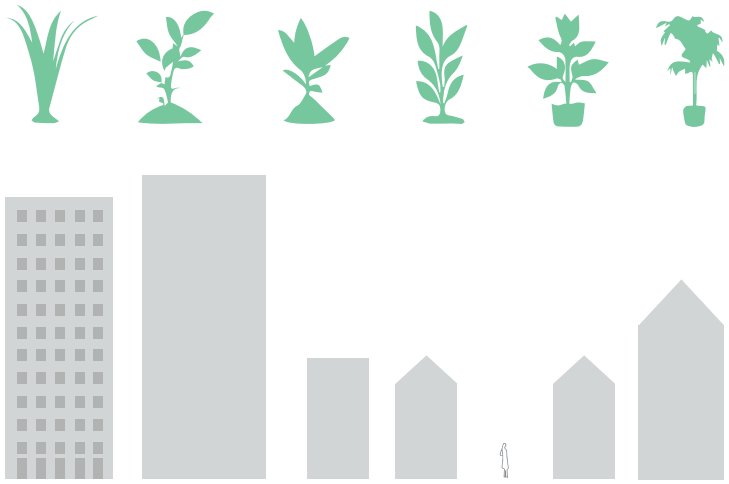
The food producing city of tomorrow

Food production versus city living



By Lisa Marije de Groene

The food producing city of tomorrow

Food production versus city living

De Stadskas

A report on research done for my graduation project; de Stadskas.

Tutors:
Architecture; Theo Kupers
Research; Pierijn van der Putt
Building Technology; Ferry Adema

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This project has 4 chapters:
We must act now
We are what we eat
Green types folow function
Make it feasible, make it work

These parts focus on different research questions, derived from the main research question; How can producing food be used as a tool to design a sustainable, lively and dense city?

The first part, We must act now! is about the problem statement, on a big scale and a small scale, about my response to these problems in the form of a hypothesis and will elaborate further on this hypothesis. It will discuss the main research question; How can producing food be used as a tool to design a sustainable, lively and dense city? And will discuss the possibilities, limitations and challenges urban agriculture has. From here the next three chapters will focus on research sub-questions that are derived from the main research question.

The second chapter, We are what we eat! is about our diets. What do we eat? What is the consequence of our eating habits? This part will have the following conclusion: A practical scheme of how much food we need for different diets, and how much space we need to provide this.

Chapter three focusses on different types of urban agriculture, with the research question: Which characteristics, functions and level of participation can different types of green have? This part will have the following conclusion: A design tool on how to use productive green to get a certain result.

The last chapter, Make it feasible, make it work! focusses on the technical side with the research question; How can productive green play a key role in closing climate and waste loops in a building? The four important cycles in a building will be looking in to, CO_2, water, waste and energy. The focus here is how the greenhouse can be integrated as much as possible in the city and the building by closing urban waste flows.

Methodology

1. Why is there a need to change?

2. What are the consequences of our habits?

3. What types of productive green are there?

4. How can productive green play a key role in a building?

1. We must act now

Why is there a need to change?

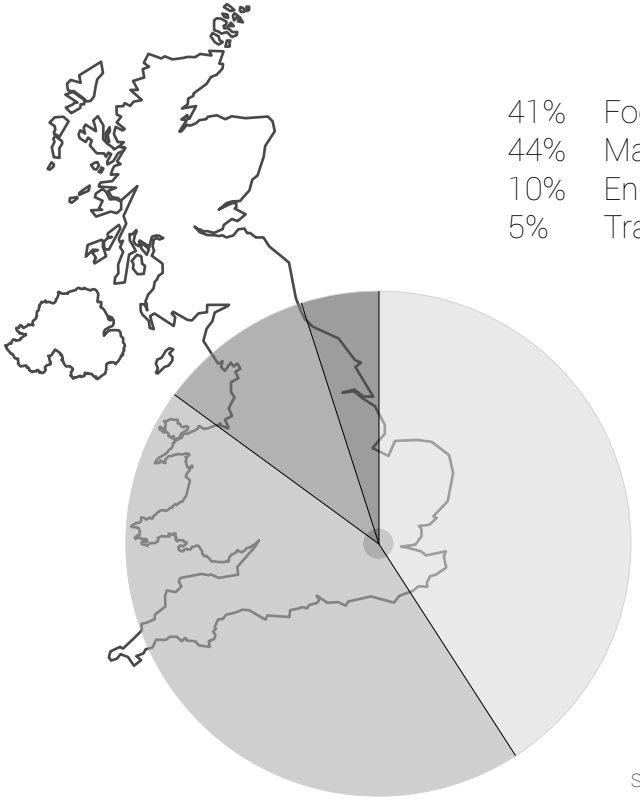
1.1 Big scale problem statement

The world is facing some serious challenges when we look into the future; the population is going from 7 billion now to 10 billion in only 35 years[1]. We've used 70% of our natural resources in only 100 years and not much is left. There is going to be a water shortage all over the world, we are facing a food and energy crisis and what we are already facing are the consequences of global warming[2].

- Over population 
- Diminished resources 
- Water shortage 
- Food crisis 
- Energy crisis 
- Global warming 

These problems are going to strike hardest in cities. Because of its size and density of people, they have very large ecological footprint's. In 1950 less then a third of the population lived in cities. For de past 50 years this number encreased rapidly. Around 2016, more then half of the global population became urban and the UN predicts that in 2050 this will be 80%[3].

To support and provide for all these people we need a lot of surface. To give an example: the city of London needs 293 times the surface of London to sustain itself. In other words, London needs 293 time the surface equal to the size of the city to be able to provide in everything it consumes. 44% of this is needed for food production[4]. That means the city of London needs more than 100 times its own size to be able to provide the city with the food they need.

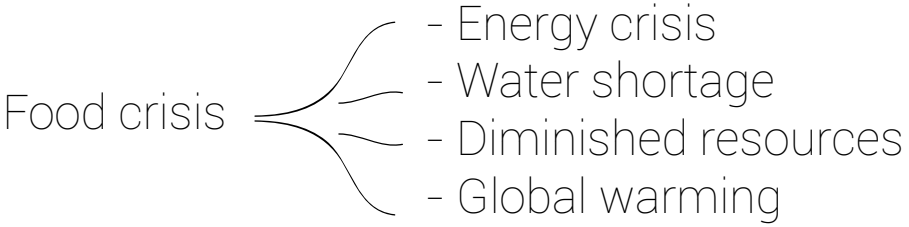


Source: Lecture by Greg Keefe

1.1.1 Response to the problem; hypothesis.

To make a difference, to try and solve the environmental problems facing the world, addressing this food crisis seems the best place to start. Agriculture is accountable for 30% of all greenhouse gas emissions, the largest emitter of greenhouse gas in the world[5]. The way we are farming is very inefficient: it's causing pollution in soil and air, the produce must travel many kilometres before it reaches the consumer and due to steep population growth, this inefficient system simply cannot feed all the people in the future[6].

I want to focus on the food issue



Addressing the food crisis and trying to come up with solutions within a city, catalyses innovations in different in other fields. When you are producing food, you have to figure out where your resources are going to come from. By combining functions, we are able to rethink the system. To give an example; all the water needed for irrigation in greenhouses can come from excess rain water, something that cities struggle to deal with.

A lot of other innovations might come up by integrating food production in the city.

Explanation of the global food crisis

42% of Earth's land surface area is used for farmland...

...the equivalent of the size of Africa AND South America combined

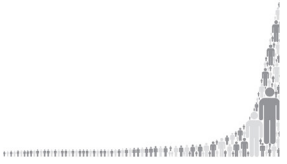
Farming is the single most powerful driver of deforestation and loss of biodiversity.

Farming accounts for 30% of all greenhouse gas emissions, making it the single largest emitter of greenhouse gasses in the world.

Fertilizers have more than doubled the nitrogen and phosphorous in our environment, contaminating our soil and drinking water.

70% of global water consumption is used for farming, causing rivers and lakes to dry up.

On average vegetables travel 2.400 km or 1.500 miles from farm to consumer, causing an extra 12% emissions prior to consumption.



With a growing population and an emerging middle class, demand for food is ever increasing, calling for smarter and more resilient solutions to feed the world.

One third or 1.3 billion tons of the world food is wasted every year...

Source: Project ReGen by Effekt

1.2 Dutch agriculture situation.

Concerns grow more and more about climate change, global warming and food security, and as result a lot initiatives to produce food sustainable are popping up in Amsterdam[1]. The recent popularity of farming food locally comes as a reaction to global problems. People want to know where their food comes from and how it is produced because they believe that the urban demand for cheap and abundant food without knowing how much effort it took to reach them, is destroying our planet[2].

1.2.1 Food production in the Netherlands

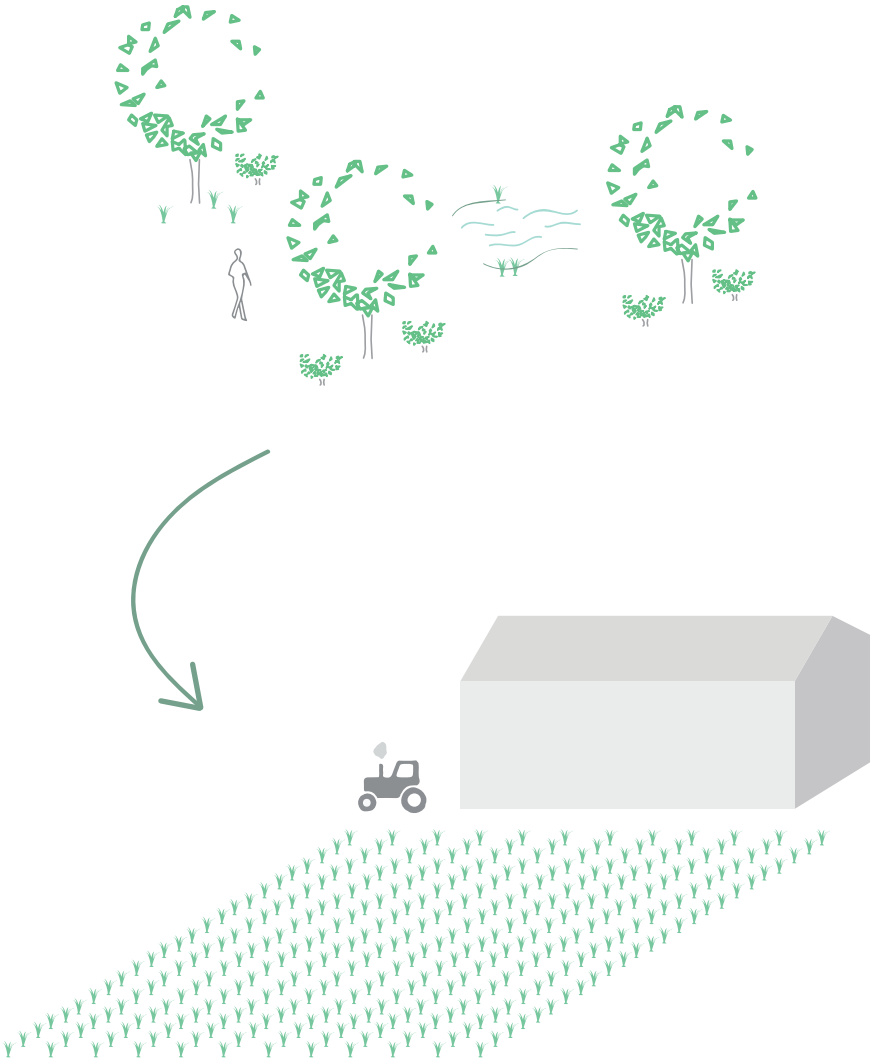
The Netherlands has a rich history regarding food production. The country has been predominantly urban already since 1650 and had to deal with little available land for food production to feed a relatively large amount of people. "The land, much of which had been reclaimed from the sea, was working overtime to feed the population" says Carolyn Steel in her book Hungry City[3]. Because of the struggle with a scarcity of land, which was also difficult to cultivate, the Dutch became the forerunner in innovative agriculture. Today we are the number two in the world in the export of vegetables[4]. Quite impressive for such a small country.

But the current agriculture methods use large amounts of fossil fuels and pesticides. The produce must travel many kilometres before it reaches the consumer, and there is a serious waste problem[5]. Also, the country side is getting full with industrialized farms, like the greenhouse megastructures you see in the Westland. In the Netherlands, food production has long reached an industrial scale that has no relation to the higly romantic conception of the country side many of us have.

To conclude:

Agriculture today in the Netherlands has the following problems:
- Use large amounts of fossil fuels and pesticides
- Produce must travel many kilometres before it reaches the consumer
- The countryside is getting full of industrialized farms
- The Netherlands has a serious waste promlem

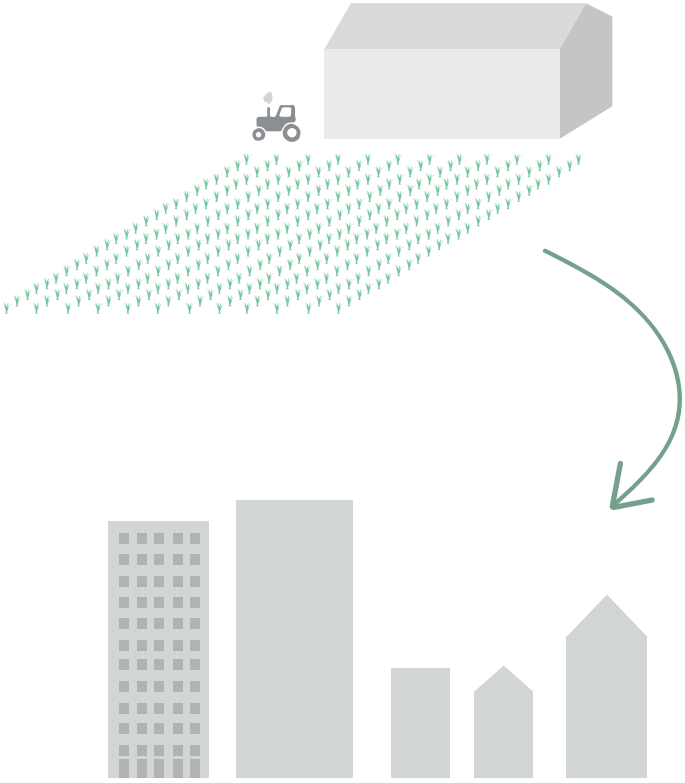
The countryside in the Netherlands is getting full of industrialized farms. It's no longer a place for nature and leisure but endless agriculture with huge farms.



1.2.2 Response to the problem; hypothesis.

To be able to stay the forerunner in innovative agriculture and to release the presuce of high-tech food production on the countryside, the Netherlands must investigate and invest in more sustainable ways of food production. There is a new approach needed to feed the city in a sustainable way. One of these approaches is integrating food production in the city; urban farming.

Urban farming can bring productive green to city by distributing the large farms from the countryside, over the city in smaller scale.



1.3 Urban farming

Bringing food production to the city will intensify the meaning of the city by adding another layer to its multiple land use. Urban agriculture can bring many solutions to city problems like dealing with excess of rainwater, the heating up of the city, decreasing biodiversity and bringing back awareness of food production. And the city gives many possibilities back. But urban farming also has challenges to overcome. Urban agriculture is complex, it comes in many shapes and forms, it deals with a lot of aspects on social and technical level and it is a relatively new concept.

1.3.1 The limitations and problems of Amsterdam.

Amsterdam has much of the same problems as other cities in the world. The city is growing rapidly[7]. The surface of the city is ever growing, meaning that the surface of rural areas is decreasing. But when the city grows, demand for food is also growing but with less and less rural areas for food production this will become a problem. The growth of Amsterdam is not due to national population growth but because people are moving from the countryside to the city. Also, less people are living in one house, in Amsterdam there is a big need for accommodation for one to two person households[8].

When the city is growing, other problems are rising too. In the Netherlands, it's going to rain more and more heavily. The cities are not able to cope with these changes because every piece of soil is covered with buildings, asphalt and other tiles which all prevent water going into the ground[9]. Another result of covering every piece of soil with hard material is decreasing biodiversity and green spaces. This is not only bad for flora and fauna but also heats up the city and creates micro-climates because these hard materials heat up very easily. In the city, there is a serious waste problem. Energy, water, gas and food, we can buy it all for a relatively small amount of money. Since everything comes to us without any apparent effort, people become indifferent to it. One third of food waste in the western world is the result[10]. We also use energy, water and gas in an inefficient way, simply because it is so cheap. Exactly this is the reason why greenhouse horticulture is so slow in switching from natural gas to solar energy. Why invest in expansive experiments on making it possible to run a green house on solar energy when the way they are doing it now doesn't costs them much at all[11].

To conclude:

Amsterdam has the following city problems:
- Rising population
- Increasing size of the city, decreasing of rural area.
- Rainwater
- Waste problem due to ignorance

1.3.2 Opportunities for urban farming.

The city doesn't seem like the best place for growing food because of these problems. Historically the city has always been the place for food consumption and the hinterland the place for the food production. Before railways these two worlds had some overlapping. People still could see where their food was coming from because it was always around them. People had pigs and chickens in their backyards, the small ports in the canals of Amsterdam always smelled like fish and streets were busy with carts full of vegetables[12]. Because of hygienic, health and infrastructure reasons the food production became more and more invisible for city dwellers.

Now, the general notion is that the city is a big contrast to the countryside. Fast living in a concrete jungle versus idyllic landscapes with a back-to-nature lifestyle. But both these visions are not reality. A city, in principle, is more sustainable because space is used much more efficient, facilities can be shared and transport is being reduced because distances are shorter[13]. Of course, because in the city we are with so many, we pollute a lot. One of the problems in a city, you don't have on the countryside, is the ignorance towards food production. Urban agriculture seems to offer the solution. By placing it on prominent locations in the city, making it accessible for everybody in the city, citizens can become familiar with the food production again and become aware of the effort it takes to produce a single piece of vegetable.

Next to raising awareness urban agriculture can help solve city problems like mentioned above. Bringing productive green to the city increases the green spaces in the city and will increase biodiversity. Farming in the city is a perfect way to deal with excess rainwater. When farming is done in soil then this can absorb more water when it rains heavily. When farming is done in a greenhouse on for example a roof then it is very favourable to make a rainwater collection system so rainwater can be used for the irrigation of the plants. Urban farming can be the solution to waste flows by making use of resources like excess rainwater, CO2 from exhaust air out of buildings and nutrients out of kitchen waste and blackwater[14]. "Urban agriculture can be used as a tool for making new connections in the urban ecosystem, connecting realms such as health, food, energy, waste management and real estate, thus making the overall network more responsive and flexible" as Paul de Graaf puts it[15]. Urban agriculture transforms these problems into opportunities. Figure 1 made by Paul de Graaf for the book; farming the city, shows the demands from agriculture versus the supply of the city and visa versa. It shows where some potentials lie.

Agricultural needs (demand)	Urban supply
Sunlight/ daylight	Sun-exposed surfaces
Nutrition/ fertilizer	Waste flows
Water	Too much water
Space	Vacant space/ temporary space
Labour	Labour force
Market	Costumers

Urban needs (demand)	Agricultural supply
Public green design & management	Aesthetics
Ecosystem services	Relatice biodiversity
Education (nature, food production)	Experience of seasons/ hands-on learning/ work experience
Jobs	Skilled and unskilled labour
Water storage	Water intake & evaporation
Climate control (cooling/heating)	Evaporative cooling
Water improvement, soil and air quality	Purification of water, soil and air
Waste treatment and management	Organic waste treatment

Source: Paul de Graaf, Farming the city

To conclude:
Urban farming can provide the following opportunities:
- It can raise much needed awerness about food production
- It can make use of urban waste flows
- It increases green spaces in the city and biodiversity.
- It prevends the city from heating up
- It can release the presure on the countryside

1.3.3 Possibilities provided by the city

Beside fixing concrete problems like water and waste management, a city like Amsterdam holds many social opportunities for urban farming. As shows in Paul de Graaf's matrix, the city provides a sales market. This means that you grow where you eat, produce doesn't have to be transported. It also means that the farmers have the possibility to not only sell the produce at, or very close to, the farm but also to edit, work and cook it to sell at a restaurant.

The city is also in need of jobs, therapeutic work and different ways of education[16]. Something urban agriculture can smartly make use off. A combination of growing and picking food, nature and environment education offers urban farmers opportunities to not only focus on food but also provide in different services like education. Childcare, kindergartens and playschools for after school hours, is also something urban farmers can specialize in. Amsterdam has a shortage of kindergartens[17]. The government in the Netherlands is lowering their contribution for childcare, parents must pay more themselves. This makes it harder for kindergartens to make their business financially viable and makes it necessary to differentiate. Urban farmers can profile themselves as green childcare with outdoor green play grounds and education in sowing and picking of fruits and vegetables. There is even a 'quality mark' for it; 'Groene Kinderopvang'. Not only childcare is a suitable service urban agriculture can provide, also care in general. Since 2013 municipalities are responsible for day-care and accompaniment for people who need care. The municipalities have to do with less money than the government had before. Urban farms can combine the care-needed with volunteers[17]. The farm is within the city so there is less transportation and there are more volunteers to find in the city.

The city can also provide in (almost) free space. After the economic crisis of 2008 there were a lot of vacant blocks in Amsterdam. These places were perfect for urban farmers because of it low costs. The economy is doing a lot better now and there are not many of these spots left.

To conclude:

Amsterdam can offer the following opportunities:
- Sales market
- A closer relation to people in general making it possible to provide also in other services like:
    - Education
    - Childcare
    - Care in general
- More posibilities for volunteers

1.3.4 Chalenges to overcome

Urban farming seems to have many answers to city problems but it still holds a few problems and challenges. First, the financially viability. It is hard to get a urban farm financially viable because the new technology for food production is expensive, they cannot compete with the enormous production scale of the high-tech food production in het Westland and land in the city is a lot more expensive then in rural areas. These problems can be dealt with in three different strategies; differentiation, diversification and low costs[18].

To keep low costs urban farmers should make use of urban resources which are not or barely utilized. A few examples are vacant land or buildings, urban organic waste for compost, excess rainwater and residual heat. But they can also make use of volunteers and people with a disadvantage on the labour market. Making use of vacant space is perfect for more socially engaged projects, it's a way to make a neighbourhood livelier, greener, safer and bring people together. But to move forward, to professionalize and become more efficient, urban farming should move away from this temporality, because in this temporality lies a pitfall19. Temporary lease contracts make it hard to attract capital intensive investments. Without investments, it is very hard to become financially viable as a company. The temporality makes it also difficult to make other business deals and collaborations. The project Uit Je Eigen Stad in Rotterdam is a very big scale project and had conversations with Nuon, a Dutch energy company, about making use of their residual heat. But because the project is not guaranteed to be able to stay at their location long enough, they couldn't close the deal[20].

Other strategies to make an urban farm financially viable is through differentiation and diversification. The later one has been discussed above; an urban farm doesn't only have to produce vegetables but can also provide other services like, education, childcare, care in general and other workshops. Differentiation is important to urban farmers because they can really distinguish themselves compared to normal super markets. Firstly because of their sustainable nature. They can also distinguish themselves through the production of specialties, 'forgotten vegetables', seasonal and local vegetables and more tasty vegetables that are hard to transport[21]. By keeping the processing and possibly also cooking within their business they can make more money.

Another problem arising when dealing with urban agriculture, is how, how are we going to integrate urban farming in the city. Everything mentioned above, all the solutions urban farming can provide is only possible when it is done on a big scale. We must understand the big scale of agriculture. In the Netherlands agriculture has reached a level of extreme efficiency and high-tech, something the country has become famous for. The romantic notion people have from the countryside with small, beautiful farms bears little relation with the high-tech productive megastructures you can find in 'the countryside' of the Netherlands like het Westland. Nevertheless, when architects work with urban farming it often evokes small scale interventions. Architects and planners focus only on the viability green structures can bring to people but the other benefits of green are being downplayed. The big scale of food production could be easily compared with the big scale cities, the scales are comparable. Yet, looking at the glass house mega 'cities' it is hard to imagine how it should be integrated in the urban fabric. We cannot simply copy these vast glasshouses into the city. Instead of looking at this issue only typologically, we need to investigate the system further and analyse it. When it is clear how the system works we can adopt it to an urban version, where the efficiency is guaranteed but is actually making use of the urban waste flows and at the same time delivering a high viability back to the residents of the city.

To conclude:

Urban farming has to overcome the following challenges:
- Financial viability
- How?

How can producing food be used as a tool to design a sustainable, lively and dense city?

2. We are what we eat

What are the consequences of our habits?

2.1 Analysis of the diet.

When urban farming is going to be implemented in the city to feed people in a more sustainable way, then it is first very important what these people need and eat.

2.1.1 Food consumption in the Netherlands

The Rijksinstituut voor Volksgezondheid en Milieu, de Dutch ministry of Health, Well-being and sport, conducted a research about the eating habits of Dutch people (2016)[22]. This was the result:

Aardappelen	73	g/dag
Groente	127	g/dag
Peulvruchten	4	g/dag
Fruit, noten, olijven	122	g/dag
Zuivel producten	355	g/dag
Vlees	101	g/dag
Brood, graan, pasta, rijst	192	g/dag
Vis, schaal dieren	15	g/dag
Eieren	12	g/dag
Vetten en olien	22	g/dag
Suiker, snoepgoed	39	g/dag
Kruiden, sauzen	37	g/dag
Hartige snacks	20	g/dag
Divers	49	g/dag
Total	1183	g/dag

In order to deal with the complex issue of diets and nutrition, there is a need to catogorize alle these ingredients:

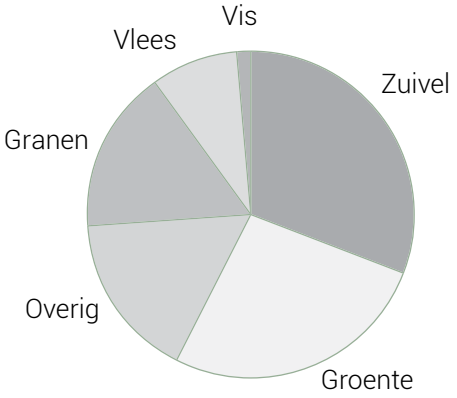
- Vegatables
- Legumes
- Fruit
- Herbs

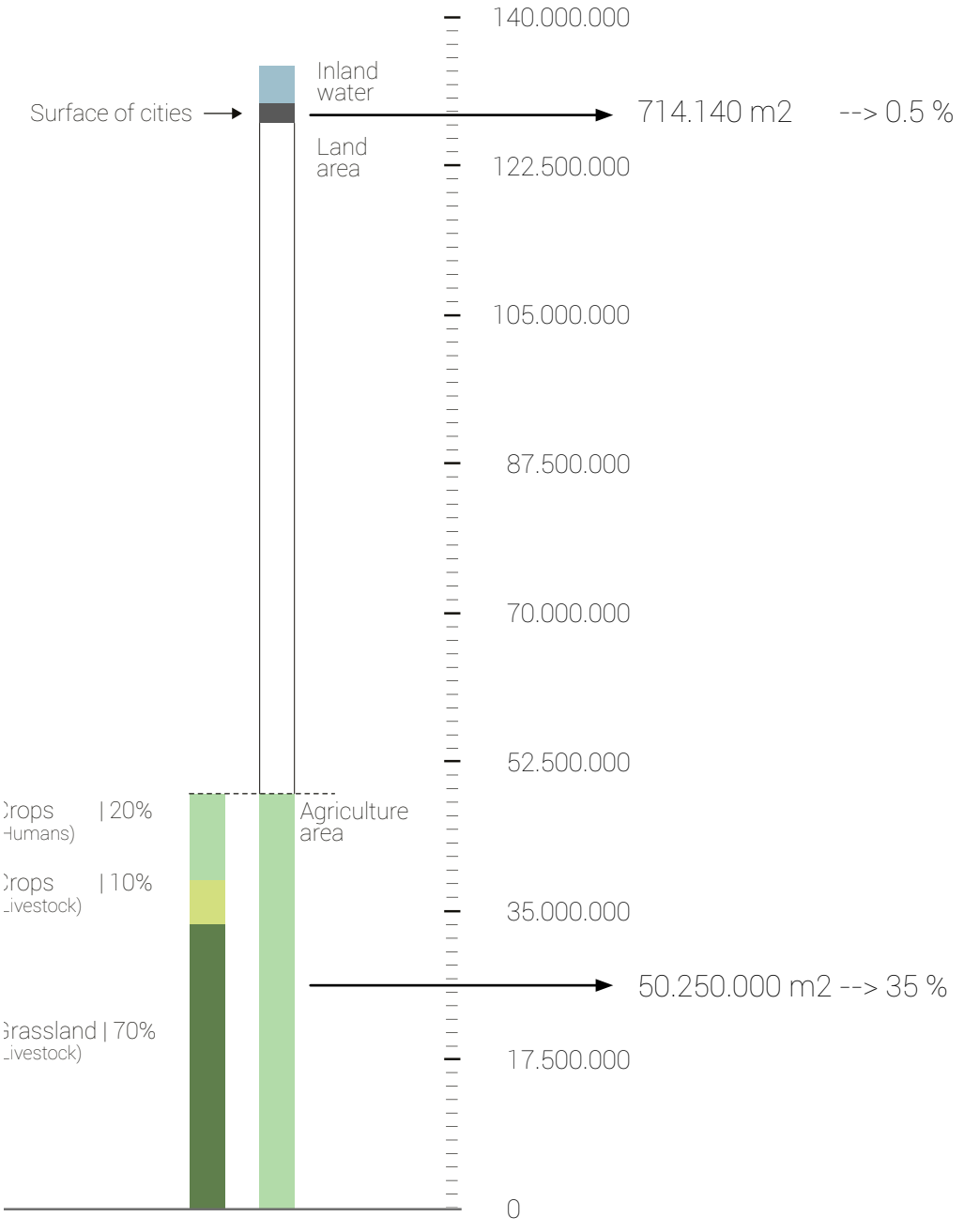
Greens

- Cereal
- Eggs and dairy
- Fish and shellfish
- Meat

The relative food consumption in the Netherlands:

Eggs and dairy:	30,9% 367 gram
Greens: (Of which 73 gram patato)	26,5% 314 gram
Cereal:	16,2% 192 gram
Meat:	8,5% 101 gram
Fish and shellfish:	1,3% 15 gram
Other:	16,4% 194 gram




140.000.000
Inland water
Surface of cities
714.140 m2 --> 0.5 %
Land area
122.500.000
105.000.000
87.500.000
70.000.000
52.500.000
Agriculture area
Crops | 20%
(Humans)
Crops | 10%
(Livestock)
35.000.000
50.250.000 m2 --> 35 %
Grassland | 70%
(Livestock)
17.500.000
0

2.1.3 Different diets, different consequences

Our diet has an ecological consequence. The food we eat needs to be produced and grown and for that we need a certain amount of land. This amount of space needed to grow food varies very much between the different food categories.

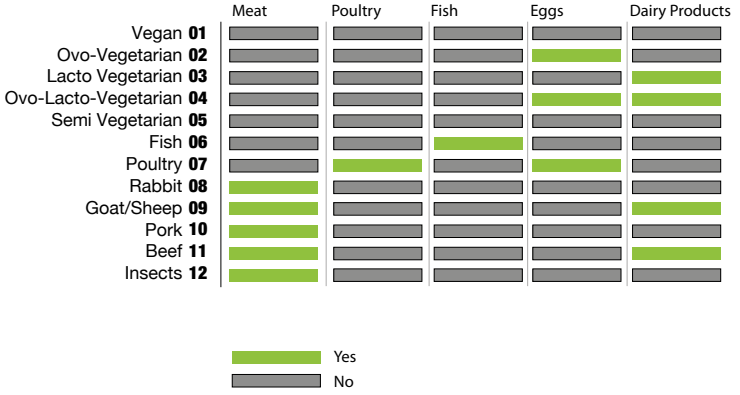
The image shows the way we use the land on earth. Earth has a surface of 510.100.000 km2. 71 % is the sea and oceans. There is 142.828.000 km2 land left and we use around 50.250.000 for agriculture, the surface of the city is only 714.140 km2. That's 35% versus 0.5%[23]. It makes it clear that we are much more space efficient by 'stacking' humans then how we are dealing with space efficiency of food production.

Food needs to be produced that provides a full diet and enough nutrition but need to be occupying less than the 7.460 m2 per person it does now. This number needs to be reduced significantly by 1. considering the effect on land-use of different diets and 2. more efficient growing systems. The first will be discussed in this chapter, the latter in the next chapter about different types of productive green.

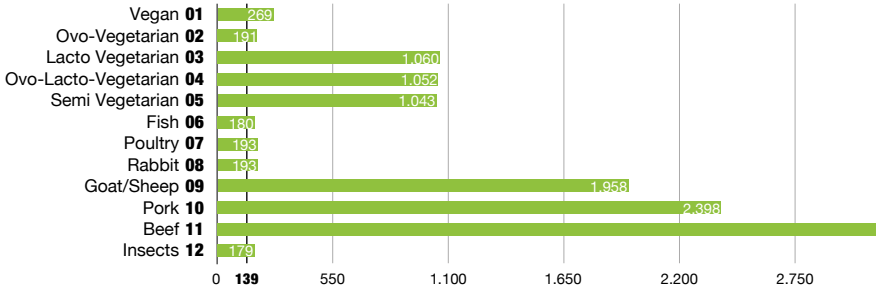
As said, the amount of space needed to grow food varies very much between the different food categories. Diatary choices have a dirrect relation with land use. Since it is not possible to just transfer the land use for food prodution to the city since it is too big, a diet needs to be compiled which is suitleble to be farmed in the city and still provides enough nutrition. To keep the high density whitin the cities, and Amsterdam's will to further desify, the food production must fit well within the boundries of a residential footprint.

The next page has a diagram of 12 different diets withs its components. The next two diagrams show how much space is needed to sustain one person in m2. These diagrams are made by Francis Liesting for her graduation project; Food and the city of tomorrow.[24]

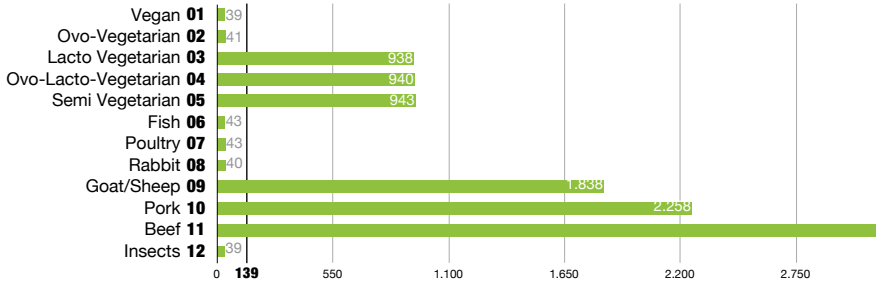
Diet components



Space implications of different diets (cereal based)



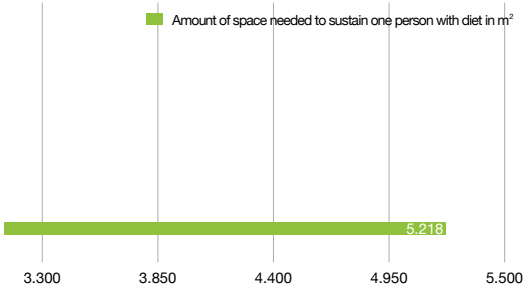
Space implications of different diets (cereal replaced)

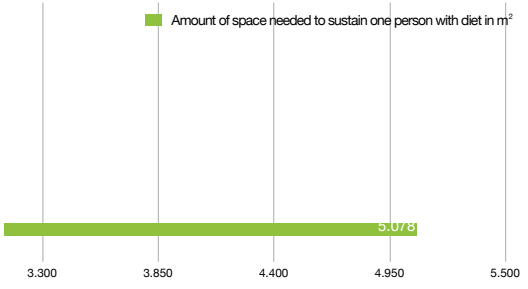


The composition of the diets is done in such a way it gives a clear overview of what the consequences are for which type of food. Instead of showing the land use for meat, it is devided, because the land use for growing chicken is very different from growing cows.

What is intersting to see is that diet 1, vegan, requeres more land use then diet 2, ovo-vegetarian. In diet 1 all necessary proteins come from plants. The carbohydrates are mainly supplied by wheat and barley, this is used to make bread and pasta. These crops need a lot of land to grow. There is less land needed when these nutrients would come from eggs.

Two componants of our diets have a large implication on our human food print and thats the production of cereal and meat. Cereal can be replaced by starchy food ingredients like (sweet) potatoes and yams. Not only do these have a higher yield, they can also be grown with the new effecient and sustainable methods like hydroponics.





2.1.3 Different diets, different consequences, in the netherlands

When researching this data, how much square meters it takes to provide a kilo of a certain vegetable or piece of meat, it becomes clear that there is no clear answer. Different studies come with different outcomes. The next study is done by the Brabantse Millieu Federatie, so it is a Dutch study based on Dutch parameters[25].

Table 1 shows the current Dutch diet (the same numbers I mentioned earlier) and what would be considered a 'healthy' diet and a vegetarian diet. Table 2 shows what the consequence in land use is for these different diets. Going from the diet the average Dutch person now has, to a more 'healthy' diet already saves almost 20% land. When we all become vegetarians the land use for the production of food will reduce with 54% according to this study.

Table 1. Overview of the average consumption per person in kg/year, for three different diets.

	Current Dutch diet	Healthy diet	Vegetarian diet
Potatoes and tubers	33.7	73.0	73.0
Vegetables	44.1	146.0	168.1
Fruits, nuts and olives	40.0	91.3	91.3
Dairy products	137.9	109.5	109.5
(Milk)	*119.6*	*91.3*	*91.3*
(Cheese products)	*18.3*	*18.3*	*18.3*
Cereal and cereal products	75.1	91.3	91.3
Meat and meat products	39.1	20.1	0.0
Eggs and egg products	4.3	7.3	7.3

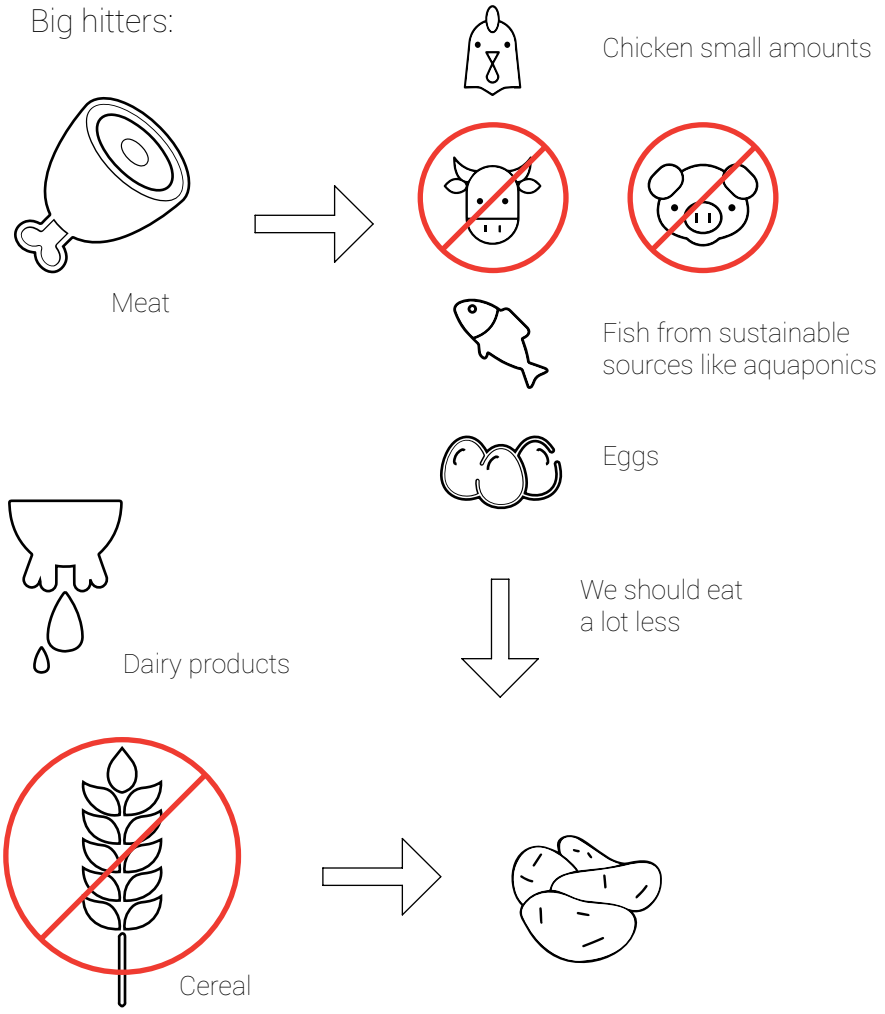
Table 2. Land use for agricultural production for an average person (m²/year)

	Current Dutch diet	Healthy diet	*Change in land use*	Vegetarian diet	*Change in land use*
Potatoes and tubers	6.7	14.6	*7.9*	14.6	*7.9*
Vegetables	13.2	43.8	*30.6*	50.4	*37.2*
Fruits, nuts and olives	20.4	45.6	*25.2*	45.6	*25.2*
Dairy products	329.7	295.7	*-34.0*	295.7	*-34.0*
Cereal and cereal products	105.2	127.8	*22.6*	127.8	*22.6*
Meat and meat products	508.5	261.1	*-247.4*	0.0	*-508.5*
Eggs and egg products	14.9	25.6	*10.6*	25.6	*10.6*
Relative land use	100%	81.5%	-	56%	-

2.2 Urbantarianism

Combining the outcome of these different studies, it is possible to create a diet that can fullfill the daily need for nutrients on a much smaller piece of land, fitting whitin the urban fabric, based on its land use.

The new diet urbantarianism:



2.3 The new urban foodprint calculation model.

As a conclusion to this research about the ecological consequence of our diets a calculation model is made. This model calculates how much space people need to grow their own food in the city.

The new urban foodprint calculation model is based on the original model, de stedelijkefood-print.nl, conceived by Jan-Eelco Jansma among others.

The original calculation model can be used to calculate how many square meters a municipality needs to feed their inhabitants and the other way around, how many people there can be fed with the amount of available space. The interface is very easy to use, you just fill in the amount of people you want or need to feed, click enter and you get the amount of space needed.

To make these calculations the model needs to know the food intake per person and how much space it takes to produce this amount of food.

1. The model works with the average Dutch diet
2. The model works with the average production methods

The calculation works like this: Foodintake / Production figures = Square meters necessary

The new urban foodprint calculation model uses the same principle to calculate how much square meters you need to feed a certain amount of people but is especially constructed for foodproduction done in the city, eaten by people in the city. The food intake per person will be different and the space it takes to produce this food will be different because:

1. The model works with a special diet. (Urbantarianism)
2. The model works with very efficient growing methods like hydroponics, aquaponics, aeroponics and vertical farming.

2.3.1 Urbantarianism

Per day in grams

450	gr	vegetables
75	gr	legumes
300	gr	fruit
200	gr	starchy root vegetables
25	gr	nuts
75	gr	fish, chicken & egg

(fish, chicken & egg per week: 1 piece of fish of 150 gr
1 piece of chicken of 150 gr
3 eggs of about 65 gr)

Per year in kilograms

200	kg	vegetables & legumes
110	kg	fruit
75	kg	starchy root vegetables
27	kg	fish, chicken & egg
9	kg	nuts

Production figures are from KWIN greenhouse horticulture from the Wageningen University. These figures must be consulted with them.

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2.3.4 Conclusion

Per person aquired:	16.8	m2 greenhouse
	2	m2 fish production
	3	m2 orchard
	2	m2 henhouse

Note: The production numbers are mostly derived from the greenhouses in the Netherlands. The Netherlands is extremly efficient in growing food, we use the most efficient growing methods in the world. The effeciency achieved in for example Het Westland is hard to match in urban farming due to many factors among which scale.

New growing methods like aeroponics and vertical farming can reduce this gap of effeciency between urban farming and greenhouse horticulture a little bit.

My recomondation would be to apply a factor 1.5 to the needed greenhouse square meters to represent this difference in effeciency.

Therefor **the aquired square meters of greenhouse per person is 16.8 x 1.5 = +- 25 m2**

3. Types of green follow function

What types of productive green are there?

3.1 Different types of green with different characteristics

Types of urban agriculture are defined by the way of cultivation together with their defining spatial characteristics. They differ in their relation to the soil and the built environment, their relationship with the essential flows of the city, and the impact they have on public space socially and aesthetically. Thus they offer different benefits to the city, and respond to different opportunities.

4 types of productive green will be discussed because these are the main types of urban agriculture you see around Amsterdam:

- City garden
- Roof garden
- Greenhouse
- Vertical farming

To grasp these different types and understand their key dynamics they are classified in different aspects, in a similar way Farming the city (2013) 'tagged' the different example project with different infographic labels.

Social: The project creates or strengthens communities and social ties, and/or supports communication and cohesion. This can be done for example by education and raising awareness about food.

Environmental: The activities are sustainable or beneficial to the environment en terms of nature, waste, energy, soil, water and air.

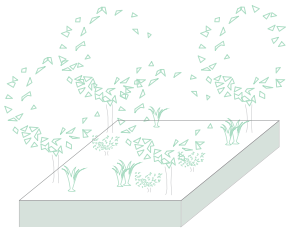
Economic: The project creates jobs, supports local economic activity and/or promotes a viable business model.

Effeciency: The project creates a proper yield of produced food.

These aspacts will be classified as -- : having a negative effect on this aspect.
- : having a no effect on this aspact, +: having a positiv effect on this aspact and
++: having a very positive effect on this aspect.

3.1.1 City garden

The city garden one of the most common forms of urban agriculture projects you see around Amsterdam.



Social	++	--> Acceseble for city residents
Environmental	+	
Economic	-	
Effeciency	-	

Social; A productive city garden is a place where city residents come together. It can be place for leisure and recreation. It is also a place where people come in contact with food production in a very casual way. Anyone is welcom to enter the garden, and can help with the procces of growing the food. There are a number of management ways possible how this is done. For example the garden is always open to be used recreational and when you want to be part of the producing of food you can sign up with the care taker of the park. It is a place where people come together, in first place for leisure, secondly to come in contact with food production.
.

Environmental; A city garden is good for the environment because of a few aspects. It helps the management of excces rainwater and it increases the biodiversity.

Economic; A city garden is not very interresting if you look at the economics. In the city it is often valuable land it sits on. Sometime urban farming happens on vacant plots or buildings. In this case it can have some economic plus sides to the neighborhood. Because it can cause the surroundings to become livelier, greener and safer and all these aspacts make the land value increase.

Effeciency; The main focus of this type of green is its scocial benifits. Therefor there is little effeciency. It can be used for fruit trees, somthing that cannot be grown in a greenhouse.

3.1.1 City garden example project; DemoTuinNoord, Amsterdam

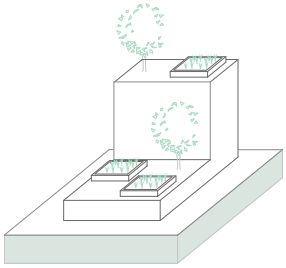
The 'Demo Garden' is situated is a garden in the notrth of Amsterdam, closeby the Noorder Park. Next to the garden is a artists collective building. Together with the people who work in that collective, local residents and businesses, URBANIA-HOEVE planted this demo garden. It is a demonstration of so many of the possibilities of growing eateble plants in the urban environment. It has a tea garden, fruit bushes, a collective kitchen garden, a food forrest and an ecological nursery. The 1500 m2 of garden provides for 9 to 10 months harvest per year. The garden has the ambition to become a part of the main ecological structure of Amsterdam North. [26]

http://www.urbaniahoeve.nl/category/urbaniahoeveprojecten/demotuinnoord/

http://www.urbaniahoeve.nl/category/urbaniahoeveprojecten/demotuinnoord/

3.1.2 Roof garden

Roof gardens are mostly used as a place to come together among the people who live in a building



Social	++	--> Acceseble for building residents
Environmental	+	
Economic	+	
Effeciency	-	

Social; A productive roof garden is a place where residents of a building come together. It is a place where people can really express their hobby which is growing food. This can be done in a few ways, people can really have ownership of their own allotment, it is also possible that the whole roof is under supervision of one person and residents can sign up to help with growing the food. There are many possibilities to arrange this.

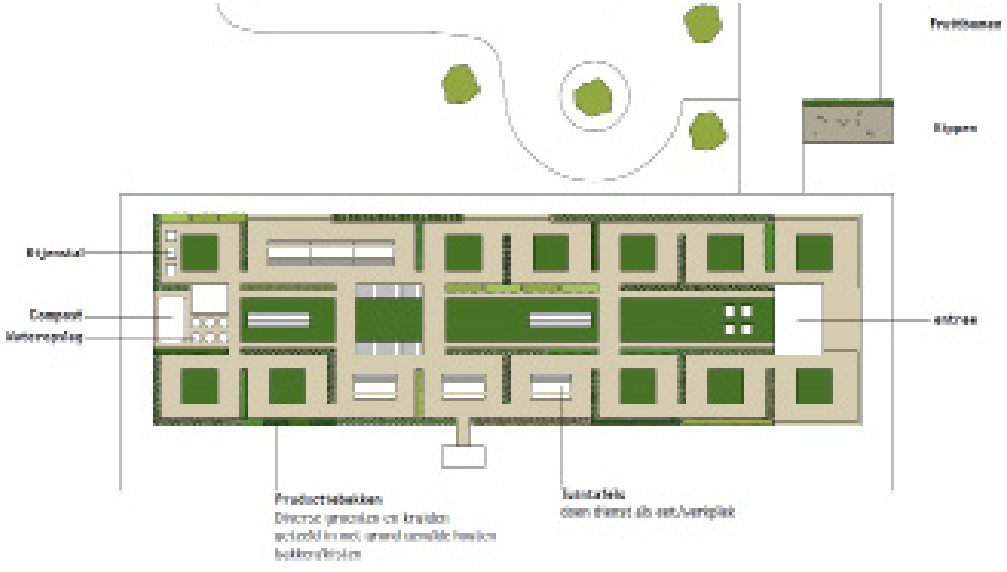
Environmental; A roof garden is good for the environment because it helps the management of excces rainwater and it increases the biodiversity. It also helps to prevent the city from heating up.

Economic; A roof garden can help increasing the value of the property. It gives an extra value to it and the building can promote it self as being sustainable.

Effeciency; The main focus of this type of green is providing space for people to grow food because they really enjoy it. This means they probebly produce some vegatables and herbs but it wont be very effecient.

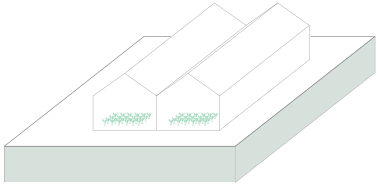
3.1.2 Roof garden example project: ZuidPark Amsterdam

After being vacant for a few years, zuidpark is completely renovated as a sustainable and attractive office building for small and bigger businesses. On top of the buidling is a roof top garden of 3000 m2. The vegatbles that are being grown here are used in the cantine of the building. The owner of the building has formed 'the Zuidpark team'. These people are responsible for the manegement and maintenance of the garden. They have formed the 'Garden club', these are people who work at the building and enjoy gardening, they can also rent their own private little allotment. When it was build, in 2012 and was back then the biggest urban farming roof in Europe.[27]



3.1.3 Greenhouse

Food is most effeciently grown in a green house. The Netherlands have become the forerunner in this innovative technique.



Social	-	
Environmental	+	--> This can vary from -- to ++
Economic	+	
Effeciency	++	

Social; A greenhouse is in principle not social. You need a (relatively) closed environment, this make it hard to let a lot of people engage in this way of food producing. Also it is highly technical. To be a part of the procces you need some knowledge about how to deal with the system, the plants and all the technique. The are some ways to let people engage more with the process. People can help pick the vegetbles or people can be visally close to it so they see the system at work.

Environmental; A greenhouse can have very varied effects on the environment The traditional ones have a very negative effect on the environment because of its big fosil fuel consumption. There are many improvements to make, and they are possible. New ideas like 'the greenhouse as energy source' can make the greenhouse much more sustainable. New high-tech greenhouses used in urban agriculture can be designed in such a way the greenhouse can make use of urban wasteflows. It this case the greenhouse will have very positive effects on the environment

Economic; A green house can be economically feaseble. It does need a high first investment but it is possible to become provitable after some years. There are a a few strategies to do this; differentiation, diversification and keeping low costs.

Effeciency; The effeciency of greenhouses is very high, the hghst of all agriculture methods. There are many different types of greenhouses with different systems to grow vegetables. The traditional greenhouses in the Westland in the netherlands are very effecient but there are new ways that are particular suited to be integrated in the city, that are said to be even more effecient.

As said, there are a few different systems that can be used in greenhouses, there are three that ar in particular suited to be integrated in the urban fabric because of their effeciency.

Different systems:

Hydroponics

Hydroponics is the soilless cultivation of plants were the nutrients the plant needs are dissolved in water. Periodically this water flows past the roots of the plant giving it all the nutrients it needs. The water gets filtered by the plants and the water that's left can be used again. In this way 90% of the water is saved compared to traditional agriculture, where all this water would go in the soil. Nutrients are also used more efficient because the roots absorb the nutrients directly. In traditional agriculture the nutrients are in the fertilizer and the fertilizer is covering a much larger area then only where the roots need it, there for it ends up in the soil not being used. This efficient way of feeding is resulting in higher yields and shorter turnovers. (Grant 2012)

Advantages:

-	no soil needed	It can grow everywhere.
-	Resources are saved	90% less water and less nutrients, which don't pollute the soil.
-	High efficiency	
-	Crops can grow year round.	

Crops:

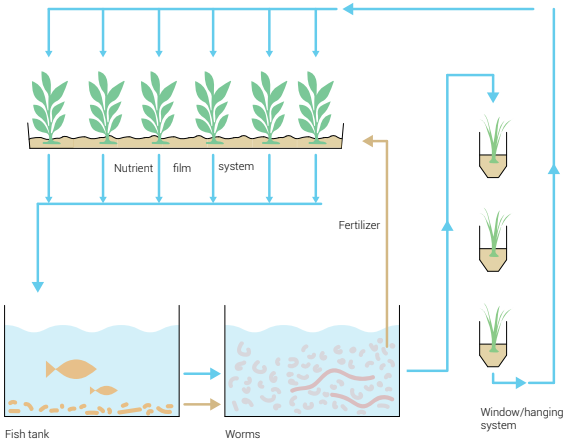
-	Leafy greens; spinach, lettuce, cabbage, rocket etc.	++
-	Herbs	++
-	Vining plants; tomato, cucumber and pepers	+
-	Root vegetables; potato, carrot, parsnip	-

Different systems:

Aquaponics

Aquaponics combines the system of hydroponics with aquaculture (farming fish). It aims for a circular system were the output of one cultivation is the input of the other. The organic waste provided by the fish serves as nutrients for the plants, the plants in return have certain waste that is used to feed the fish.

In this way there is no need for expensive fertilizer. It does depend on what kind of crops your growing if it gives enough nutrients to the fish and the other way around. These extra nutrients can be put in the system via fish food. This way of farming is highly efficient, it has the potential to increase yield ten times compared to traditional farming.
(Effekt, ReGen)



Advantages:

- no soil needed
- Resources are saved
- High efficiency
- Crops can grow year round.
- Fish also farmed in a sustainable way

It can grow everywhere.
90% less water and almost no nutrients because of circular system,

Crops:

-	Leafy greens; spinach, lettuce, cabbage, rocket etc.	++
-	Herbs	++
-	Vining plants; tomato, cucumber and pepers	+
-	Root vegetables; potato, carrot, parsnip	-

(Some particular crops work better with aquaponics and some better with hydroponics)

Different systems:

Aeroponics

Aeroponics is also a system based on soilless cultivation. With hydroponics and aquaponics the roots of the plants are periodically submerged in water, with aeroponics the water, including the nutrients are sprayed on the roots on the crop. This is a better system for root vegetables like potatoes. The plants don't have a growing medium (soil or water) so they are grown in special structures to separate the roots in the air to maximize the contact with the nutrients. According to NASA (2006), aeroponics can sace up to 98% of water and 60% fertilizers.

Advantages:

- No soil needed — It can grow everywhere.
- Resources are saved — 98% water and 60% fertilizer
- High effeciency
- Crops can grow year round.

Crops:

- Leafy greens; spinach, lettuce, cabbage, rocket etc. ++
- Herbs ++
- Vining plants; tomato, cucumber and pepers ++
- Root vegetables; potato, carrot, parsnip ++

Disadvantages:

Aeroponics seems to have the best results but as a big disadvantage is that the system requires a lot of technical knowledge to run the system, it is also very expensive.

Conclusion of the three main efficient growing methods:

Hydroponics and aquaponics are very similar and have similar outputs in terms of crops. They can very much complement each other because one system is slightly more efficient for a certain crop then the other but they do need similar techniques. Aeroponics seems like the best way to go but it is very expensive and technically complicated, this is only worth it for growing root vegetables because they simply cannot grow in a different way.

3.1.3 Greenhouse example project: UrbanFarmers Den Haag

A former Philips factory in The Hague, was renovated to accommodate Europe's largest aquaponics rooftop farm. Urban Farmers is a company based in basel and this greenhouse in The Hague is the second one they've built. the design is done by architecture firm Space&-matter.

The construction consists of a 1200 sq.m of greenhouse on the rooftop and a 900 sq.m of space for fish cultivation on the floor below. Together, they form a symbiotic system for fish and vegetable production, Aquaponics. Both floors also house irrigation systems, technical installations and the fish and vegetable processing rooms.

The greenhouse itself is high-tech and doesnt invite for much interaction with visitors. Space&matter made an interesting design were this interaction is optimilized by creating a visible conection. When entering the first of two floors the visitor immediatly sees the fish-tanks of the aquaponic system. Next to this area you have space for the open stairs to the next event space. From this area you can look into the greenhouse. In this way the floors are closely connected and the visitor is always in close contact of the whole food production proccess[28].

Numbers:

Productive space: 1900m2
- Green house: 1400m2
- Fish tanks: 500m2

Event space: 300m3
- Entrance, cooking classes, market place, bar.

Produce per year:
- Greenhouse: 4.500.000 gram vegetables:
  Lettuce, cucumber, pepers, tomatoes, eggplant.
- Fish tanks: 1.900.000 gram fish
  Talapia fish.

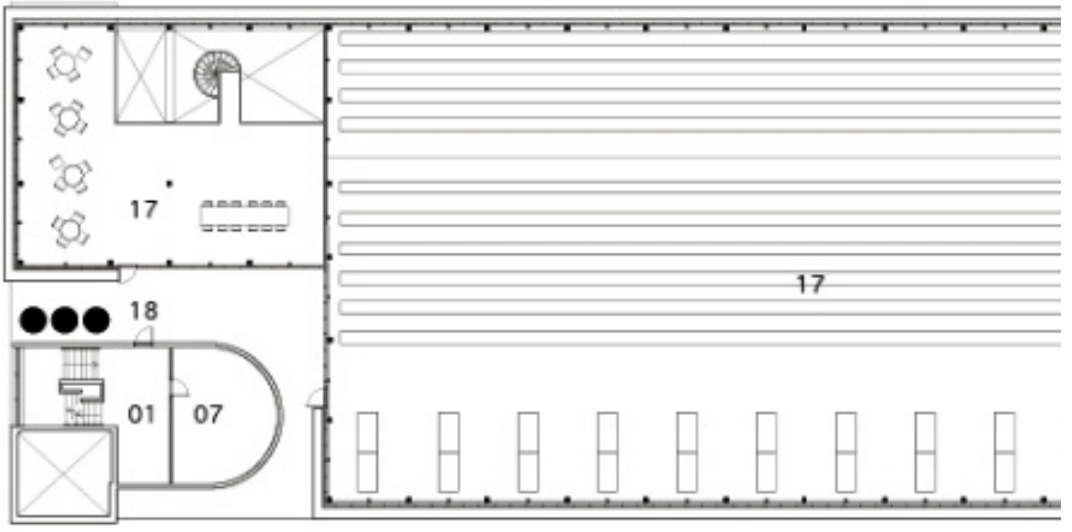
People eat 215 gram vegetables a day. Thats +- 78.000 gram vegetables a year.

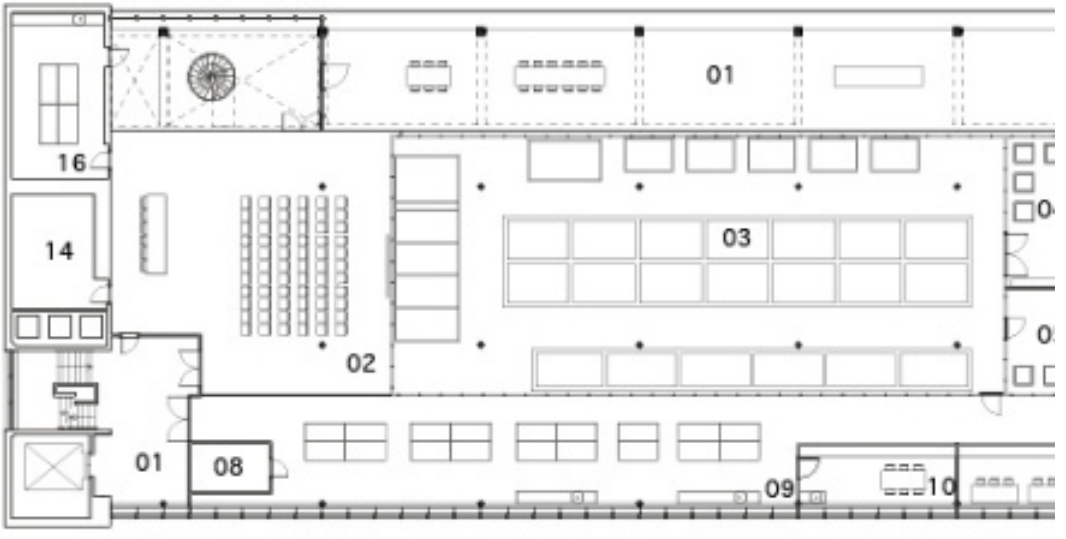
Then we need about **25 m2 of greenhouse to provide for 1 person**.

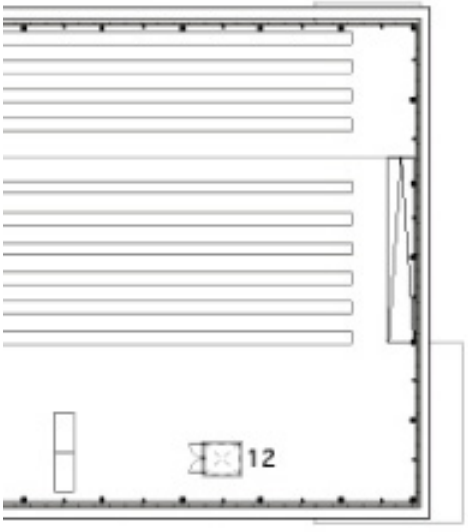
People eat 15 gram fish a day.Thats 5460 gram fish a year.

Then we need about **1,5 m2 of fish tanks to provide for one person**.[29]

3.1.3 Greenhouse example project: UrbanFarmers Den Haag







01 corridor
02 event space
03 fishtank room
04 irrigation room
05 fish processing
06 fertilizer room
07 storage
08 cold storage unit

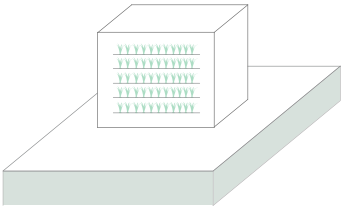
09 vegetable processing
10 workshop
11 office
12 elevator

13 toilet
14 technical room
15 changing room
16 kitchen

17 greenhouse
18 outdoor

3.1.4 Vertical farming

Vertical farming is the most recent development in urban farming. It is the stacking of food production in a highly technical environment.



Social	-
Environmental	-
Economic	-
Effeciency	++

Social; Vertical farming doesn't have any effect on social relations. It is a completely artificial environment, closed of from the ouside. This means there is no interaction possible with visitors.

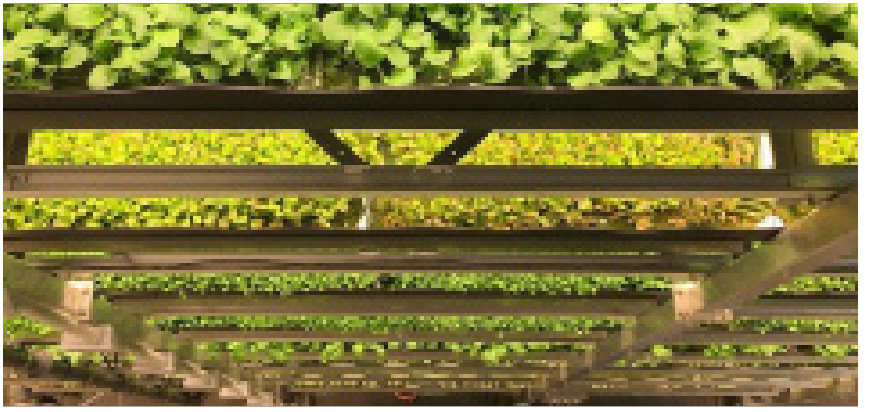
Environmental; The vertcal farm doesnt do much for its environment because it is closed of from its surroundings.

Economic; Vertical farms can become economicly independant. Since it is such a new way of farming the starting costs are relatively high and it is still quite experimental. Yet there are already some companies that are growing food this way on a big scale like

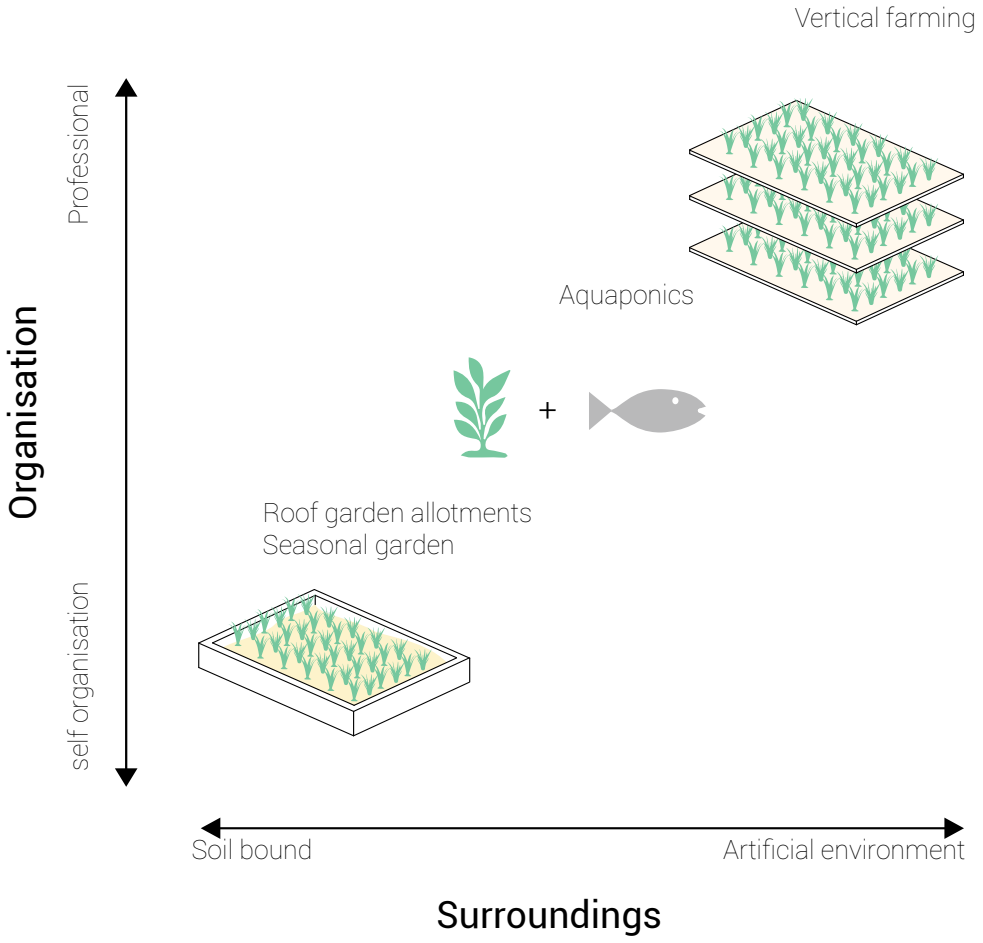
Effeciency; A vertical farm is highly effecient. It cannot grow all crops, mainly leafy greens and herbs but the way this is done is extremely effecient. A vertical farm does uses a lot of energy because it issnt getting any heat from the sun. On the other hand is a vertical farm very effecient in its use of water and nutrients.

Vertical farming is stacking the production of food. Not just one floor of foodproduction and on the other floor again, with 3 meters in between. It is putting the food as close together as possible and integrating it into one system. This needs a lot of technique, these vertical farms look almost like industrial labs.

3.1.4 Vertical farming example project Aerofarms

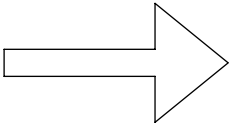


3.1.4 Conclusions Different types of productive green



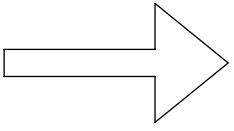
3.1.4 Conclusions Different types of productive green

In order to become more sustainable, food production systems must move from a linear production model to a circular system.
For urban food production to become a part of the solution to the global food crisis it is necessary to combine efficiency with integration in the urban environment. We need a substantial amount of food to feed a city in a sustainable way. At the same time this process of food production needs to be visible. People need to become aware through participation, just observing or actually taken part in the process. It is crucial to combine the agri- industrial perspective with the integrated territorial perspective for urban farming to became really succesful.



The agri-industrial perspective:

Based on a closed system philosophy using advanced technique.

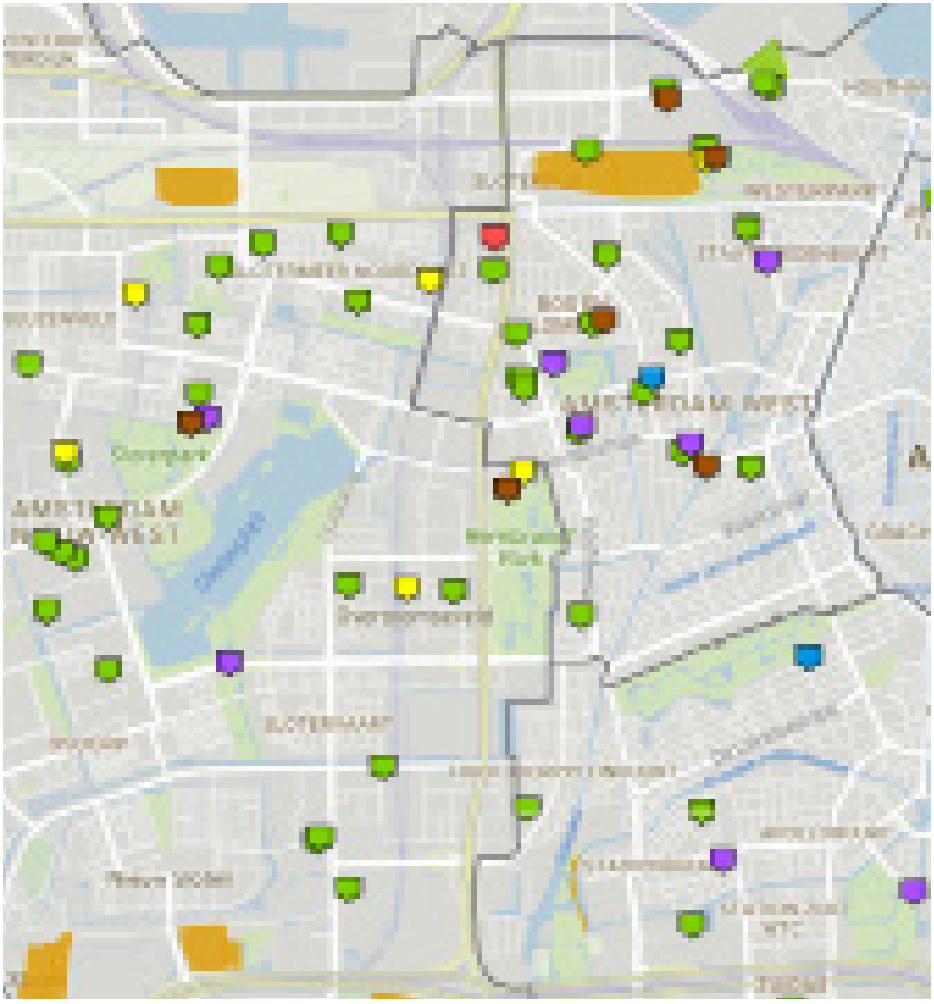


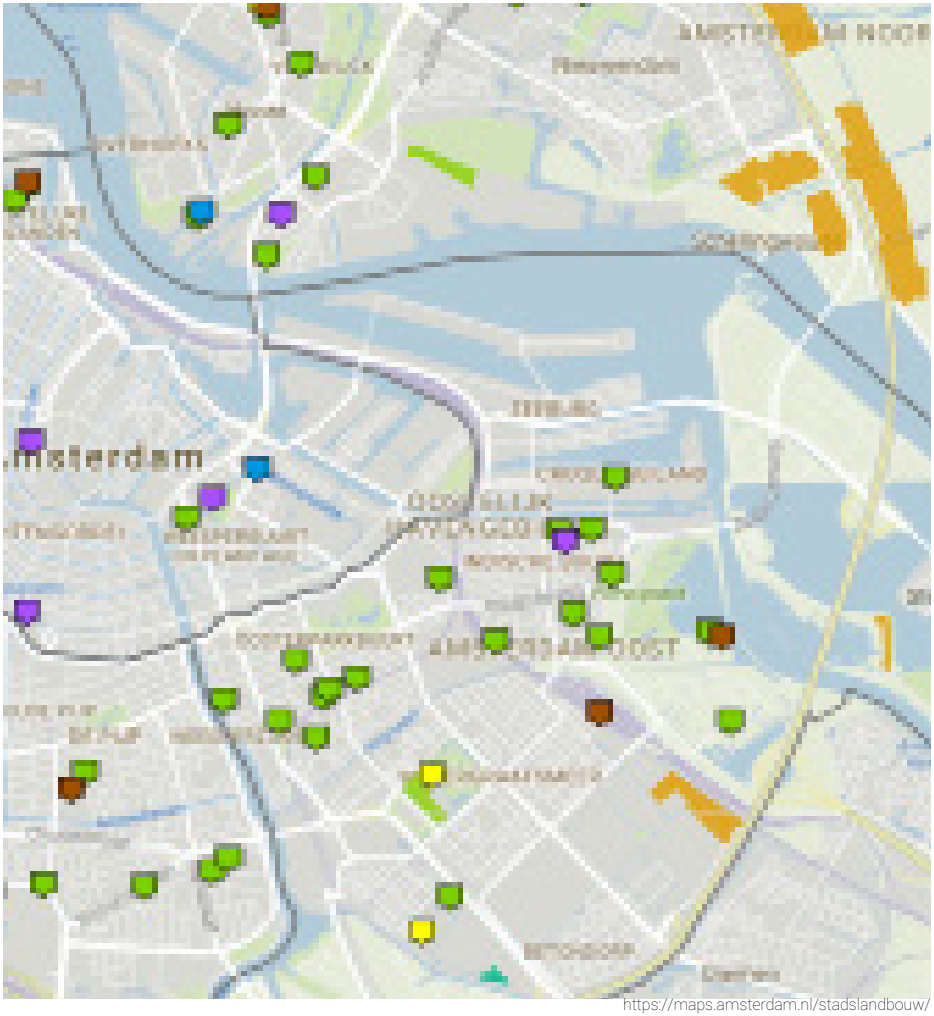
The integrated territorial perspective:

Rooted in an open system philosophy where nature is invited back into the production system

3.2 Different types of urban farming in Amsterdam

Amsterdam already has quite some urbanfarming intiatives. But in the city centre, it is almost completely absent.





https://maps.amsterdam.nl/stadslandbouw/

3.3 Case studies, productive green in relation to living

3.3.1 ReGen Village, Almere, by Effekt.

Project name	ReGen Villages
Typology	Masterplan, residential, agriculture
Location	Almere, The Netherlands
Year	2016
Status	Ongoing
Size	15.500 m2
Client	ReGen Villages Holding B.V.
Collaborators	James Ehrlich
Design Team	Tue Hesselberg Foged, Sinus Lynge, Kasper Reimer, Esbjen Jensen, Toni Rubio Soler, Christoffer Gotfredsen, Laura Gobbi, Yulia Kozlova, Lavinia Andreea Marcu, Evgeny Markachev, Weronika Marek, Rikke Aaskov.

"ReGen Villages is a new visionary model for the development of off-grid, integrated and resilient eco-villages that can power and feed self-reliant families around the world.

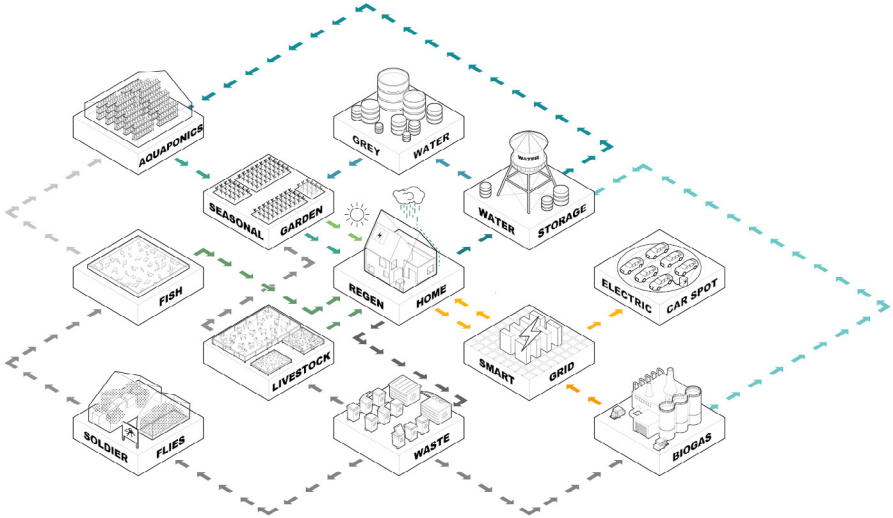
ReGen stands for regenerative, where the outputs of one system are the inputs of another. The concept has a holistic approach and combines a variety of innovative technologies, such as energy positive homes, renewable energy, energy storage, door-step high-yield organic food production, vertical farming aquaponics/aeroponics, water management and waste-to-resource systems.

With the integration of such technologies, ReGen Villages holds a potential in changing some of the challenges of a growing population, increasing urbanization, scarcity of resources, the growing global food crisis as well as reducing the global CO2 emission and reducing the burdens on municipal and national governments in dynamically changing planetary and economic times.

ReGen Villages is all about applied technology. Already existing technologies are simply being applied into an integrated community design, providing clean energy, water and food right off the doorstep. ReGen Villages adds not only environmental and financial value, but also social value, by creating a framework for empowering families and developing a sense of community, where people become part of a shared local eco-system: reconnecting people with nature and consumption with production." (Website Effekt)

The ReGen project has the same starting point as this project, it reacts to the same global problems as discussed at the beginning of this research. ReGen also puts food production in the middle of the whole self-sufficient living structure.

The next image explaines the system of this self-sufficiency.



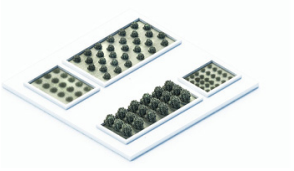
Waste: 1. Household waste is sorted into different categories so it can be reused for multiple purposes. 2. Bio waste that is not compostable is used in the bio-gas facility. 3. Compost becomes food for the soldier-flies and lifestock. 4. The soldier-flies are fed to the fish, and waste from lifestock is used to fertilize the seasonal garden. 5. The waste from the fish become fertilizer for the plants.

Food: 1.The aquaponic system produces vegatables and fruit. 2. the seasonal gardens provide a wide variety of produce. 3. Lifestock and fish provide the primary protein food source.

Water: 1. The settlement collects and stores rainwater. 2. Water from the biogas facility is added to the water storage. 3. Grey water is seperated. 4. Grey water is used to irrigate the seasonal gardens. 5. Cleanwater from the water storage is added to the aquaponic system when needed.

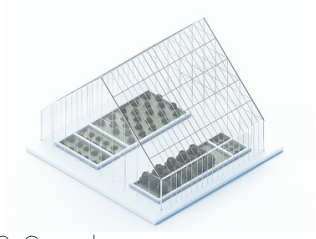
Energy: 1. The solar cells on the settlement provide energy for the homes and distrubutes the surplus to the smart grid. 2. The energy production from the biogas is added to the smart grid. 3.The smartgrid distributes the enery when needed, for example to charge the cars.

The ReGen project devide the productive green in different catagories:

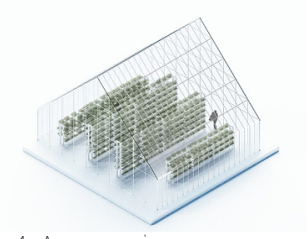


1. Seasonal garden

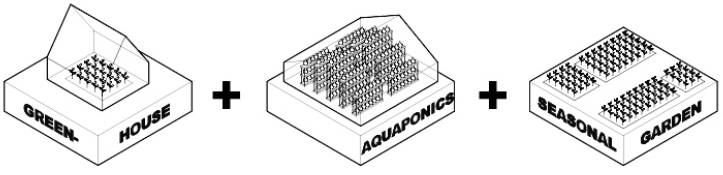
2. Heated greenhouse



3. Greenhouse



4. Aquaponic



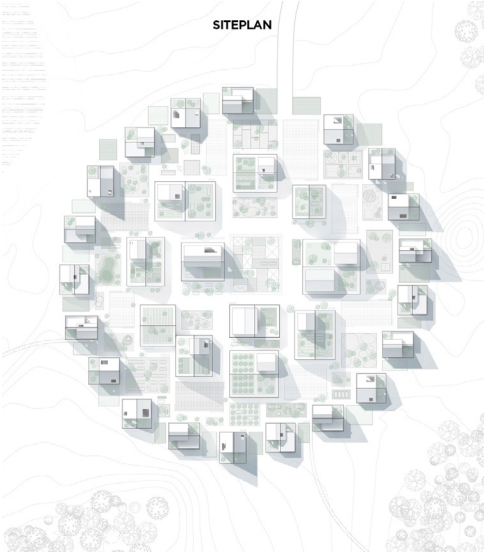
GREENHOUSE
AREA:
40M2

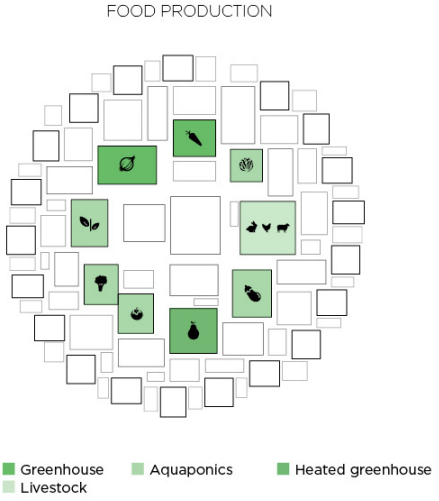
AQUAPONIC
AREA:
300M2

SEASONAL GARDEN
AREA:
100M2

They claim to need in total 440 m2 of food productionsurface to be able to provide for the daily needs of nutrient for three people, with the exeption of space for lifestock. This means 146m2 of food producing area is needed to provide food for one person. Based on research done this seems too much. Effekt doesnt provide its calculations how they came to this number. Urban farmers say they can profide 45 tons of vegetables a year with a production space of 1500m2. This mean they can provide the vegatables intake of 60 people, meaning you only need 25m2 per person. They dont provide for example potatoes which take more space to produce. The tables of diet concesequences show us for a vegan diet you only need around 40m2 of food-producing area per person. The big difference is that this project is in a rural area, they dont need to achieve the high density like this project need.

These different types of green have different locations in the project. It is interesting to see that the seasonal garden is something less formal and doesnt have a fixed place in the site plan. This can mean that the seasonal garden can be for example integraded in the personal dwellings. This division of proffesional green and less formal green is interesting.





The project in Almere has different typologies for the dwellings. These show again that they are not so much concerned with high density as this project must be.


TYPOLOGY 1A
HOUSE 80 M2
GREENHOUSE 20 M2


TYPOLOGY 2A
HOUSE 110M2
GREENHOUSE 20M2
TERRASSE 20M2


TYPOLOGY 2C
HOUSE 130M2
GREENHOUSE 20M2
TERRASSE 20M2


TYPOLOGY 3A
HOUSE 140M2
GREENHOUSE 5M2
TERRASSE 40M2


TYPOLOGY 1B
HOUSE 80 M2
GREENHOUSE 20 M2


TYPOLOGY 2B
HOUSE 120 M2
GREENHOUSE 25M2


TYPOLOGY 2D
HOUSE 120M2
GREENHOUSE 15M2
TERRASSE 15M2


TYPOLOGY 3B
HOUSE 140M2
GREENHOUSE 10M2
TERRASSE 50 M2

In this image it is visible that the green is integrated in the personal living space. This has a technical aspact to it and a social one.

Technical: The green house around the dwelling functions as a climate buffer. In winter the sun heats up the cold air in the greenhouse. This way the air gets pre-heated before it reaches the dwelling. In summer it means the greenhouse will get very hot but by opening windows in the greenhouse you can create natural ventilation for the whole house.

Social: There is a direct connection between the production of food and the dwelling, it is pre-cense in you everyday live. In this case it seems it is privatly owned this space. It is imaginable in a bigger complex to have this area as a common area for the residents of the entire building or to clusters of dwellings. This can increase social encouters.

This image looks very apealing but after the reachers thats been done I think this is unrealistic. The growing system looks like aeroponis or hyproponics, this is highly technical and you need to be trained to do this job. Also, it is in an artifical environment that needs to stay clean. It wont be suited for social gatherings.

The image does represent a vision. Combining productive green with social aims, bringing people closer together. This is a very interesting concept and will be one of the aims in this project in Amsterdam.

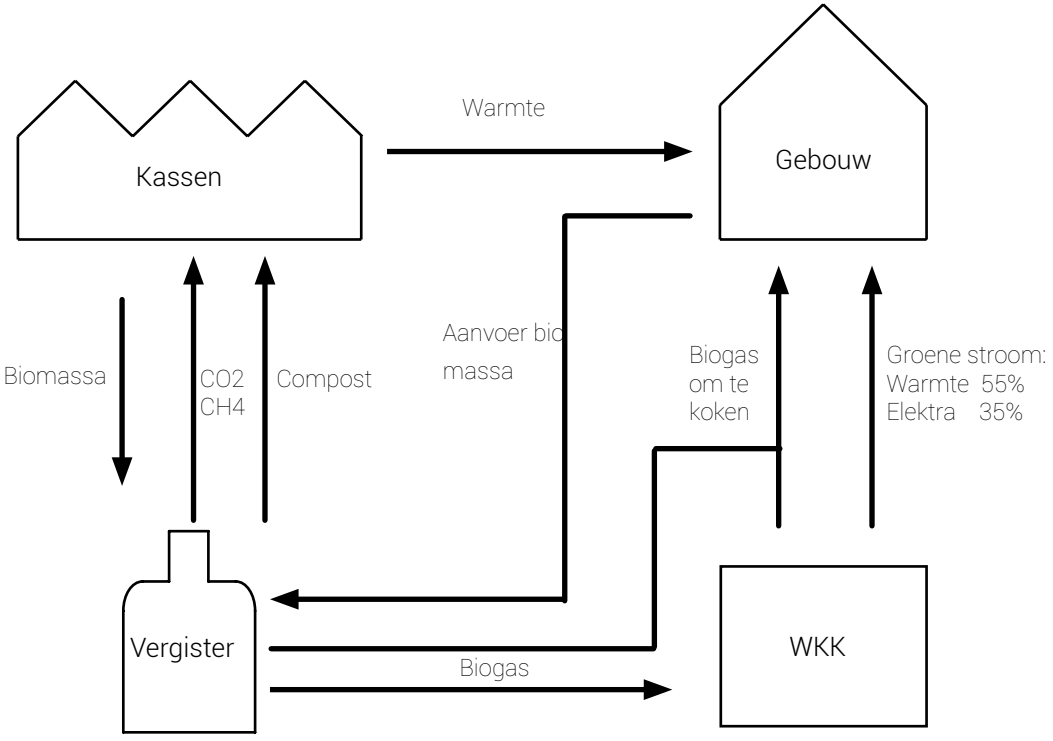
4. Make it work

How can productive green play a key role in a building?

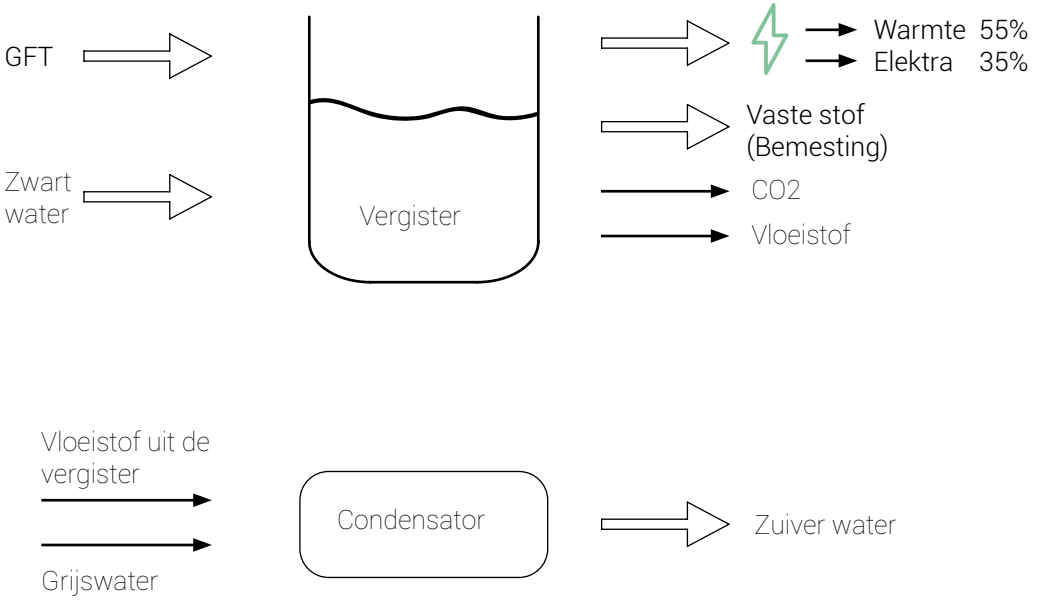
4.1 Closing loops and saving resources.

Urban farming has the advantage of the consumers being close to the production. This means that outputs in the food system are more easily reused as inputs. The food production is able to enjoy the benefits of the proximity of the consumers, whereas the consumers enjoy from the benefits of the proximity of the greenhouses that produce their food. Not only in terms of fresher food that can be traced back to a sustainable source that is verifiable, but also by using the excess heat that is produced by greenhouses as warmth in the households. When collecting the food waste of households in return the greenhouses have extra compost to use, and need less fertilisers. Also when source separation toilets are applied in the households, much nutrients can be retrieved and used for food production.

4.1.1 Greenhouse as key element

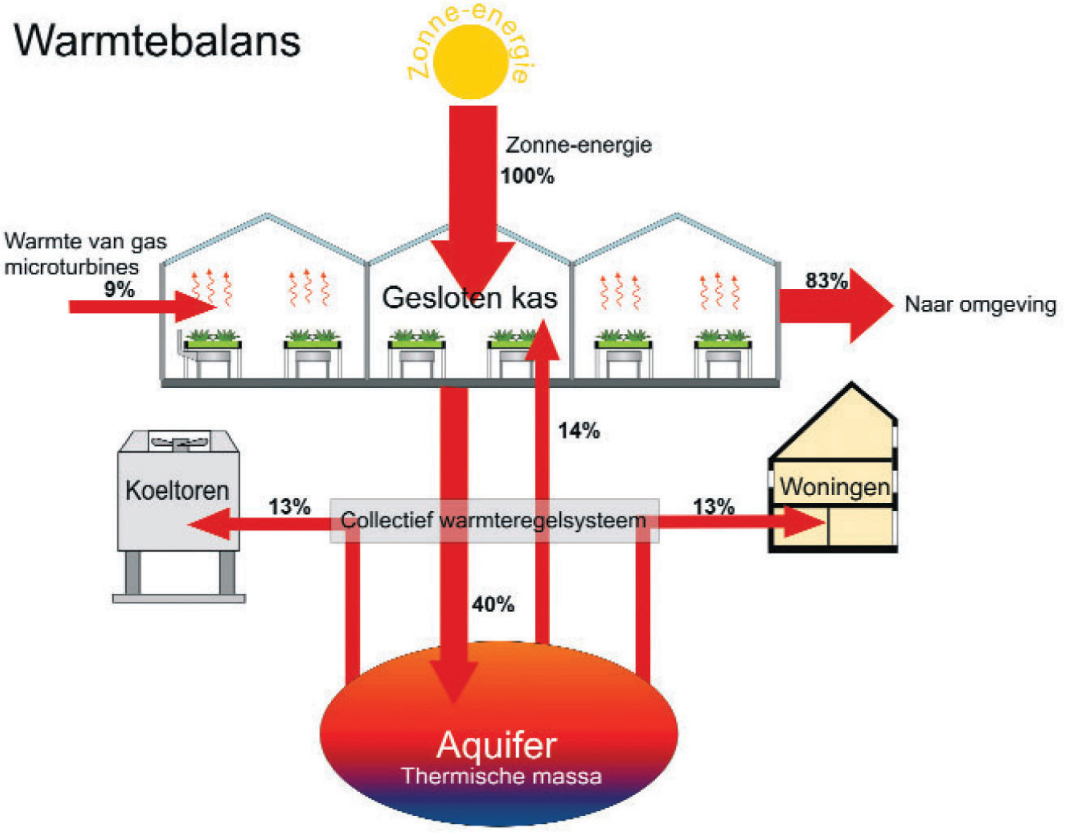


4.1.2 Biogas facility principle



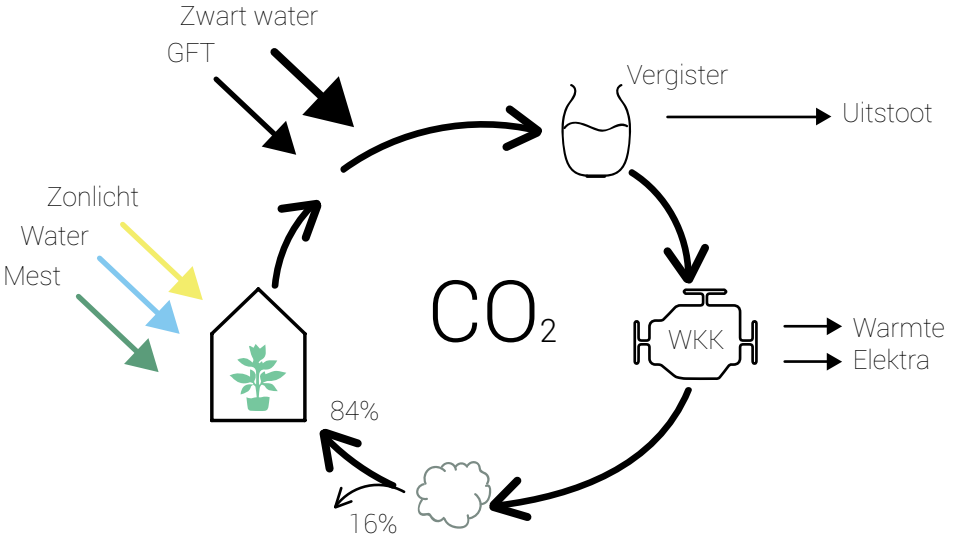
4.1.3 Warmth

'A green house as an energy source' concept



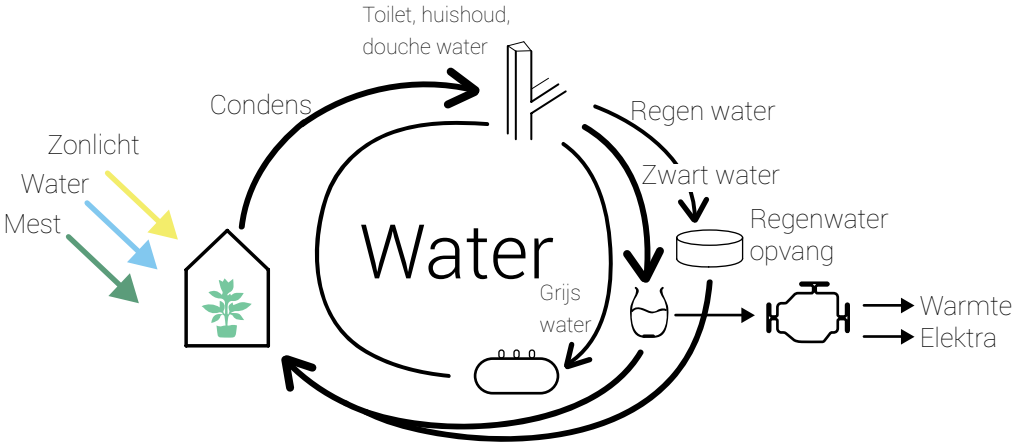
De Zonneterp – een grootschalig zonproject 2005

4.1.4 Different cycles; CO2



4.1.5 Different cycles; Water

How to deal with rainwater is a very important issue to the municipality of Amsterdam. It rains more frequently and more intens and the city cannot cope with this excess rainwater. Integrating green with a buildingblock can contribute to smart and inovative solutions to the managment of rainwater in the city.



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