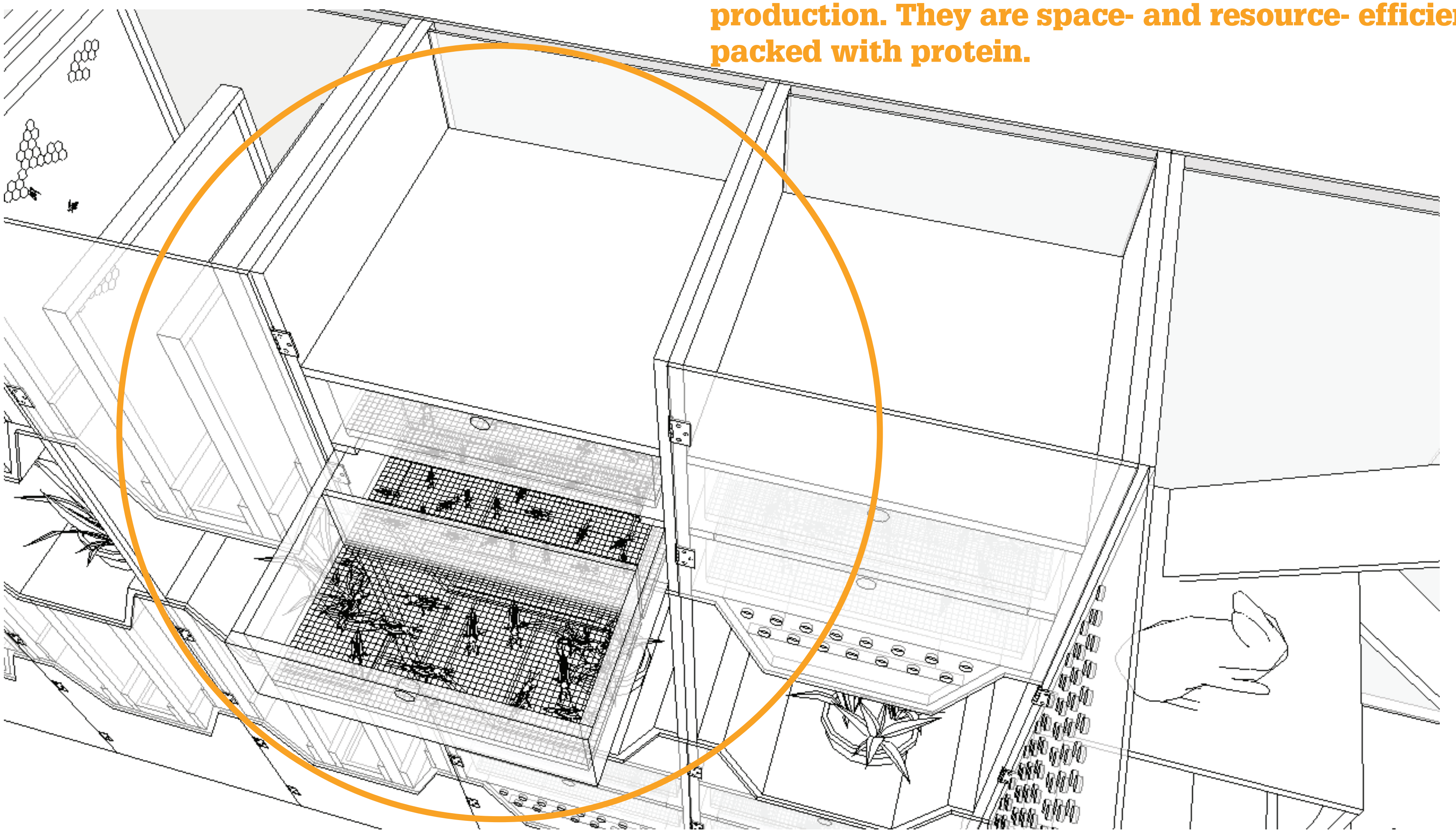
Insects can also be fed to fish in case of over-production. They are space- and resource- efficient and packed with protein.



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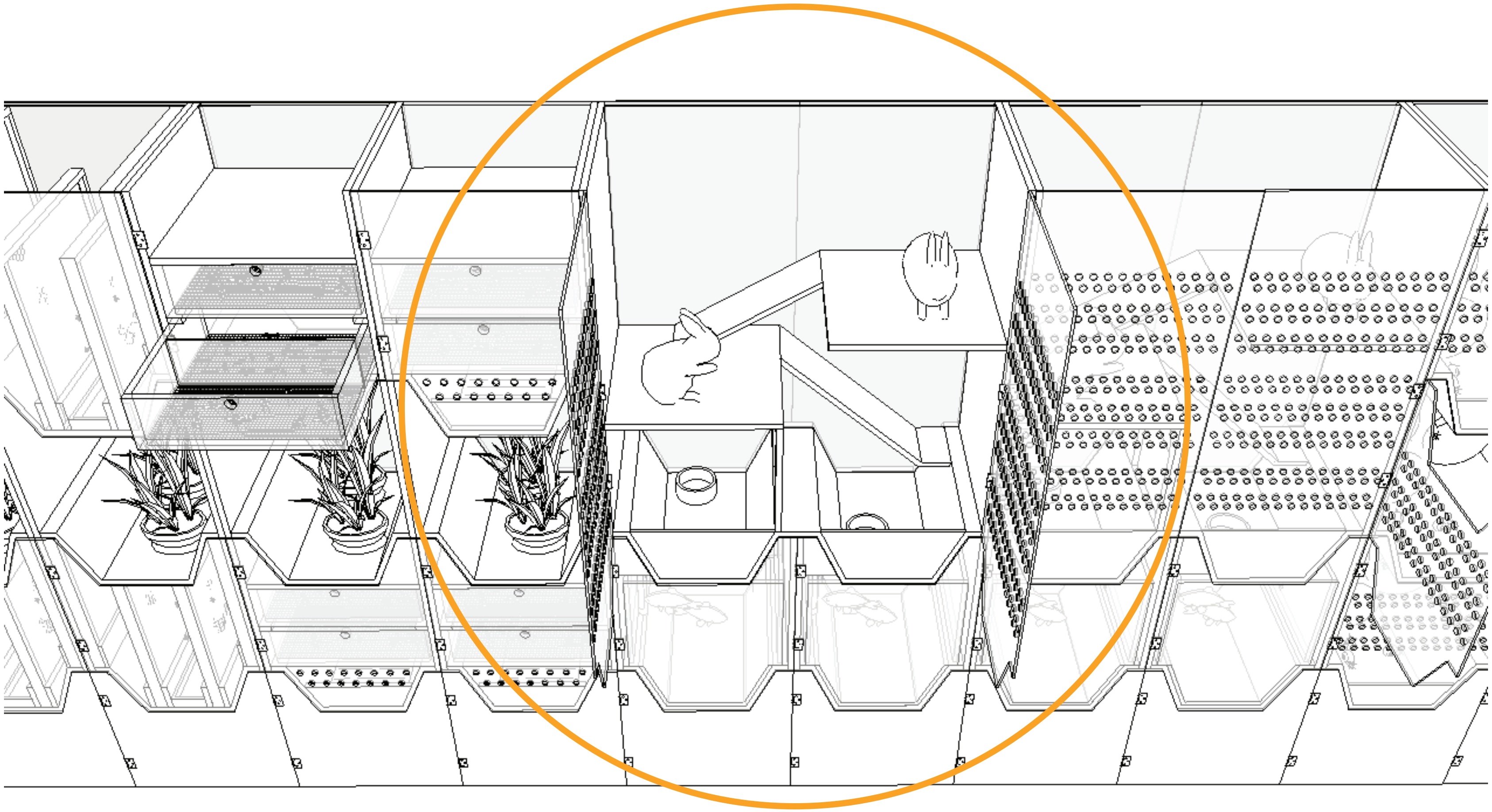
Rabbits are a very efficient source of meat based protein.



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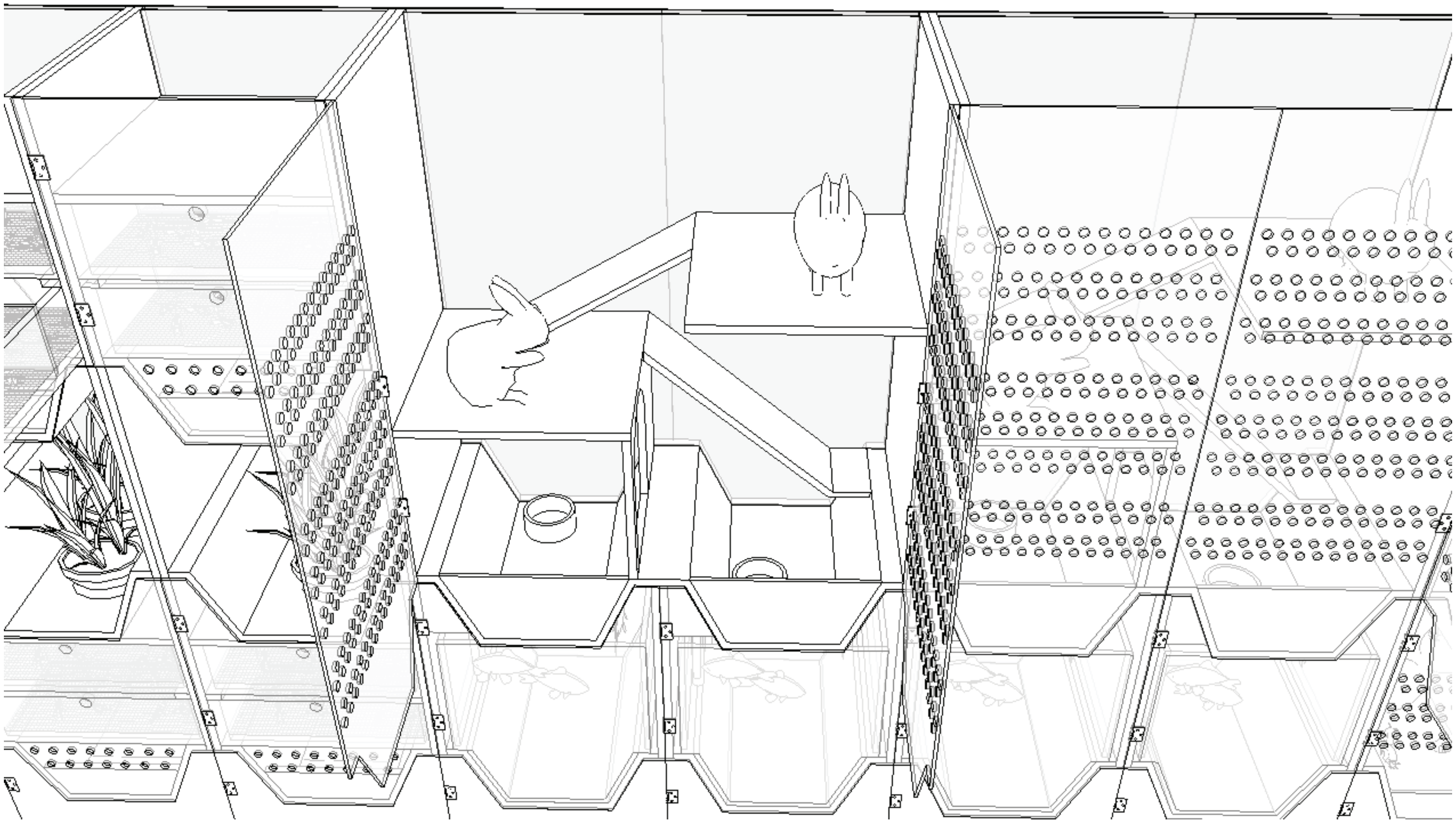
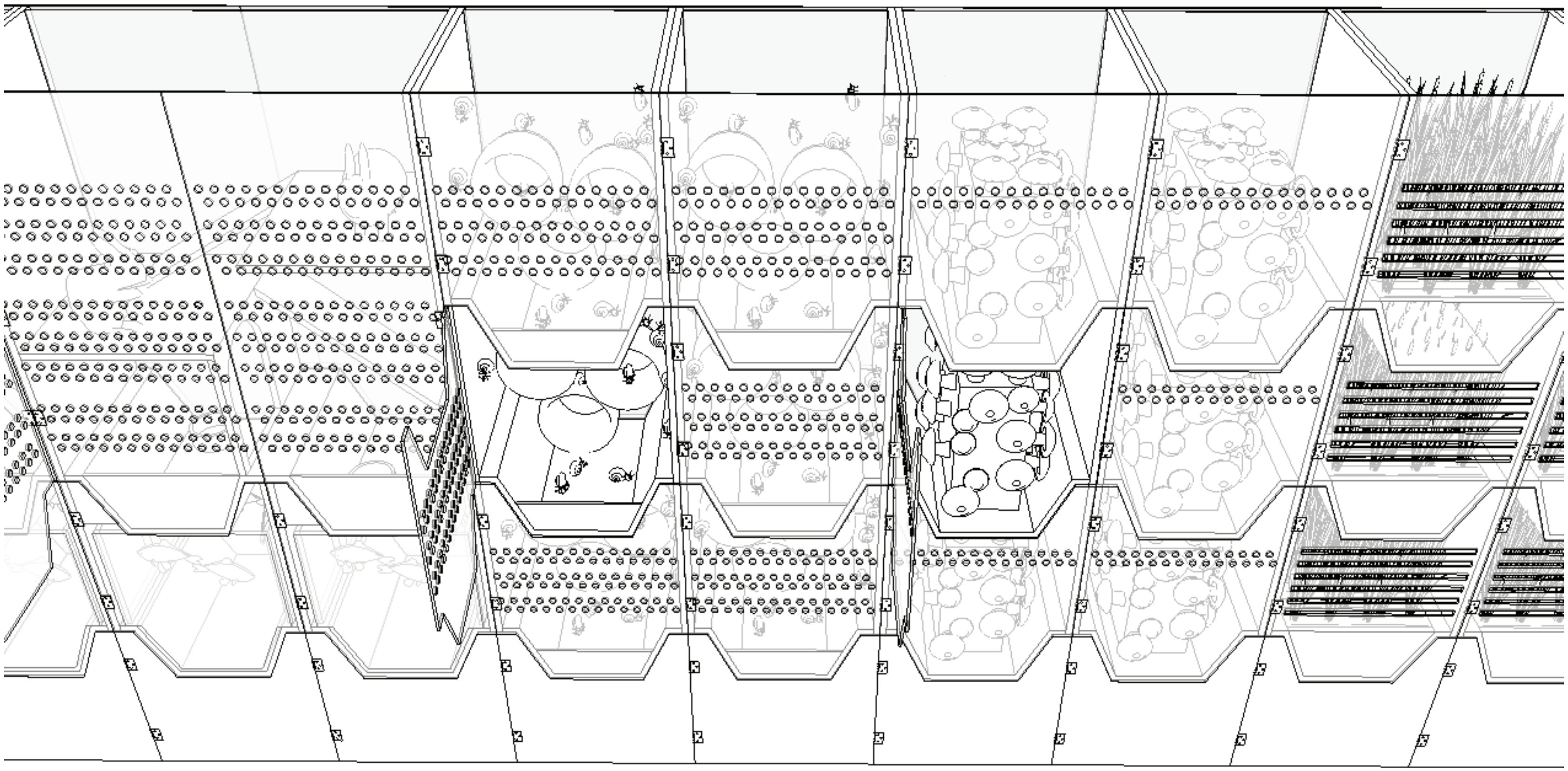
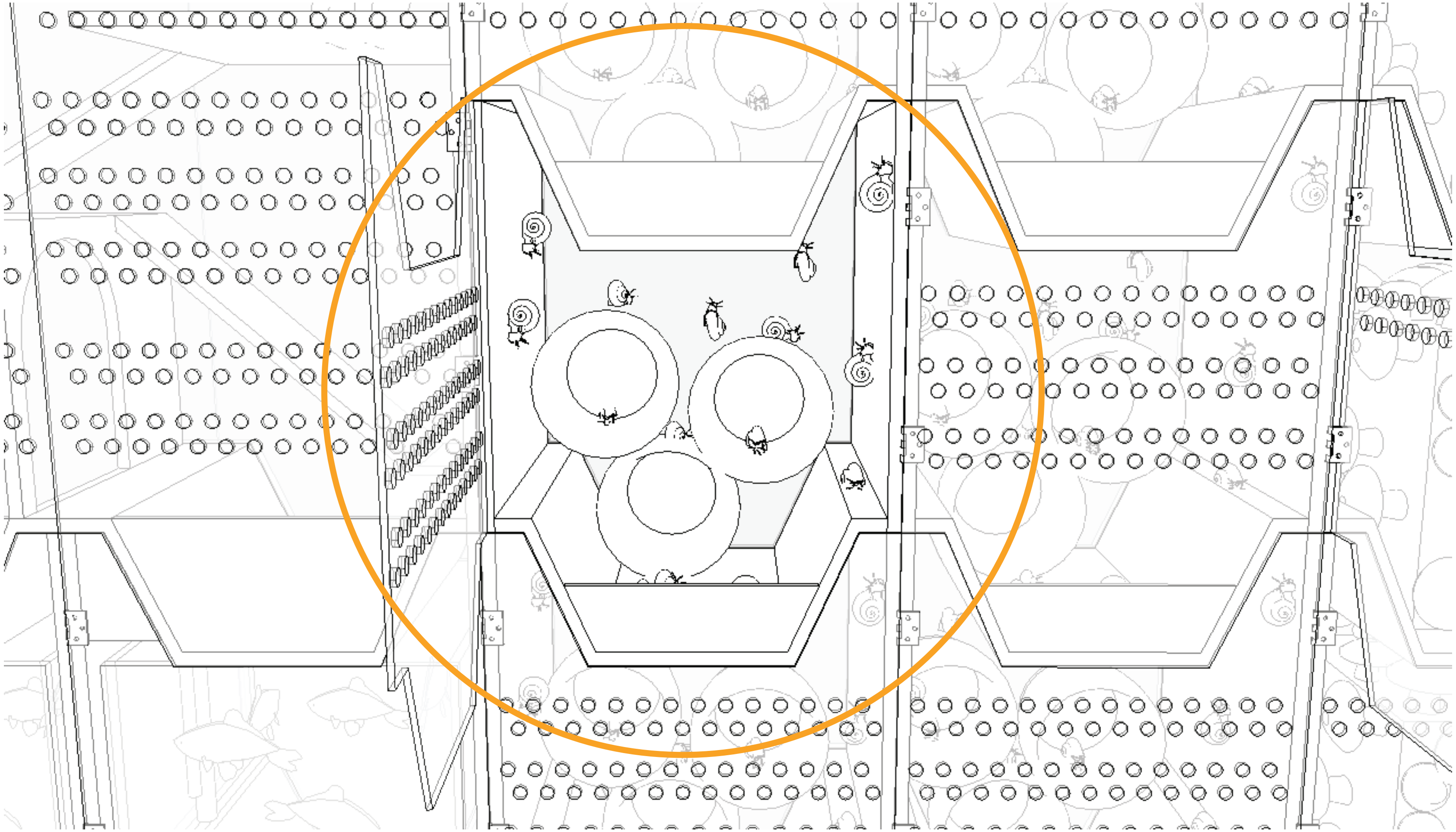
They can be fed with plant parts that are not used for cooking. They produce cold manure, which means manure that can be directly used, without composting.

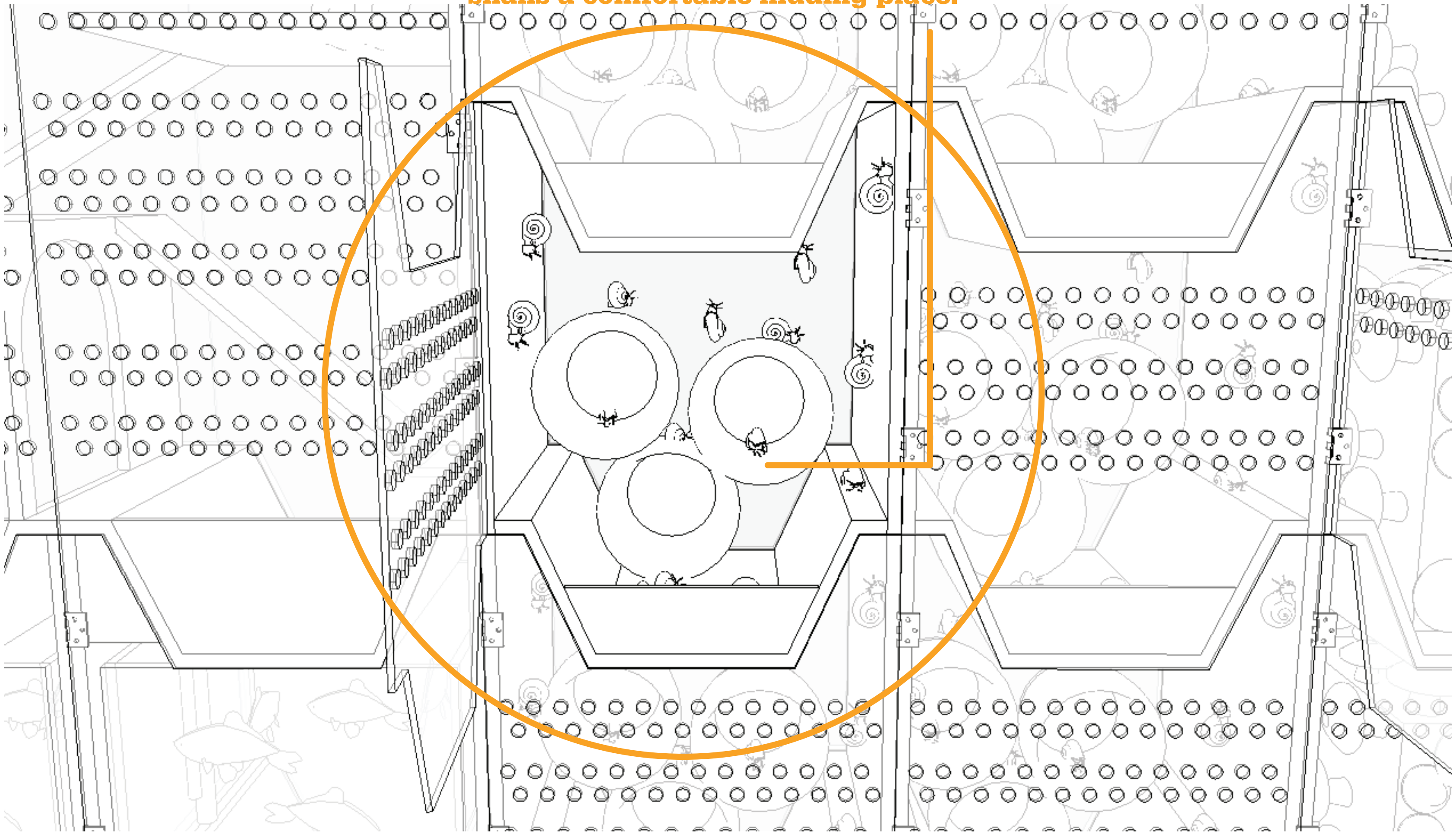




Snails are space efficient, help brake down plant waste and thrive on humidity.



The ceramic pots capture water, offering the snails a comfortable hidding place.



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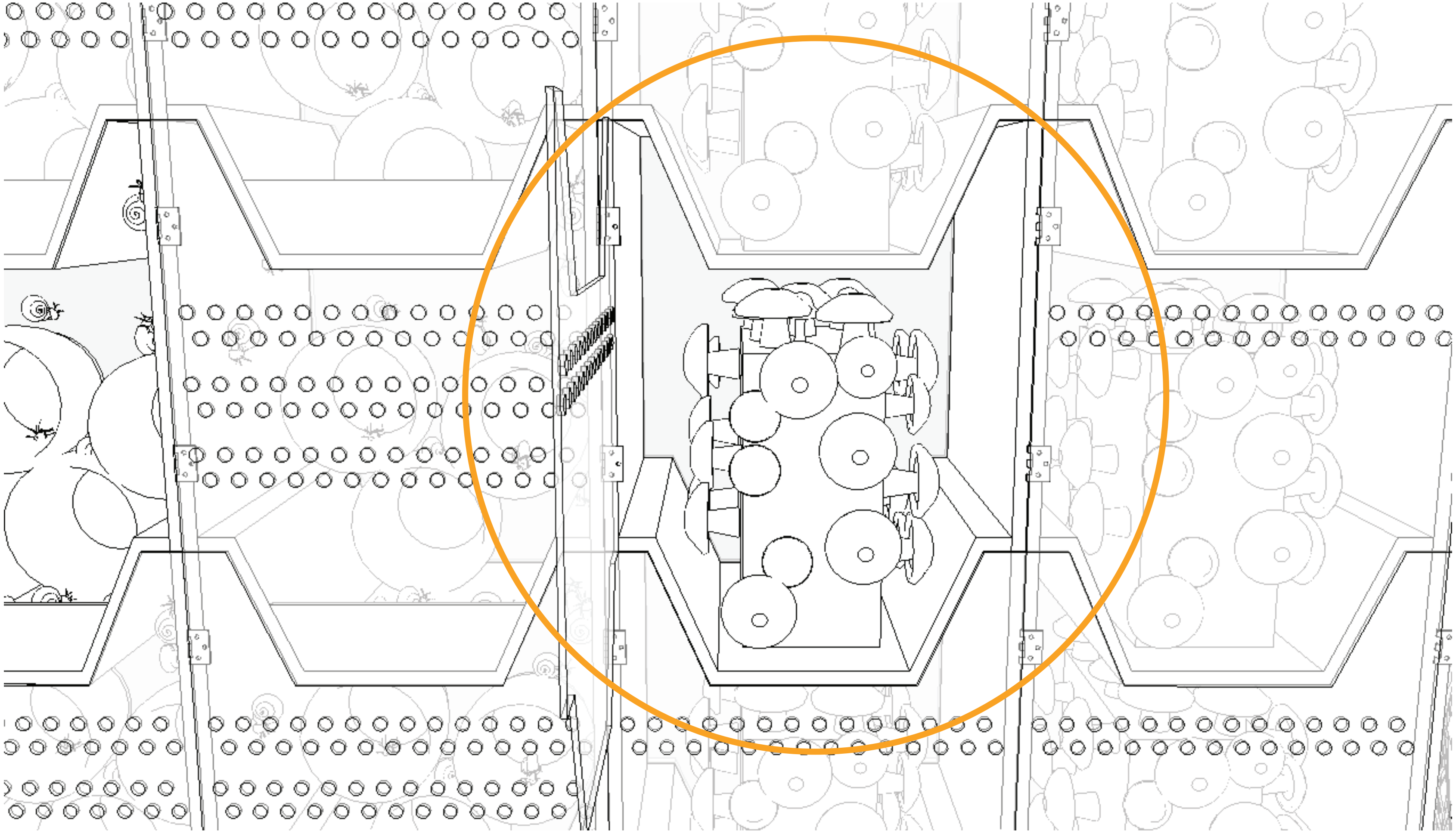
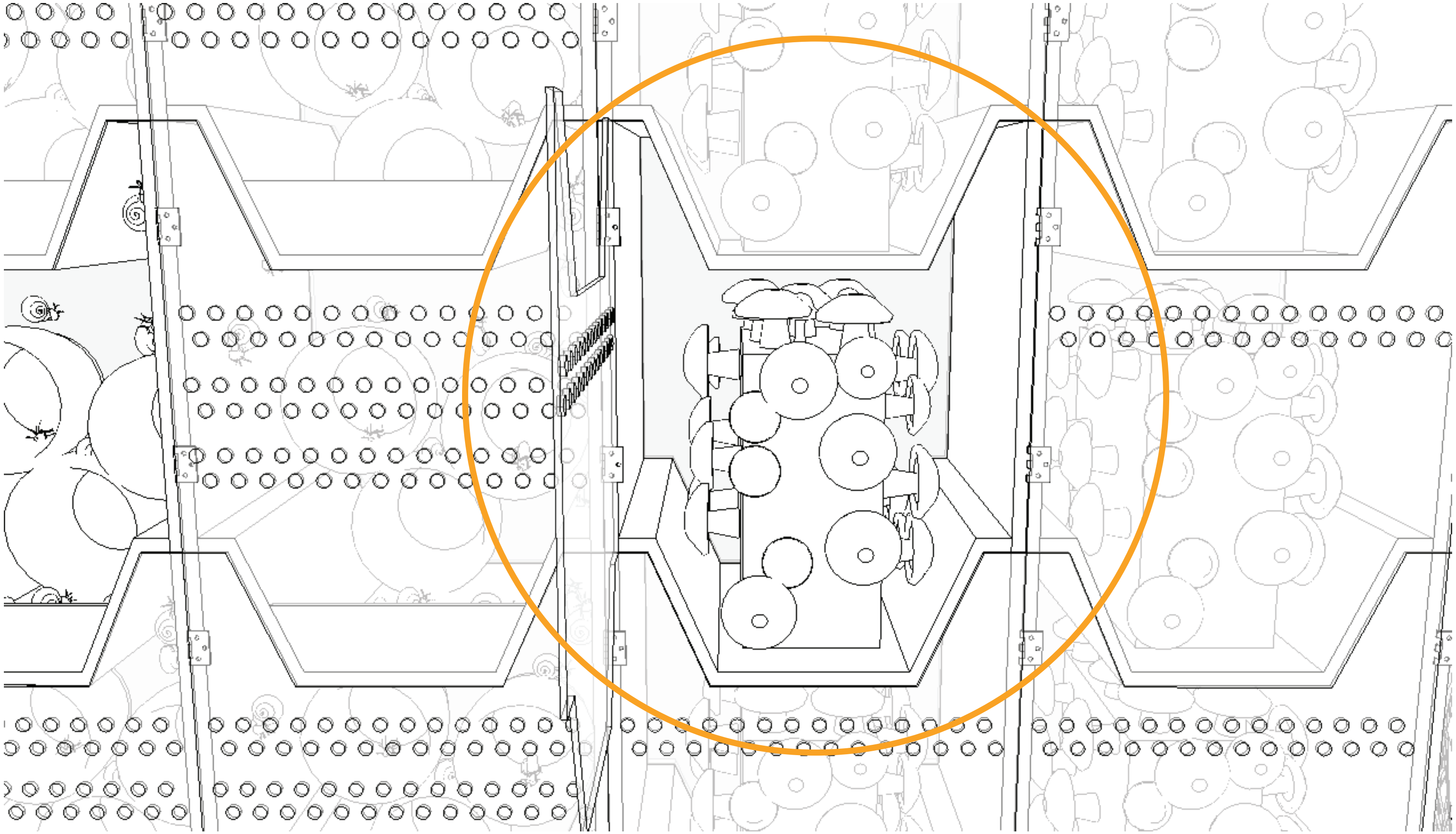
Mushrooms grow easily on a dried plant base.



Like snails, they need humidity, so they work well closely.



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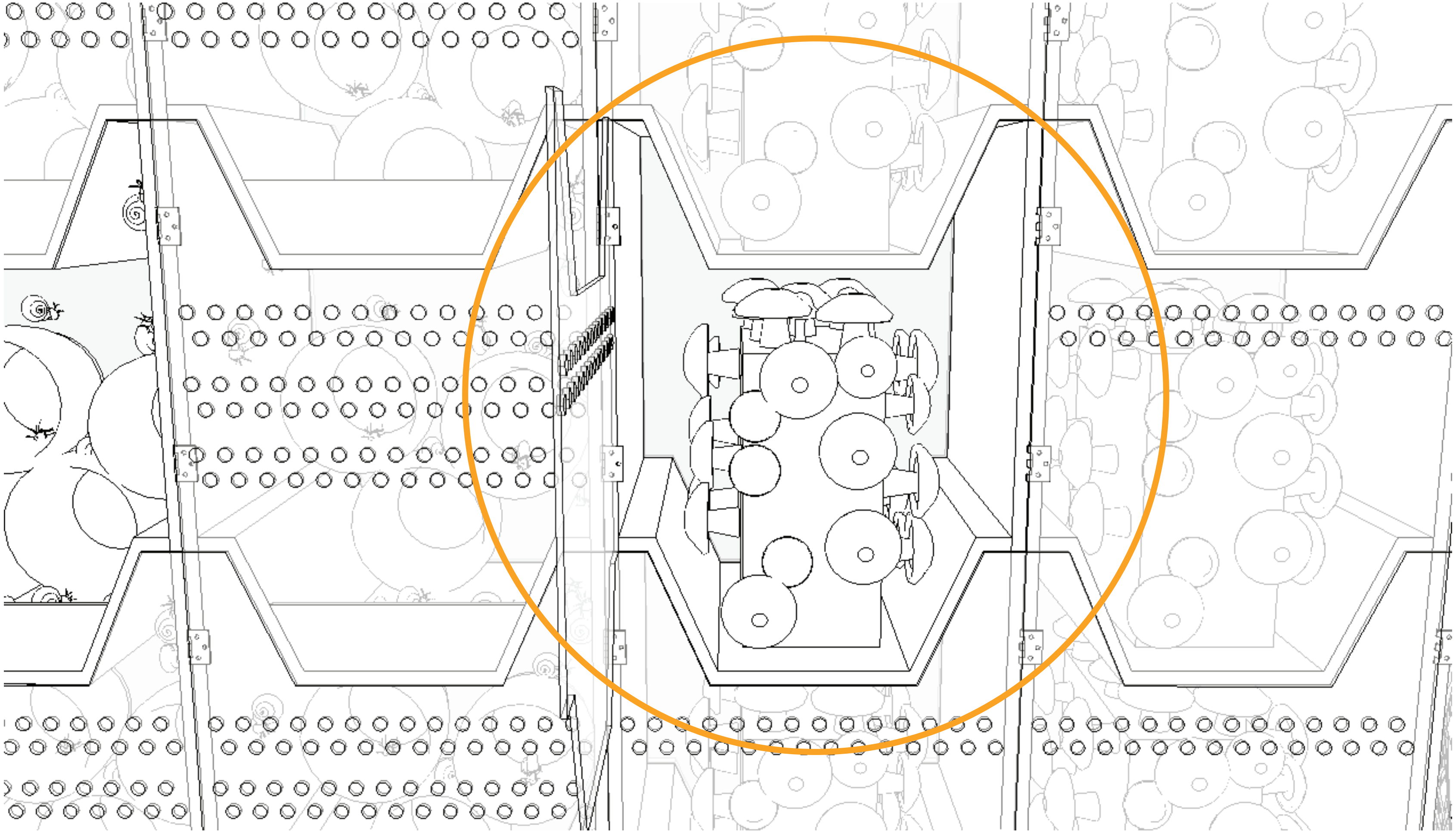
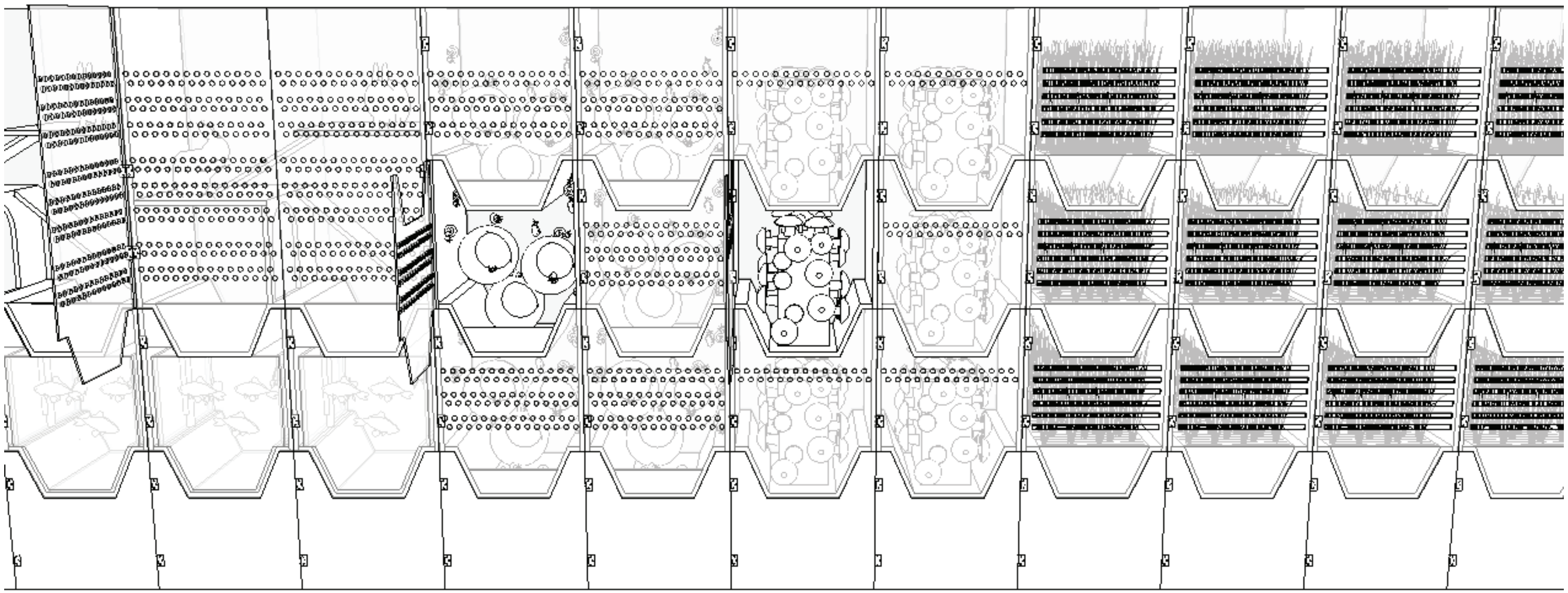
And like snails, they need shade, thus being ideal for the north orientation.



Different needs of humidity and fresh air lead to different types of openings.

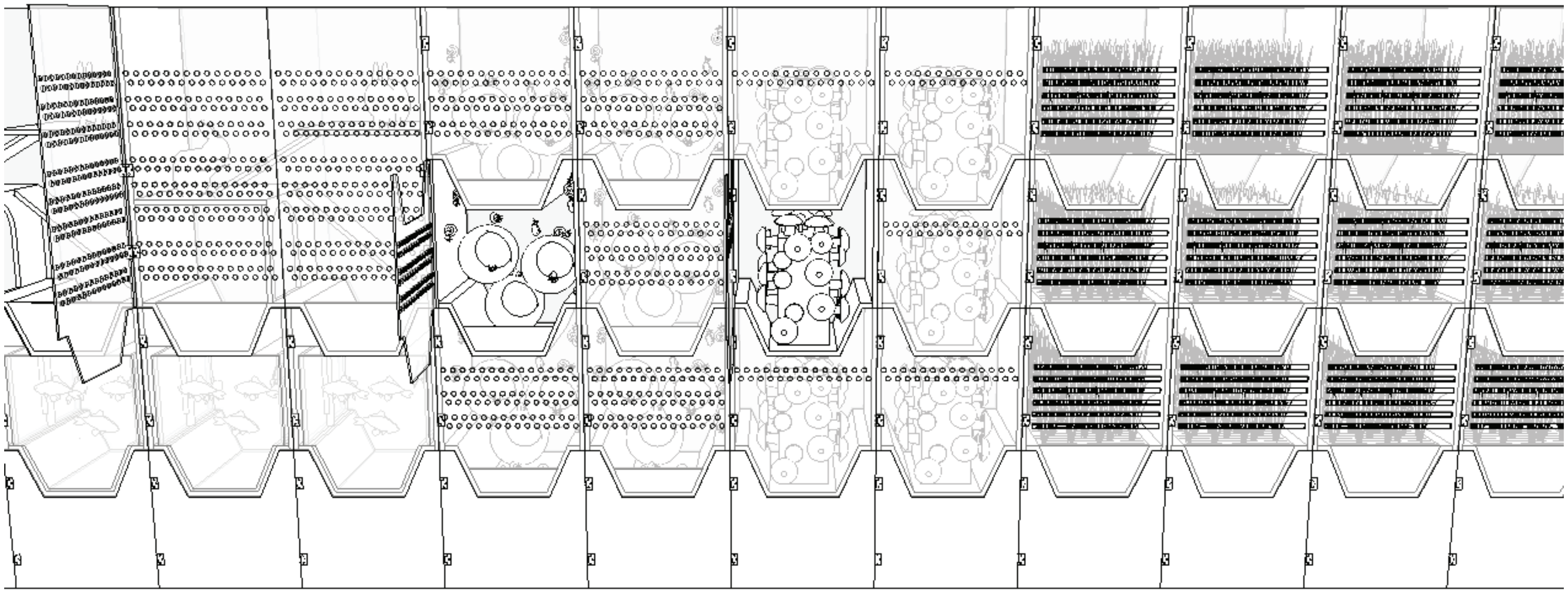


Snails: 25% open

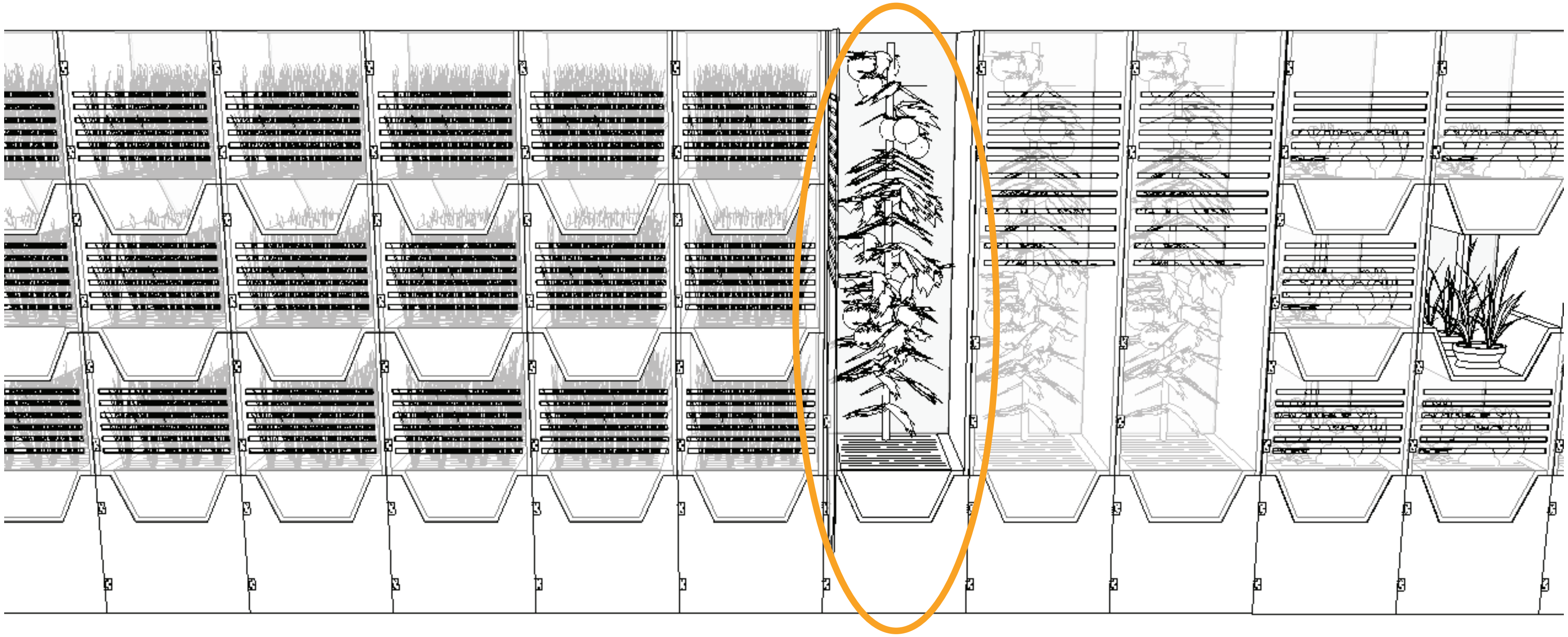
Quinoa seeds: 30 % open

Mushrooms: 5% open

Rabbits: 40% open



Plants that grow upwards and vine-like plants



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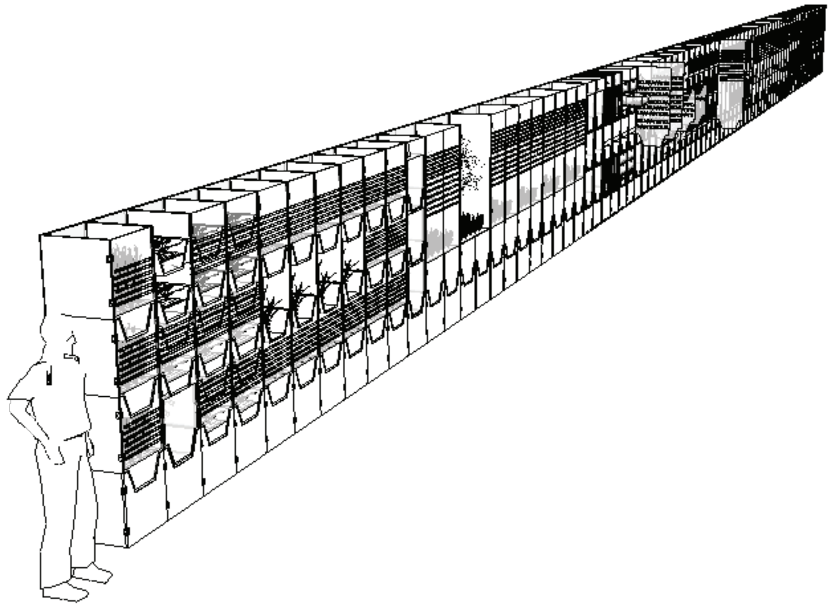
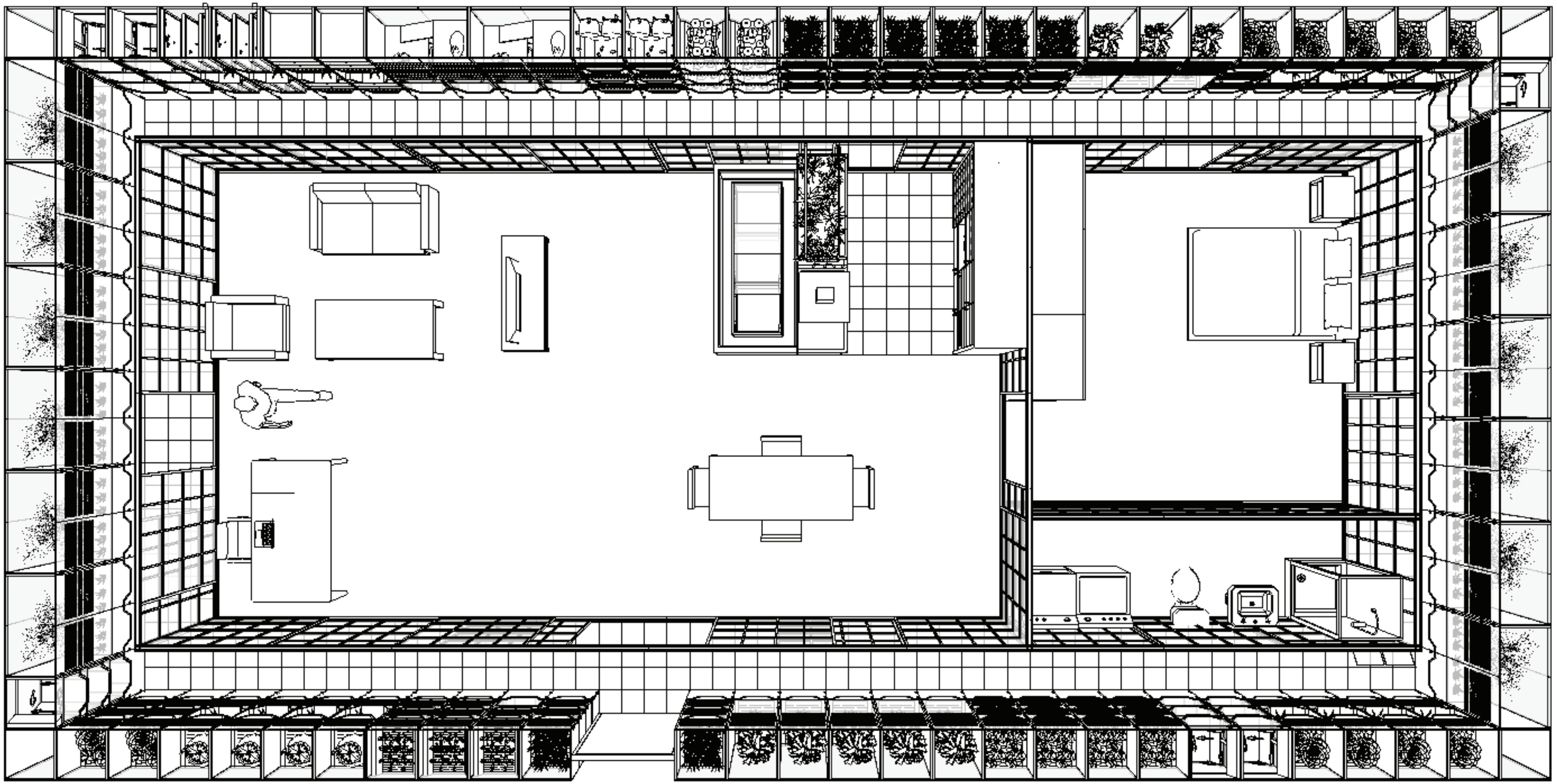
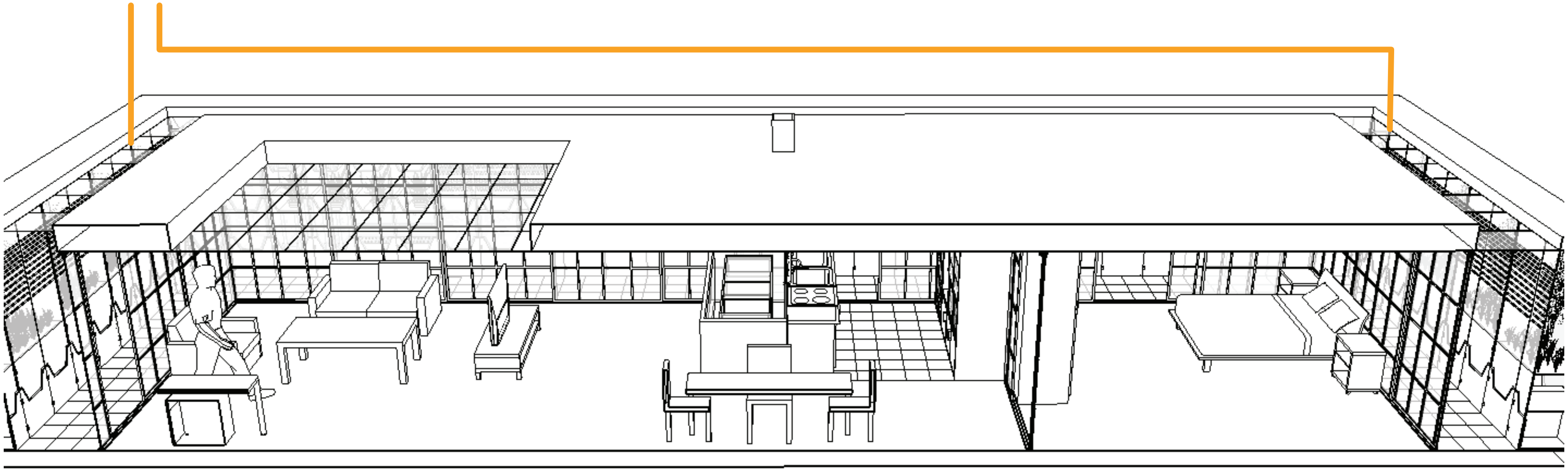


The i-Dwelling



The food prodution corridor has fresh air access through the top. This way humid, warm air can leave the dwelling without entering the living area.



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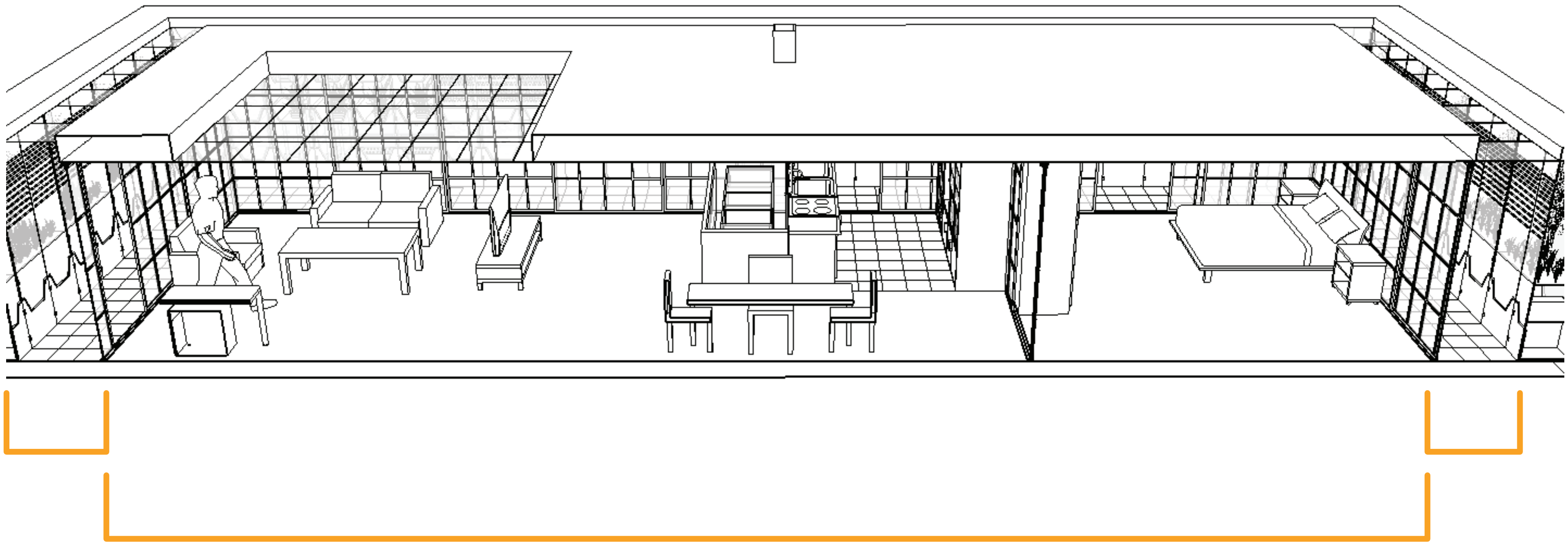
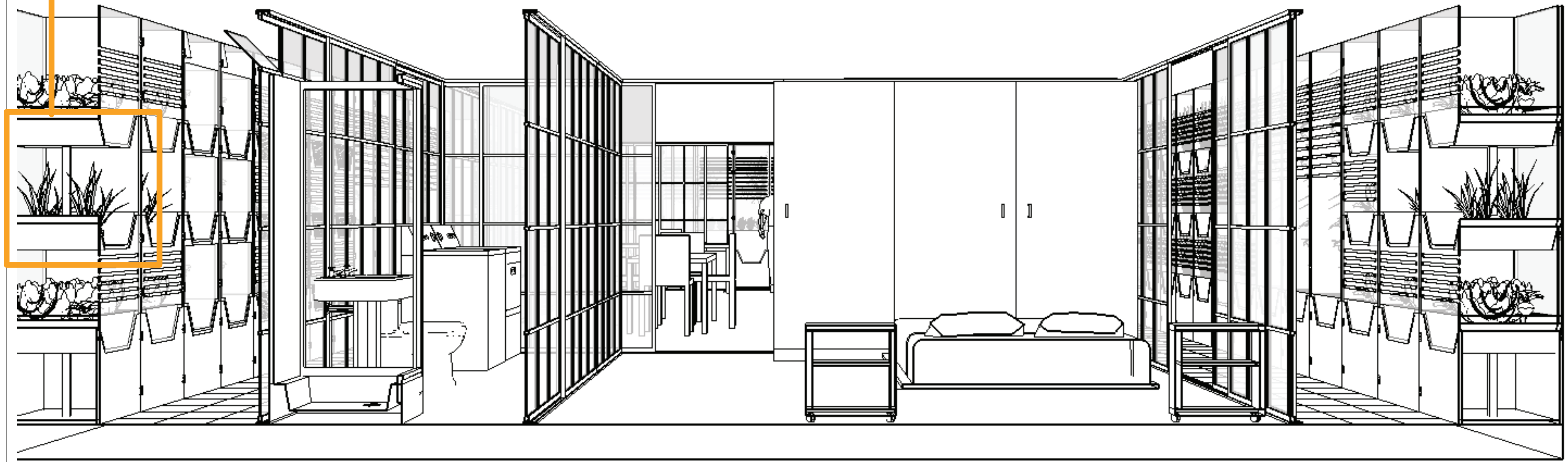


Climate zone 1:
humidity due to evaporation of the grow-crates

Climate zone 2:
Living area: by opening and closing the shoji-like panels, humidity and temperature can be adapted according to the climate.

Climate zone 1:
humidity due to evaporation of the grow-crates

Parts of the GROW-facade open to allow fresh air in and promote circulation through the ceiling openings.



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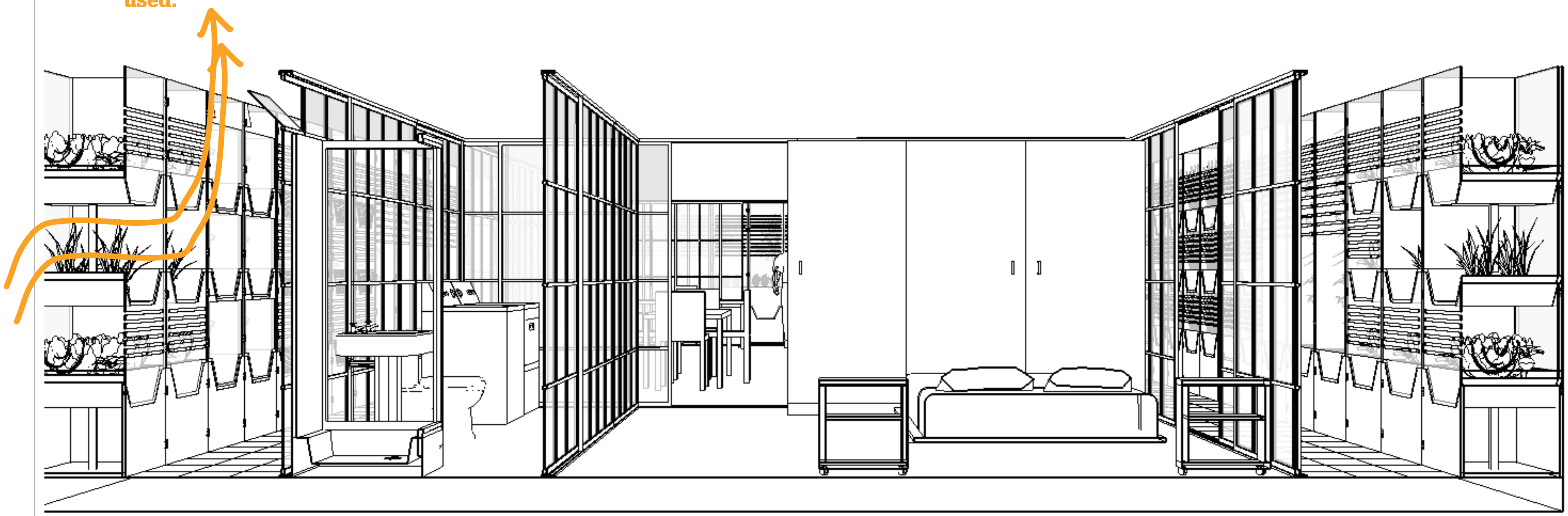
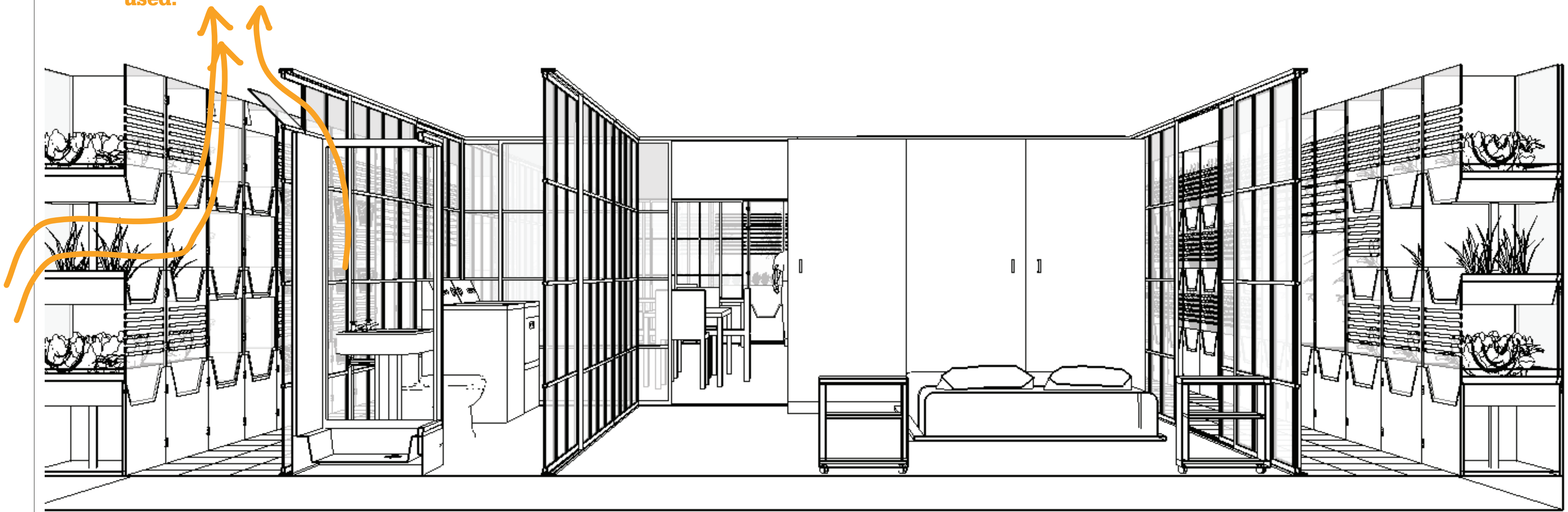
The bathroom is another area that accumulates humidity. To solve this issue, shojis that have inclining openings are used.



The bathroom is another area that accumulates humidity. To solve this issue, shojis that have inclining openings are used.



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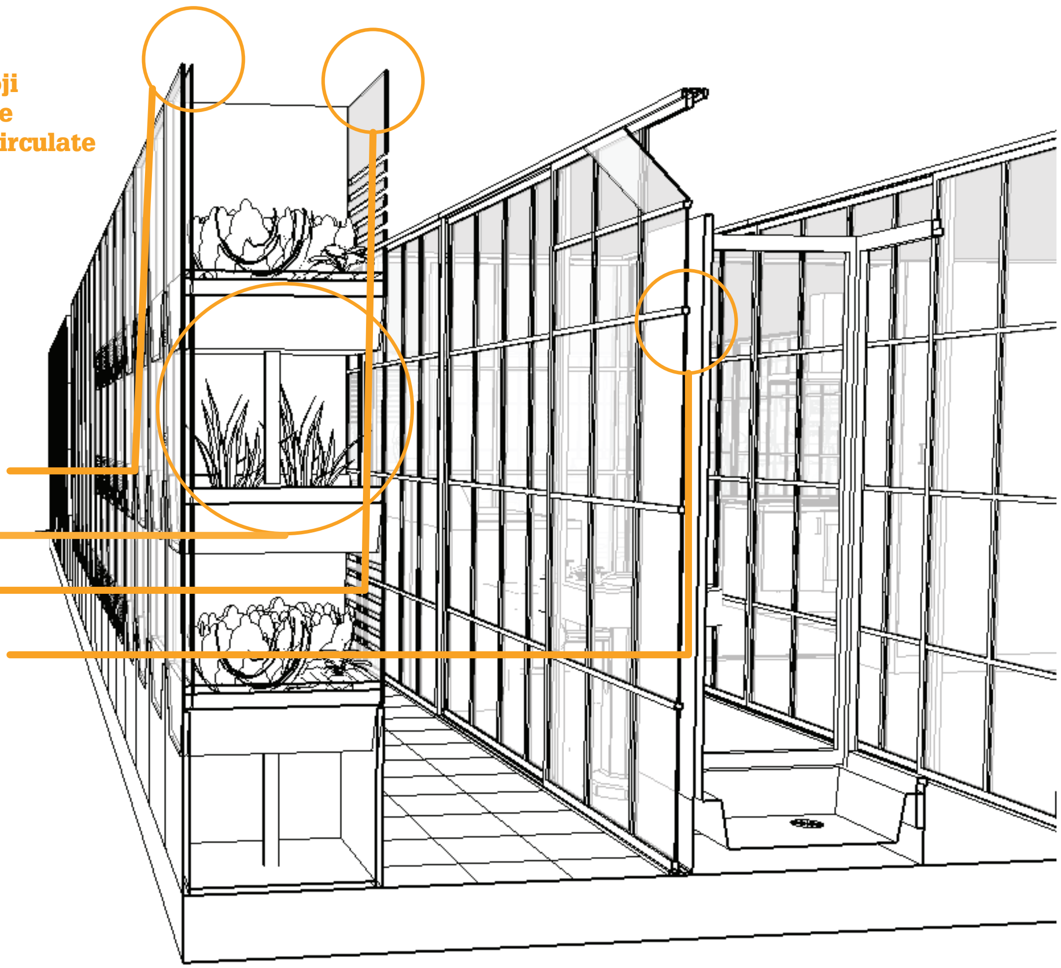
Summer

In order to cool the living area, shoji panels, ceiling openings and facade openings are kept open, to let air circulate freely.



Winter

-The double glazing at the outside,

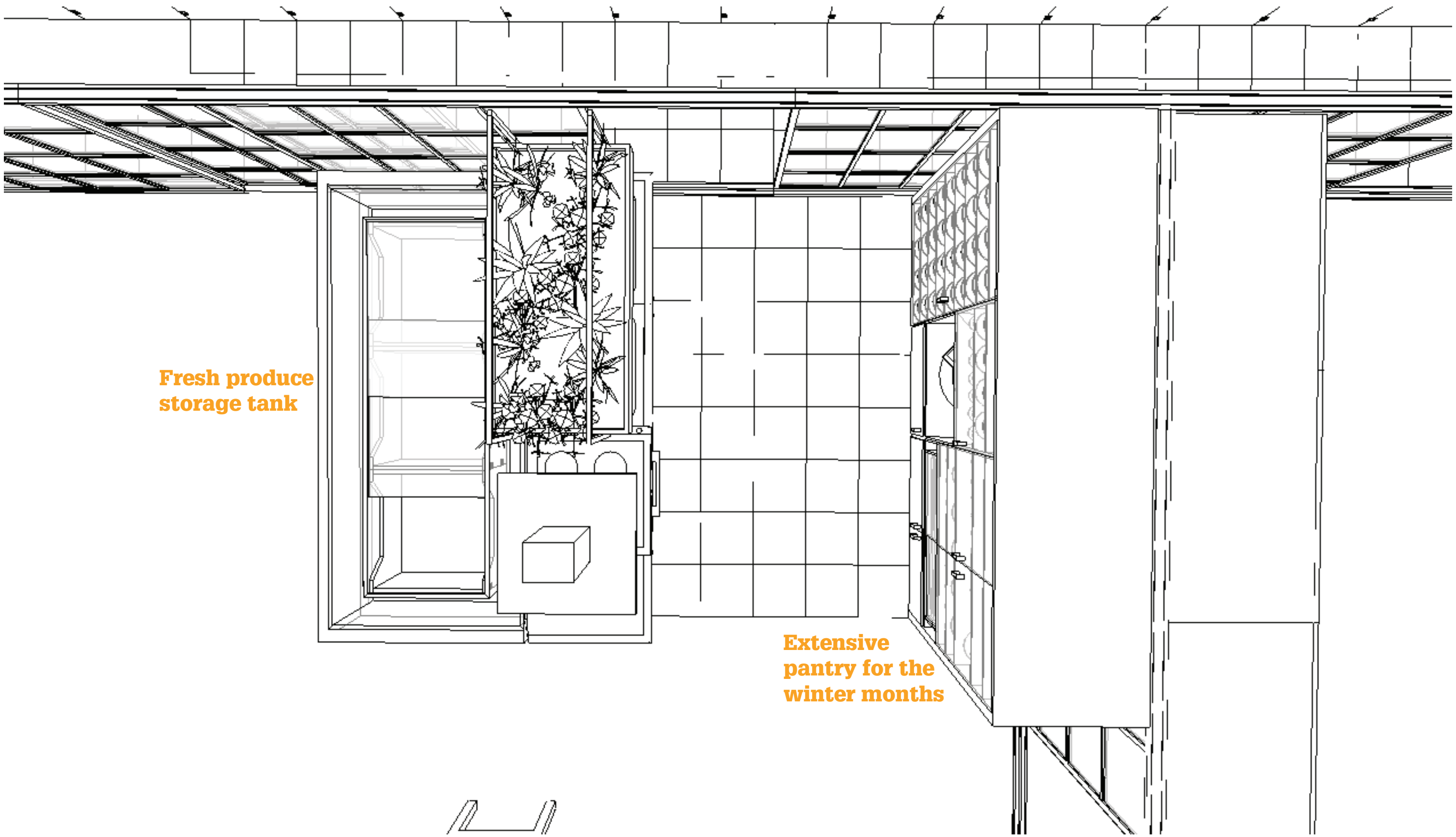
-the 60 cm crate zone,

-the single glazing,

-the GROW hallway and the shojis

are multiple layers making sure that the cold does not enter the living area.

The kitchen of the i-Dwelling has some added characteristics.



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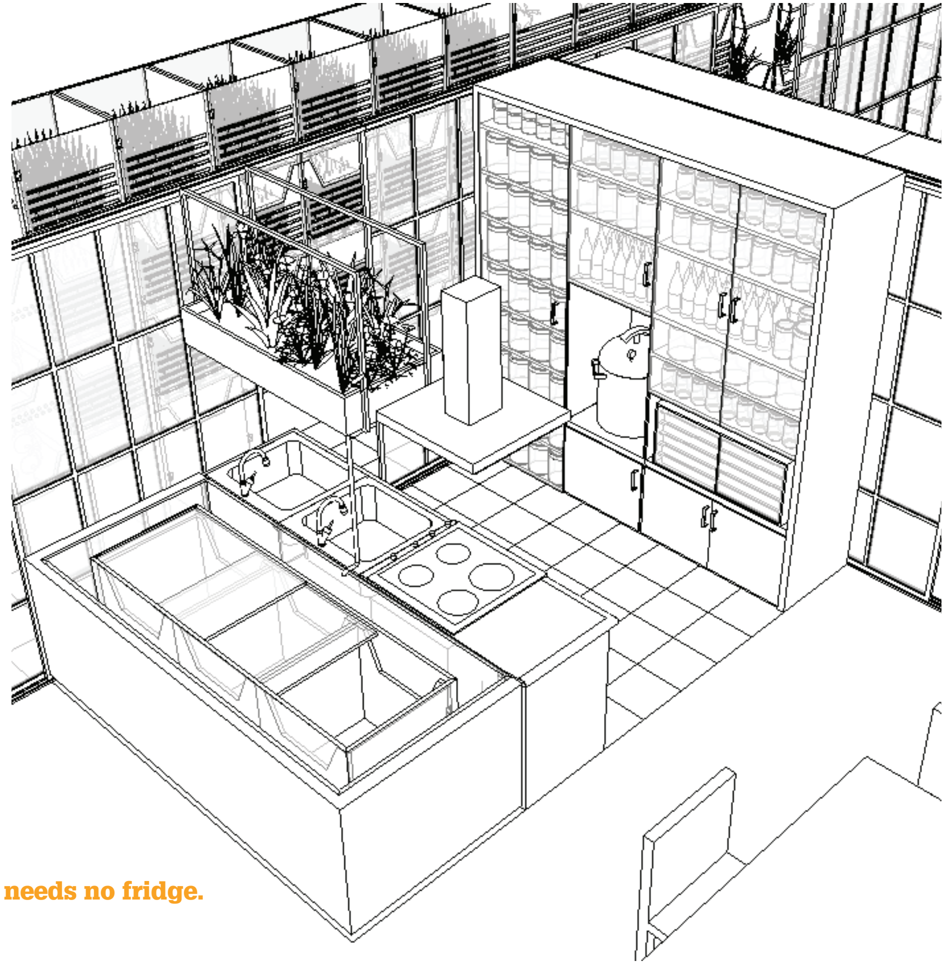
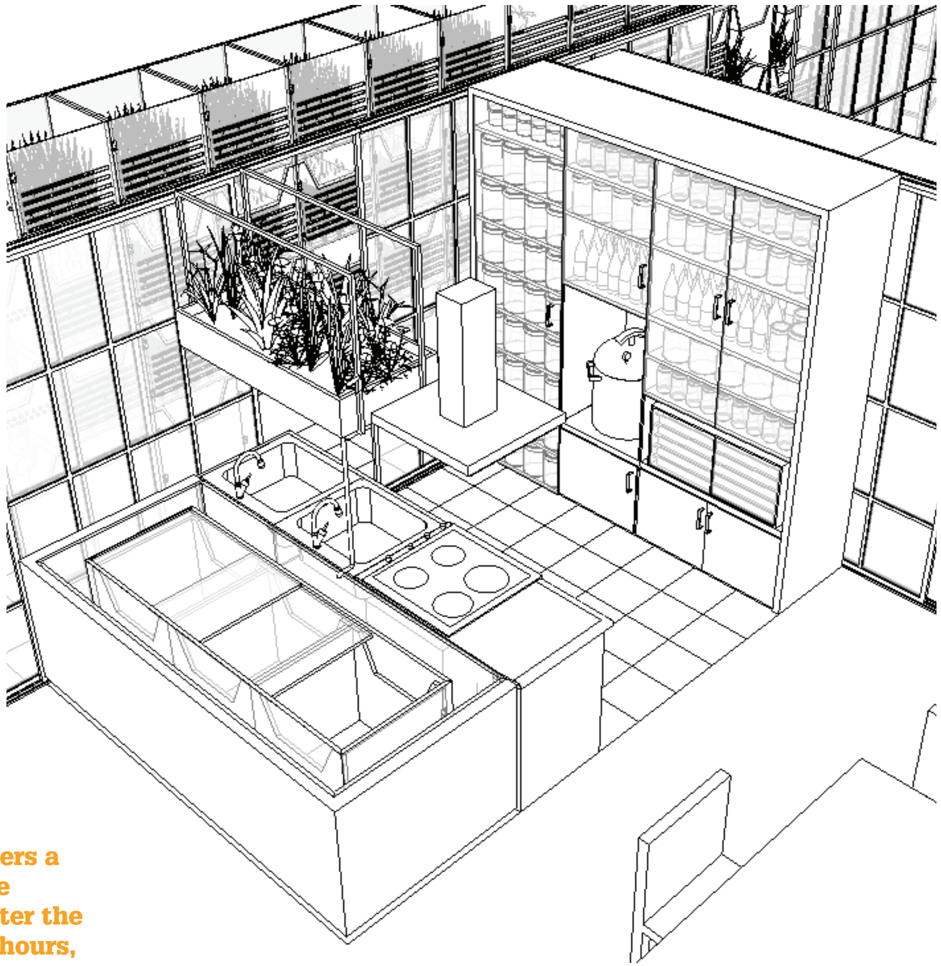
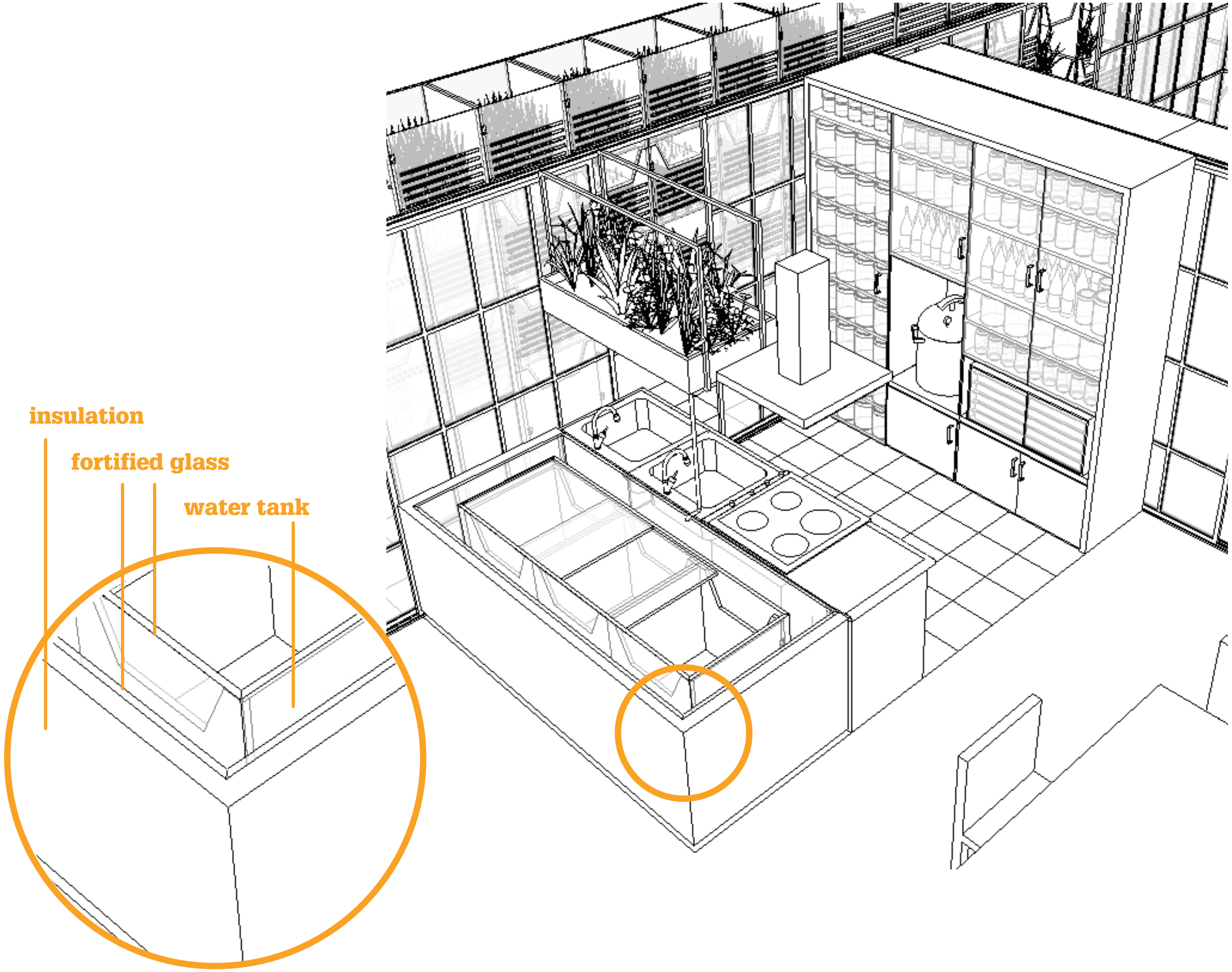


The i-Dwelling needs no fridge.



This storage configurations offers a temperature between 5-7 C. The underground water used to water the crates, stays in the tank for 12 hours, cooling the produce.


insulation
fortified glass
water tank

The i-Dwelling kitchen needs equipment.
As there is minimal food production during winter, canning is immportant to ensure food supplies for these months.

A pressure canner is easy to use and can ensure that pickled vegetables, marmelades, seeds, nuts and legumes will be well preserved, without the need of freezing.

A food drier is also useful as it can be used to create dried fruits and dark leafy greens "chips". These will ensure that the user has an adequate intake of vitamins and minerals throughout winter.

But, what can I eat?

A.M. Symvoulidou

Why invest in i-Crates?

-personalized food production

-no trips to the grocery store

-personal control of food quality

-passive system (minimal energy for heating/ cooling)

-adaptability to family size

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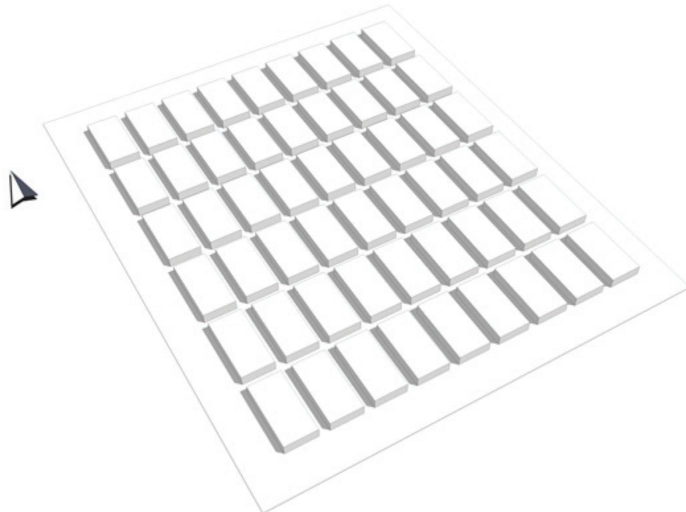
Microclimate



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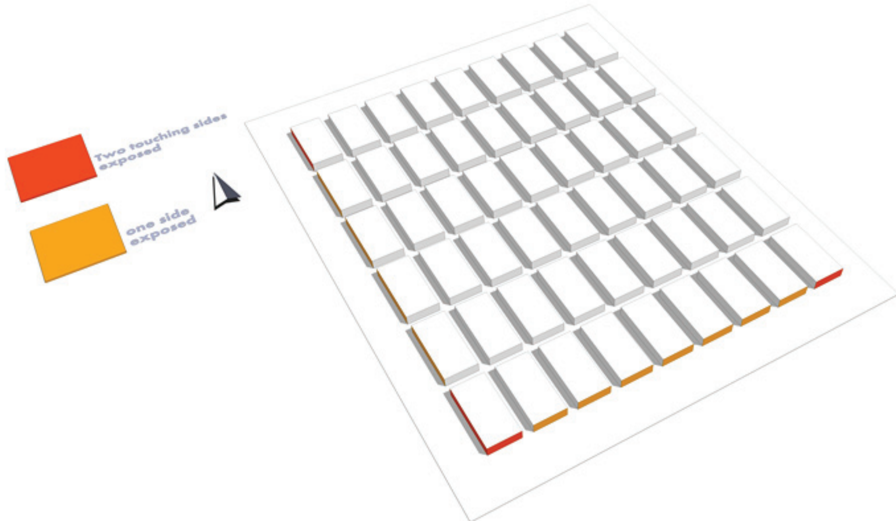

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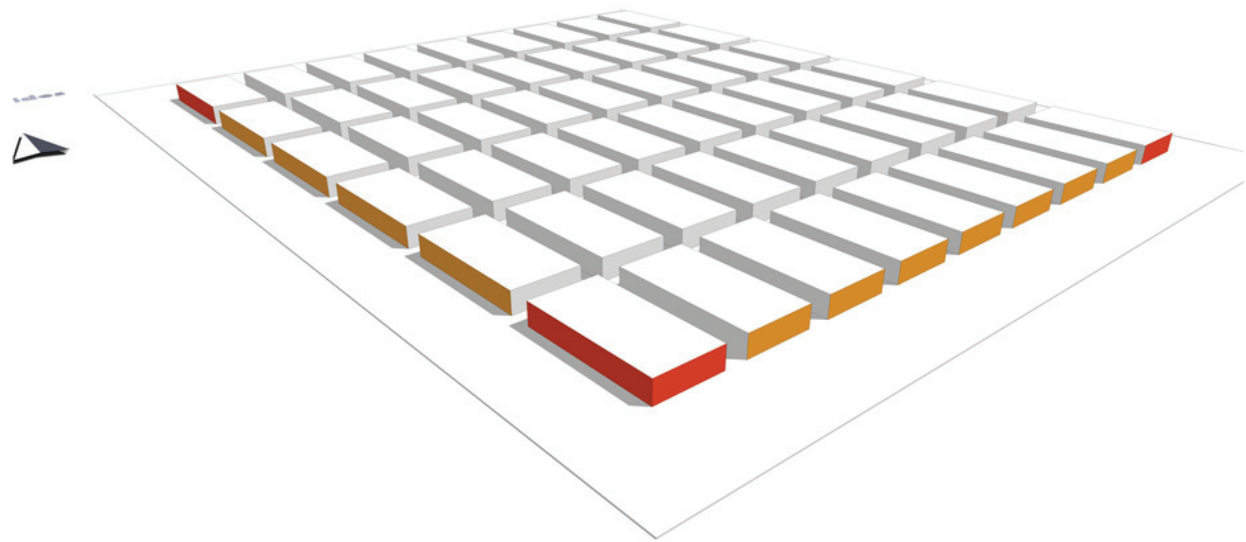
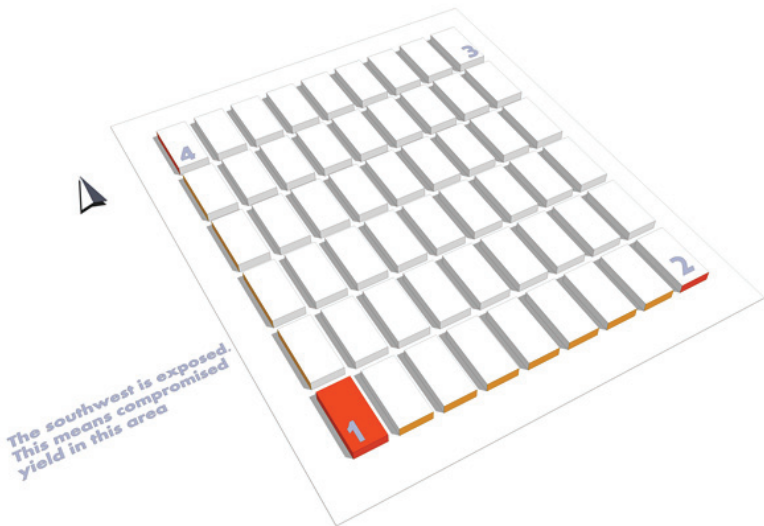
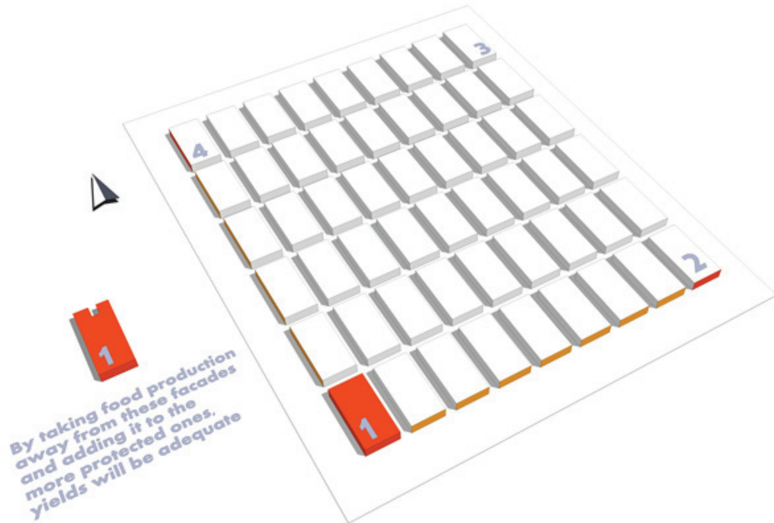
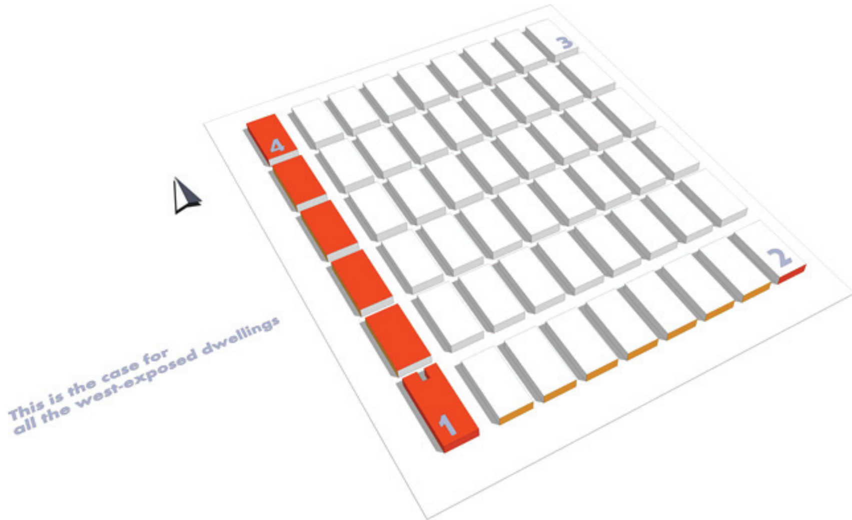



The southwest is exposed.
This means compromised
yield in this area
1
2
3
4


3
4
2
1
1
By taking food production away from these facades and adding it to the more protected ones, yields will be adequate



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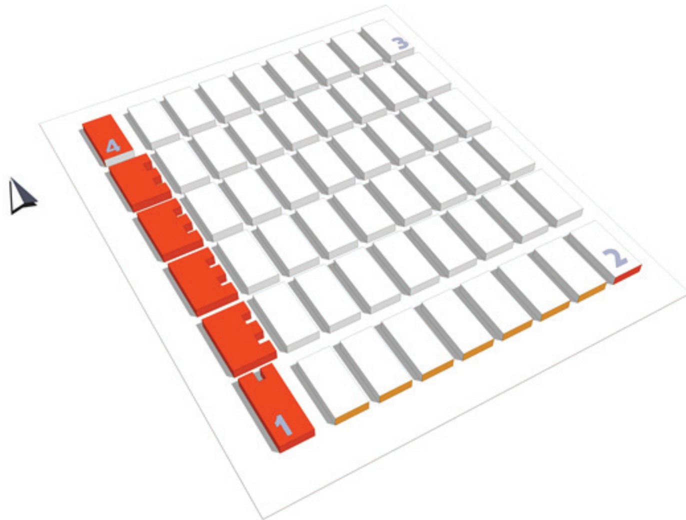

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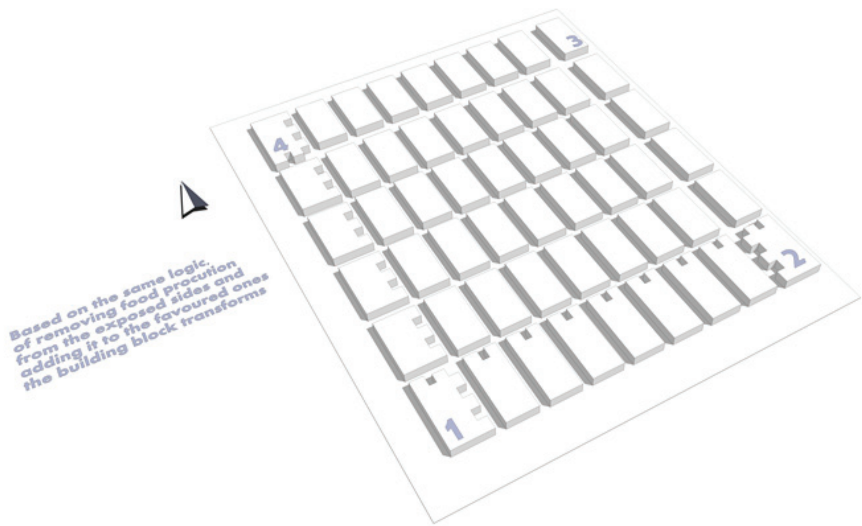
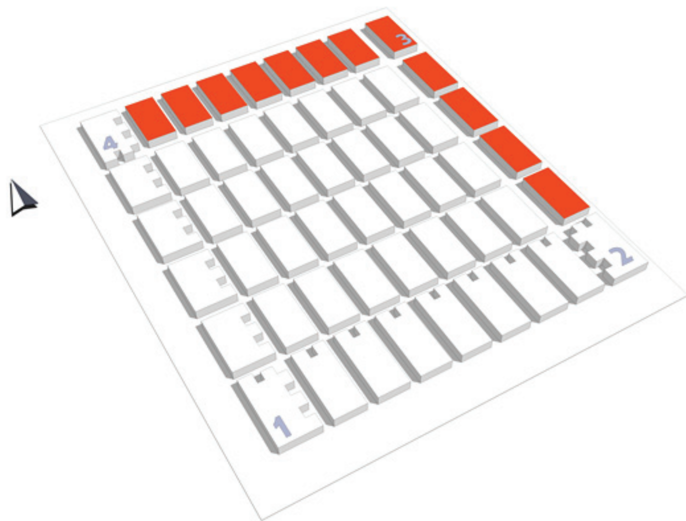
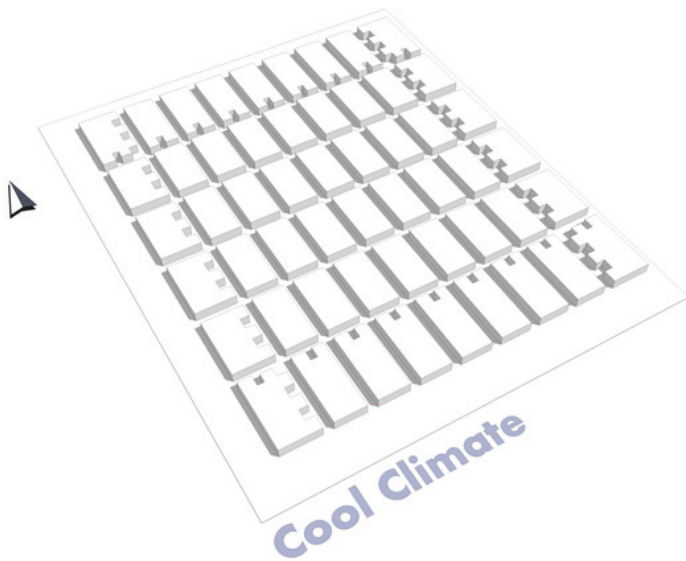
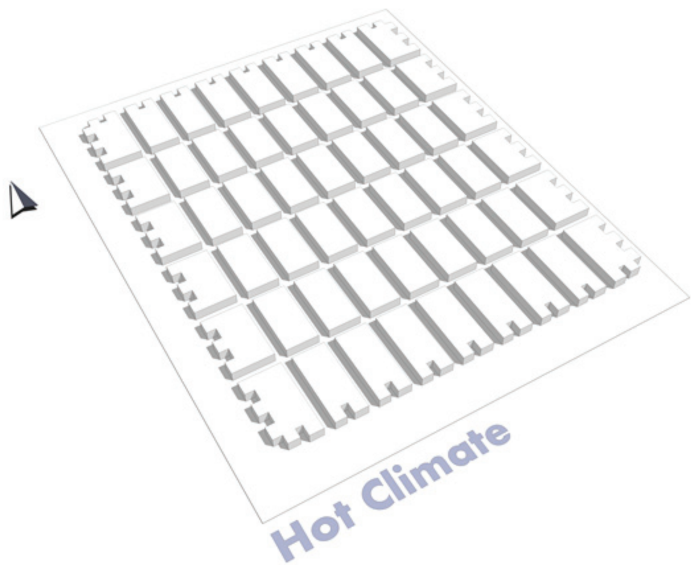
In this area the south facades
are exposed. Despite the favourable
sunlight, this can still lead
to compromised yields during
the cooler months (Feb., Mar., Apr.,
May, Sep., Oct., Nov.)
1
2
3
4


Based on the same logic,
of removing food procution
from the exposed sides and
adding it to the favoured ones
the building block transforms
1
2
3
4


4
3
2
1


Cool Climate



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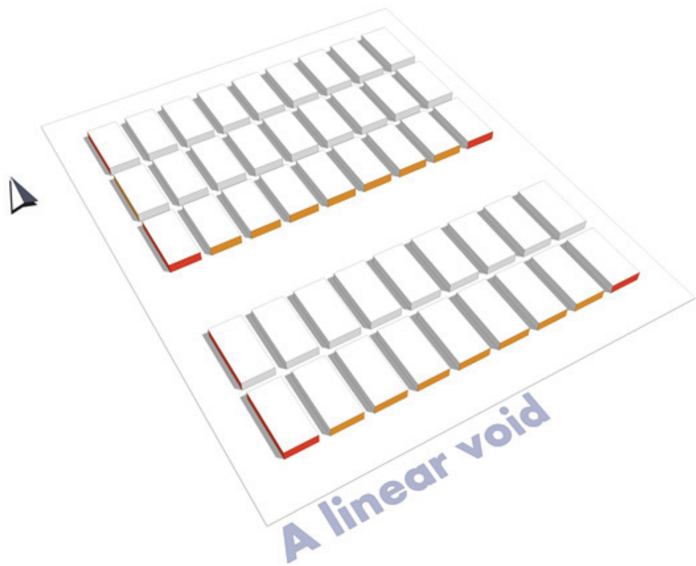

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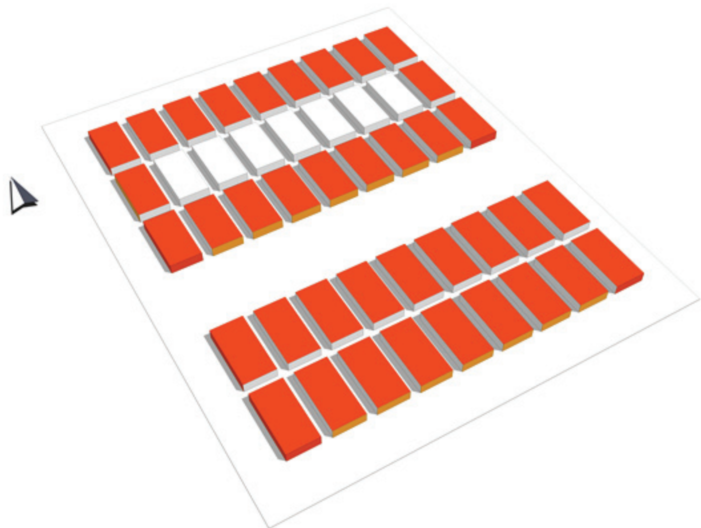

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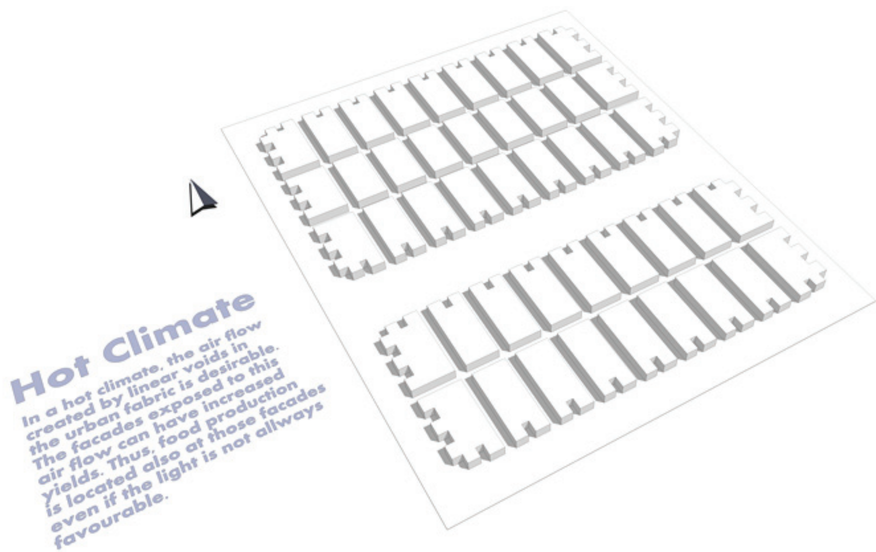

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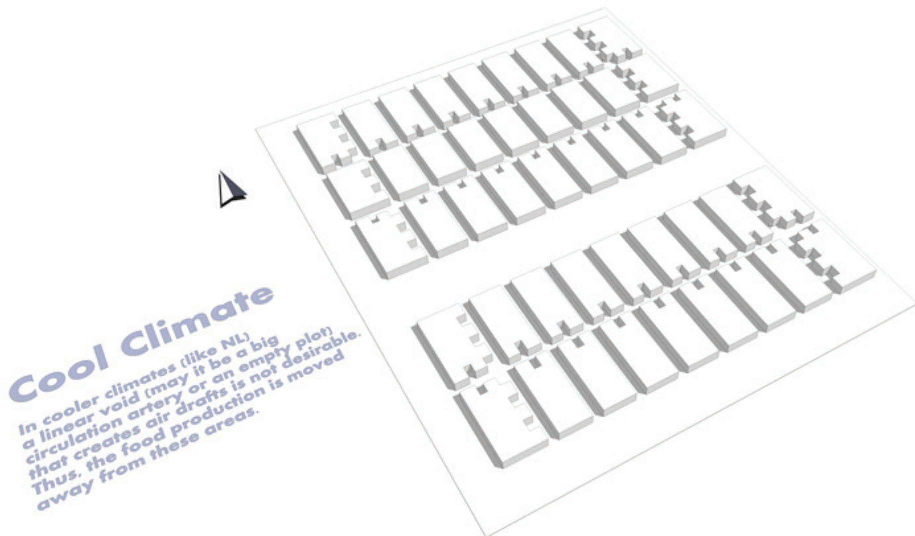

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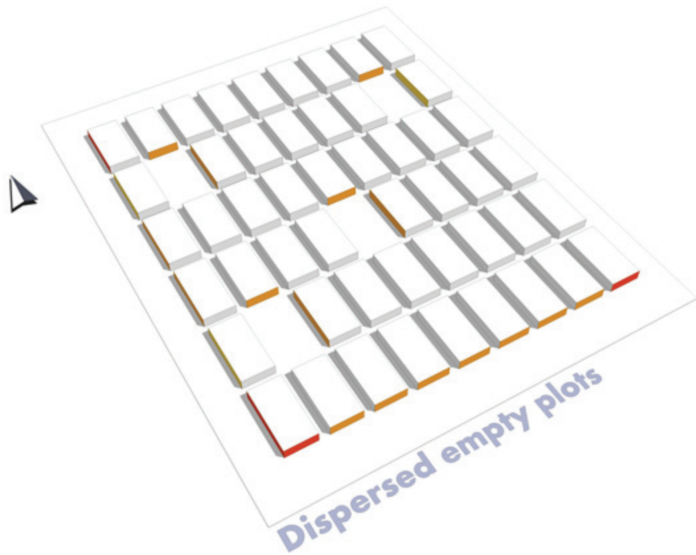

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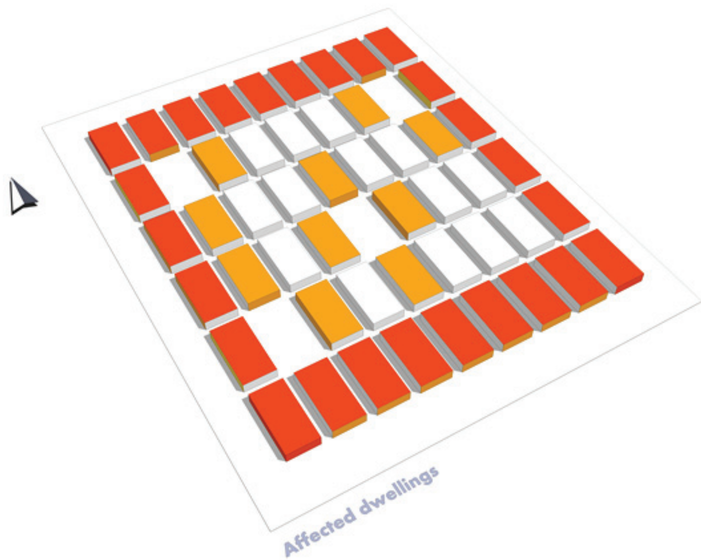

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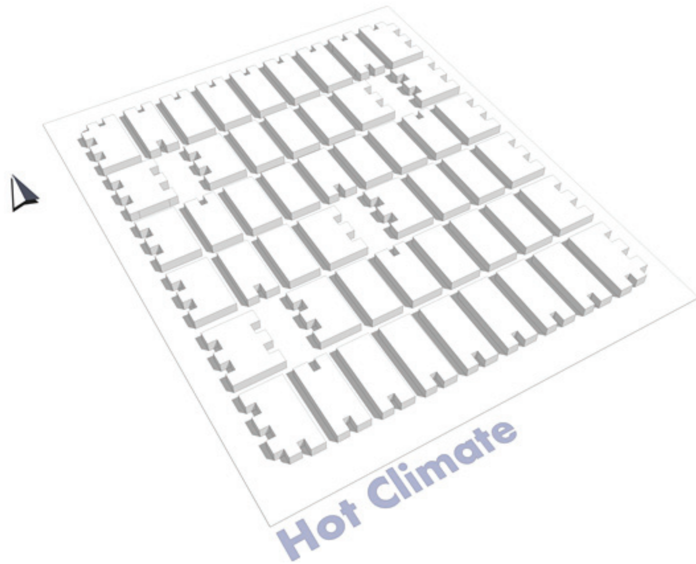
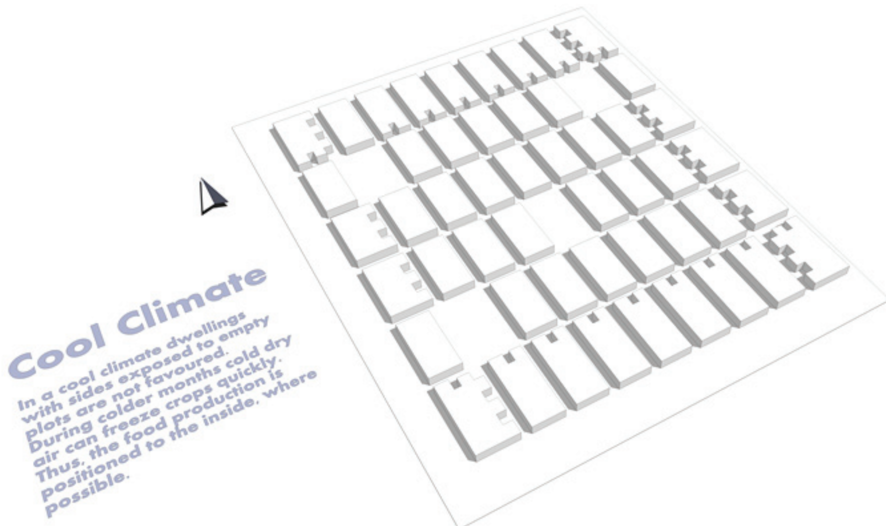

Hot Climate



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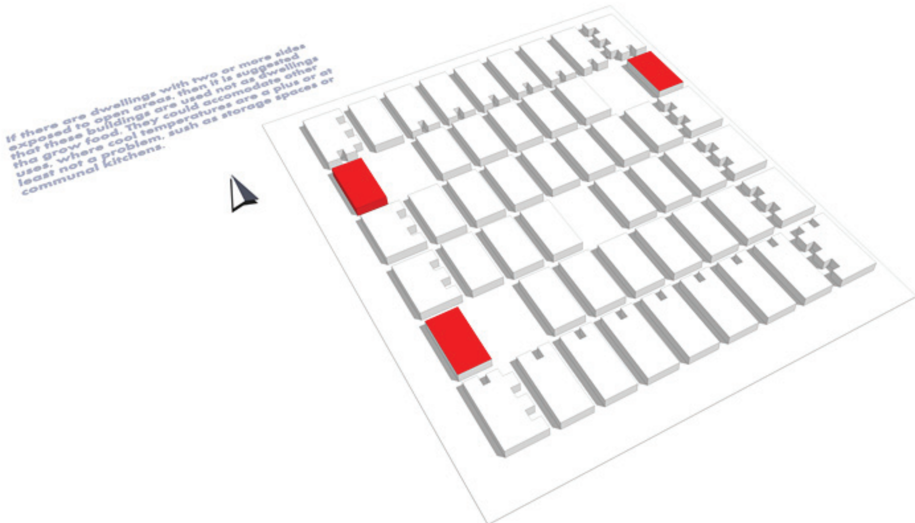

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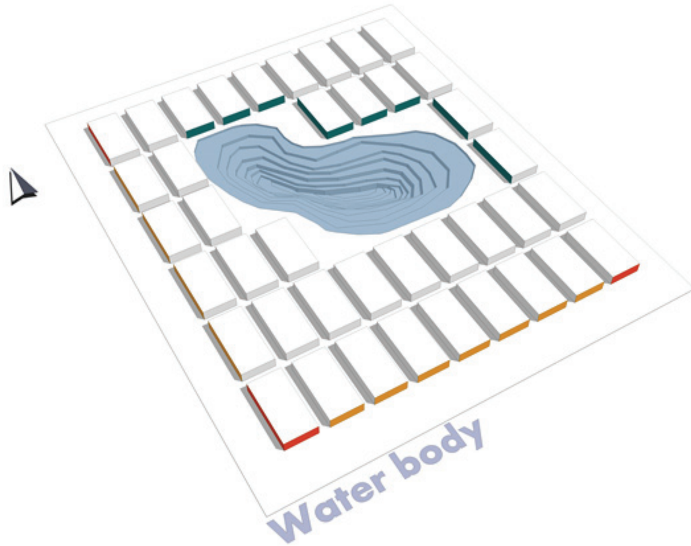

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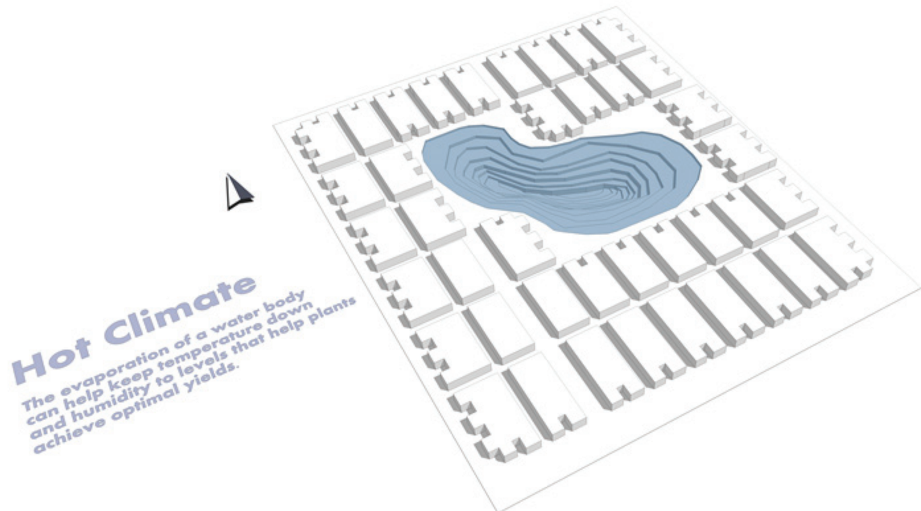
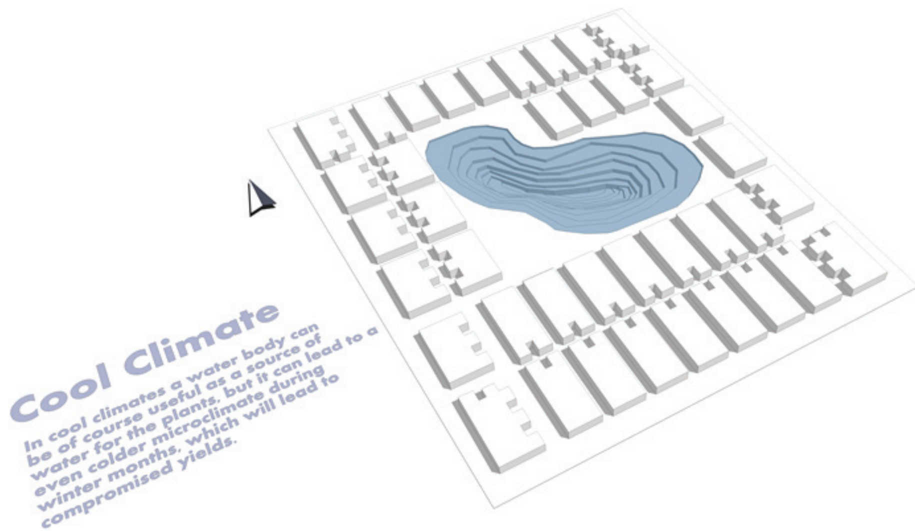
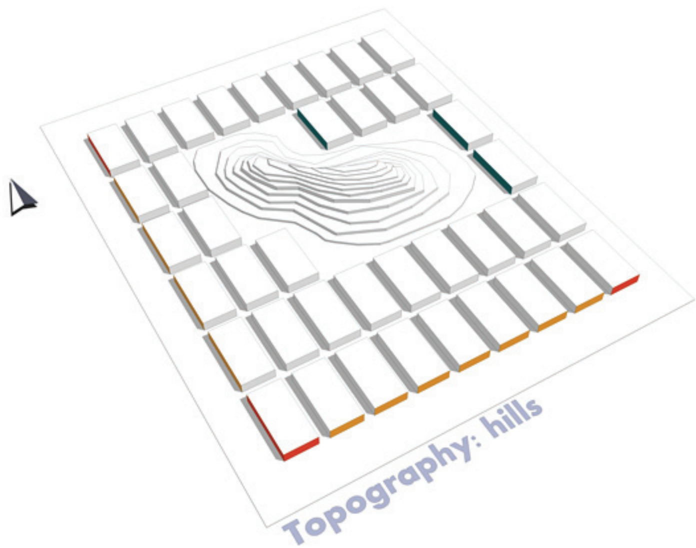

Hot Climate
The evaporation of a water body can help keep temperature down and humidity to levels that help plants achieve optimal yields.


Cool Climate
In cool climates a water body can be of course useful as a source of water for the plants, but it can lead to a even colder microclimate during winter months, which will lead to compromised yields.



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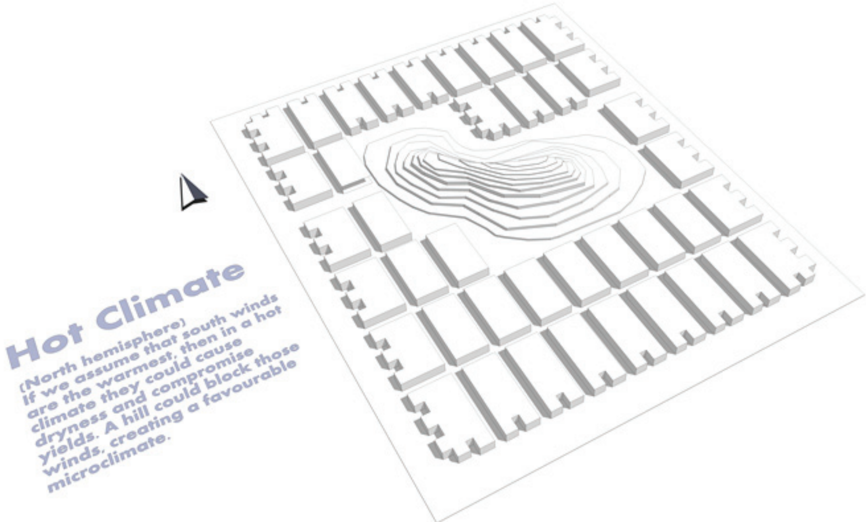
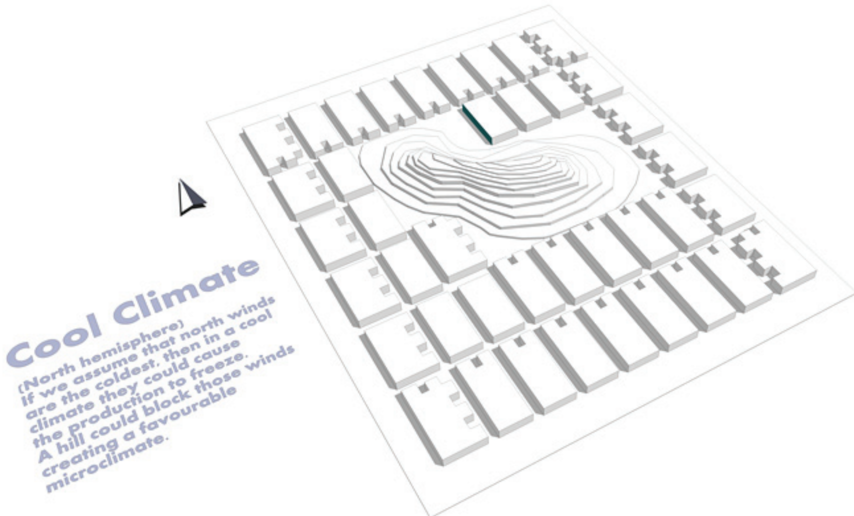

Hot Climate
(North hemisphere)
If we assume that south winds
are the warmest, then in a hot
climate they could cause
dryness and compromise
yields. A hill could block those
winds, creating a favourable
microclimate.



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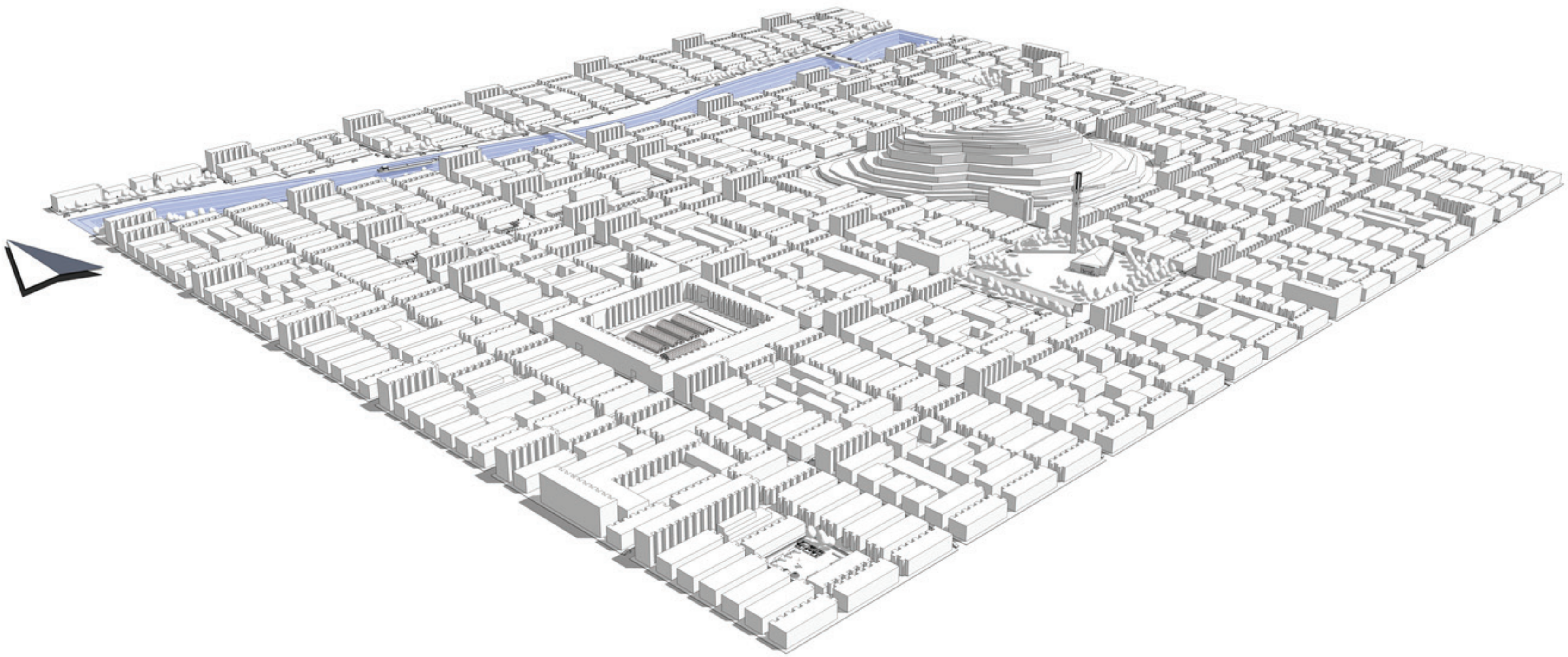
The i-Food City



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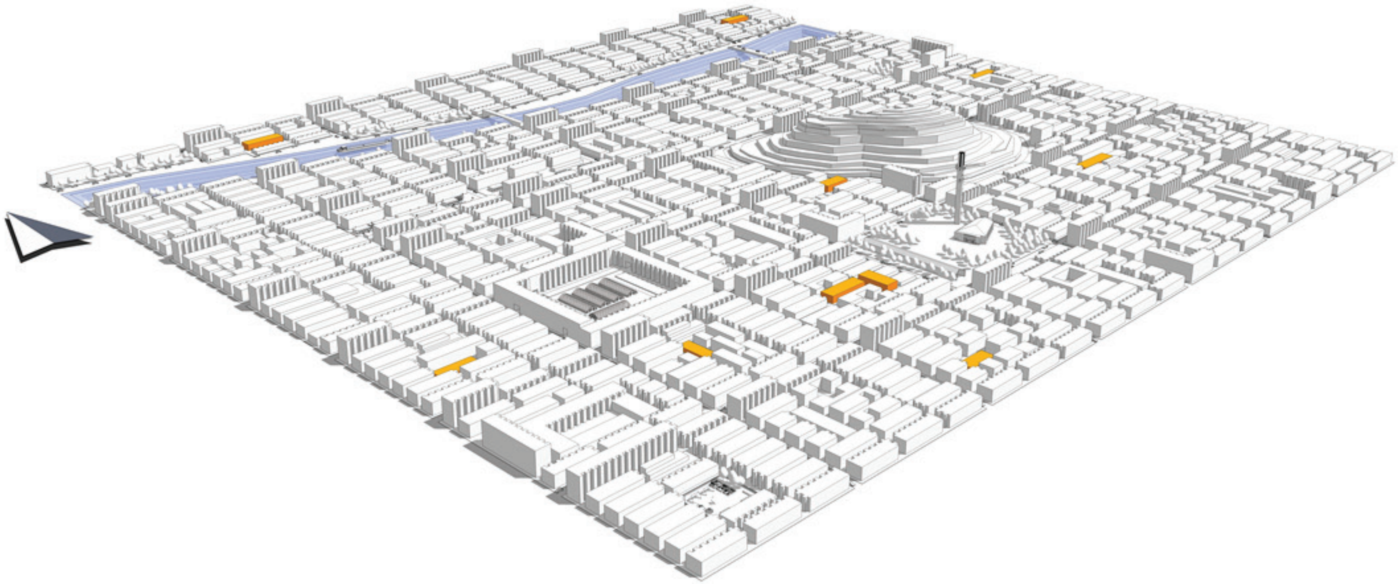

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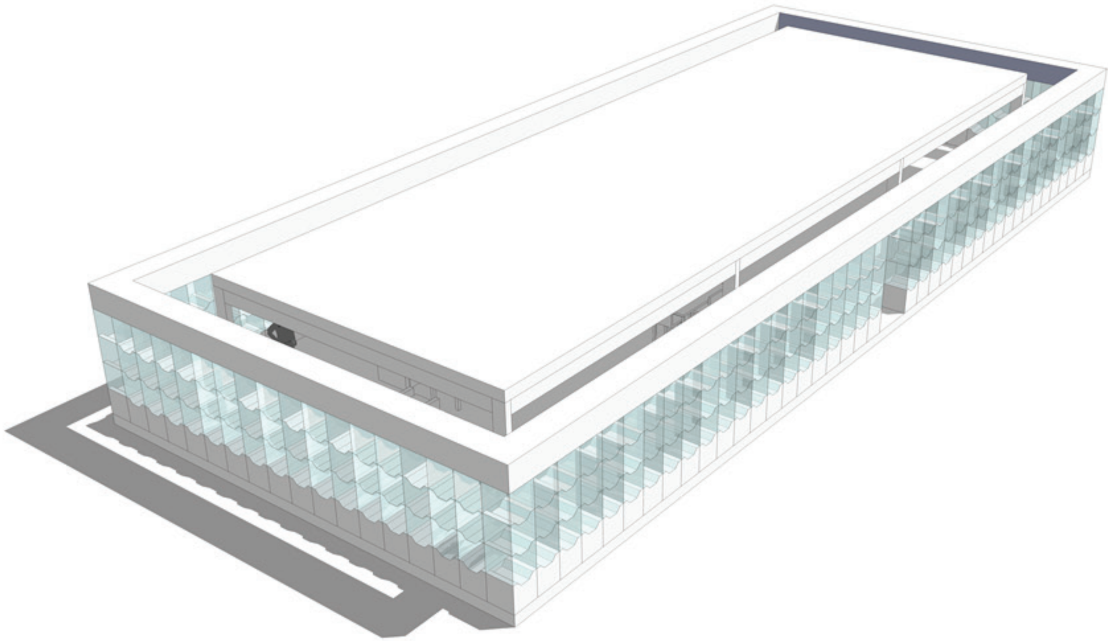

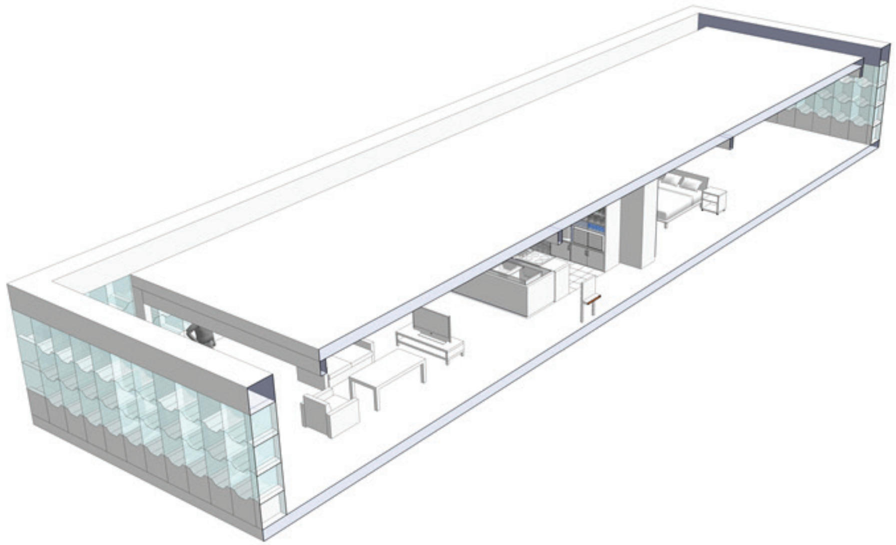

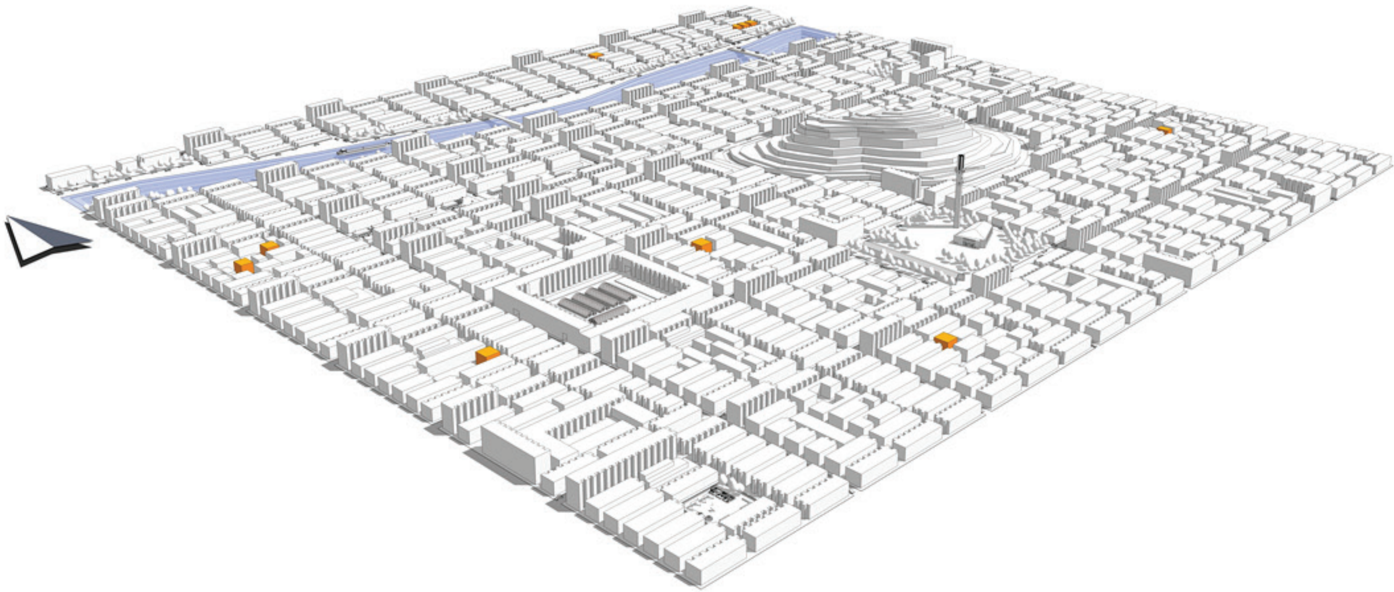

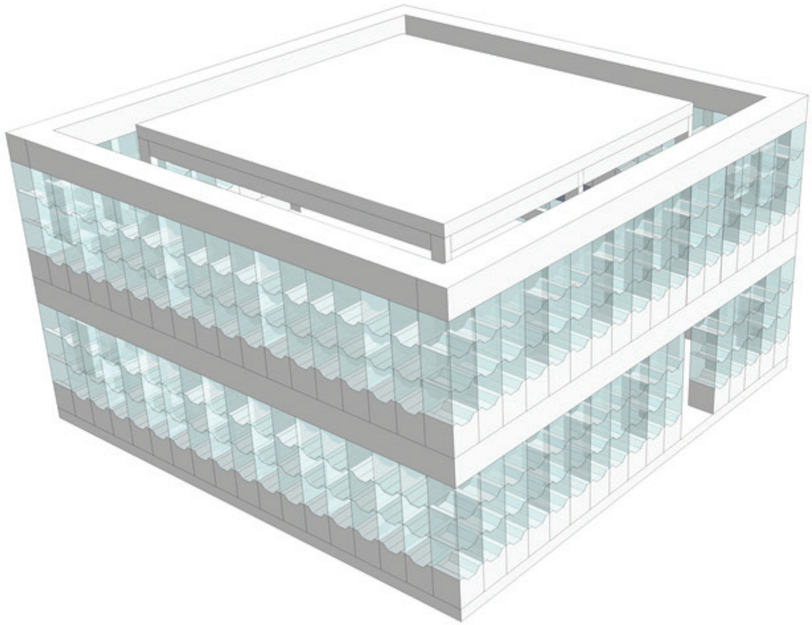

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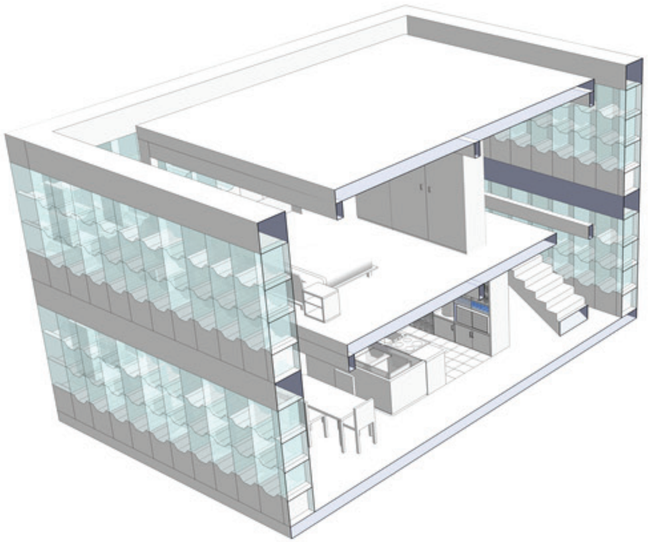

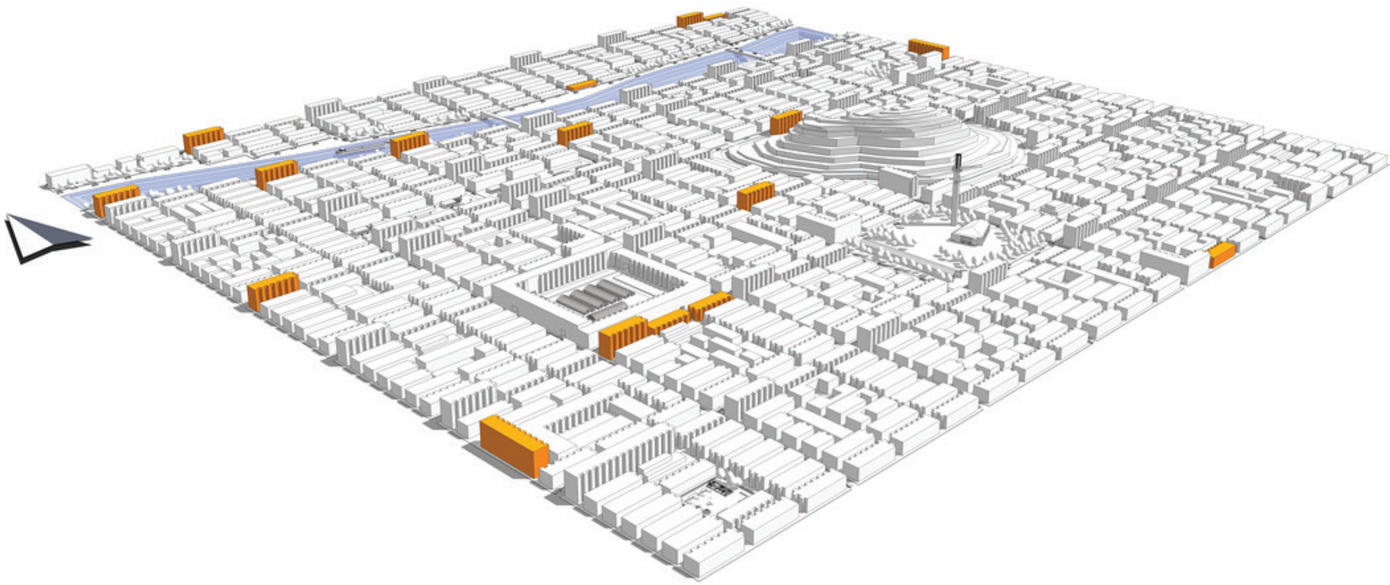

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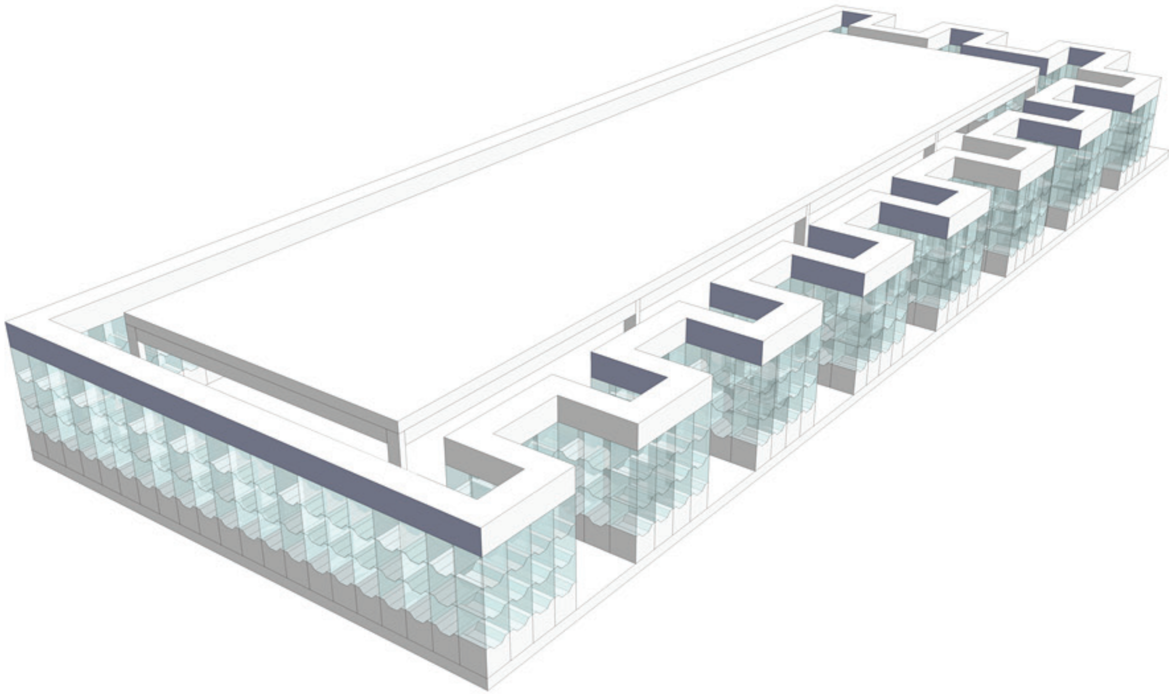

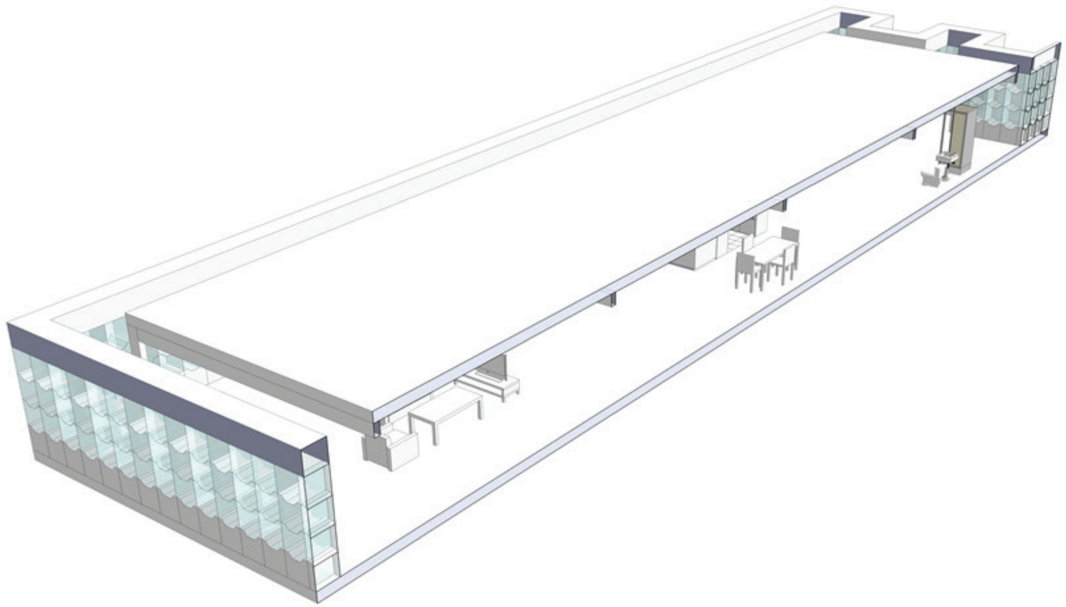

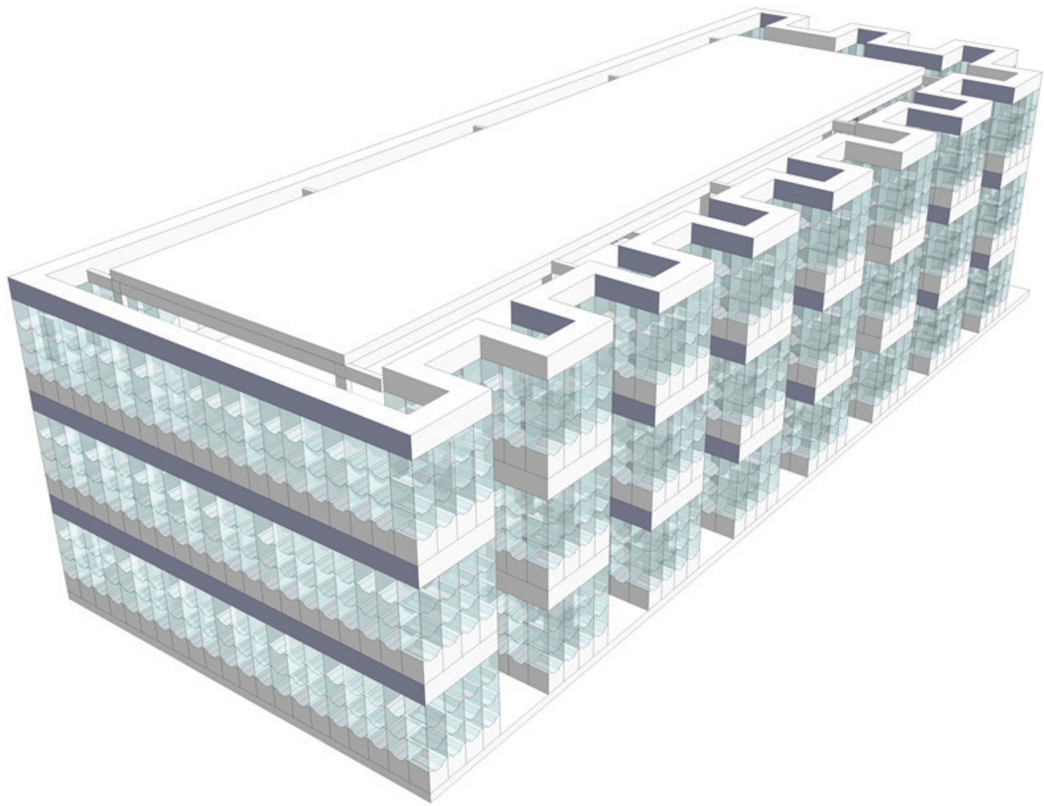

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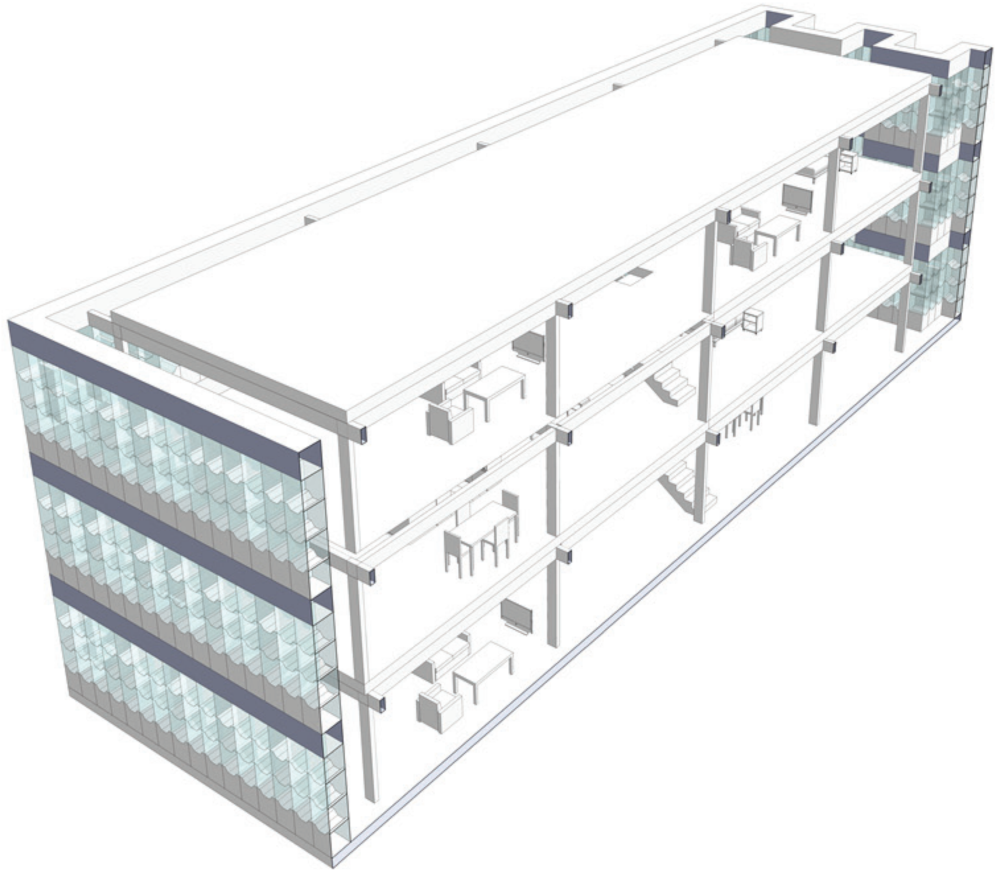

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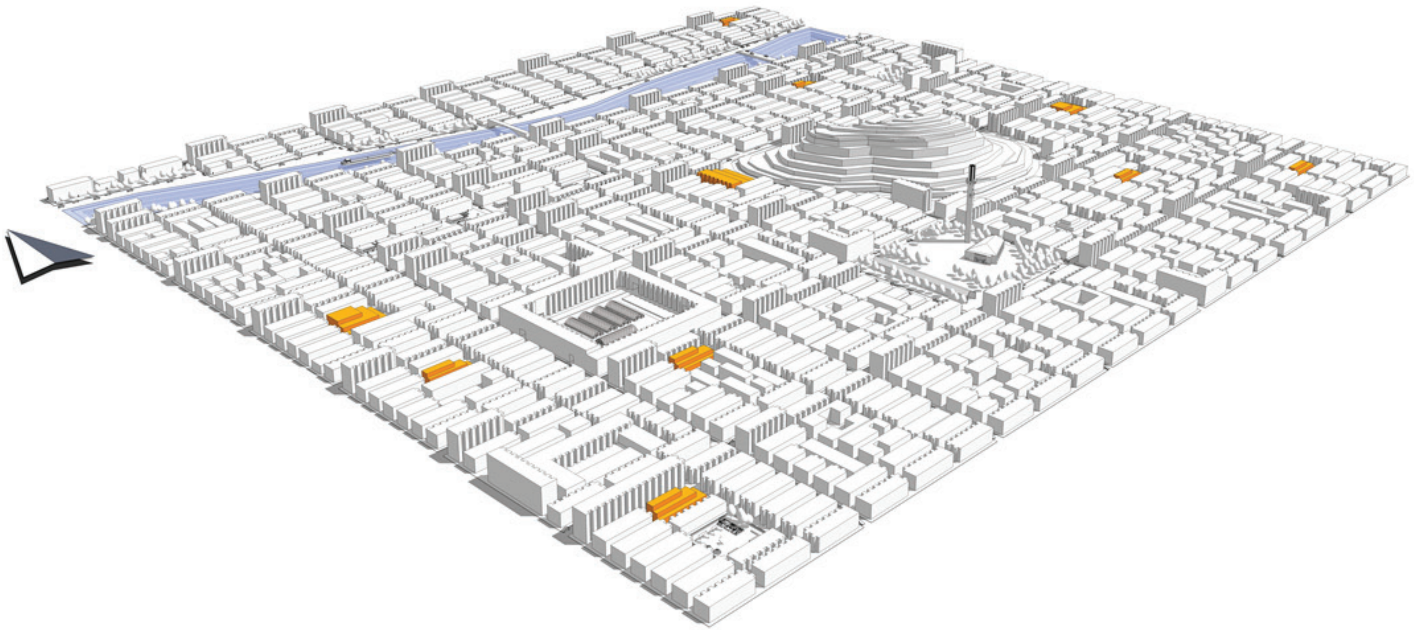

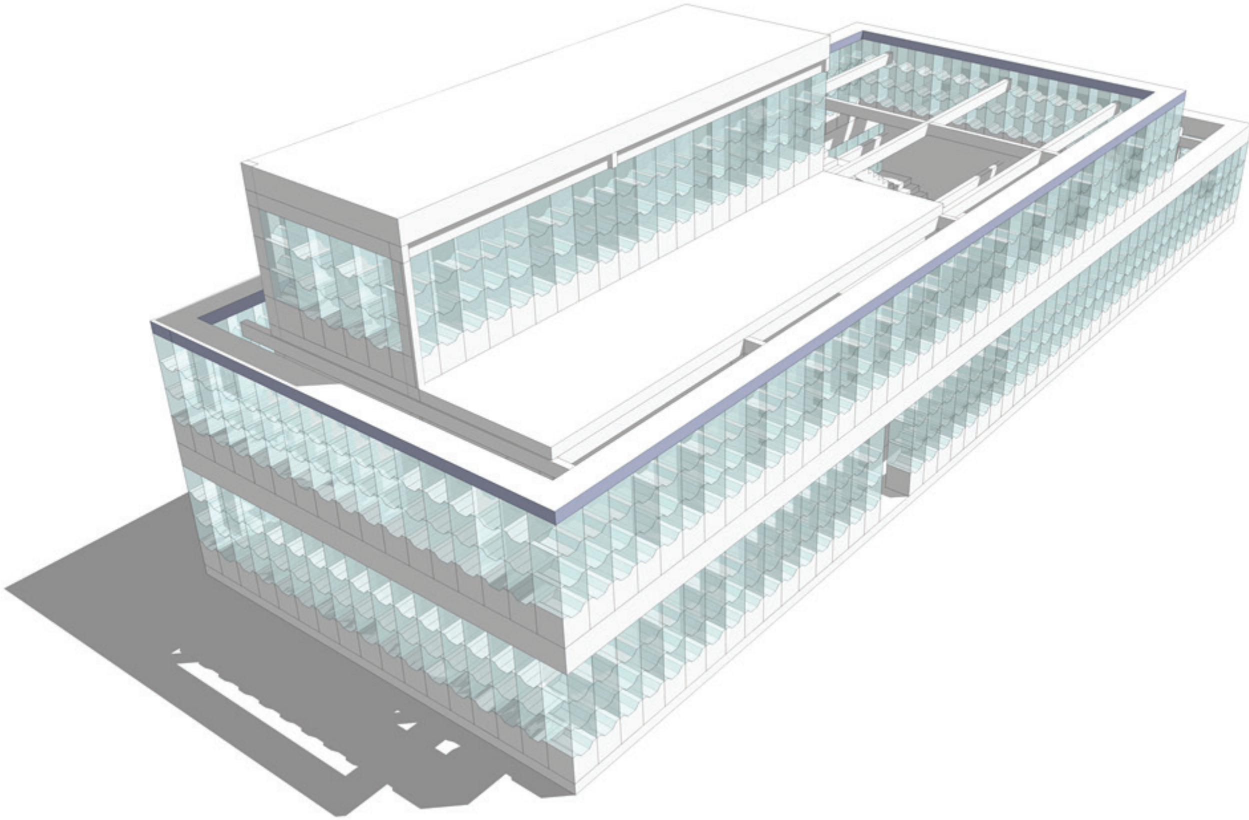

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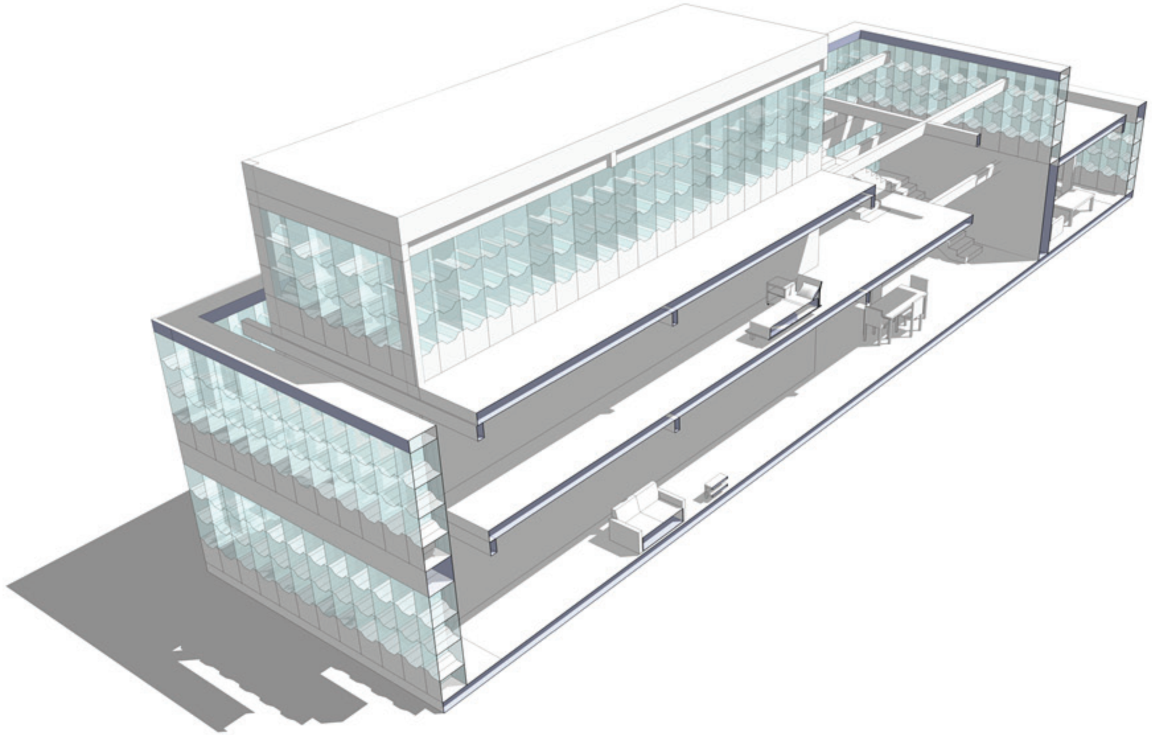

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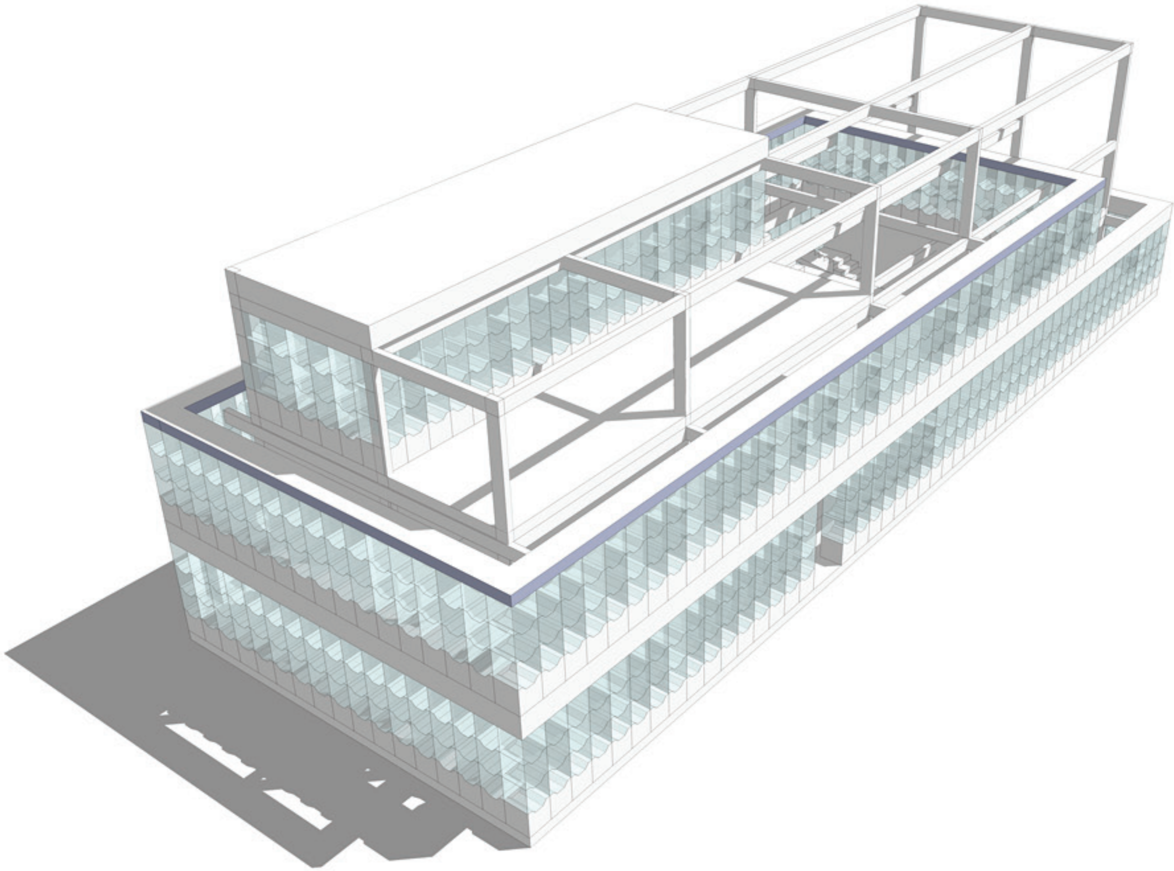

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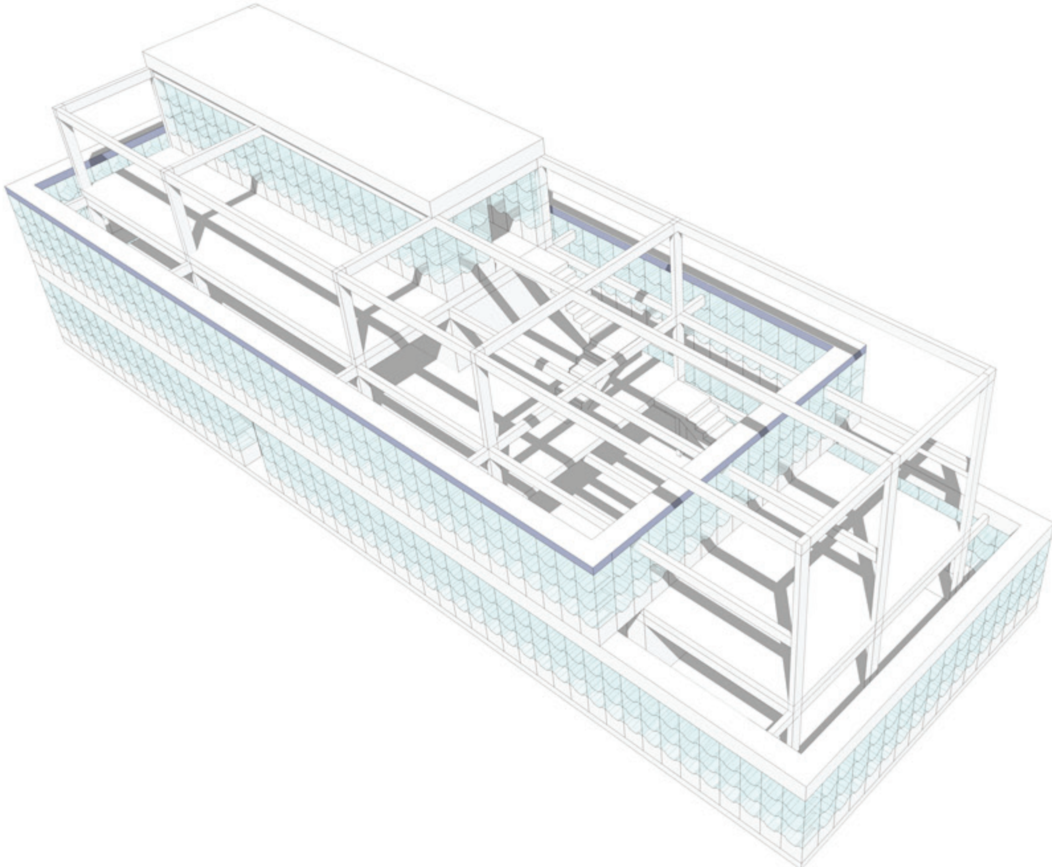

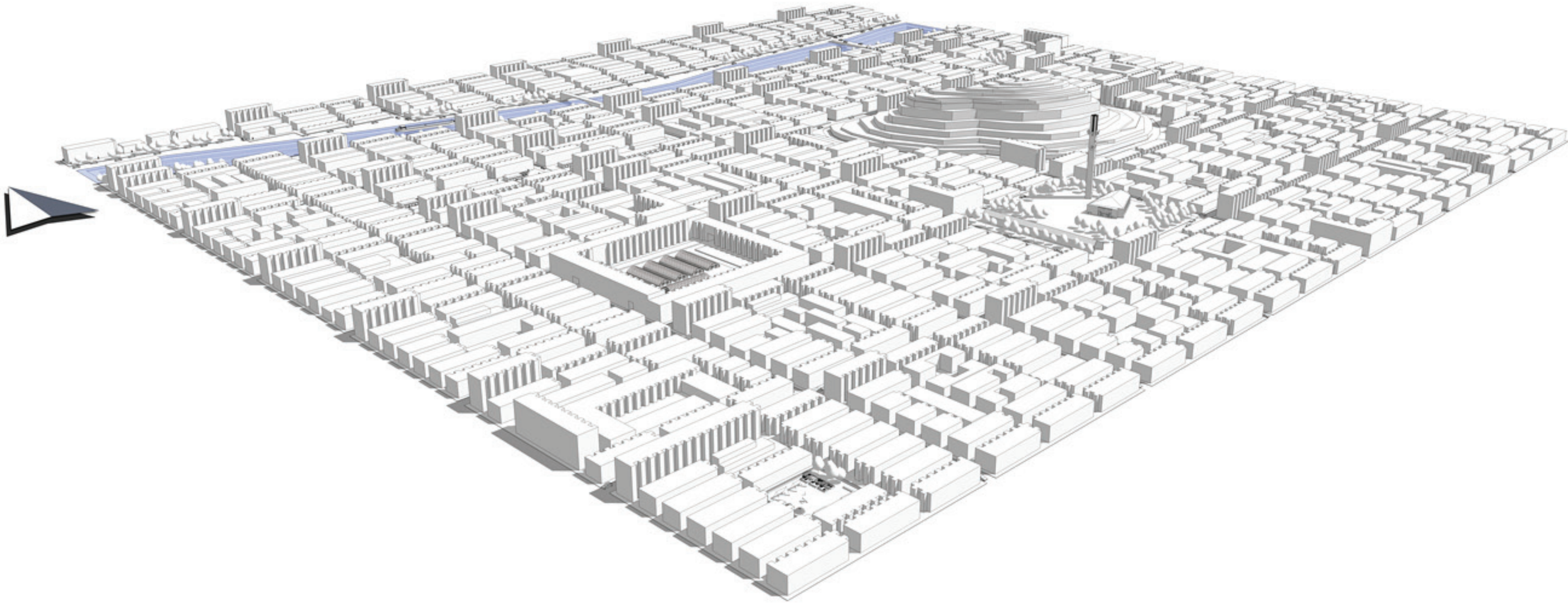

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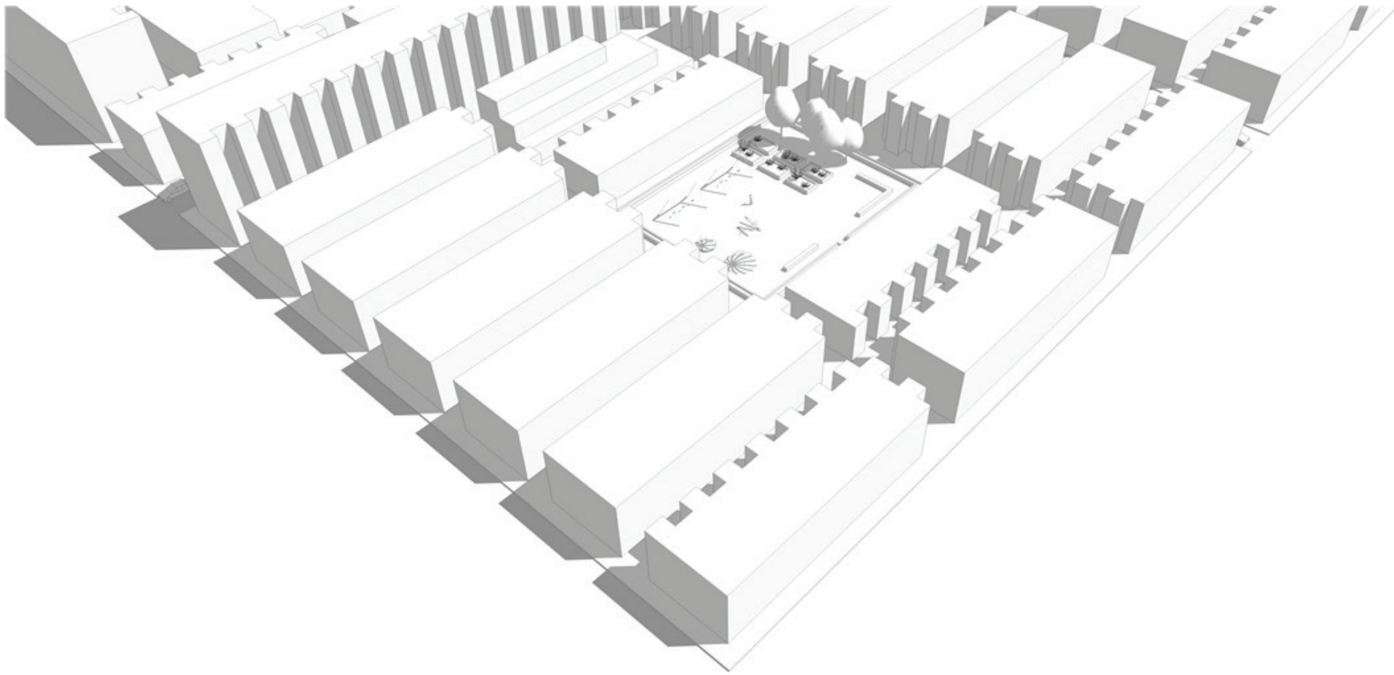

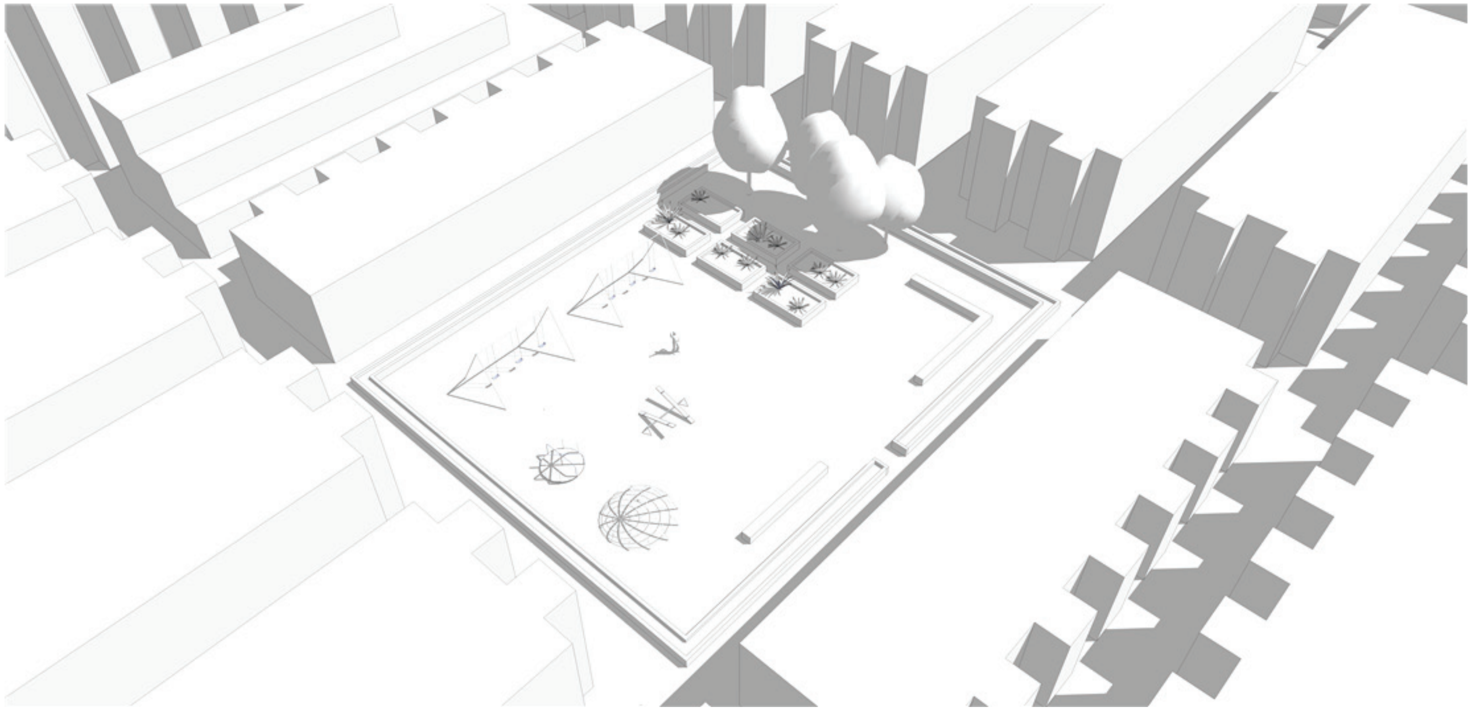

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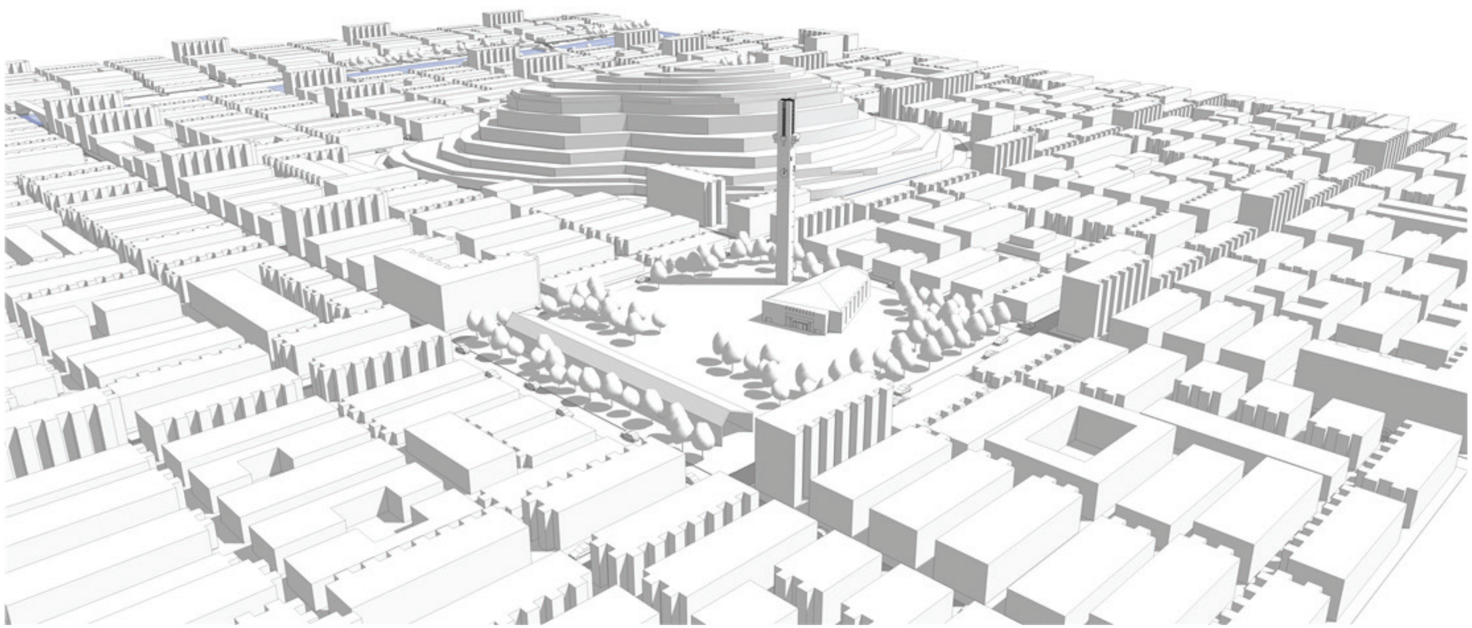

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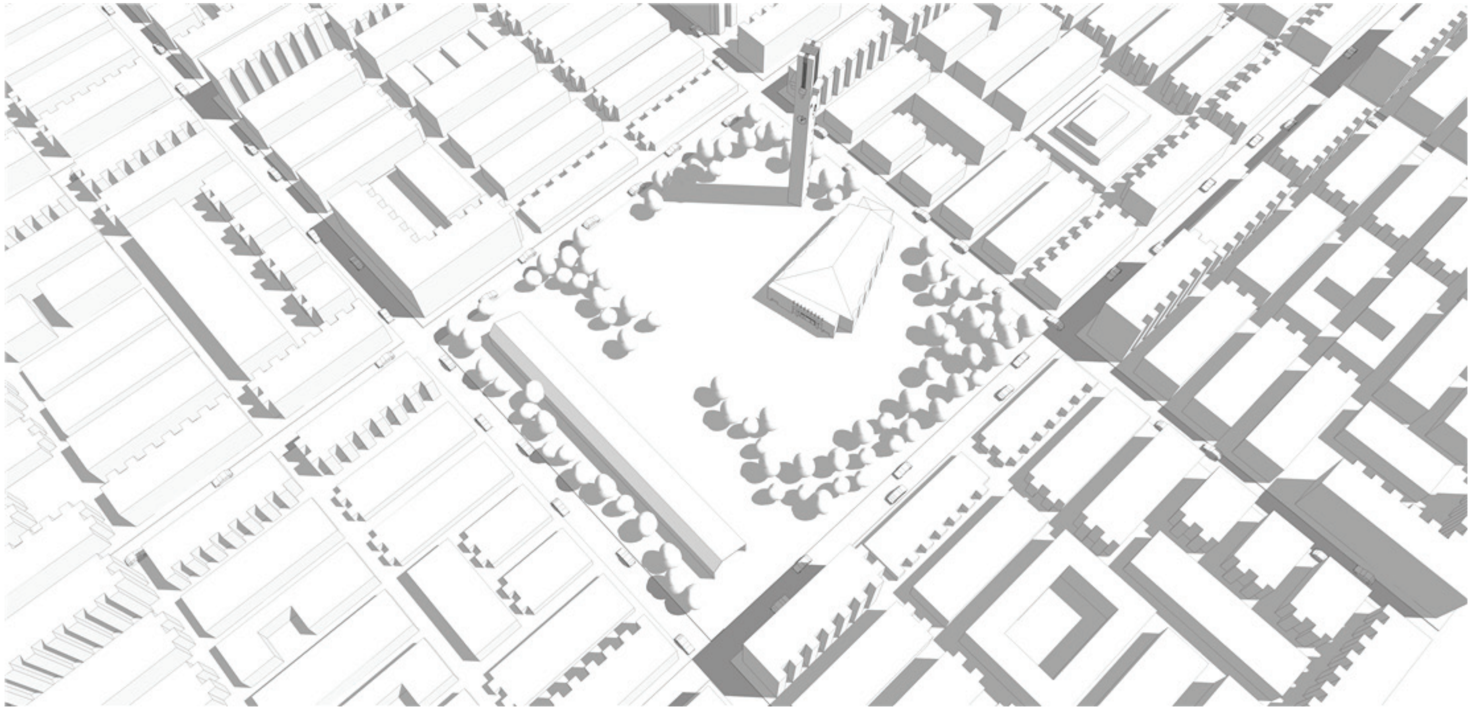

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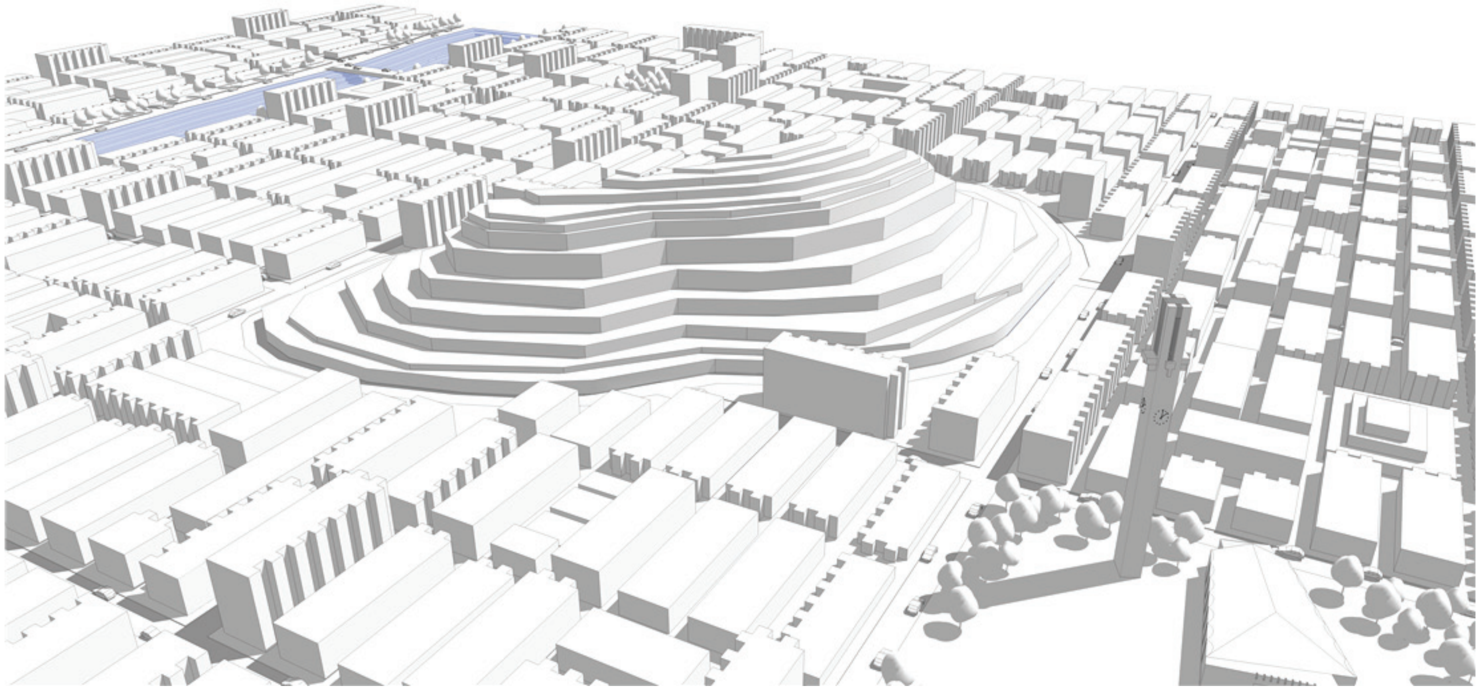

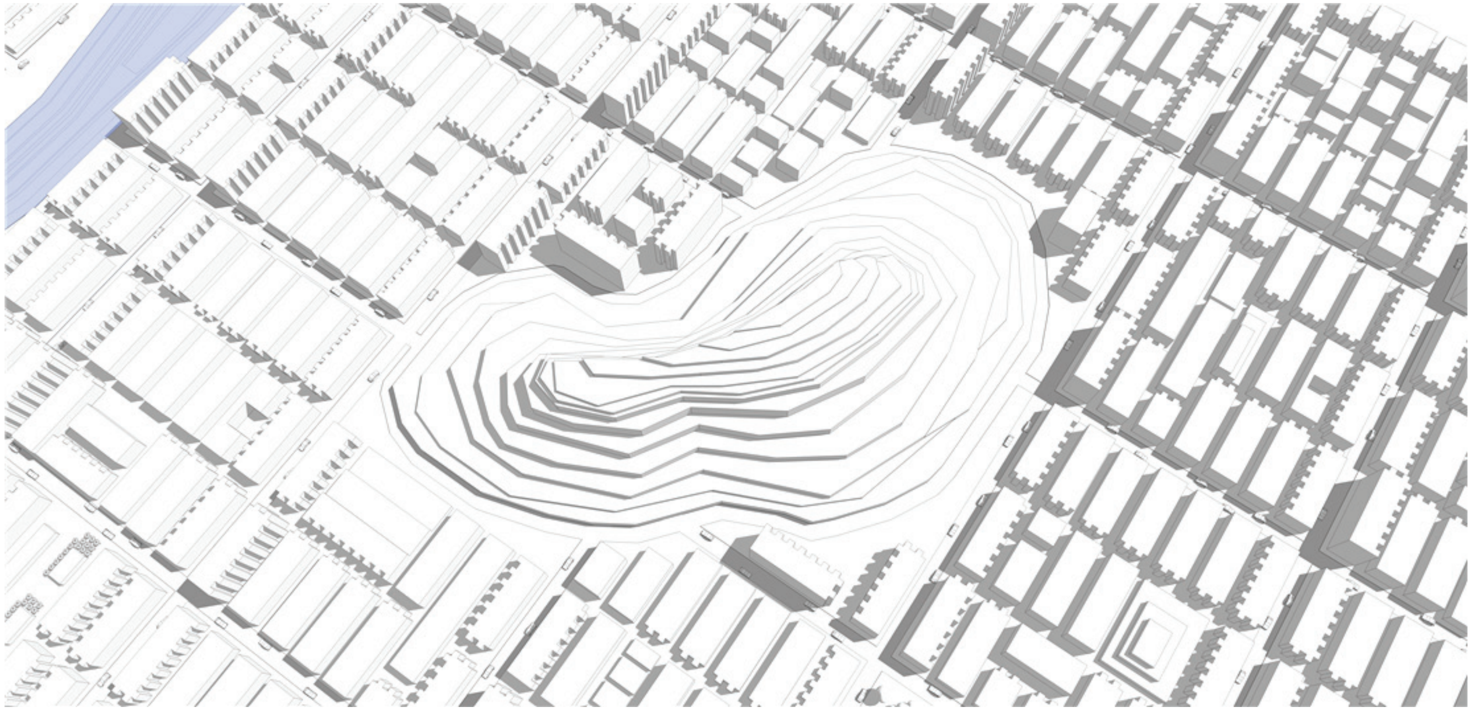

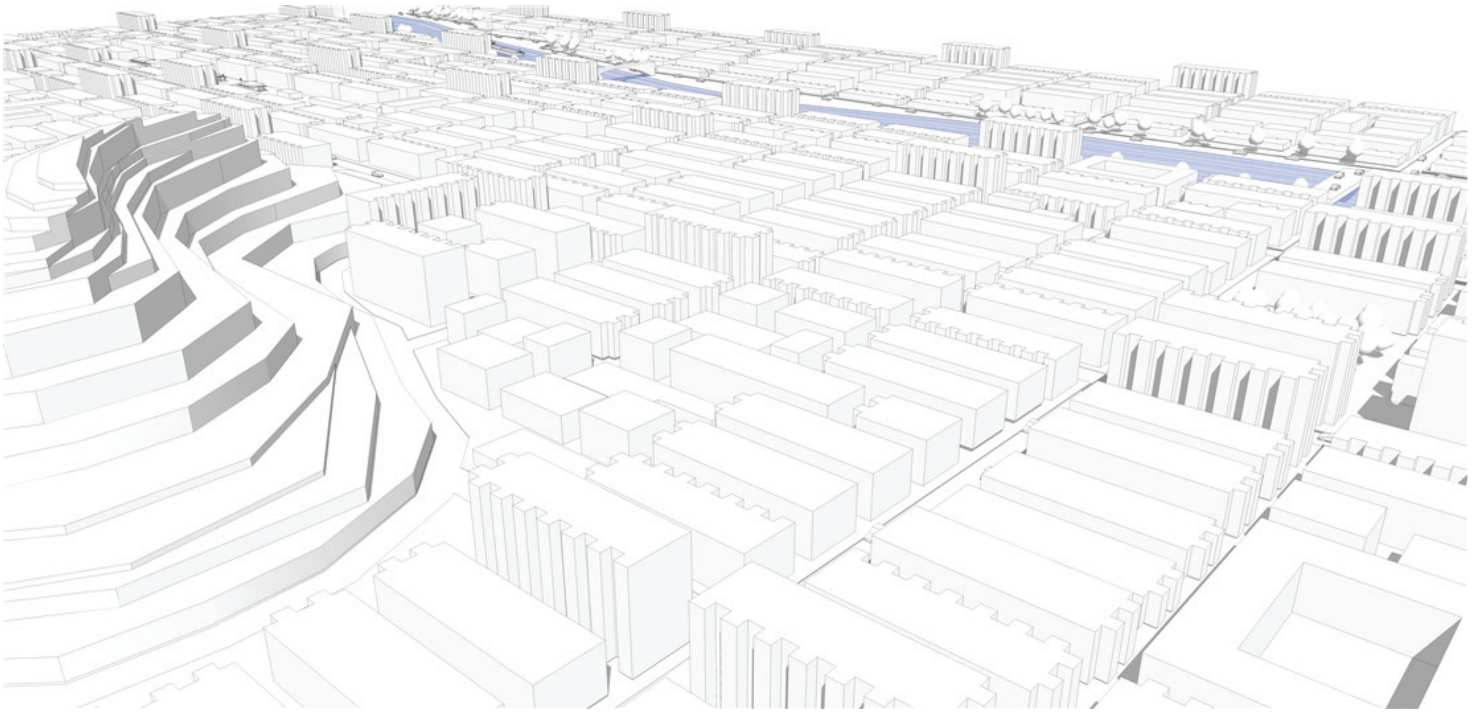

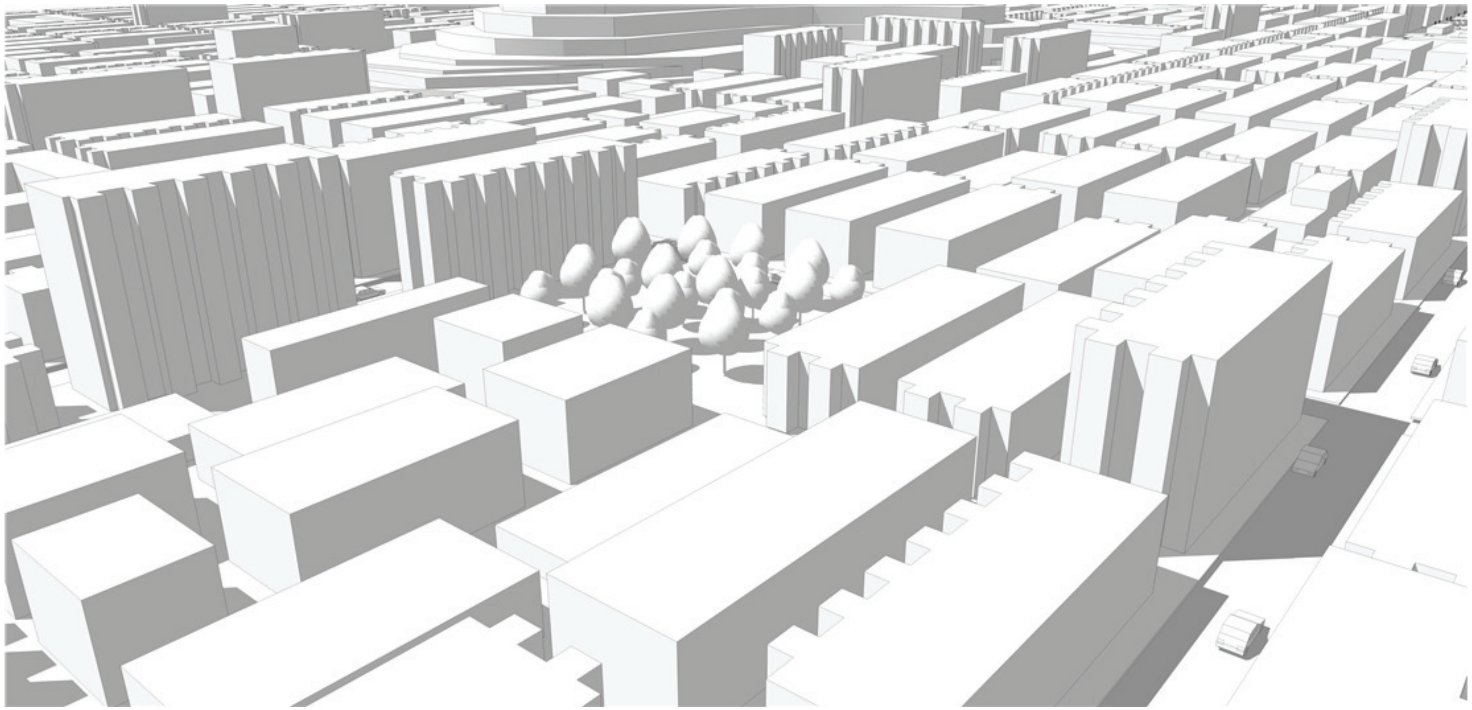

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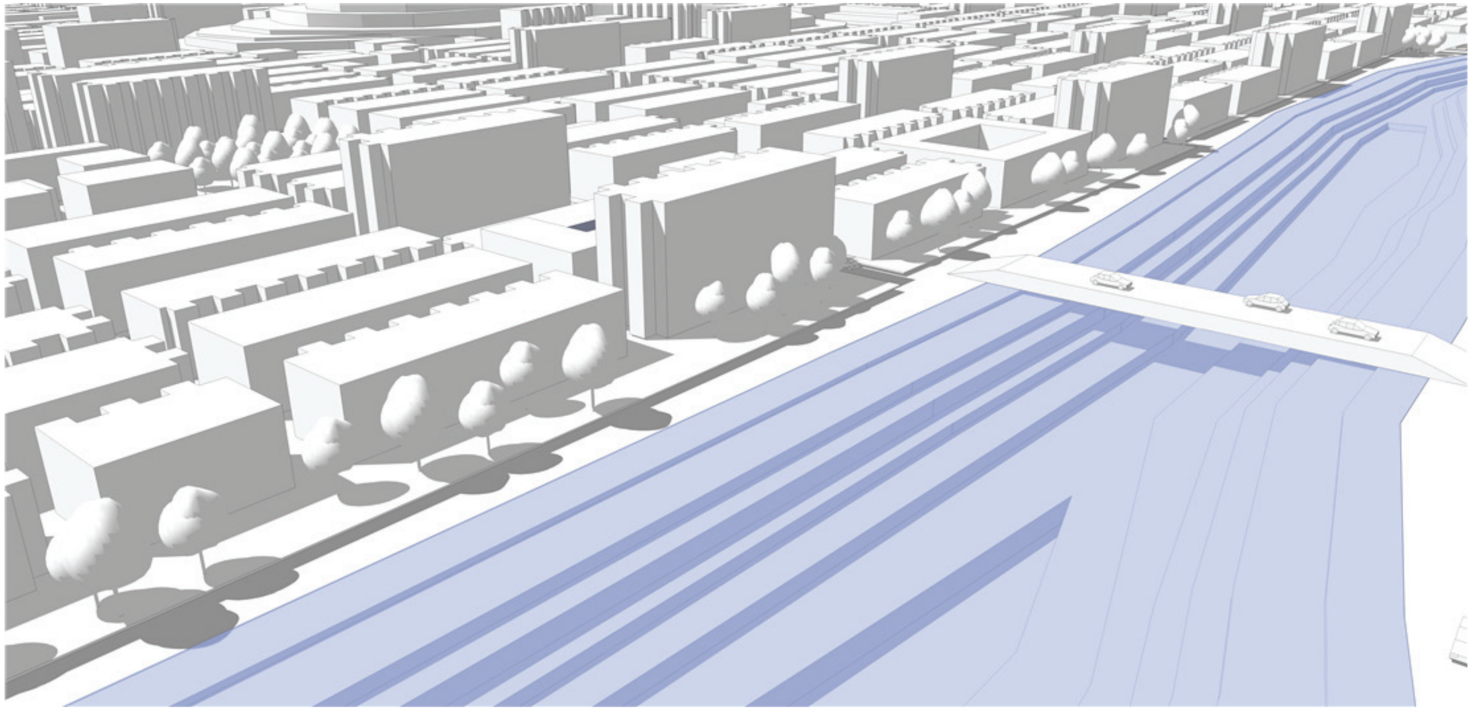

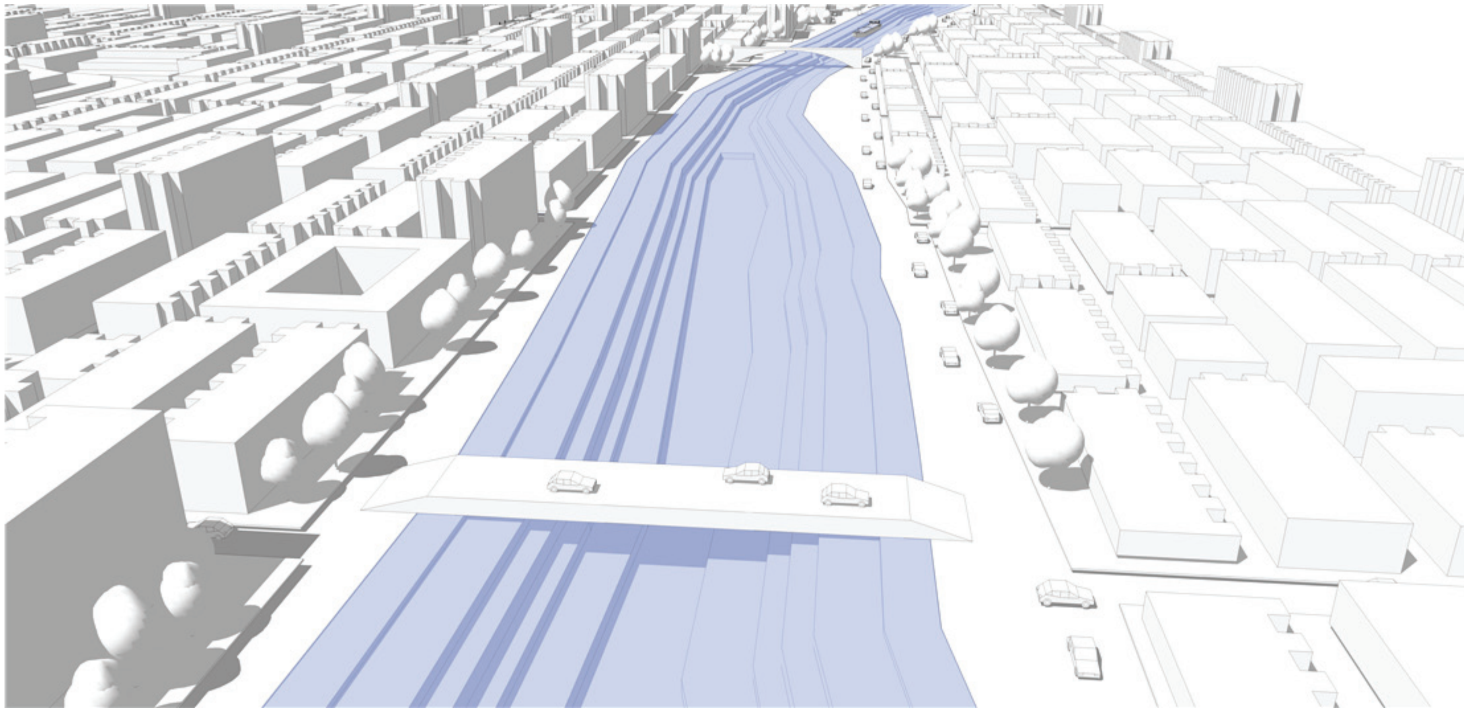

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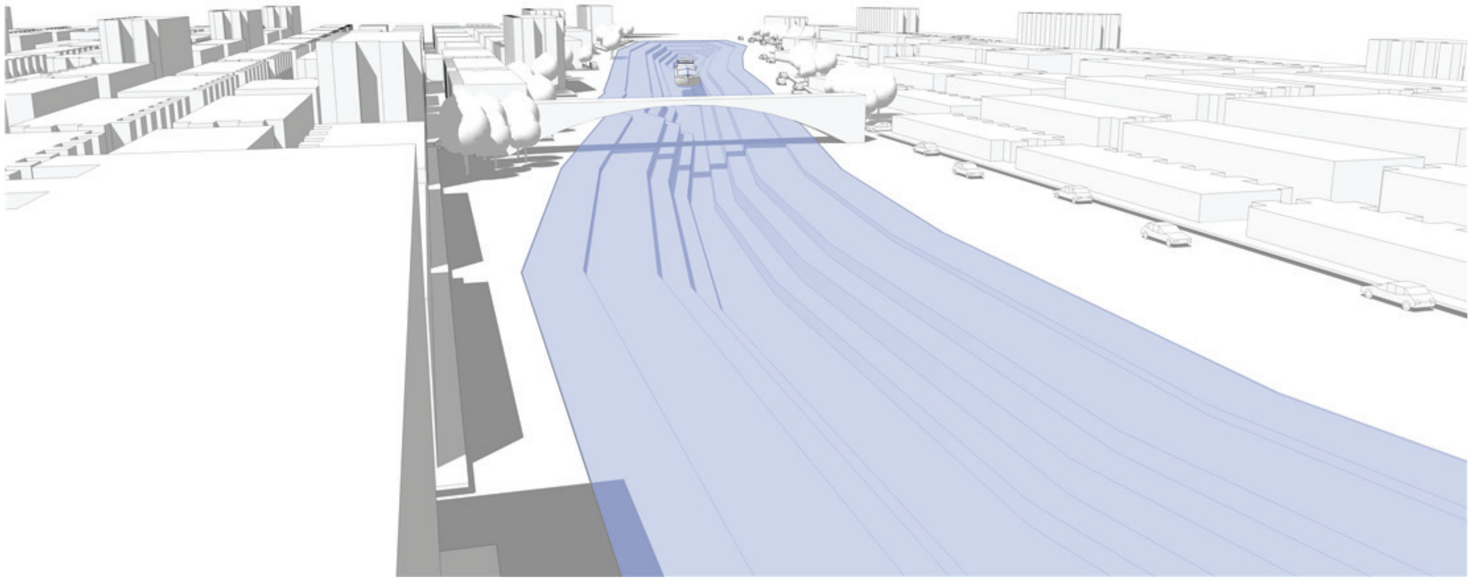

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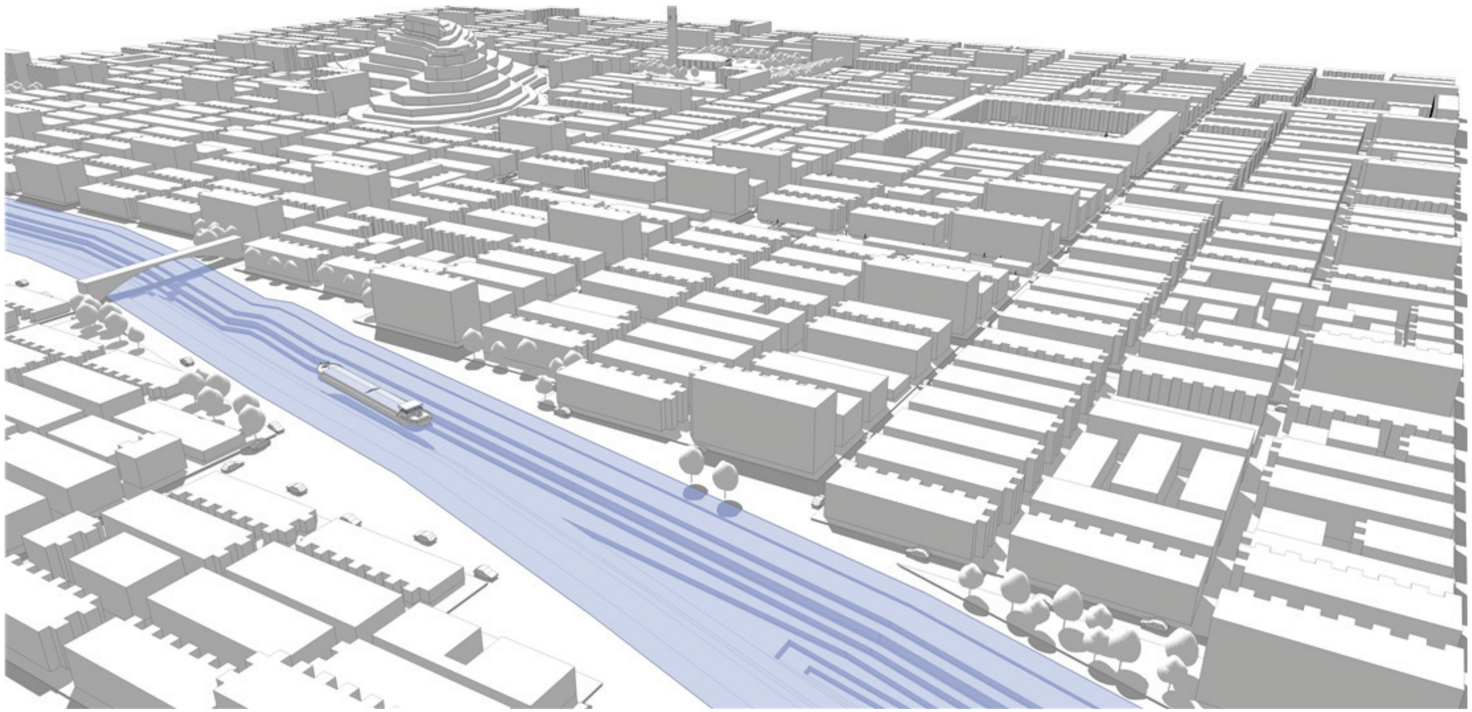

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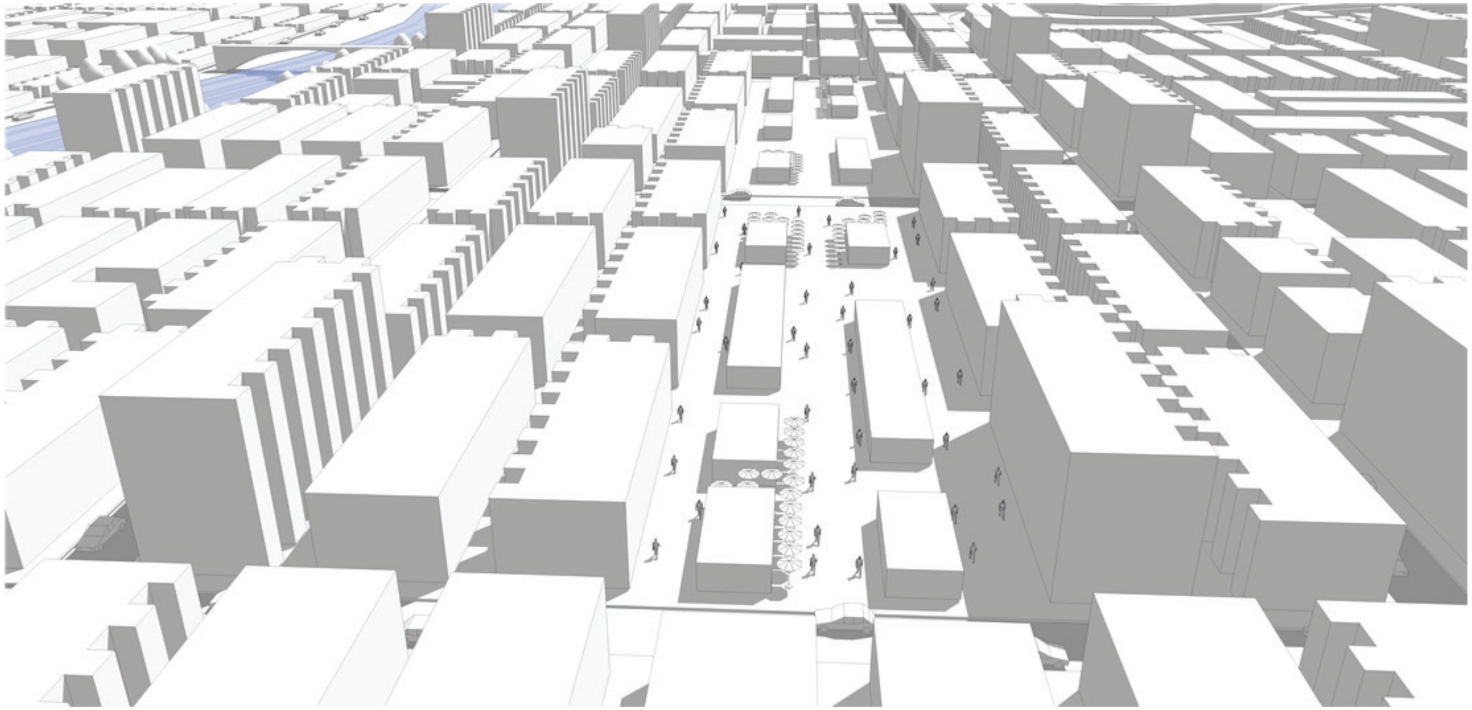

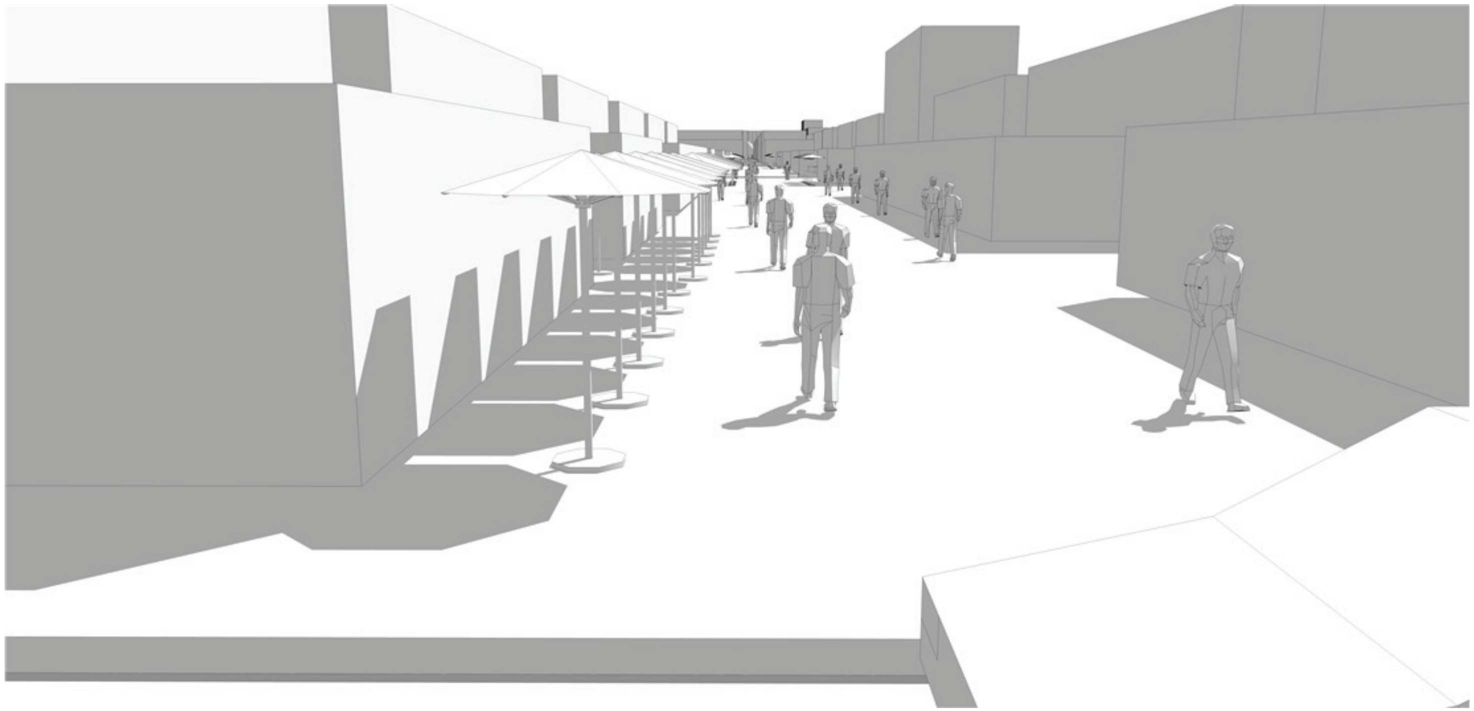

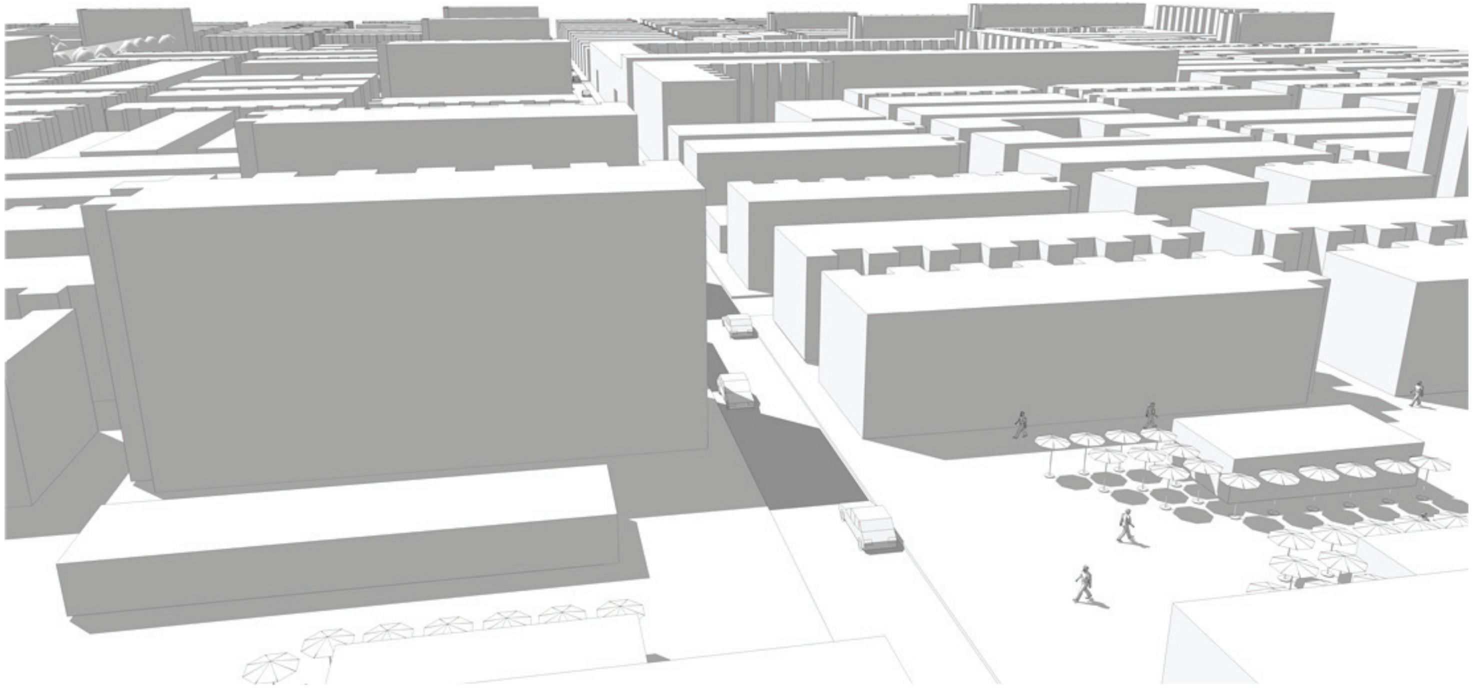

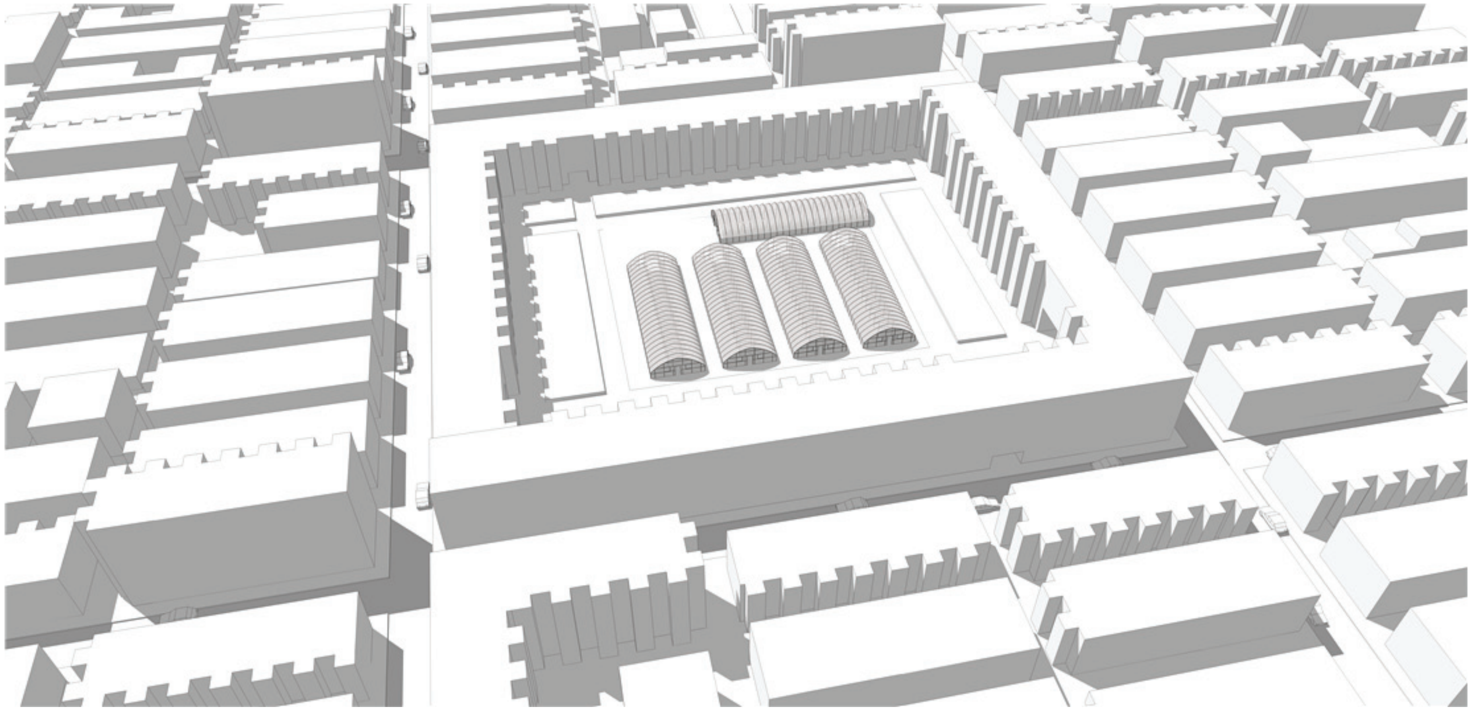

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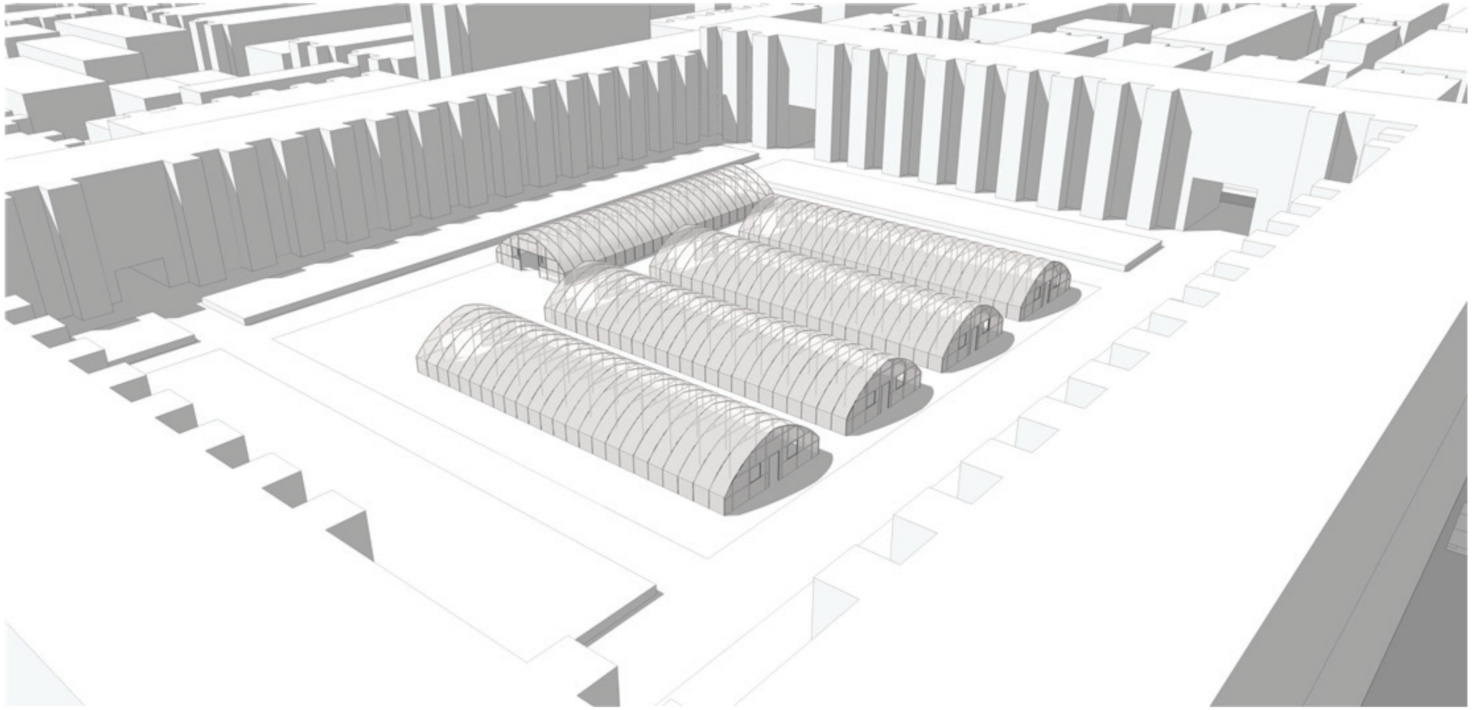

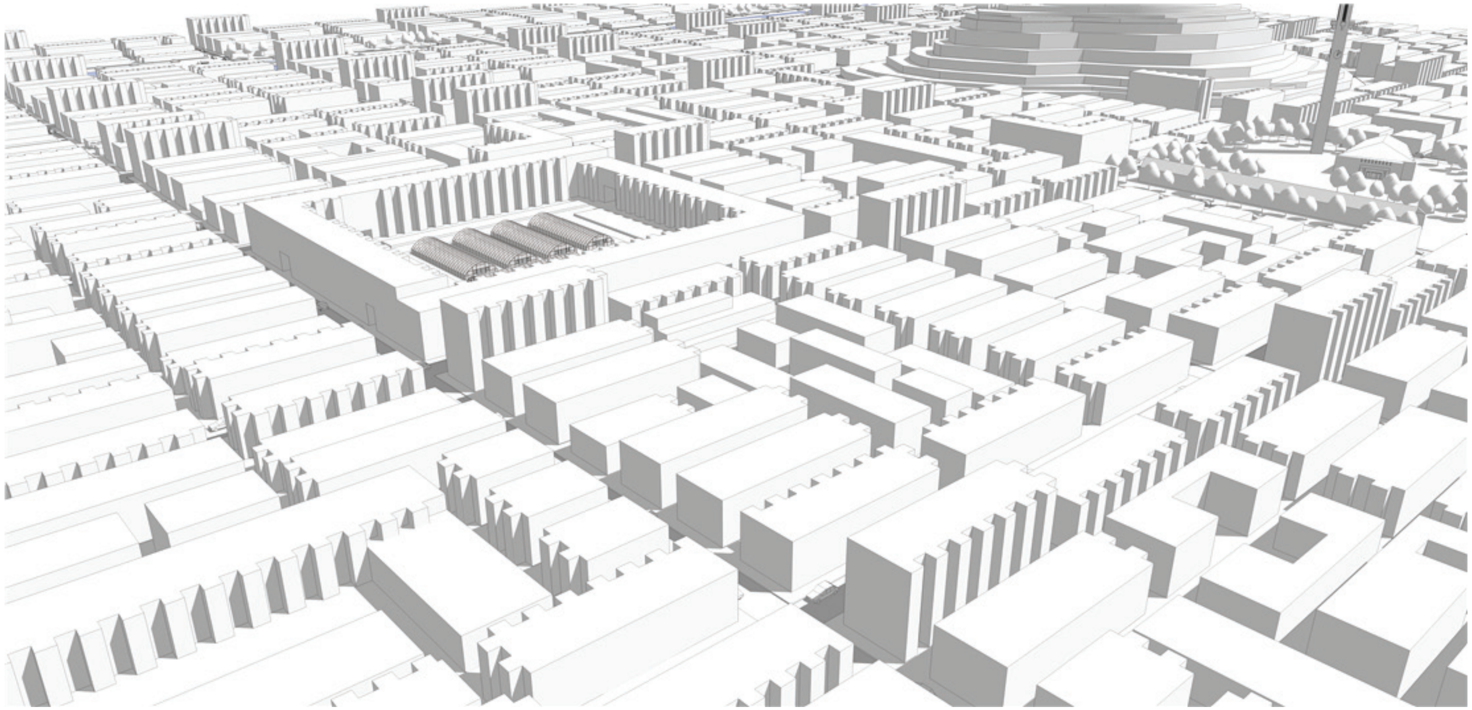

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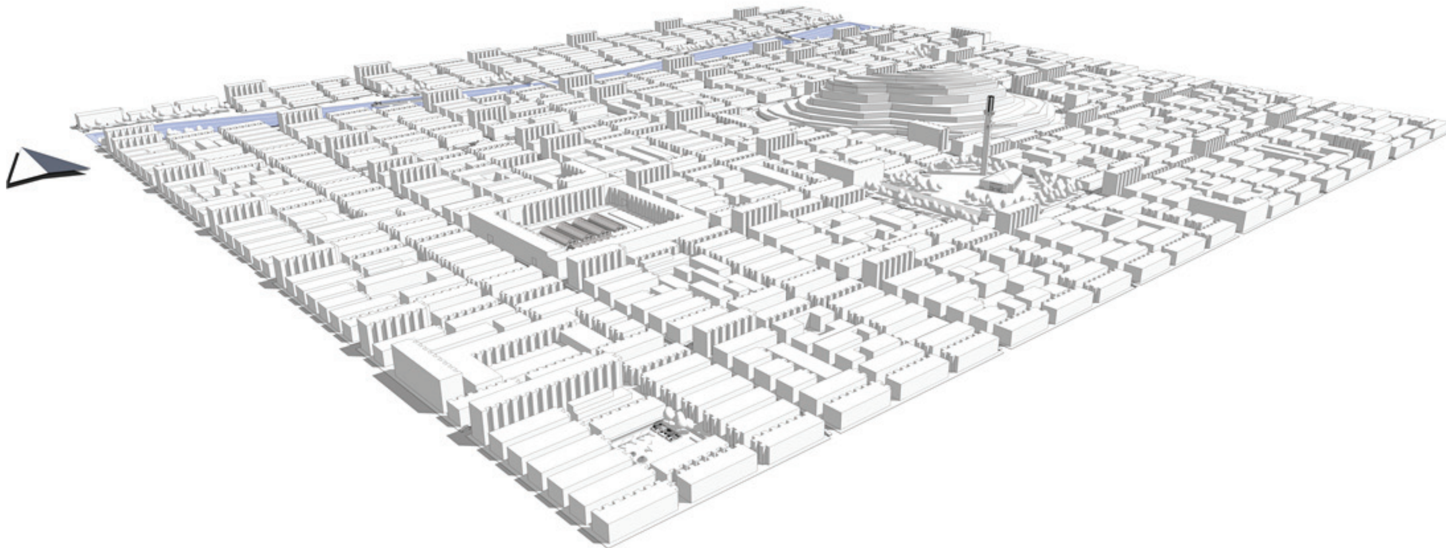

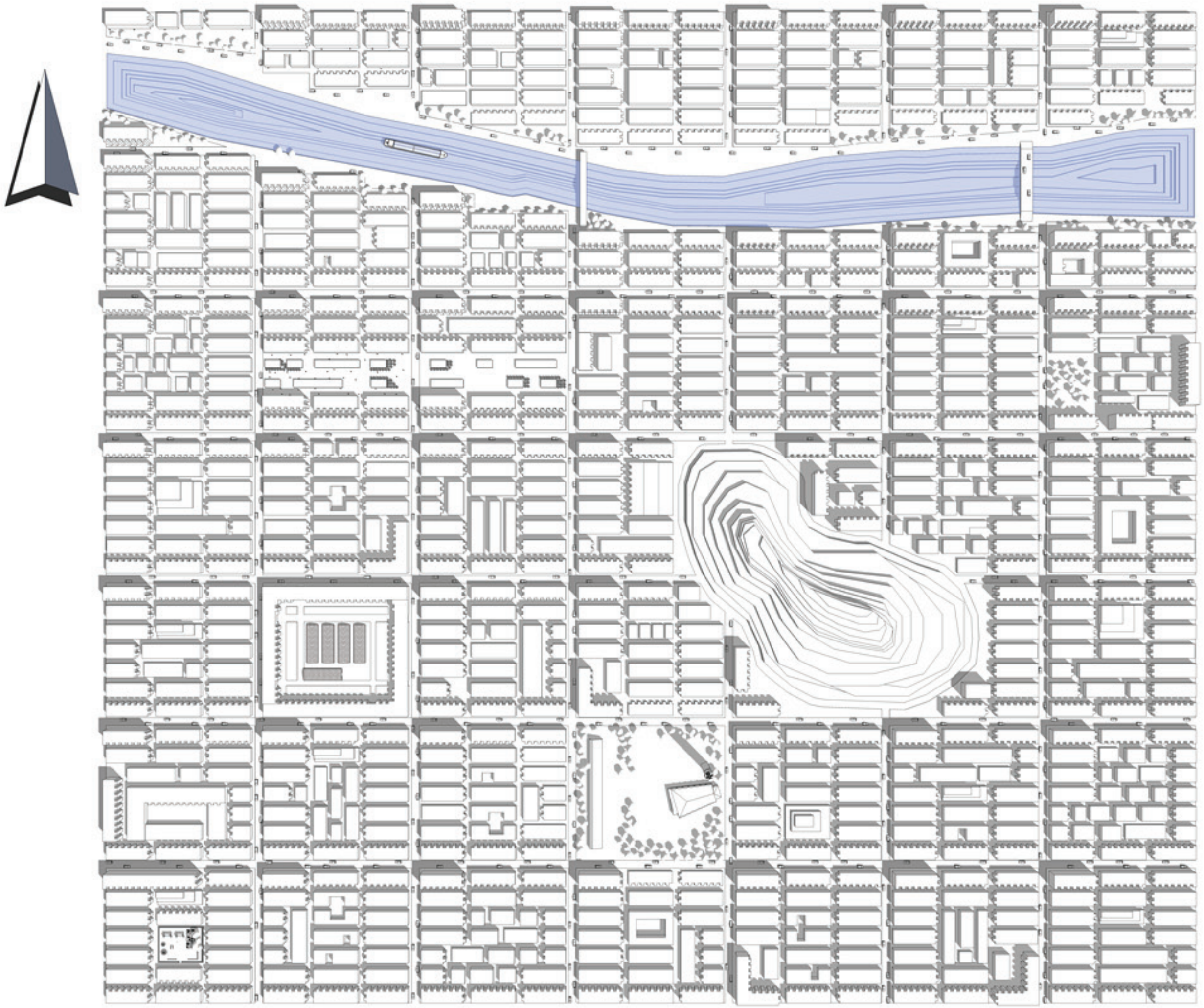

9000 inhabitants per km2

Conclusions

- Innovation: i-Crates system
- Efficient food ingredients: insects, fish, snails, mushrooms etc
- Improved diet: 80% fruits and vegetables, 20% animals
-Living area: user regulated microclimate
-GROW area: only natural light/ heat used
-Small farming scale, easy to care for
-Standardized crates system, mass procution friendly

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Further Research

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-Water cycles: Aquifers are being drained. Alternatives?

-Waste cycles: plant- and animal waste to compost. Quantification.

-Social aspects:

-how easy is it for people to change diet?

-how could collective cooking/ storage work efficiently?

-Economical aspects: quantification of the benefits of this alternative grow method on different levels (environment-healthcare-natural resources-biodiversity)

-Marketing and design aspects: how could the i-Crates and the i-Dwelling be improved?

Reflections

AgroCity

The Why Factory has pointed out and started researching the importance of the relation of food and the city a few years ago. The Food City studio and the City Pig-Pig City in collaboration with MVRDV are products of this research. This year's graduation studio looked deeper into food production methods and the efficiency thereof .

(the relationship between the methodical line of approach of the studio and the method chosen by the student in this framework)

The approach of this research and design project is based on creating a new model for local food production, where consumers produce and process their own food as much as possible. As the surfaces needed to produce and process the food is one essential parameters for the design of such a bottom-up food production, the research starts with a calculation of the necessary surfaces. For this calculation, the starting point is the average need of calories per person, based on the average European consumption. With that as a basis, calculations of food portions and ingredients, yields and food production surfaces were done. The first step of the research was to identify the surfaces that would be needed to feed the earth population in 2050.

It quickly became obvious that with the current food production methods and the current food consumption trends, that would not be feasible. In order to identify which could be a solution to the problem, the food related urgencies needed to be identified. Different layers of food production affect different areas of the environment and our lives: Commercial agriculture methods cause desertification and use up large amounts of fossil fuels. Livestock is space inefficient but meat consumption keeps increasing. The grain that could feed third world countries is fed to animals, to provide developed countries with more meat. Corporations like Monsanto patent genetically modified seeds and make farmers buy new seeds every year, as they contain "suicide genes". Only a few varieties of food ingredients made it to the commercial scene, thus depriving us of different micro nutrients that were found in different varieties of the same species. Food companies are pushing over-consumption of their products -like dairy and wheat- leading consumers to health issues like food intolerance, obesity and diabetes. These, and more issues caused by contemporary farming methods -including waste and energy problems- were identified and analysed.

Looking for solutions to these challenges, alternative methods of food production were studied. Methods such as hydroponics, aquaponics, polyculture and the biointensive method. The common denominator of these practises is the fact that they use space efficiently, filling every free square meter of ground (or water) with as many plants and organisms as possible.

This way water and nutrients are used to the fullest degree and there is no space for weeds to grow. These methods also work as closed systems. Some plants enrich the soil with nutrients that are important to others. Fish manure can fertilize the ground. The roots of the plants filter the water. And food waste coming from plants can be used as compost. This way, by imitating nature's way of combining organisms, space efficiency can be greatly increased compared to common farming practices. A new series of calculations, based on the starting formula, was done to verify the surface gain that could be achieved.

(the relationship between the theme of the studio and the subject/case study chosen by the student within this framework (location/object))

In order to make use of these research results, the choice was made to focus on three main aspects:
1. innovative farming methods, using natural light
2. a proposal for an optimal diet, both for the individual and the environment
3. an effort to bring the control of food production back to the individual.

There is good reason to invest on innovation and revisit low-tech growing methods of the past. Scientists do not know exactly when we will run out of fossil fuels, but they know we will. By using natural light and natural fertilizers, both energy and fossil fuels consumption is drastically reduced. Transportation, that causes also a lot of fossil fuel consumption, is also minimized when growing food at home.The first key point led to focusing to specific diet ingredients, that showed impressive efficiency with the new methods. Vegetable, fruit, seeds, some grains are some good examples. Even some animal products, such as eggs, fish meat, honey, rabbit meat, chicken meat can be produced in minimal space, without issues of animal welfare. An interview with Wageningen expert Arnold van Huis pointed to an interesting new direction: insects as a source of protein. Low maintenance and very space efficient, insects seem to be the future. On the other hand, goats, pigs and cows and their products are not space efficient choices, especially if consumers care about animal welfare and want to be provided with free range, grass fed meat. Also, the numbers do not add up. By 2050, with the population being 9 billion, there simply won't be enough space for this kind of choices.

Based on these observations and nutrition related research, an optimal diet is proposed. It is a "cross breeding" of pescetarianism and ovo-vegetarianism. Practically, this means that the diet consist in it's larger part of vegetables and fruit, but fish, eggs and honey are also available; as well as insects. There is scientific proof that humans can get enough protein from non-animal sources, but eggs and fish provide the extra safety.

The third key aspect is based on two urgencies: the lack of space and the fact that food production is not transparent for the consumer. By growing their own food within their home, within the city, people have total control of how their food is being produced and they can as well choose what they want to grow, based on their personal preferences.

(the relationship between research and design)

The idea of integrating food production with the city is not that new. Several vertical farming projects or conceptual proposals have appeared the last years, based on the food urgencies. As cities grow and eventually even merge, creating mega cities, the agricultural areas traditionally found outside the city might not even exist in a few years. Thus, space for food growth needs to be found within the new city context.

The way that this project uses design to address these issues, is by a bottom up approach. The buildings are made out of modules that contain food production. A series of modules with matching dimensions serve as building material for the shell of the building. The modules are interchangeable, allowing the user to adapt the food production based on his/her diet preferences. A chicken coop can be replaced by eight root vegetables modules and a tomato module can be replaced by a mini aquaponics setting for fish and sprouts.

This model works on a Do It Yourself basis. An application/software allows the individual to calculate the amount of growing units needed, based on the size of the family. Then, he/she can purchase the modules and start building. There is a set of instructions that defines in which orientation each module performs the best. For example, herbs need sun, while mushrooms can do without. This way, the individual can decide how to position the modules in order to have optimum yields. A set of start-up configurations is given, to help with the design choices, based on the available building area. In a low density city, a flat configuration can be fitting, while in a high dense area a tower house configuration might work best. Other generic options are pleated façades -as they allow for a larger number of modules to have access to light- and terraced houses, as they take advantage of the favourable orientation.

(the relationship between the project and the wider social context)

With this DIY system, each one takes care of their own food and their own dwelling. But by collaborating the inhabitants of a city can achieve greater efficiency in different levels. Storage is one of them. Instead of having separate -energy consuming- freezers, they can agree on building collective underground storage structures. Much like the root cellars that have been used throughout history, these construction use the stable ground temperature to keep food in an edible state for a very long period of time, without energy consumption. Another reason that people might choose to build collectively is natural ventilation. Even in high structure of many floors, if designed properly, air conditioning is not needed. Double façades can work as

air shafts and combined with strategically designed openings, they can offer to the user an all-natural climate control. One more reason for collaboration has to do with the diet. A cow requires 1200 square meters of grazing area, and food safety would require having at least three of them. This means that if one person wanted to grow their own food and include milk or cheese in it, they would need to take care of three cows and 3600 square meters of grassland. But a cow produces 5 litres of milk per day in nature (and 45 in factory farms), so the milk could even bee too much for one person. By collaboration these issues can be solved. Building blocks or neighbourhoods of 20 or 50 people could commonly take care of a small animal farm, enough to provide them with meat and dairy products. For the project to remain sustainable, the consumption of such products should be kept in levels much lower than they are today. Red meat consumption once a month and dairy two times a week is a reasonable, healthy consumption according to nutritionists.

AgroCity has two more ways to bring the inhabitants closer and favour personal interaction: collective kitchens and produce markets. Collective kitchen/restaurants can be positioned even in every building block, in order to encourage common meals and cooking, as a way to exchange produce/ingredients and save energy used for cooking. Each dwelling is equipped with cooking facilities, but hopefully the way of life of the AgroCity inhabitants helps to grow awareness of environmental issues and leads to more every-day-life responsible choices. The produce markets give to the inhabitants the option to try the things their neighbours grow. If they prefer it to their own production, they can then replace some of their modules with different ones.

What can be studied deeper?

Food production is an extremely complex issue that involves lots of factors. Surface, growing techniques, sunlight and air flow have been studied in AgroCity to an extend that allowed for the design to become realistic and not stay conceptual. There are though parts of the research chapters that did not make it to the end and they definitely deserve design solutions.

Water is one of these subjects. Using average rainfall and surface areas, some first calculations have been made, to define which part of the water consumption can be covered by rain water. It seems that rainwater is not enough, especially in the southern Europe Climates. There are methods to purify and recycle water and innovation can greatly help with this issue.

Waste in another challenge closely related with food production. AgroCity deals with the issue to a great extend by reducing animal pastures and the consumption of animal products. Waste coming from vegetable sources can easily be transformed to compost. The same is true for manure, but the issue is that the livestock industry nowadays produces enough manure to fertilize many times the agricultural area of earth. A part of eat can be used for methane production but a great deal ends up in incinerators or even regular landfills, causing further air pollution. The question is, would there be a way to deal with waste without causing environmental issues and keeping animals as part of the diet, as is now?

A more directly design related topic that can be studied further is the implementation in existing cities. The size of the modules allows them to occupy abandoned office buildings, terraces, empty building blocks within the city. This is clear and feasible. But what would be interesting, would be the study of a specific existing city and testing if all the food production needs of the city could be met by modules feeling up the empty spaces. Would there be enough space for natural light to come through? Would there be enough space for parks and other public spaces? What about streets? What about the interaction of the city pollution and the quality of the food produced? It is true that plants filter pollution and create agreeable microclimate. But are their parts still safely edible after they have filtered city smog? A wide range of case studies of cities with different densities and different dietary preferences could give a more clear view, weather a bottom up food production approach could be a part of the solution of the upcoming food crisis.

Extra Research Sources:

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