Designing a Do It Yourself Hydroponic Garden

Master Thesis Project
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GRADUATION REPORT

Designing a Do It Yourself Hydroponic Garden

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PREFACE

The world population is expected to grow to a number of 9 billion people around midway of the century. At the same time, taken into account the increase in welfare, caloric and nutritional demands will increase drastically. Global food demand is increasing rapidly. At the same time, by some estimates, world grain production has stabilized or even decreased since the late 1980's. Ground water tables are falling in over half of the world agricultural area's and soil erosion is rampant. As well, since the current system of agriculture is largely depending on (depleting) fossil fuels, food security is insecure. Last but not least; agriculture contributes a substantial amount to environmental impacts such as global warming and environmental pollution.

The question of how to feed the futures world population, specifically in a healthy and sustainable way, will be one of the biggest questions of the coming decades. Therefore, the way we produce the food we eat is under development. With movements for slow food, organic food, home growing, permaculture and technological innovation.

One potential solution that meets both the requirements derived from a growing population as well sustainability demands is hydroponic agriculture. Hydroponic agriculture, or hydroponics in short, is a modern technology involving plant growth on inert media in place of the natural soil. Hydroponics maximizes the yield per space unit. This brings possibilities to grow food at the place of consumption: in the cities. By 2050 it is expected that 70% of the world population will live in urban areas. .

Mistrust of consumers towards processed supermarket foods and awareness of sustainability have boosted the popularity of growing vegetables at home. Hydroponics are yet largely implemented in commercial greenhouse fruit and vegetable production and also slowly start to find their way towards the hobbyist home grower. They offer many advantages above traditional soil agriculture that are specifically beneficial for space limited urban areas. Therefore hydroponic urban farming is a potential answer of how to feed the 9 billion people in 2050. Last but not least it is a fun and rewarding activity of producing food.

This report shows the process of designing a hydroponic garden that allows people to grow fruits and vegetables at home.

INTRODUCTION

EXECUTIVE SUMMARY

In this report the Vision In Product design methodology has been executed in order to come up with new search areas for product development. “Sustainable home-growing of fruits and vegetables in the city” was defined as the domain to which context relevant factors have been found in the external analysis.

Before the external analysis was conducted the reason and the relevance of the chosen topic of this graduation assignment is explained. Several trends such as health, sustainability, economic, demographic and political factors coincide. In order to meet the demands of the future world population the way food is produced will have to change to a more sustainable system. At the same time, being able to feed the growing world population, will require a drastic increase in produce. As a response a trend is visible where small scale agriculture is moving into the city. This trend is called urban farming and has potential to re-establish the connection with the food we eat. Producing at the place of consumption may reduce food miles and thereby lower the emissions of food production. The emissions due to transportation however only account for a small part of the total emissions. A more significant benefit is possible when reducing unnecessary food waste and energy due to storage. Making food local and personal again is likely to enable this change in behaviour.

Within the domain of urban farming there are a lot of developments going on. The external analysis conducted in this report tends to foresee a future vision based on context factors relevant to the domain.

Vision

The combination of, health (healthy food), sustainability (raised environmental awareness), technological (digitalization), economic (financial crisis) and social (DIY communities), -factors will increase the demand for healthy, sustainable and locally produced food.
A growing group of people has lost belief in the government and large corporations to meet up with these demands. This group of venturous people will therefore decide to realize their own initiatives. This allows them to actively participate and feel involved in the process of making the world a better place. The need for challenges and ventureship is in the DNA of the target group of millennials. Realizing their own ideas will be a way to express their individual identity .
The people supporting this countermovement to the industrialization of society want to reconnect with nature and find a new balance between humans, nature and technology. Here technology is not necessarily seen as a threat that has to be excluded. Rather a balance is sought that combines best of both worlds.

How a new product design can be relevant in this future is defined within the mission statement. The mission statement can be seen as the design challenge of this design project.

Mission

To stimulate sustainable behaviour and allow people to reconnect with nature and the food they eat by enabling them to grow fruits and vegetables at home. Most people want to do this with the least amount of effort but at the same time they want to feel involved in the process.
The product needs to make people feel involved in making the world a better place and allow different users to determine their own level to which the product challenges them. The right balance in combining nature and technology (ease of use) will have to be sought in order to achieve this goal.

The analysis phase ends with a list of requirements which the new design has to meet. This will be the input for the second phase of the design process: idea and concept development.

Different people have different ambitions and interests in what and how they want to grow vegetables. Some users want to grow year round, which requires the system to be suitable for indoor use, while others only

want to grow outside in the summer season. Starting point for the concept and ideation phase was to design a modular vegetable garden that allows different users to setup a system according to their own personal skills and ambitions. Two opposite scenarios were visualized to reflect the behaviour of a user with a profile of low involvement and of a user with high involvement. The low involved user wants to have a plug and play system with low maintenance while the high involvement user wants the system to challenge them. As a DIYer he wants to be able to add new modules to the configuration as well to design improvements himself. Both profiles also distinguish from another by the approval of using artificial resources that require electricity. Within the ideation phase, different ideas for modularity and stackability were developed.

From a business perspective a DIY beta version was developed first. This DIY version will be shared freely online. This allows to first build a community of enthusiasts that can help to undo the product from its flaws. These early adopters will provide valuable feedback on the interest of the target group which will then help to develop a version that can be sold commercially.

The beta version of the final product is named the Flatfarm. It contains both ready made parts that can be bought at a local gardening center, as well as parts that are made on a laser cutting machine. The vector cutting files of the Flatfarm can be downloaded for free. The parts can then be produced locally at home, a FABLAB or a local laser cutting service. It is also possible to order the laser cut parts online. The name Flatfarm comes from the fact that the laser cutter produces flat sheets of wood. The sheets are designed to fit the proportions of mailbox mail and thus are easily transportable.

On the website users can get advice on the carbon emissions of growing specific crops according to their system configuration and the season they are growing in. These carbon emissions are derived from a life cycle assessment and compared to the emissions of fruits and vegetables bought at the supermarket.

At the end of the report recommendations for further development and product launch are given. Improvements on ease of use have to be made before an improved commercial version can be launched.

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METHODOLOGY

Throughout the report the main findings are presented in the form of context factors and can be recognized by these symbols.

S STATES

Are the stable factors included in any context. They refer to phenomena that appear as fixed, but do not need to be so in the long run.

P PRINCIPLES

Are (more or less) stable patterns in life, from physical and biological to social and psychological; they can be laws of nature and fundamental human concerns or patterns of behaviour.

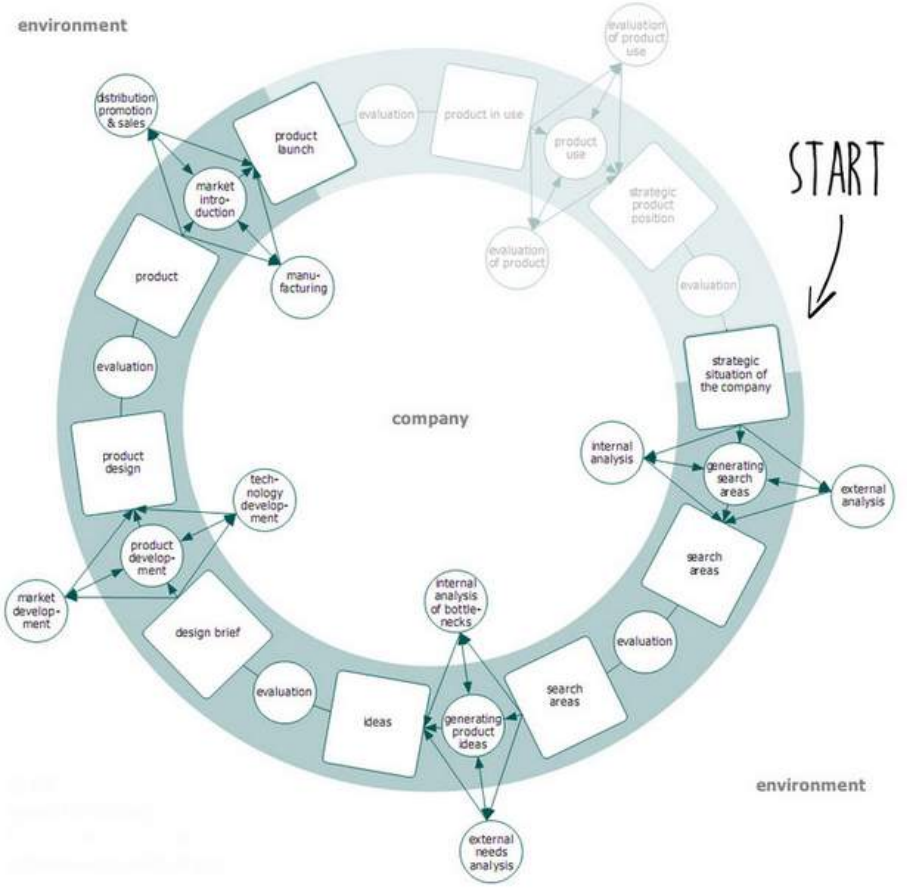
T TRENDS

Are reflections of developments in the behaviour of people.

D DEVELOPMENTS

Are defined as changing or unstable patterns in the environment or (concerns of) people in general. Developments can thus refer to technological, economical, social, environmental, cultural, etc changes in the world around us.

▼ Figure 2.1 Delft Innovation Model process



The structure of this graduation project is derived from the Delft Innovation Method developed by Jan Buijs. The goal of the project is eventually to develop a new product and also to bring it to the market. Since the idea still has to be developed, and boundaries are only set within the domain, the process starts with a strategic external analysis. This analysis should lead to generating search areas to be further explored and developed into product ideas. In the next phase one of these ideas should be elaborated to the level of a product design. A market introduction plan will be the final phase of this graduation project.

Within the scope of the assignment on sustainable agriculture the following research questions should be answered in the strategic analysis phase:

Research Questions

What will the future (five to ten years) look like regarding growing fruits and vegetables in the city?

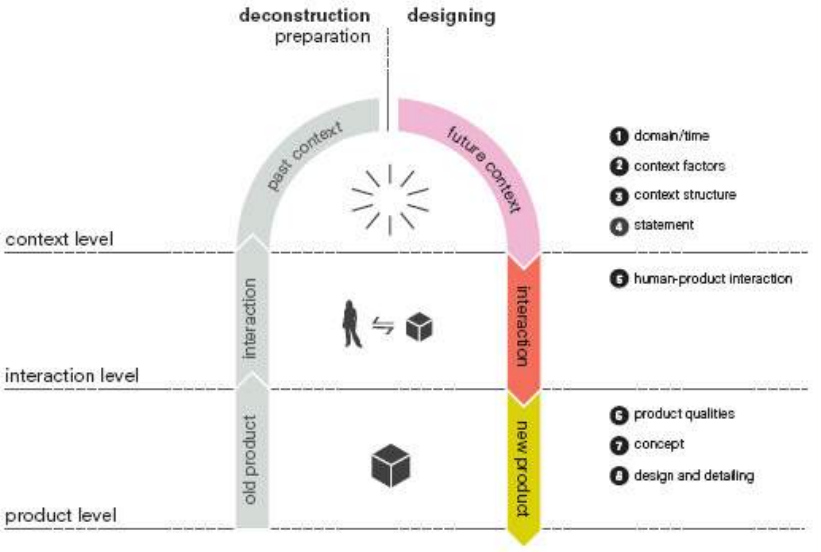
What product would be of value in that future context and what would it look like?

The strategic analysis should lead towards the definition of a design challenge. The major part of the graduation project will focus on the translation of the design challenge into a tangible product.

To structurize the design process, the VIP (Vision In Product design) method will be used.

Within the VIP process the definition of a domain will allow to do context specific research. Defining the context factors in VIP will represent the external research phase of the DIM model. Respectively; grouping the context factors and defining a statement and interaction in VIP will represent the creation of search areas and product ideas

▼ Figure 2.2 Vision In Product design process



DOMAIN

The VIP process requires to set a domain, which is the focus area of the design process, the area that is aimed to make a contribution. The domain is set to define a border to which the context factors are relevant. For this design project the domain was set as:

“Sustainable home-growing of fruits and vegetables in the city”

CONTEXT

Context factors can be divided into trends,developments, states and principles. They should be relevant to the chosen domain of “Sustainable home-growing of fruits and vegetables in the city”. The context will serve as a frame of reference for design decisions that will be made in a later stadium of the design process.

GETTING STARTED

This chapter explains the starting point of this graduation assignment. The context of the assignment, as well the relevant historical events, developments and trends are explained. In other words it explains the reasoning behind the selection of this topic and why it is relevant as a graduation project for a product designer.

RATIONALE

Increasing world population

The world population is increasing rapidly. Whether we can produce enough food to feed this population is something people have questioned before. In 1798, Thomas R. Malthus predicted a future of human suffering due to a population outgrowing its food supply. In the 1960s most western countries were self sufficient in the food they needed to feed themselves. But the population growth rates triggered the alarms of governments causing them to repeat Malthus predictions. At the same time however, the green revolution (High yield crops and machine intensive agriculture), remarkably increased the food production resulting in higher amounts of food per capita. This intensification of agriculture that allowed to feed the growing population came however at the downfall of the environment, which becomes noticeable today. Secondly, with the projection of a world population of 9 billion in 2050 [Godfray et al, 2010], the necessity of a second green revolution becomes apparent. With a world that is now more aware of the consequences of environmental pollution it is obliged to be a green revolution that really lives up to its name.

The question of how to feed the futures world population, specifically in a healthy and sustainable way, will be one of the biggest questions of the coming decades.

Urbanization, globalization and food security

70% of the world population is expected to live in cities in the year 2050 [WHO, 2014]. The industrial revolution separated the city from the countryside. It also set the foundation for a global economy where production and consumption no longer had to be at the same place or near each other. Globalization has resulted in many western countries becoming dependent on other countries in

D *70% of the world population is expected to live in cities by 2050. [WHO, 2014]*

order to feed their population. With regard to the political situation in the world, many countries strive to restore their food security and become self-sufficient again.

The industrial revolution has been the starting point for a century of technological innovation and development. It has brought people prosperity and many benefits. But at the same time it has shifted people away from nature. The quality of life for people living in the city can be greatly improved by the implementation of natural surroundings in the landscape.[Maller et al, 2005]

Sustainable agriculture

The surface of the earth roughly consists of 70% of water and 30% of land ["Earth-Wikipedia", 2014]. Much of this land is not suitable for agriculture. Only around 10% of the land is arable. Nearly all potentially arable land is already exploited today. Boosting production by expanding the area of agricultural land thus seems not possible. New ways of increasing the yield per space unit will have to be developed. Either through means of selective plant breeding, genetic modifications, vertical farming and technological innovation of growing plants.

With the intensification of agriculture, manual labour was replaced by machines. It is apparent that the current system of food production is dependent on fossil fuels. In the past industrialization, genetically modified crops and fertilizer intensive agriculture have raised yields drastically. However the public opinion towards them have changed as well. Health and environmental concerns have increased the demand for organically cultivated crops. Among consumers there is a growing awareness and responsibility towards the environment. Sustainable food production is among them. This growing awareness is noticeable in many sustainability trends that are happening in the world today. Organic food is an example of a current development in sustainable food production. Organic farming responds to site-specific farming and crop conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote

D *Nutritional and caloric demands will rise. [Tilmana et al, 2005]*

ecological balance, and conserve biodiversity. [Wiki] Organic food production brings benefits from the elimination of fertilizer pollution and use of pesticides. However these benefits are often offset by the extra food miles covered to bring these vegetables to the Dutch consumer [Garnett, 2006]. This points out the importance and possible improvements of locally produced food.

Urban Farming

As a counter trend for the past decade we see food production finding its way from the countryside back towards the city where the food is consumed. The phenomena is called Urban Farming and is often presented as a sustainable solution. Urban farming is seen as the answer to the question of how to feed the population of the future world that besides higher demand for nutrition and caloric crops also demand a greener production. Urban farming however is a relative new phenomenon and still has to prove itself as a feasible alternative to traditional agriculture.
Urban farming localizes production and consumption to the same place. This means that food has to travel less distance before it reaches your plate. Food miles are a common measure to quantify the impact our food has to the environment. However food miles only consider the transportation of our food while their are many more important factors that have to be considered from the viewpoint of environmental concern [Garnett, 2006]. These factors include: use of pesticides, fertilizer and water, as well as social issues such as trade with developing countries. But lets have a look at the impact of transportation first.

Environmental impact

The environmental impact of the consumption of fruits and vegetables accounts for 2.5% of the total greenhouse gas emissions in the UK [Garnett, 2006]. About 83% of the lifecycle GHGE CO_2 in the agrifood system was due to production and processing. Only 11% was accounted by transportation which includes 4% for direct delivery (farm gate to retail). [Cleveland et Al, 2011] All little bits help but these numbers show that eliminating or optimizing the transportation will have a very small improvement on the overall. A study of the University of California calculated a reduction <1% GHGE if all food in Santa Barbara California would be produced locally [Cleveland et Al, 2011]. In addition it is important to note that "locally" is a controversial term and that a reduction of the amount of food miles will not always result in an reduction of the associated GHGE. A UK study states that if consumers drive more than 7.4 km to purchase organic food directly from the farm, the GHGE are greater than "the emissions from the system of cold storage, packing, transport to a regional hub and final transport to customers

S *Most food losses in high income countries occur at retail and consumer level.* *[Garnett,2006]*

S *One quarter of the fruits and vegetables harvested is going to waste.* *[Garnett, 2006]*

doorstep used by large-scale vegetable box suppliers" [Garnett, 2006] Nor is it always energy efficient to produce crops locally. A DEFRA case study indicated that tomatoes being imported from Spain may have a lower carbon footprint in terms of energy efficiency than tomatoes grown in greenhouses in the UK. [DEFRA, 2005]

There may be other areas where urban farming, more specifically growing vegetables at home, can have a more significant improvement. For instance on the prevention of food waste. Around 25% of all harvested fruits and vegetables are never consumed [Garnett, 2006]. This means that 25% of the total GHGE are unnecessary. When growing vegetables at home, the relationship with the food we eat becomes much stronger and the unnecessity of food waste becomes more apparent, likely causing it to reduce drastically. This points out that stimulating a behavioural change is likely to have the greatest effect.

This change of behaviour aspect also accounts for the use of resources used to grow crops. Industrialization has transformed the agri-sector from small scale to mass production. The food sector has become dependent on use of fossil fuels, fertilizers, pesticides and genetically modified crops. Small scale urban farming, or growing fruits and vegetables at home, allows consumers to have control over the process or build relationship in small communities based on trust. Use of fertilizers and pesticides can be prevented while small scale farming excludes the necessity of fossil fuel consuming machinery.

S *The biggest contribution to the total environmental impact in the food chain are due to local transportation and storage of food on account of the consumer.* *[Cleveland et Al, 2011]*

CONCLUSION

The way food is produced will have to change in order to meet the caloric, nutritional and sustainability demands of the future world population. Urban farming, where food is produced in the cities can meet up to these demands, but do not per se. Reduction of food miles do not always compensate for energy-inefficiency of locally produced foods. Also the space that is potentially available for agriculture is limited in the city. This requires thoughtful and cautious handling. The biggest potential of growing food in the cities is the potential of behavioral change of people. About 25% percent of the fruits and vegetables that are harvested are never consumed. Storage of fresh foods in refrigerators also account for a significant part to the environmental impact of food. Growing fruits and vegetables at home can eliminate these downsides and thereby help to make a more sustainable food production system. Last but not least, growing your own vegetables is fun and improves quality of life of the people who practise it.

THE ANALYSIS

This chapter shows the results of the external analysis conducted within the domain of urban agriculture. An interview with an urban sociologist touches upon the social aspects of urban gardening. The motivations of growing fruits and vegetables at home are mentioned as well an analysis into trends developments, competitors and technology is presented. The chapter ends with a summary of all the important context factors, which are then clustered into meta factors. Based on these clustered factors a future context is sketched in a vision. How the new product design will be of relevance in this future context is explained in the mission statement.

EXTERNAL ANALYSIS

Interview

The domain focusses on the context within the city. In the past years a trend is visible where small scale agriculture initiatives are moving into the city. The trend is called urban farming. In order to better understand the underlying rational and social motivations of this trend an interview was conducted with Hans Spierings, Urban Sociologist at the Hogeschool Rotterdam. Conclusions of this interview are summarized in this chapter. See appendix [2] for full interview transcription.

Frans Spierings Urban Sociologist.

The Exit, Voice, and Loyalty theory by Albert O. Hirschman describes the responsive behaviour of humans when they perceive a decrease in quality of goods (or a neighbourhood in this example). This model was used by Frans Spierings as an example to describe the sociological behaviour of the inhabitants of Rotterdam. Fifteen years ago, a tendency has been visible where people moved away from Rotterdam Zuid towards the suburbs of Rotterdam (Capelle, Nesselande) because they were dissatisfied with the quality of life in the neighbourhood. This tendency is called selective migration. Within the model of Hirschman this behaviour is described by "exit". "Voice" describes the behaviour where people express their dissatisfaction by means of politics, by voting or in debating. Loyalty has sociological motivations, it describes the behaviour where people actively participate and thereby try to improve their neighbourhood. Frans Spierings explained a tendency is visible where citizens more actively participate to stimulate social cohesion in their neighbourhood, either by cause of economic, sustainability and cultural factors. The theory of "empowerment of citizens" (Burgerkracht) by De Boer en Van der Lans describes the phenomenon where citizens have gained

S *A tendency is visible where citizens more actively participate to stimulate social cohesion in their neighbourhood, either by cause of economic, sustainability and cultural factors.*

more abilities and power to organise things. He believed however this only applied to the middle class , people with higher income and extensive social networks.

Furthermore he explained that within the city there always is a tension in social cohesion. People want to express their individuality but at the same time like to meet people that have the same interests, to share their ideas. The Government of Rotterdam stimulates social cohesion with subsidies among its inhabitants which allow for the implementation of urban agriculture initiatives. Whereas new technologies (internet, social media) make social cohesion more accessible, he stated he does not believe that the trend of urban farming is technology driven but rather socially driven.

P *People need social cohesion*

MOTIVATIONS TO GROW VEGETABLES AT HOME

Financial

The main reason for growing fruits and vegetables at home according to a survey conducted by the Garden Writers Association Foundation [GAWF ,2013] was found to be cutting the costs of groceries. This however requires some thoughtful planning and smart purchasing of high value crops.

Health

There is nothing more fresh than eating fruits and vegetables that you have harvested minutes before. A study showed that children who were often served homegrown produce were more than twice as likely to eat five servings of fruits and vegetables a day compared to kids who rarely ate homegrown fruits and vegetables. [JADA, 2011]

Environmental

Growing locally may to some extent reduce food miles and energy or emissions related to storage of food[Tilmana et al , 2005]. Redefining the relation you have with the food you eat, by growing it yourself also allows for a behavioural change that can reduce waste. Pollutive fertilizers and pesticides can be excluded as well. [Telegraph UK, 2011]

Food safety

Being able to sustain in your own consumption is a reassuring thought. The turbulent political situation in the world has raised the awareness of people and governments of the potential consequences of food insecurity [TED talk - A garden in my apartment, 2011]. Growing at home allows to partly restore food safety.

Well being

Gardening reduces stress [Maller et al, 2005]. People tend to like to be surrounded by a natural environment. Gardening is seen as a fun and rewarding activity that also allows for social interactions. Growing your own vegetables can evoke a sense of pride. Often people state that vegetables from their own garden have far better taste compared to vegetables from the grocery store. Last but not least, growing vegetables is fun and allows you to grow crops that are not available in the grocery store.

Educational

Growing your own vegetables requires you to learn new things in order to successfully grow a plant from seedling to harvest. It is a great experience and the gained knowledge can often be proudly shared with others. Teaching kids where food comes from might be an essential part of their education. [Telegraph UK, 2011]

Trust

There is a growing mistrust of consumers towards sustainability claims of (large) companies [Deloitte, 2014]. Growing your own means you exactly know what you put in and on your vegetables. People want clarity and to be convinced they make the right choices ["Doesitstick - Good Food", 2014]. They rather trust people they know personally than believe the claims of impersonal multinationals. [Vrij Nederland, 2014]

P *People want to feel connected with nature.* [Maller et al, 2005]

D *People mistrust sustainability claims.* [Vrij Nederland, 2014]

S *People want clarity and conviction they make the right choices.* ["Doesitstick - Good Food", 2014]

D *People have lost the connection with the food they eat. A stronger connection can be beneficial for the environment.* [Cleveland et al, 2011]

S *The objectives of people that follow a 'good food for the environment' movement are often to contribute to a food system that will enable more food to be produced with less energy used; less food wasted and less environment destroyed.*["Doesitstick - Good Food", 2014]

P *People are eager to learn new things and share them with others.* [Tough, 1971]

P *Food is strongly connected with cultural values and personal preference.*

T *People grow their own vegetables to be able to fully control the process.* [Telegraph UK, 2011]

TARGET GROUP

"Sustainable home growing of fruits and vegetables in the city" seems to be of particular interest to a young group of people within their twenties and thirties. People of this age are called millennials. Millennials (also known as the Millennial Generation or Generation Y) are the demographic cohort following Generation X with birth years ranging from the early 1980s to the early 2000s.

Characteristics of millennials relevant to the chosen domain are:

"Millennials say the government is not doing enough. The government has the greatest potential to address society's biggest issues but are overwhelmingly failing to do so." [Deloitte, 2014]

"Millennials are eager to make a difference. Millennials believe the success of a business should be measured in terms of more than just its financial performance, with a focus on improving society among the most important things it should seek to achieve." [Deloitte, 2014] "David Burstein describes Millennials' approach to social change as "pragmatic idealism," a deep desire to make the world a better place combined with an understanding that doing so requires building new institutions while working inside and outside existing institutions." [Burstein, 2013]

◄ Figure 4.1 Millennials gardening on a rooftop in the city

S *Millennials think companies and governments are not doing enough. They believe they have to make their own contribution to make the world a better place and are eager to make a difference.* *[Burstein, 2013], [Deloitte, 2014]*

GARDENING TRENDS

Square foot gardening

The method has been around for some years but gained extra popularity recently. The method is based on traditional soil based cultivation, however smart planning and crop combinations make it much more space efficient compared to the traditional way of growing crops. Therefore the method is very suitable for people with limited space.

The practice combines concepts from other organic gardening methods such as densely planted raised beds and biointensive attention to a small, clearly defined area. This method is particularly well-suited for areas with poor soil and for beginner gardeners (Bartholomew, 2005).

Edible estates

Edible estates is an initiative to create a series of regional prototype gardens that replace domestic front lawns, and other unused space in front of homes.

They want to rethink the green space within social housing estates as an asset which can contribute to personal and community well being. They see growing food as a possibility to foster community participation and action. Their gardens are a visual evidence that positive changes are taking place. Their manifesto further points out aspects of biodiversity, natural habitats and health and well being.

Rooftop Gardens

The space limitation in cities has moved people to expand in a vertical direction. Rooftop gardening is the concept where rooftops of buildings are used for community gardens.

DIY projects

Websites such as Instructables have active communities who share knowledge and ideas on the topic of growing fruits and vegetables at home. Windowfarm is one of the most popular examples of a lively DIY gardeners community.

Zero carbon food

Zero Carbon Food is a company that is growing pea shoots, rocket, red lion mustard, radish, tatsoi, pak choi and miniature broccoli in tunnels beneath London.

The carbon footprint of organically grown fruits and vegetables is 10-35% lower compared to vegetables grown traditionally. [Schader, 2010] However manual labour is four times higher for organically produced vegetables and therefore the prices of organic food are higher. Technological innovations such as energy efficient lighting and hydroponics have resulted in new movements that aim to reduce the footprint of fruits and vegetables to zero by use of these energy and resource efficient technologies.

Restaurant Gardens

Vertical garden inside O'Hare Airport is a first. 44 different types of organic herbs and vegetables are growing in the middle of Chicago's busy international airport.
A trend is noticeable where restaurants grow the food used in their recipes themselves. Most heard motivations are the availability of the freshest vegetables and the possibility to grow organic. Both factors have a positive influence on taste since fruits and vegetables are often harvested before they are fully mature/ ripened which negatively influences taste. Organic food is by some also believed to have better taste than vegetables grown with traditional cultivation methods.

CONCLUSION

The above trends show that urban gardening is a lively and developing movement. From analysing the above trends a cohesion becomes visible. There seems to be a movement where people no longer wait for governments and companies, but take their own initiative to make a change.

T *Small scale farms are moving into the city.*

T *City Gardens make use of vertical space as a solution for space limitation.*

S *People like to show that they contribute to make a positive change.*

DIY MOVEMENT

The time where crafting your own sweater was something only your grandmother would do has moved to the past. "Generation Y has become generation DIY" is the title of the online article by Jeff Fromm, marketing strategy consultant and millennial consumer trend watcher. Millennials are using technology, creativity and entrepreneurism as they take on more and more DIY projects. The co-creation and customizations trend is the industries response to this growing group, allowing customers to participate with the brand. Sharing your unique creation with the world is an essential element of the DIY culture. This allows others to reproduce or even add to a particular project. In this way a community can be built on sharing knowledge and ideas. The websites Pinterest and Instructables are examples of online DIY communities, that allow the DIYers to find hundreds of inspirational DIY project ideas.

Generation Y consumers seem to have embraced the do it yourself culture because they wanted to develop their own ideas. If a millennial can not find what he or she wants, they will build it themselves.

▲ Figure 4.2 DIY tin planters from the website instructables.com

Modularity and customization

The phone blocks concept went viral in 2013. It became a figurehead for the customization and modularity trend that has been going on recently. It can be grouped under the broader trend of sustainability. Modularity is popular both as a concept to avoid unnecessary waste and to make the product better fit the individual preferences of the user. It offers interesting possibilities from a marketing perspective, allowing new customers start with an entry level that can be upgraded with additional purchases.

T *The DIY movement is thriving due to a young venturous generation and the availability of sharing in online communities.* *[millennialmarketing, 2014]*

T *The DIY generation tends to build things themselves rather than to wait for big corporations to do so.* *[millennialmarketing, 2014]*

IKEA hacking

IKEA hacking is the DIY phenomena where Ikea products are not seen as end products but as the building materials for constructing new ideas. For Ikea hackers, Ikea is no longer a home ware, but has become a DIY store. IKEA has stores all around the globe and their products are affordable to a great amount of people. Thereby IKEA hacking has the potential of reaching a big audience. Especially when a new design has the incentive to contribute to a better environment. Logically the total impact will be bigger if lots of people make a small contribution compared to when only a few people make a large contribution.

▼ Figure 4.3 IKEA HACK hydroponic desk by Antonio Scarponi

P *Sharing information and knowledge is an essential DIY principle.*
[millennialmarketing, 2014]

T *Modularity may reduce waste and allow for easy customization.*

TECHNOLOGY

To grow fruits and vegetables you need soil. Well, that is how it used to be for centuries because with the cultivation method called “hydroponics” it is possible to grow plants without soil.

Hydroponics

Hydroponic agriculture, or hydroponics in short, is a modern technology involving plant growth on inert media in place of the natural soil, in order to uncouple the performance of the crop from problems associated with the ground, such as soil-borne diseases, non arable soil and poor physical properties [Savvas, 2003]. Hydroponic agriculture has many advantages over traditional soil based agriculture. Increases in yield can go up to a striking 4-10 times compared with conventional outdoor soil culture [Resh, 2011]. It requires much less water, is easier to treat for pest and diseases and excludes potential fertilizer pollution. Another great advantage that relates to the increasing scarcity of arable land is the possibility of higher density planting [Resh, 2011]. Combined with the potential of vertical agriculture, where grow beds are stacked on top of each other, hydroponics maximizes the efficiency of space and yield per space unit. The different hydroponic methods are described in this paragraph.

NFT system

The plants are grown in a constant flow of nutrient enriched water. The water is spread out so as to flow in approximately 1-3mm of depth over a flat surface. This creates a film of water, which flows over the root system of the plant.

Drip irrigation

The plants are propagated in a rockwool cube then grown on in a rockwool slab. The plants are individually fed using drippers. These drip emitters are designed to deliver at a set rate at a pre-set volume of water per hour. Each dripper is wired to an infrastructure of tubes and delivery pipes, which are fed by one master pump.

Eb and Flow System

Flood and drain systems work via a bottom flood, which over a period of pre set time floods two thirds to three-quarters of the growing medium. Then, once the flood cycle reaches the desired height, the pump stops and gravity then pulls the water back to the tank. Then, depending on the size and depth of the system, some time later the cycle is repeated.

Kratky

The suspended pot non-circulating hydroponic method only requires an initial application of non-circulating nutrient solution which must be of sufficient quantity to supply the entire cropping period. Electricity and pumps are not needed. The water uptake of the plant creates an air gap in the container which enables the roots to take up oxygen.

SMART SENSORING

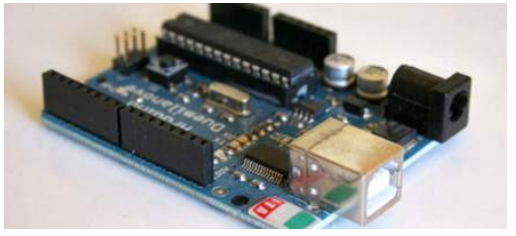
With sensors and actuators becoming cheaper and cheaper we see a development where consumer products are becoming “smart”. Also more often products are connected with the internet, making it possible to send and receive data to and from online databases. The ubiquity of smartphones enables remote monitoring and control.

Parrot Flower Power

Parrot Flower Power is a sensor that when “planted” close to a plant in a pot or in open ground provides real-time measurements of the factors essential for healthy growth and then sends updates to the free app on your iPhone, iPad, or iPod touch. By keeping an eye on soil moisture, fertilizer, ambient temperature, and light intensity, you can provide just the right care to help your plants thrive.

Niwa

Niwa uses a number of sensors and actuators to create a perfect environment for your plants to grow healthy and strong. She controls the temperature, humidity, and light cycles and her automated irrigation system will also water and feed your plants whenever they need it. Through the dedicated app, Niwa will ask you for help so she can accurately tell what stage of growth your plants are at.



GardenBot

GardenBot is a free open source Arduino microcontroller based monitoring system that supports soil temperature, light and moisture sensors as well controlling automatic water valves.

HarvestGeek

HarvestGeek is a similar design to the GardenBot but is a pre-assembled commercial version. HarvestGeek is connected with the Cloud, sharing information in a database and can be controlled through a web platform.

T *Remote monitoring of plants is conquering the consumer market due to ubiquity of smart phones and sensors.*

COMPETITORS

Growing fruits and vegetables at home has been a trend for the past years. The market of products for this target group is expanding rapidly. In this chapter a competitor analysis is done to determine which factors are greatly valued by the target group.

A selection of twelve different products that compete within the market of growing vegetables at home have been compared. These products could be divided into four overall categories; DIY systems, low technology systems, high technology systems and systems differentiating on design. Table [1] shows the scores of the comparison that was made on the following factors:

Design: A high score means that the product distinguishes itself from its competitors by its styling. Specific attention to use of form, material and detailing make that the product, that from its origin has a technical feel to it, is suitable as a design object fitting in the lifestyle of the user.

Technology: Smart technology, such as sensors and actuators can monitor the situation and take over tasks from the user, such as watering plants or adjusting the lighting conditions. This makes the process of growing plants and the life of the user much easier and will also likely result in higher yields. Therefore products that have technology implemented score high.

Price: High investment costs will likely scare new customers to buy the product. Therefore a high score on price means that the product has a (positive) low price.

Setup & maintenance: This factor takes into consideration the amount of work that is needed to build and maintain the system. Low maintenance and build up time are qualified as positive aspects and will result in a high score.

Expected Yield: If the design allows for maximum yield per space unit, and thus allows for small plant spacing or makes uses of vertical space, the score will be high.

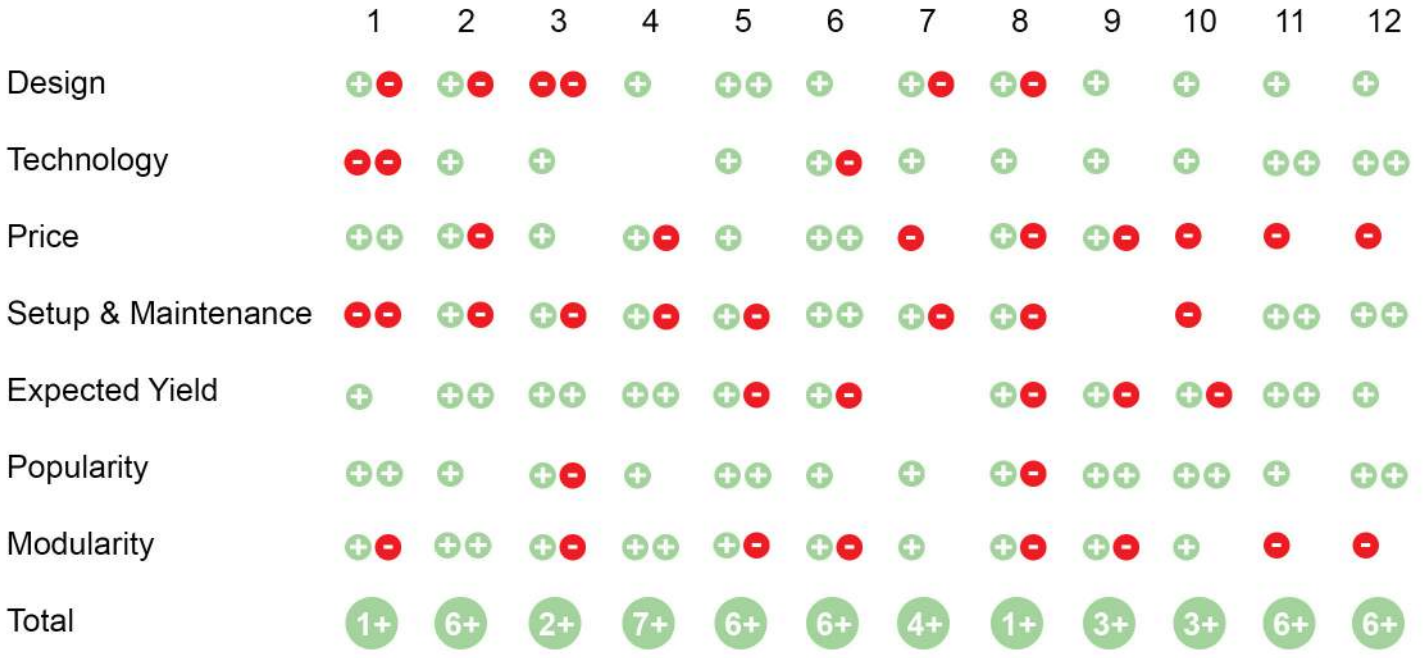
Modularity: A modular product would allow for the user to spread investment costs by giving him the opportunity to add modules according to its personal configuration. A design that allows for modularity thus has a high score.

1. Square Foot Gardening
2. DIY Window Farm
3. DIY IKEA Hydroponics
4. Window Farm

5. Modern Sprout
6. Grow Floats
7. Tower Garden
8. Herbs Garden

9. Aquafarm
10. Aqualibrium
11. Nano Garden
12. Niva

S *The ideal product for urban farming would be modular, have sophisticated styling and is easy in use and maintenance.*



The competitor analysis shows that there are different combinations of aspects in the designs that result in a high total score.

Modularity and Vertical farming

Product 2 and 4 (DIY and commercial window farm) score high for their allowance of modularity and their expected high yield per space unit since the design allows for the use of vertical space.

Cost price and Design

Product 5 and 6 (Modern Sprout and Grow Float) score high for their low price and their refined styling. Which make them suitable as an entry level purchase for people that are new to growing vegetables as well these design products can serve as a lifestyle product that reflects its user.

Technology and Ease of Use

Product 11 and 12 (Nano garden and Niwa) retrieve their high scoring from the implementation of smart technology that minimizes the necessity of maintenance.

EXPERIMENT

Kratky vs. Windowfarm

The internet provides a rich source of information for anyone interested in growing vegetables with hydroponics. The amount of options can even be a little overwhelming. Two methods, namely the Kratky method and the Windowfarm have been selected, respectively for their simplicity and their popularity. During the previous months (starting from September) experiments with both methods have been conducted. A comparison based on personal experiences was made. This section provides an overview of the results.

▲ Figure 4.4 Kratky in and outdoor

Kratky

In the technology section of this report an overview of the different hydroponic methods are given. The kratky method in particular distinguishes itself in the list by the simplicity and ease of use of this method. The Kratky method requires no pumps and thus no electricity. The required maintenance is also very low and requires only an installation of the initial setup. Therefore this method is very suitable in a situation where ease of use is important. An overview of the advantages and disadvantages of the kratky method compared to the general method of hydroponics is given below.

Many herbs and vegetables have been successfully grown using the Kratky method. This method requires no maintenance and is therefore very suitable for beginning hydroponic growers. However, the current configuration of the kratky method does not allow for stacking the buckets and therefore does not make optimum use of the vertical space. The image collage above shows the progress of using used food containers for growing spinach, basil, lemongrass, parsley and mint. In September and October some experiments with growing vegetables outside have been successfully conducted. In October and November the buckets have been moved to a window sill and artificial LED lighting has been added. A Heated propagator glasshouse has been bought to sprout seeds in a controlled environment.

Conclusion kratky method

The kratky method is a plug and play method of hydroponics which is very suitable for beginners and for people that want to grow fruits and vegetables with the least amount of effort. The method only requires an initial setup and does not require any maintenance up to the time of harvest. This also allows to grow plants without worrying about watering your plants daily or weekly.

▲ Figure 4.5 PET windowfarm

Windowfarm

As another experiment a windowfarm was built from used PET bottles. The instructions can be downloaded from the internet. It turned out not to be easy to get all the right parts since some parts mentioned in the US instructions are not available here. Also the installation of the windowfarm requires some time and skills and at the overall costs of around €100 it does not come particularly cheap. Growing herbs and vegetables in the windowfarm also turned out not to be easy. So far the first experiments seem not to turn out successful; although all the instructions have been followed it seems like the plants drown under the use of too much water. Alterations in the watering time schedule might give better results.

Conclusion Pet bottle Windowfarm

Growing fruits and vegetables in the pet bottle windowfarm turned out not to be easy. First of all the installation requires skill, time and the parts are not cheap. The method also requires to refill the nutrient reservoir every two to three days. It requires electricity to run the air pump which also makes quite some noise. The results of the first experiments with growing herbs in the Windowfarm did not turn out successful.

Kratky	Window Farm
+	+
•No electricity required.	•Can grow all types of plants.
•No maintenance, only initial setup and harvest (can add nutrient solution to keep nutrient level constant).	•Can give the plant specific nutrient solution corresponding to plant growing stage when refreshing reservoir.
•Very efficient with water (no spill).	•Space efficient (No big water reservoir required).
-	-
• More difficult with fruity vegetables.	• Have to refresh water every week.
• Not stackable and water reservoir requires some extra space.	• Water is spilled when reservoir is refreshed.
• Harder to adjust nutrient solution according to growing stage of the plant.	• Requires electricity.
	• Pump makes noise.

CONTEXT FACTORS

The external analysis above has resulted in numerous factors that are believed to be influential on the domain of "sustainable home-growing of vegetables in the city". Below an overview is presented of all the Principles, States, Developments and Trends that were found.

Principles

P *People want to feel connected with nature.* [Maller et al, 2005]

P *People need social cohesion.*

P *Food is strongly connected with cultural values and personal preference.*

P *People are eager to learn new things and share them with others.* [Tough, 1971]

States

S *One quarter of the fruits and vegetables harvested is going to waste.* [Garnett, 2006]

S *Most food losses in high income countries occur at retail and consumer level.* [Garnett,2006]

S *The biggest contribution to the total environmental impact in the food chain are due to local transportation and storage of food on account of the consumer.* [Cleveland et Al, 2011]

S *People want clarity and conviction they make the right choices.* ["Doesitstick - Good Food", 2014]

S *The objectives of people that follow a 'good food for the environment' movement are often to contribute to a food system that will enable more food to be produced with less energy used; less food wasted and less environment destroyed.* ["Doesitstick - Good Food", 2014]

S *A growing amount of people mistrust sustainability claims.*

S *The ideal product for urban farming would be modular, have sophisticated styling and is easy in use and maintenance.*

S *A tendency is visible where citizens more actively participate to stimulate social cohesion in their neighbourhood, either by cause of economic, sustainability and cultural factors.*

S *Millennials think companies and governments are not doing enough. They believe they have to make their own contribution to make the world a better place and are eager to make a difference.* [Burstein, 2013], [Deloitte, 2014]

S *People like to show that they contribute to make a positive change.*

Developments

D *70% of the world population is expected to live in cities by 2050.* [WHO, 2014]

D *Nutritional and caloric demands will rise.* [Tilmana et al, 2005]

D *Remote monitoring of plants is entering the consumer market due to ubiquity of smartphones and sensors.*

D *People have lost the connection with the food they eat.* [Cleveland et al, 2011]

D *People mistrust sustainability claims.* [Vrij Nederland, 2014]

Trends

T *Small scale farms are moving into the city.*

T *Local economies are emerging as countermovement to globalisation.*

T *The DIY movement is thriving due to a young venturous generation.* [millennialmarketing, 2014]

T *The DIY generation tends to build things themselves rather than to wait for big corporations to do so.* [millennialmarketing, 2014]

T *Sharing information and knowledge is an essential DIY principle.* [millennialmarketing, 2014]

T *City Gardens make use of vertical space as a solution for space limitation.*

T *Modularity may reduce waste and allow for easy customization*

T *People grow their own vegetables to be able to fully control the process.* [Telegraph UK, 2011]

META FACTORS

The above context factors have been analyzed in order to see how they related to each other and whether any coherency between the factors can be derived. That analysis has resulted in the following context clusters called Meta factors.

Do It Yourself: empowerment and involvement in making a change

S A growing amount of people mistrust sustainability claims. S Millennials think companies and governments are not doing enough. They believe they have to make their own contribution to make the world a better place and are eager to make a difference. T The DIY generation tends to build things themselves rather than to wait for big corporations to do so. T The DIY movement is thriving due to this venturous generation. S A tendency is visible where citizens more actively participate to stimulate social cohesion in their neighbourhood, either by cause of economic, sustainability and cultural factors. This group of millennials is empowered to organise things. They have increasing spare time (working 3 or 4 days a week) and have the need for challenges, adventures and entertainment. They fulfill them by realizing their ideals and ambitions by executing personal DIY projects.

Adapting a sustainable and healthy lifestyle: Going back to nature, and bringing technology along

Technological developments have made life easy for us today. In the supermarkets of the western world we have all the food imaginable available throughout the whole year. However, at the downside of this, there is a growing health problem regarding obesity and vascular diseases as a result of these unhealthy processed foods [Kelly et al, 2008]. D People have lost the connection with the food they eat.The relation between us and the food we eat has become poor along the way. For some people that relation has only become the time their food has to spend in the microwave. Many people have no idea anymore, what ingredients are in their food, where it comes from and how it's made. The whole food chain, with genetically modified crops, chemical fertilizers, and food additives is developed around the profits of the food industry. The way food is produced today is both harmful to us and to our environment. P As a result, people want to feel connected with nature again. Countermovements become visible. T Small scale farms are moving into the city. This shows that people are adapting to

more healthy and sustainable lifestyles, trying to reconnect with their food and nature around them. D On the other hand a phenomena is visible where remote monitoring of plants is entering the consumer market due to ubiquity of smartphones and sensors. It seems like the generation of millennials wants to go back to nature while taking technology along.

Cohesion vs Individuality: being part of a movement while preserving your individual identity

P People are eager to learn new things and share them with others. P People like to show that they contribute to make a positive change. T Sharing information and knowledge is an essential principle in the DIY movement. P People like to find people that have the same interests. People need social cohesion. But at the same time they want to be unique and have personal preferences that shape their individual identity. There is a tension between expressing your individuality but nonetheless belonging to a group. P Food is strongly connected with cultural values and personal preference. Globalization, mass production and standardization has put the ability to express your individuality under pressure. T Local economies are emerging as countermovement to globalisation. This enables for better adaption to local and individual preferences. T Modularity and customization options are currently emerging as an answer to the demand for sustainability (reducing waste) and customization (individuality). S The ideal product for urban farming would be modular, have sophisticated styling and is easy in use and maintenance.

Vision

Based on the context factors and meta-factors a vision was formed that describes a projected future scenario for the year 2020.

VISION

The combination of, health (healthy food), sustainability (raised environmental awareness), technological (digitalisation),economic (financial crisis) and social (DIY communities), -factors will increase the demand for healthy, sustainable and locally produced food.

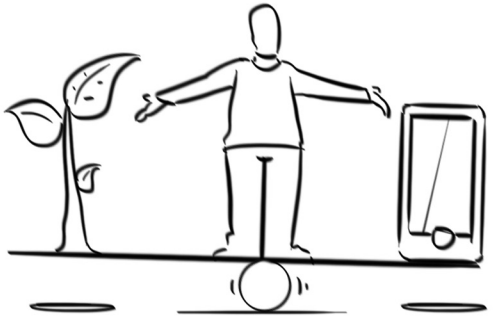
A growing group of people has lost belief in the government and large corporations to meet up with these demands. This group of venturous people will therefore decide to realize their own initiatives. This allows them to actively participate, and feel involved in the process of making the world a better place. The need for challenges and ventureship is in the DNA of the target group of millennials. Realizing their own ideas will be a way to express their individual identity but at the same time people need social cohesion and want to be part of a group with the same interests and ideals.

The people supporting this countermovement to the industrialization of society want to reconnect with nature and find a new balance between humans, nature and technology. Here technology is not necessarily seen as a threat that has to be excluded. Rather a balance is sought that combines best of both worlds.

A growing DIY community will start and realize their own initiatives.

Increase in healthy and sustainably produced food

People rather start their own initiatives than to wait for companies or governments to do so



Redefining the balance between nature and technology

MISSION

To stimulate sustainable behaviour and allow people to reconnect with nature and the food they eat by enabling them to grow fruits and vegetables at home. Most people want to do this with the least amount of effort but at the same time they want to feel involved in the process.

The product needs to make people feel involved in making the world a better place and allow different users to determine their own level to which the product challenges them. The right balance in combining nature and technology (ease of use) will have to be sought in order to achieve this goal.

Allow different users to determine their own level to which the product challenges them.

Enable people to reconnect with nature and the food they eat

Some people prefer a system that requires the least ammout of effort

Different people have different ambitions

DEVELOPMENT

This chapter shows the process of transforming the abstract results of the analysis phase into a tangible product. The chapter starts with the list of requirements which are derived from the mission statement. These requirements are converted into product features in the ideation and concept development phases. The first prototypes were build and tested during this phase. The chapter ends with the embodiment of the concept into the final product.

LIST OF REQUIREMENTS

Focus on ease of use and plug and play experience

The product allows to grow a great variety of crops and allows to spread the moments of harvest over time

The product should be modular in order to adapt to the demands of different users (customization) and allow them to define their own level of difficulty and involvement

The product allows for growing year round and is transportable for indoor and outdoor use

Modularity allows for an affordable entry level that can be updated later

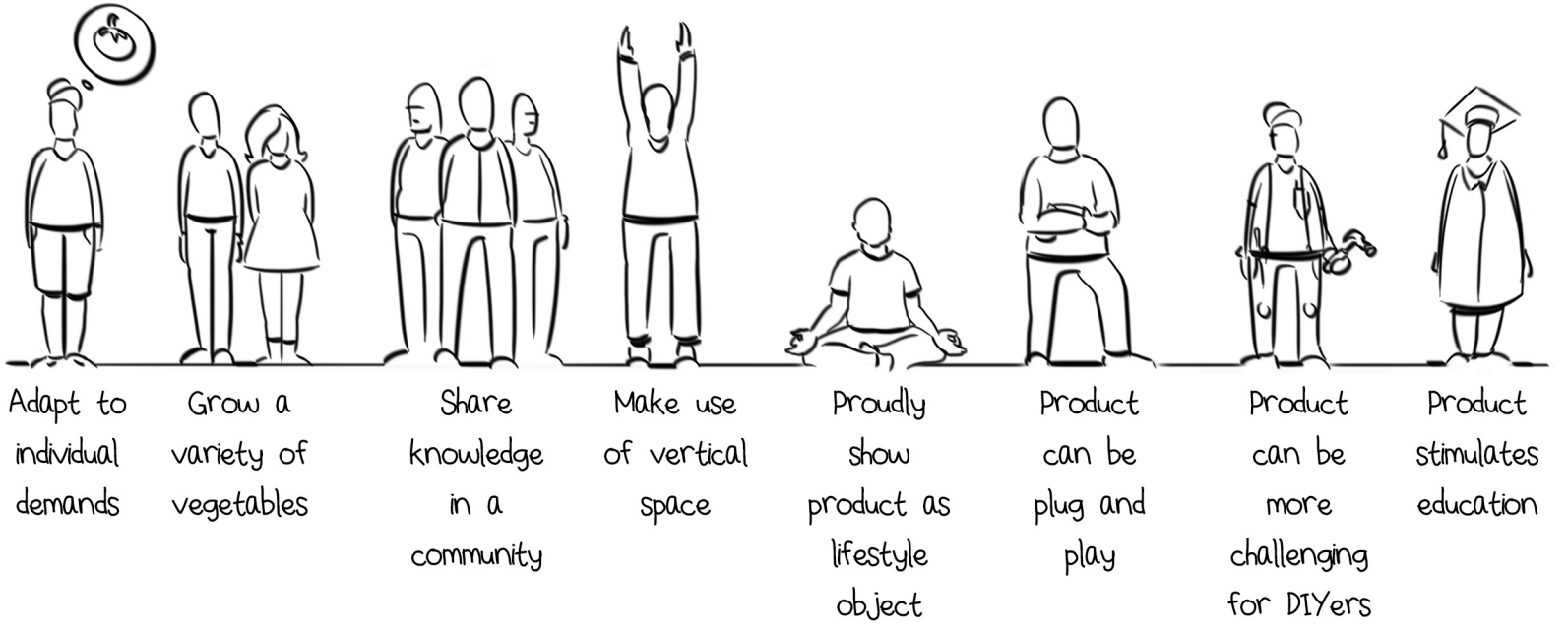
Allow people to build a community around the product enabling them to exchange experiences
The product maximizes the yield per space unit, efficiently making use of vertical space

The product has refined and sophisticated styling and represents a lifestyle object that allows users to proudly show it to others

Implementation of technology to maximize efficiency and ease of use

Preferably the design allows for a free DIY version and a more sophisticated/ pre-assembled commercial version

The product should communicate how it works so people understand what is going on.



▲ Figure 4.6 visualization of the list of requirements

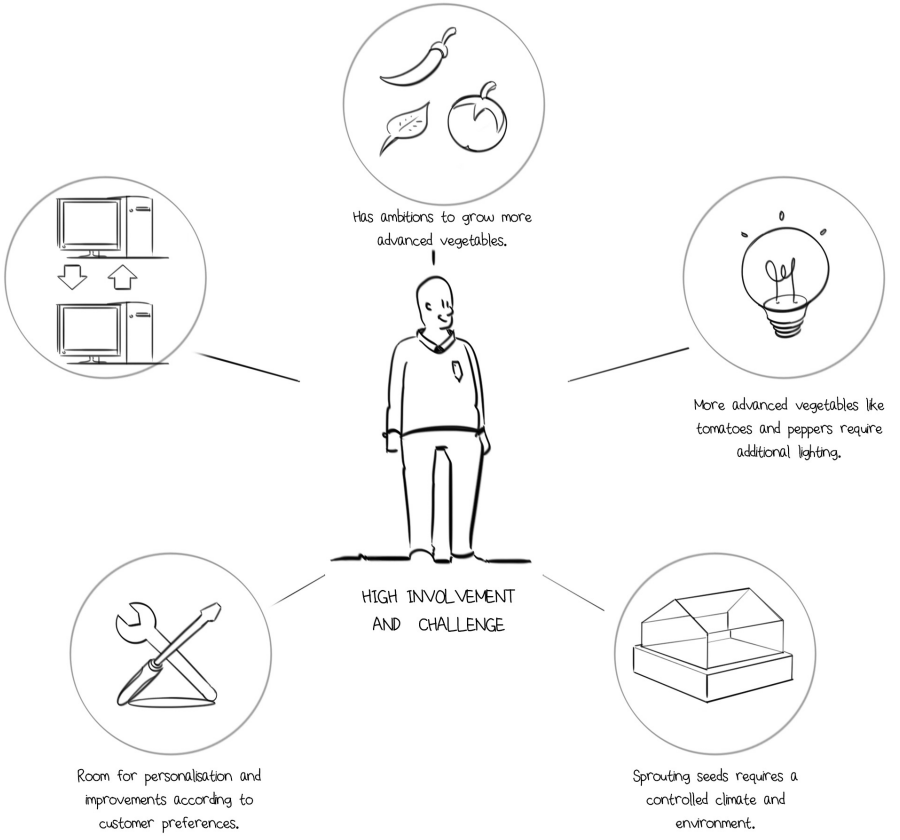
SCENARIO

Within the mission statement it is described that the product should allow people to feel involved and challenged up to their own ambition level. Two scenarios have been visualized to explain the differences in demands between a “low involved user“ and a “high involved user“.

High involvement and challenge

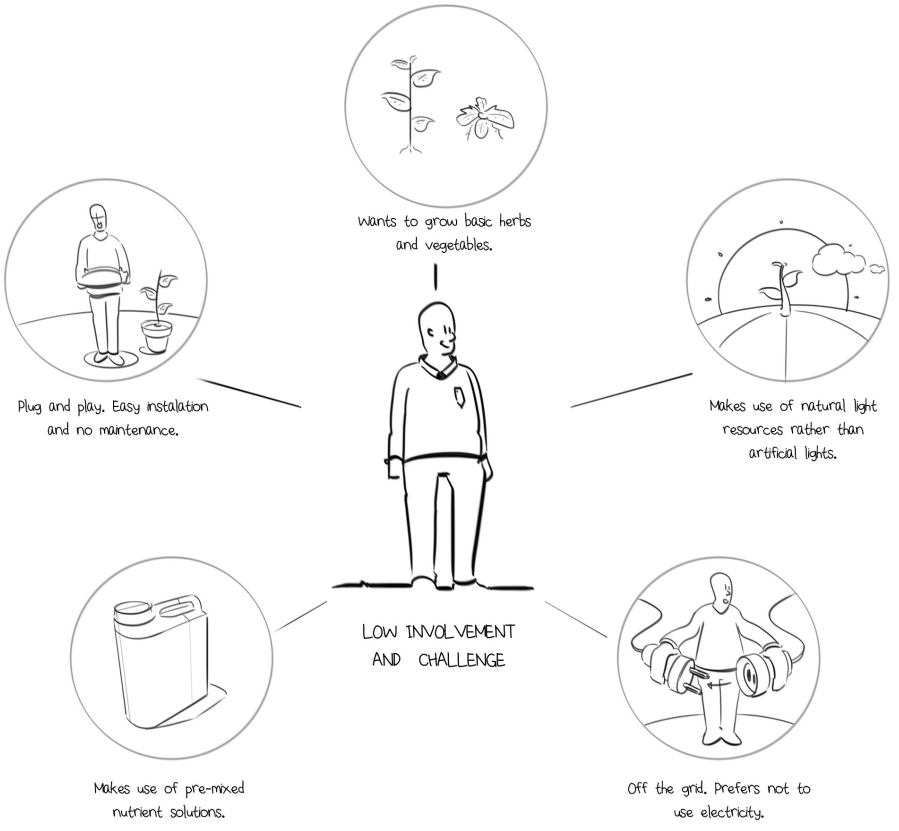
People within the group of millennials are people that want the product to be challenging and demanding for a high involvement of its user. This means they want to be able to personalize and make improvements to the system according to their own preferences. They are happy to share these improvements with others. The “high challenge and involvement” group has higher ambitions in terms of the crops they want to grow. This will require more advanced components to their system setup of which some may require the use of electricity.

▼ Figure 4.7 Scenario visualization of high involved user.



Some users want a product with high challenge and involvement while others prefer a plug and play system with very low maintenance.

▼ Figure 4.8 Scenario visualization of low involved user.



Low involvement and challenge

The group of "low involvement and challenge" are people that may not have the time and skill to grow advanced crops. They are satisfied with growing relatively easy crops such as herbs and lettuce and prefer a plug and play system with low maintenance and easy installation. This is also the group of people that prefers to grow without the use of artificial resources such as lighting and heating.

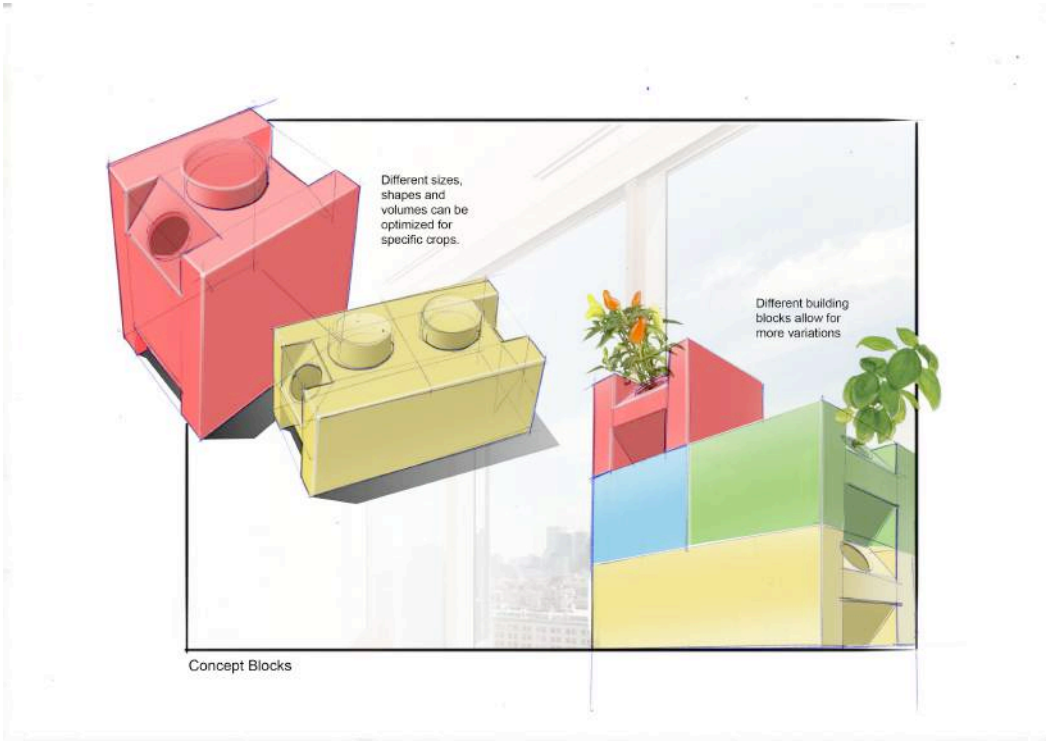
Some users want to grow year round with the help of artificial resources while others prefer to grow off the grid, without the use of electricity.

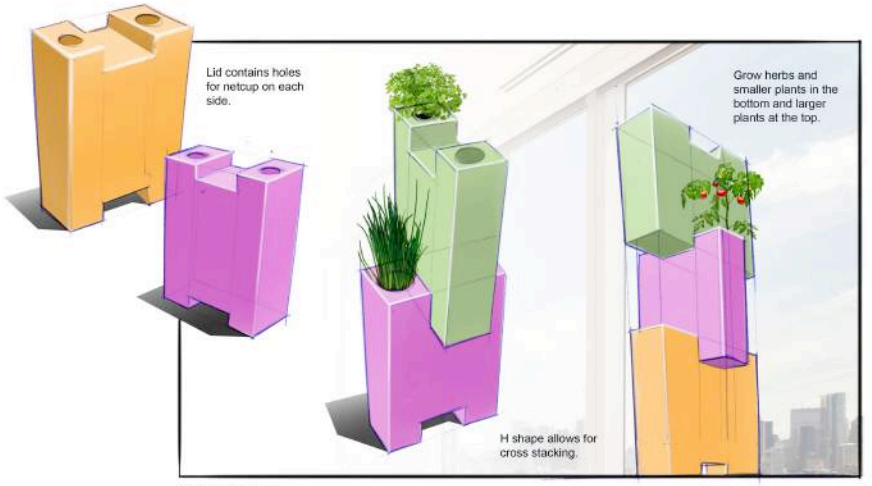
IDEATION

The ideation phase was the first phase were the findings of the analysis phase were transformed into product features.

Different ideas for modular components and stackability were visualized. Some early CAD models were made to examine the feasibility with more exact proportions.

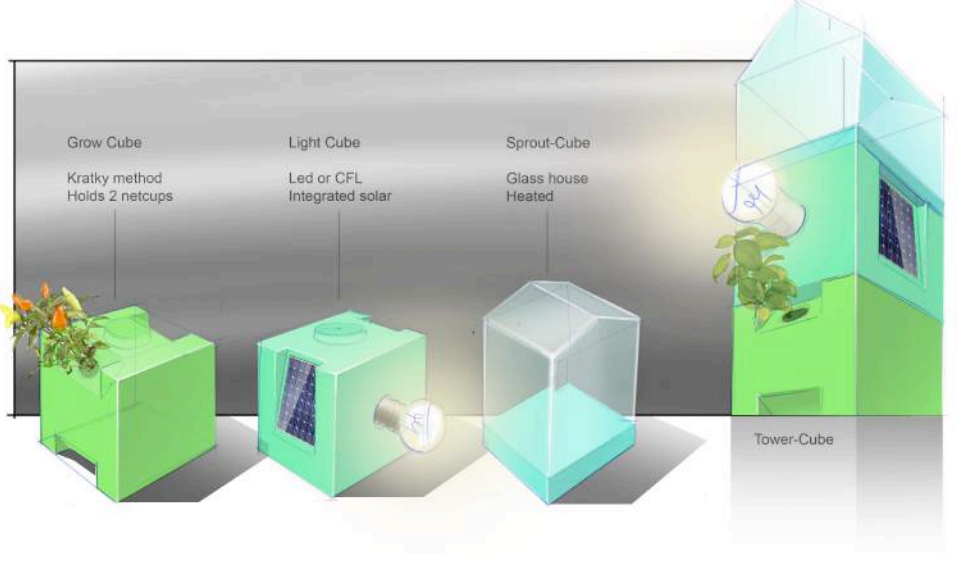
Stacking different modules allows for creating a personalized product configuration.





Concept Cross

▲ Figure 4.9 CAD model examining the feasibility of stacking.



Stackability allows for efficient use of vertical space.

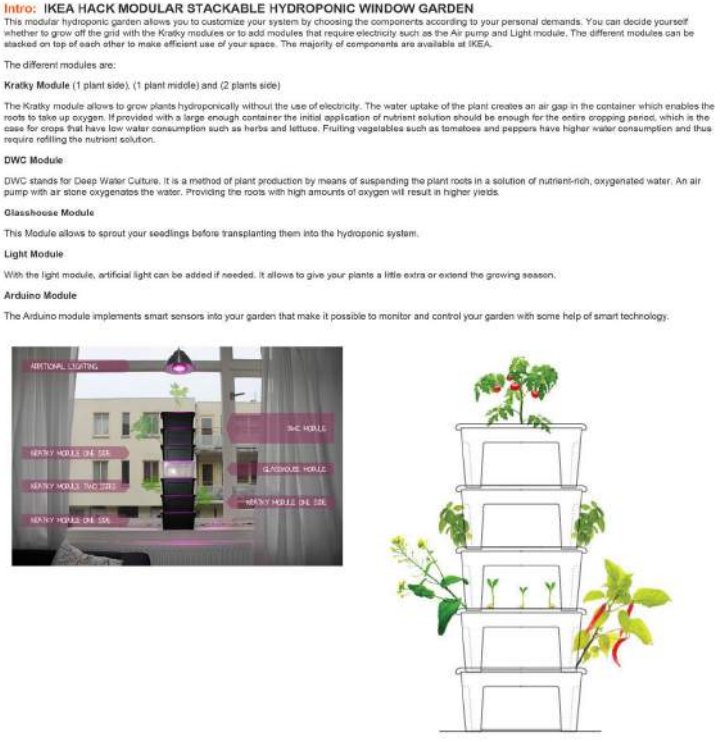
DIY IKEA HACK

The Value Proposition section of the business model canvas (p.75) describes the business case of developing an free DIY version next to a commercial version. This DIY version allows to build and get feedback from a community of enthusiasts. This feedback can be used to develop a commercial version for people that may not have the interest, time or skills to build the DIY version.

The first instructions of the DIY version was shared on the online DIY platform www.instructables.com. It is constructed mainly out of IKEA products, which allows people from all over the world to have access to the required components.

See full instructions in appendix [3].

▼ Figure 4.10 IKEA hack hydroponics Instructions booklet from instructables.com



Intro: IKEA HACK MODULAR STACKABLE HYDROPONIC WINDOW GARDEN

This modular hydroponic garden allows you to customize your system by choosing the components according to your personal demands. You can decide yourself whether to grow off the grid with the Kratky modules or to add modules that require electricity such as the Air pump and Light module. The different modules can be stacked on top of each other to make efficient use of your space. The majority of components are available at IKEA.

The different modules are:

Kratky Module (1 plant side), (1 plant middle) and (2 plants side)

The Kratky module allows to grow plants hydroponically without the use of electricity. The water uptake of the plant creates an air gap in the container which enables the roots to take up oxygen. If provided with a large enough container the initial application of nutrient solution should be enough for the entire cropping period, which is the case for crops that have low water consumption such as herbs and lettuce. Fruiting vegetables such as tomatoes and peppers have higher water consumption and thus require refilling the nutrient solution.

DWC Module

DWC stands for Deep Water Culture. It is a method of plant production by means of suspending the plant roots in a solution of nutrient-rich, oxygenated water. An air pump with air stone oxygenates the water. Providing the roots with high amounts of oxygen will result in higher yields.

Glasshouse Module

This Module allows to sprout your seedlings before transplanting them into the hydroponic system.

Light Module

With the light module, artificial light can be added if needed. It allows to give your plants a little extra or extend the growing season.

Arduino Module

The Arduino module implements smart sensors into your garden that make it possible to monitor and control your garden with some help of smart technology.

http://www.instructables.com/id/IKEA-HACK-MODULAR-STACKABLE-HYDROPONIC-WINDOW-GARD/

This DIY version allows to build and get feedback from a community of enthusiasts.

Step 2: DWC Module

Parts Needed

2x IKEA SAMLA 5l with lid
Air pump that fits in the SAMLA box (28x20x14 cm), with 1-4 outlets
PVC tube that fit with the outlets of the air pump (6mm outside- 4mm inside diameter)
Airstone

Tools Needed

- Drill
- 2 inch bit
- 0.25 inch bit (6-6.5 mm)
- Spray paint (optional to camouflage the air pump)

http://www.instructables.com/id/IKEA-HACK-MODULAR-STACKABLE-HYDROPONIC-WINDOW-GARD/

The popularity of the topic of hydroponics and growing fruits and vegetables at home was proven by the large attention the "IKEA HACK MODULAR STACKABLE HYDROPONICS WINDOW GARDEN" got on the Instructables platform. The design was featured on the front page and got more than 8.000 views in the first week.

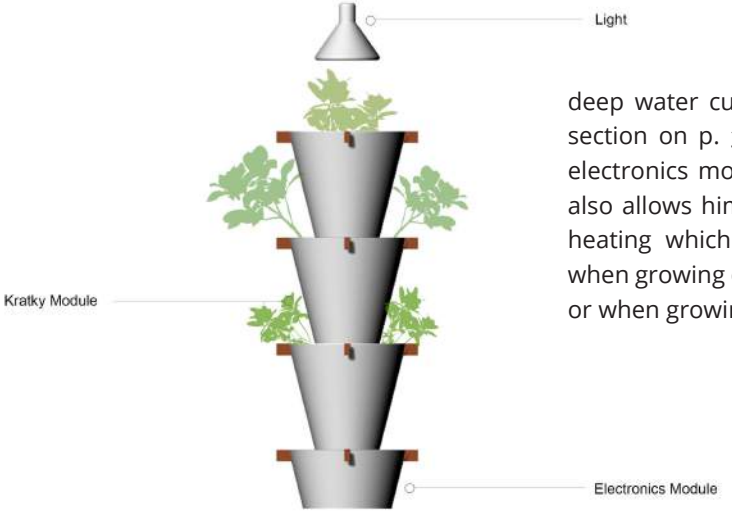
▲ Figure 4.11 Krakty cucumber plant

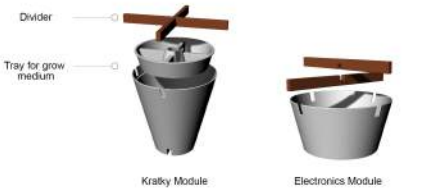
▲ Figure 4.12 Krakty system in winter

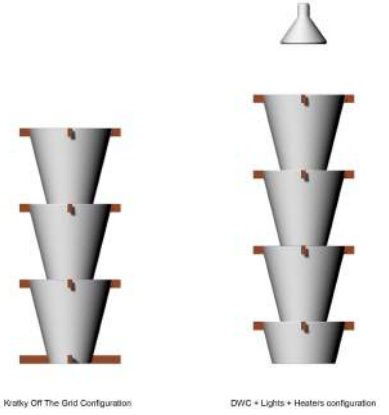
CONCEPT

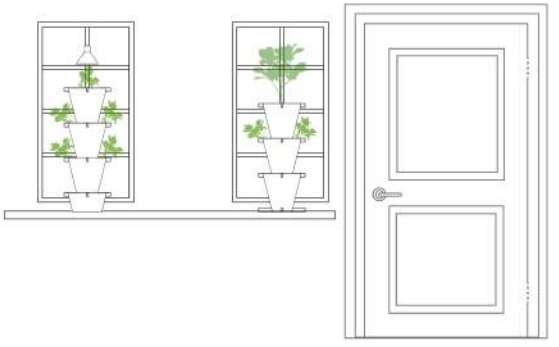
Besides the free DIY version a more sophisticated version was developed for commercial purposes. This version has more sophisticated styling and functionality compared to the DIY version.

Modularity and stackability are still integrated in the concept. Thereby the user can build his own personal configuration according to his preferences. As a beginner the user can setup a Kratky configuration that does not require any electricity. Later he can determine to update this Kratky system to a drip water or deep water culture system (See technology section on p. 32). He will have to add the electronics module to his system then. This also allows him to add artificial lighting and heating which will give him better results when growing outside of the summer season or when growing more advanced crops.

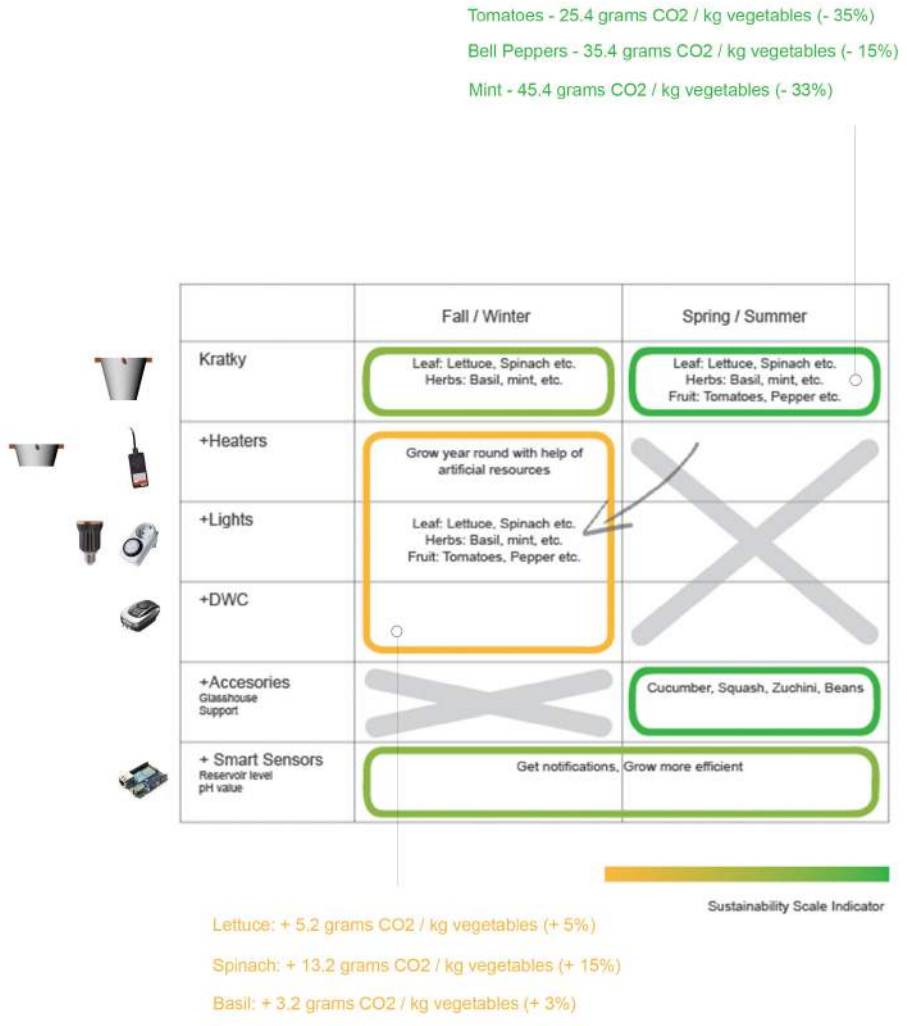








For people that may not have the time or skill to build the DIY version there is a commercial version with more sophisticated styling and functionality.



◄ Figure 4.13 Sustainability indication schedule

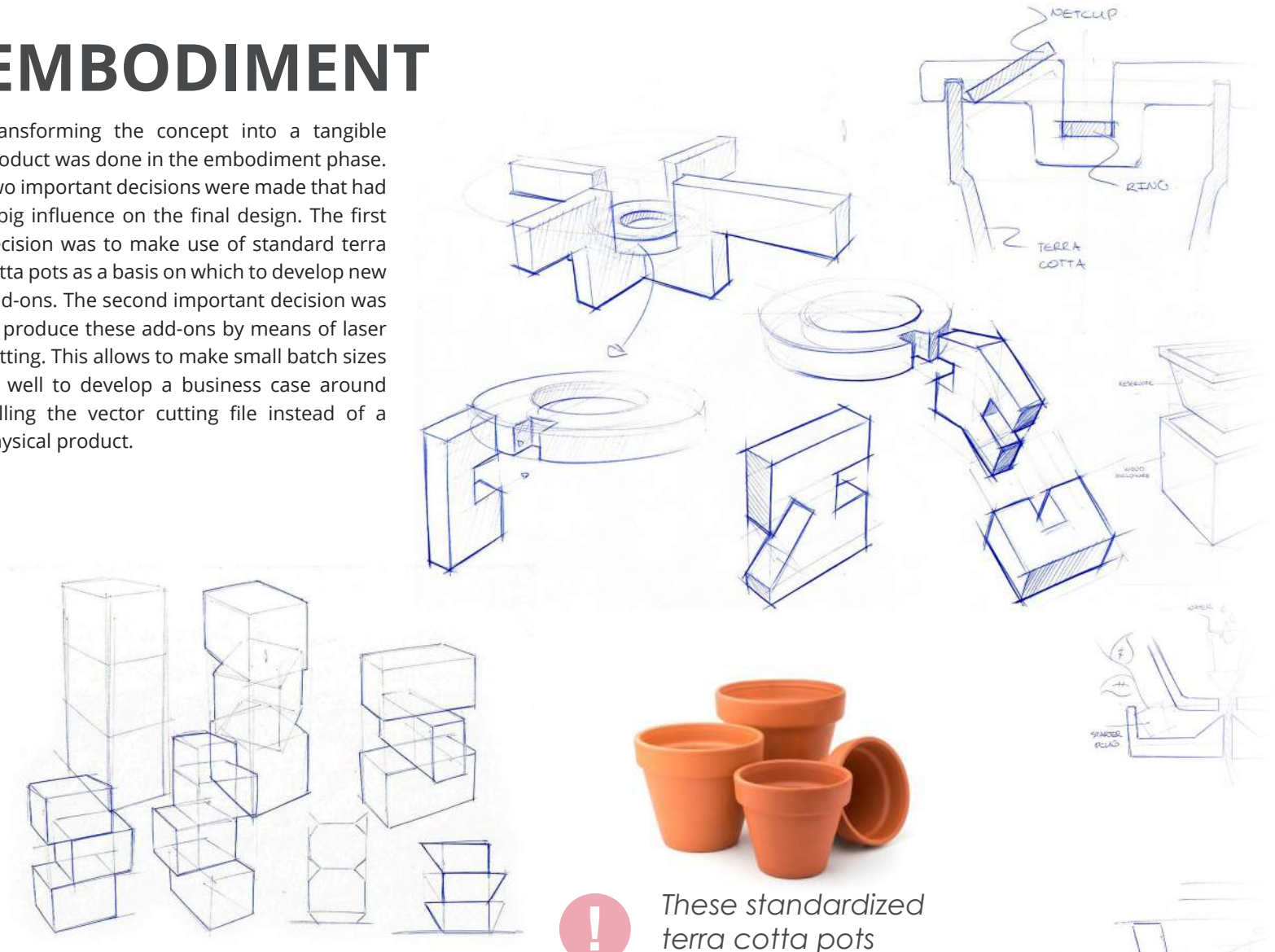
Sustainability indicator

Growing fruits and vegetables at home can have a positive influence on reducing the amount of CO_2 emission. However, this depends on which crops are grown with help of what resources. The sustainability indicator (figure 4.13) shows the different modules on the left and the seasons on top. According to the system configuration and the season he or she is growing in, the user can get an indication of the amount of CO_2 his system is emitting. This score is compared to the CO_2 emission of fruits and vegetables from the supermarket. A positive result will be shown in green while a negative result will be shown in orange. Thereby the user can determine whether it is a good idea or not to grow tomatoes in winter.

The sustainability indicator schedule provides information about the carbon emission of growing different crops with different modules according to the season.

EMBODIMENT

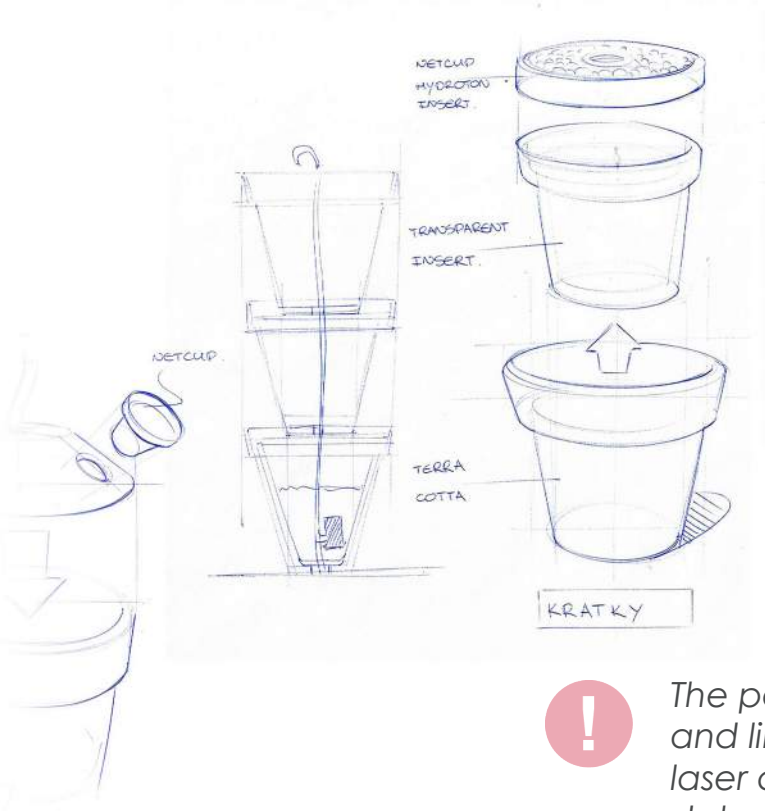
Transforming the concept into a tangible product was done in the embodiment phase. Two important decisions were made that had a big influence on the final design. The first decision was to make use of standard terra cotta pots as a basis on which to develop new add-ons. The second important decision was to produce these add-ons by means of laser cutting. This allows to make small batch sizes as well to develop a business case around selling the vector cutting file instead of a physical product.

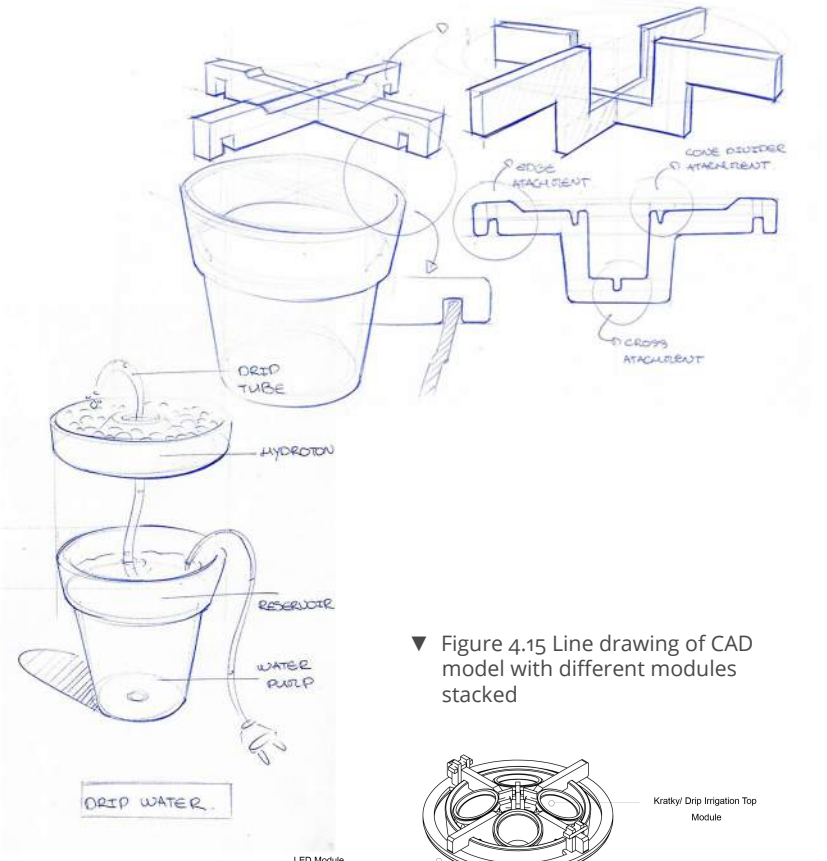


▲ Figure 4.14 Embodiment sketches

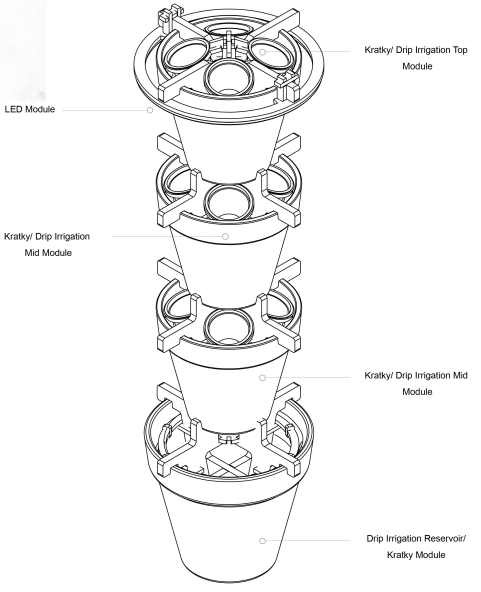
These standardized terra cotta pots were used as the startingpoint for new add-ons.

In the embodiment phase the decision was made to produce the parts by means of laser cutting.





▼ Figure 4.15 Line drawing of CAD model with different modules stacked



The possibilities and limitations of laser cutting have determined the shape of the final design.

PROTOTYPE

The prototype provided valuable insights for improvements to the design. Multiple iterations have been made on the initial design to solve problems that became apparent from testing the prototype. These are listed below:

- Improve stability.
- Improve clamping tolerances to avoid the necessity of glue.
- Prevent water leakage from top cross.
- Add fixture for Kratky and reservoir bags.
- Add closure for reservoir and Kratky to prevent light from entering the container.
- Replace plastic net cups with laser cut ones.
- Improve top water dispenser.
- Prevent water evaporation from reservoir and Kratky modules.

1. Laser cut parts
3. Net pots Assembly
5. Cross assembly

2. Net pots Assembly parts
4. Cross assembly parts
6. Kratky reservoir assembly

▲ These images show the parts and sequence of constructing the prototype.

◄ These images show the construction of a rejected prototype. The proportions turned out to be too large to fit in an indoor environment of a house.

▼ Figure 4.16 Making the prototype in the workshop

7. Inserting Net Pots
10. Bottom reservoir parts
13. Lights Module

8. Inserting the sub-assembly in the terra pot
11. Cross assembly bottom reservoir
14. Lights Module Assembly

9. Assembled Grow Module
12. Bottom Reservoir Drip Irrigation Assembly
15. Stacked Modules

The first prototype was assembled using glue. Iterations on the prototype have made it possible to assemble the product by clamping forces, excluding the necessity of glue.

THE PRODUCT

This chapter contains the presentation of the final product. It explains the production process and the used materials in further detail. As well the concept of the product service system is explained. A calculation of the production costs is included at the end.

FLATFARM

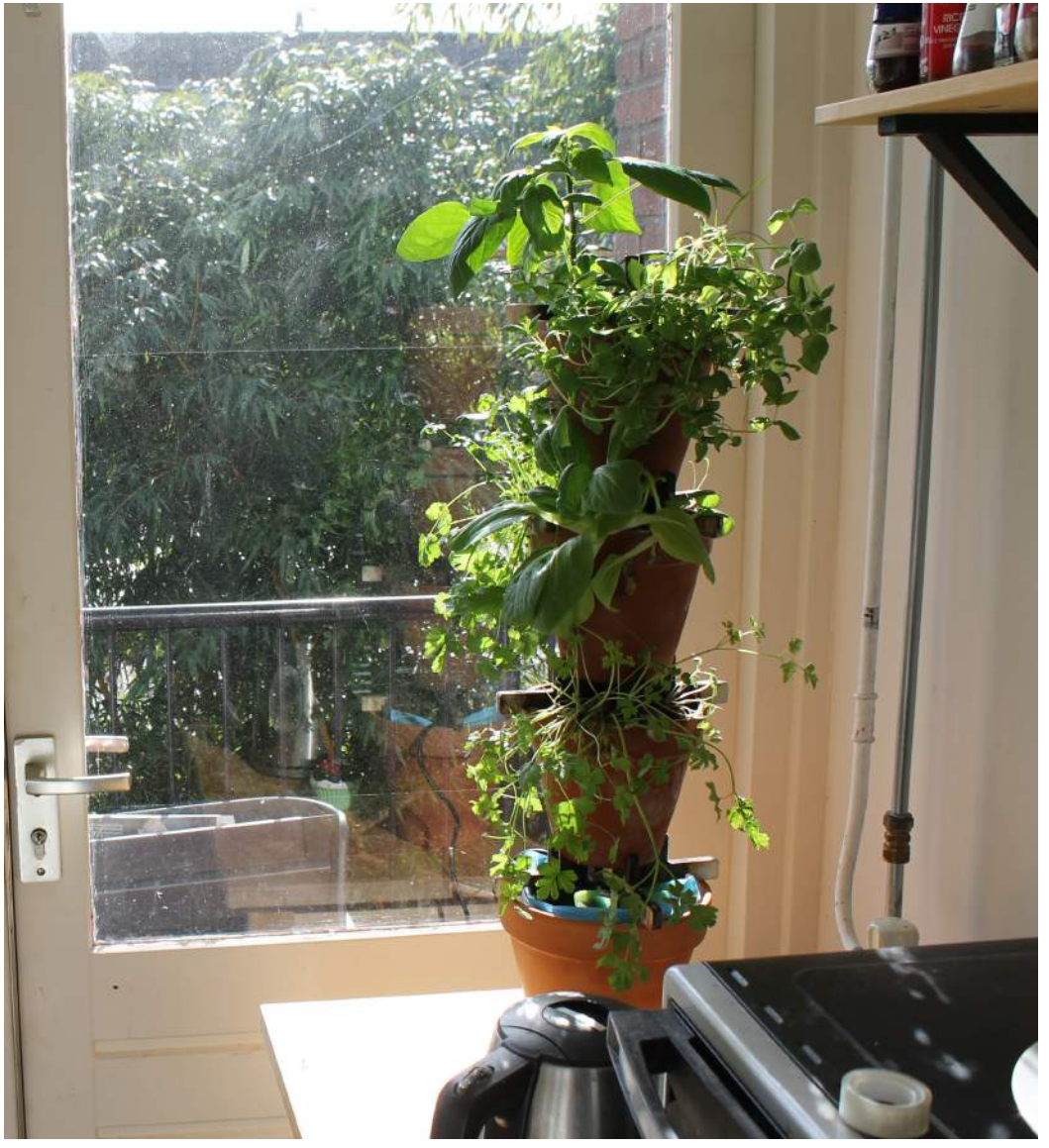
Flatfarm consists of an open source modular hydroponic system and a community website where information is shared.

Flatfarm is a product service system that enables users to grow fresh fruits and vegetables at home. Flatfarm consists of an open source modular hydroponic system and a community website where information is shared. With Flatfarm users can set up a system according to their own preferences, by adding the specific modules they need for growing their crops.

Flatfarm makes uses of a combination of ready made products and laser cut parts. This keeps production costs low and minimizes the transportation impact. The vector cutting files are freely available from the Flatfarm website. After download, users can produce the parts locally at a nearby FABLAB or laser cutting service. The vector files can be adjusted according to the improvements the user wants to make. Laser cutting also allows for users to design new add-ons for their system. If the user has no access to a laser cutting service nearby or prefers to order the parts, they can order from the Flatfarm website. The laser cut parts have been designed to be transported in a flat packaging.

The ready made parts are standards that are available all over the world. When the user selects the modules he wants to use, he will get an overview of all ready made parts he needs to buy locally. In the future, different vector cutting files will be available for different standard ready made parts.

Laser cutting allows for users to design improvements and add-ons for their system.



The website will provide clear information of the environmental impact of growing specific crops in specific seasons according to the resources used.

◄ Figure 5.1 Flatfarm 3 segment configuration with bell pepper plant and different types of herbs in the kitchen

The Flatfarm website provides information of which crops can be grown according to the season and the resources used. It also allows for a community to share their knowledge and experiences with the system. Improvements to the system can be shared and exchanged. Questions can be asked and will be answered by the community or the website moderator. The website will provide clear information of the environmental impact of growing specific crops, in specific seasons according to the resources used.

OVERVIEW

▲ The parts of the Flatfarm can be divided into two categories: Ready-mades and laser cut parts. The images above show the required parts to make a drip system setup. The laser cut sheets in the front of the image are (left to right) a top, mid and bottom module.

The parts in the top part of the image are the ready-mades that have to be bought at a local DIY or gardening store.

▼ The image shows an assembled three segment flatfarm with drip system reservoir.

▲ The flat laser cut sheets have to be assembled into three dimensional parts. No glue is required since the parts are held together by clamping force.

Update the system with Add-on modules such as LED lights.

▼ The modular design allows to update the system at any time. LED lights can be added.

◄ Users can determine themselves whether they want to grow with or without the use of electricity. When growing without electricity a method called the Kratky method is used. Plastic bags are used as a reservoir to hold the nutrient solution in the Kratky system.

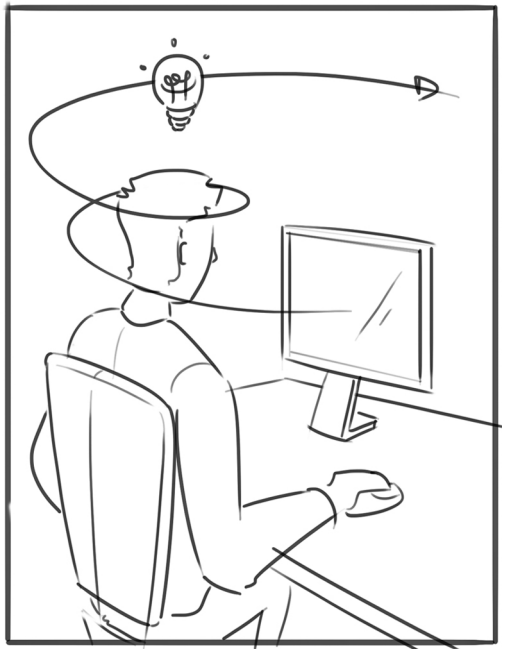
▼ When everything is assembled, plants can be added. This images shows a four segment drip system flatfarm with: Basil, parsley, mint, pakchoi, bell pepper, lemon grass, camille, coriander and chive.

PRODUCT SCENARIO

The scenario below describes a situation of how the product service system could be used.

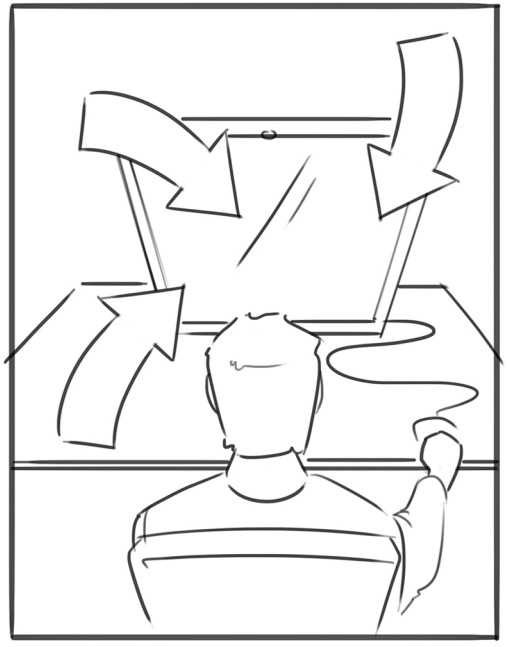
1. Inspiration

Bob surfs to the Flatfarm website to get inspiration and determine his growing plan. What kind of crops he wants to grow in which season and whether he wants to use artificial or only natural resources. He determines what kind of system he wants to build.



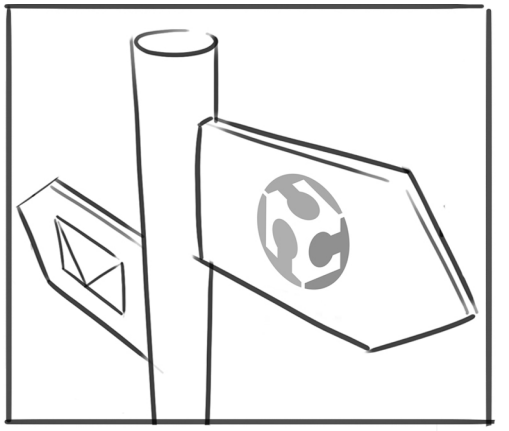
2. Create Wish list

He adds the required modules to his wish list.



3. Choose production

Bob can choose to produce the laser cut parts locally or mail order them from the website. If he chooses to produce them himself he can freely download the vector cutting files. The website also provides an overview of FabLabs and laser cutting services worldwide.



4. Ready-Mades list

He will also be provided with an overview of ready made parts.

5. Shopping

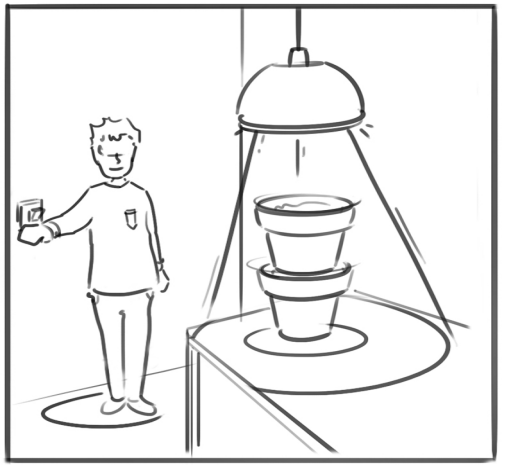
These parts can be bought at his local gardening and do it yourself store.

6. Assemble

When Bob has gathered all the required parts he can start assembling his system. The instructions can be found online.

7. Community

The website provides a source of information on which plants to grow and their according growing and nutrient schedules. The forum and community will allow for a Question and Answer section. It also allows to share improvements to the system.



8. Update

Bob can choose to update his system with new modules when he wants to grow different plants or in a different season.

The flatfarm vector cutting files for laser cutting can be produced locally or bought from the flatfarm website.

LASER CUTTING SHEETS

The production method of laser cutting offers a few advantages over other production methods which are of particular use in this project.

Batch sizes

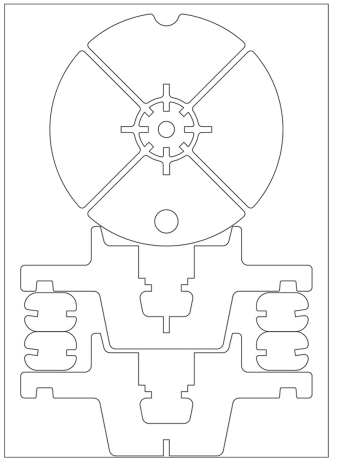
Laser cutting allows to make single piece batches at relatively low cost, since there are no investment cost to be made on tooling. This gives users the opportunity to make improvements to the vector files and have the laser cutter produce their unique adjusted design.

Local production

With FABLABS arising, laser cutting is available everywhere around the world. This allows for local production thereby excluding the necessity of transportation.

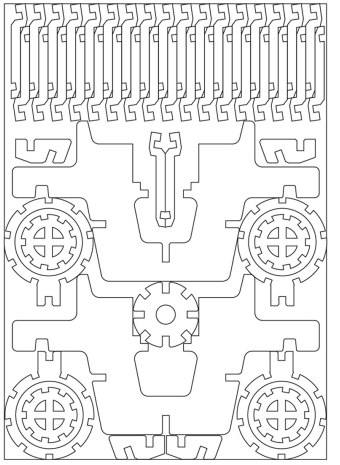
Flat transportation

However, if people prefer to buy at Flatfarm from the website it will be transported in a flat packaging. The sheets are designed to fit the proportions of mailbox mail.



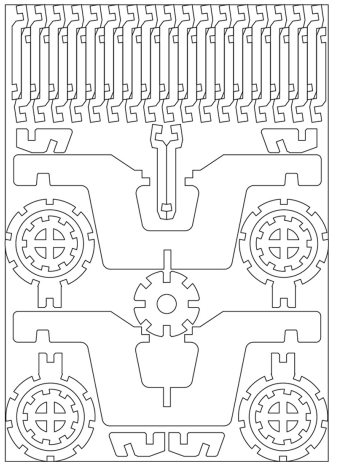
Laser cutting BOTTOM module sheet

Bottom assembly cross
Lid reservoir



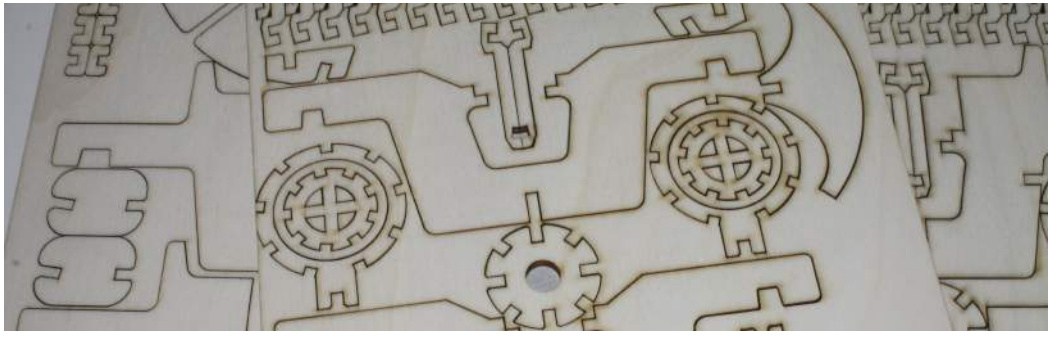
Laser cutting MID module sheet

4x net cup
Mid assembly cross



Laser cutting TOP module sheet

4x net cup
Top Assembly cross



▲ Figure 5.2 Laser cut wooden module sheets

MATERIAL AND COSTS

Terra Cotta pots
3 x € 1,0

total = € 3,0

Where to buy: Gardening center.

Polypropylene bags
3 x € 0,1

total = € 0,30

Where to buy: Supermarket or IKEA

Tubes
1 x € 1,0
1 x € 0,50
total = € 1,50

Where to buy: Gardening center or aquarium shop.

Water Pump
1 x € 10,0

total = € 10,0

Where to buy: gardening center or aquarium shop.

Clock timer
1 x € 2,50

total = € 2.50

Where to buy: DIY store.

Nutrients

Where to buy: Gardening center.

Clay pebbles
1 x € 5,0

total = € 5,0

Where to buy: Gardening center

Laser cutting
Material: € 5,0
Production: € 25,0
total = € 30,0

Where to buy: Produce at local Fab Lab or buy online.

Total cost Kratky system:
€ 38,3

Total cost drip water system:
€ 52,3

The total cost of a Kratky system flatfarm is estimated on € 38,3 and a drip system flatfarm will cost approximately € 52,3.

BUSINESS MODEL CANVAS

This graduation project is intended to lead towards the development of a new business. The business model canvas was filled in at the early stage of the graduation project to provide an overview of the potential structure of the future business.

Customer segments

The business is aimed to serve a group of people that enjoy the activity of growing fruits and vegetables at home. This may either be people that do this out of an ideology, called environmentalists, or people that like to build and construct things as a hobby, called Do It Yourselfers. These two characteristics are widely represented within the group of "millennials".

Value Proposition

The target group will be served by means of a physical product allowing them to grow fruits and vegetables at home. As well by the means of sharing knowledge and information through an online medium. This online medium could also serve as an community and platform for members to share their ideas. "Customers" can either choose to buy a specifically designed product version or build the free DIY version through the information that is available on the platform.

Channels

The initial product launch has to be realized by raising capital with crowd funding. In a later stadium a webshop could be added to the sales channels. Selling products through retailers could also be added later.

Customer relationships

Primary touch points with the customer will be online.

Revenue streams

Selling products will be the main revenue stream. Advertisement on the online platform (Youtube advertisement, etc.) could become a secondary revenue stream in a later stadium.

Key resources

This will firstly be the research and development team.. Secondly, but definitely not to be underestimated is the marketing part, allowing to reach the customer segments.

Key activities

The main activity of the company will be product development. In a later stadium, marketing and sales will be added or may be outsourced.

Key partners

At the initial stage of the product launch a crowd funding platform will be one of the most important key partners that will determine the success of the business. Later, partnerships for production and transportation will also have to be developed.

Cost structure

Research and development costs, production and the crowd funding and retailers fee account for the costs within the business.

"Customers" can either choose to buy a commercial product version or build the free DIY version through the information that is available on the platform.

▲ Figure 5.3 Business Model Canvas

FINALIZING

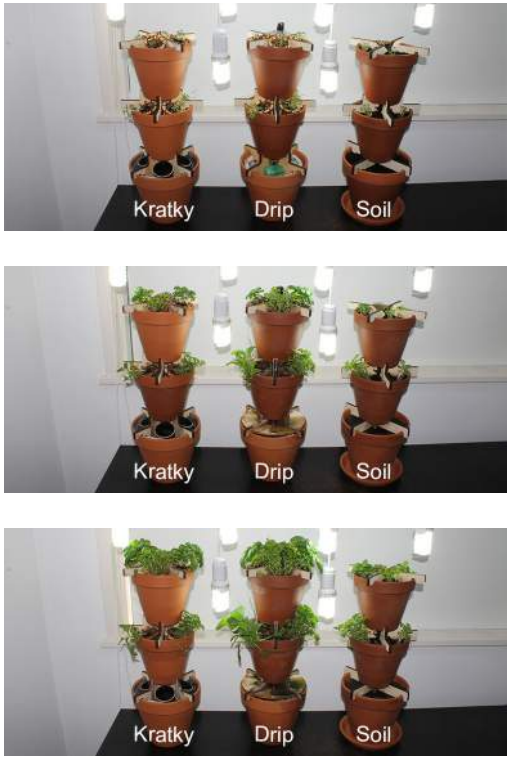
The final chapter contains an evaluation of the final product as well a reflection on the overall process. A sustainability analysis was done to be able to compare the environmental benefits of the system with other solutions. Recommendations for further development are made at the end of the chapter.

FLATFARM VS SOIL

A test setup was made in order to compare the efficiency of the new product. Three growing methods have been compared. Figure 6.1 shows this test setup. The images shows (from left to right) the Kratky hydroponics method, the drip system hydroponics method and the traditional soil based method. The experiment was conducted from February till March. CFL light bulbs were added as artificial lighting to complement the weak winter sun. The figures show the progress of plant growth over a time span of three weeks.

Expectations

Hydroponics should allow for higher yields and faster plant growth, as well should consume much less water compared to soil based agriculture. Hydroponic yields can go up a striking 4-10 times [Resh, 2011]. Plants use up to 85% less water and can grow 30% faster [Modern sprout]. These statements were derived from literature research. But do these statements apply for the design of the Flatfarm?



▲ Figure 6.1 These three images show a kratky system, drip water system and a soil based system over a time span of three weeks.

It is interesting to see a minor difference between the growth rate of the kratky and drip system method.

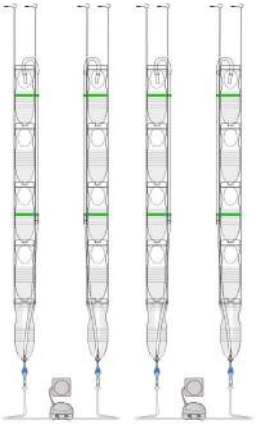
Results

The results after three weeks show that the plants in the hydroponics drip system setup (middle) have the fastest growth. At the second place, with only small difference in plant size is the Kratky hydroponics system. The setup with soil has the slowest plant growth as can be seen in the figures on the left. These results are in line with the expectations and proves the efficiency of the hydroponic systems compared to soil based agriculture. It is interesting to see that at this point (3 weeks time span) the difference between the kratky and the drip system method seems relatively small. However the advantages of the drip system method could yet become more apparent in a later stadium.

The drip system method shows the fastest plant growth, followed by the Kratky method and at last place the soil based method with a significant difference in growth rate.

FLATFARM VS WINDOWFARM

▲ Figure 6.2 Four column flatfarm



▲ Figure 6.3 Four column PET windowfarm

▲ Figure 6.4 Four column commercial windowfarm

Figure 6.2 - 6.4 show a comparison between the Flatfarm and two versions of the windowfarm.

The Flatfarm has a more sophisticated design compared to the PETfarm, but scores lower compared to the commercial windowfarm. The terra cotta pots make the flatfarm more appealing than the re-used PET bottles of the PETfarm.

The price of the Flatfarm is comparable to that of the DIY PETfarm, but considerably lower than the commercial Windowfarm.

The windowfarm is considerably easier to assemble than the DIY PETfarm, which also requires specific tooling. Collecting all the required parts of the PETfarm can consume quite some time because the parts are specific and have to be ordered at different shops. The parts of the Flatfarm can all be bought at the gardening center.

The Flatfarm has four grow beds per bucket, compared to one grow bed in the Windowfarms. This means the Flatfarm has room for four times more plants in the same space.

The modularity of Flatfarm enables DIYers to improve the system according to their own personal preferences.

	Flatfarm	PETfarm	Windowfarm
Design	+	+−	++
Technology	+	+	+
Price	+−	+−	−−
Setup & Maintenance	+−	−	++
Expected Yield	++	+−	+−
Modularity	++	+	+−
Total	6+	1+	3+

▲ Figure 6.5 comparison table between the flatfarm and the two versions of the windowfarm.

LIFE CYCLE ASSESSMENT

A fast track life cycle analysis has been conducted, comparing the carbon emission equivalent of fruits and vegetables bought in the supermarket with vegetables grown with the Flatfarm.

For this particular LCA the CO_2 equivalent of growing 1 kg of tomatoes vs. buying one kilogram of tomatoes in the supermarket was compared. Tomatoes have been selected since they have one of the highest CO_2 emissions per kg produce. The spreadsheet used to do this analysis can easily be re-used to compare different types of crops later.

▼ Figure 6.6 Comparing the CO_2 emission of 1 kg of tomatoes from the flatfarm vs the supermarket

HOME GROWING

Scenario of growing 2 indoor periods and 1 outdoor	periods	kg CO2 per kg tomato produce	Total	
Outdoor 1 period with natural resources (kratky)	1		0,93	0,93
Indoor 2 periods with artificial resources (drip water + LED)	2		6,5	13
		total co2 for GROWING tomatoes year round		13,93

BUYING FROM SUPERMARKET

	3			
Idemat2012 Tomato, organic			4,79	
		total co2 for BUYING tomatoes year round		14,37

	3			
Idemat2012 Tomato, standard			3,28	
		total co2 for BUYING tomatoes year round		9,84

Scenario

When growing tomatoes year round, one can grow with solely natural resources during the summer. However, in the other seasons growing tomatoes would only be possible with help of artificial resources such as lighting. This means one can grow for one period off the grid and for 2 periods with help of artificial resources. Two Flatfarm configurations have been analyzed in the LCA. The kratky configuration, which requires no electricity and the Drip water configuration with LED lights added. Figure 6.7 shows an overview of the LCA conducted for the Flatfarm with LED and water pump. Figure 6.6 shows a summary of the LCA results. Growing tomatoes of the grid will have a CO_2 emission equivalent of 0,93 kg compared to between 3,28 and 4.79 from tomatoes from the supermarket.

The total CO_2 emission of growing tomatoes year round according to the scenario of 1 period without and two periods with the help of artificial resources is 13,93 kg CO_2 per 3 kg of tomatoes. Buying 3 kilograms of tomatoes in the supermarket for have an CO_2 equivalent of between 9,84 and 14,37 kg.

! *Growing a kg of tomatoes, off the grid in the flatfarm will have an CO2 emission equivalent of 0,93 kg per kg tomatoes. A kg tomatoes from the supermarket has an CO2 equivalent of between 3.28 and 4.97 kg.*

Scenario 1kg tomatoes with LED light and Waterpump

DWC sytem with one tomato plant. Expected (average) yield= 5 kg and 5*25 = 125 L water required (25-40 liter water per kg tomato produce

				*LCI name in Idemat, Ecoinvent or CES or other source**	*carbon footprint (kg CO2 equivalent)*	**result**	**percentage**
Material							
Part	*type*	*weight (kg)*	*area (m2)*				
Pot	Terra Cotta	2,4		Idemat2014 Stoneware	0,3	0,72	2,224
Flatfarm laser cut	Wood	0,429		Idemat2014 Poplar	0,17	0,071973371	0,222
Hydroton	*Clay*	0,03		Idemat2014 Rockwool	1,5	0,045966633	0,142
Nutrients							
PVC Tube 9mm	*PVC*	0,04		Idemat2014 PVC (Polyvinylchloride, market mix)	2,1	0,084160856	0,260
PVC Tube 12mm	*PVC*	0,01		Idemat2014 PVC (Polyvinylchloride, market mix)	2,1	0,021040214	0,065
Waterpump	*PP*	0,25		Idemat2014 PP (Polypropylene)	2,1	0,519994259	1,606
PRODUCTION							
Part	*type*	*weight (kg)*	*area (m2)*				
Pot		2,4					0,000
Flatfarm laser cut			0,2625	Idemat2014 Cutting Al. laser	0,17	0,043765198	0,135
Hydroton							
Nutrients							0,000
PVC Tube 9mm		0,04		Idemat2014 Extrusion PVC	0,39	0,01568004	0,048
PVC Tube 12mm		0,01		Idemat2014 Extrusion PVC	0,39	0,00392001	0,012
Waterpump		0,25		Idemat2014 Injection moulding	1,1	0,2725	0,842
TRANSPORT							
		m3	*km*				
pots	200 pots/m3						
Production to Distributor (Italy to delft)		0,0005	1600	Idemat2014 Truck+container, 28 tons net (max weight/volume ratio 0,41 ton/m3) (m3.km)	0,0288	0,023070629	0,071
Distributor to home		0,0005	3	cycling	0	0	
Waterpump and tubes							
Production to distributor (shanghai to R'dam)	1200	0,000833333	22.000	Idemat2014 Container ship (max weight/volume ratio 0,84 ton/m3)	0,0068	0,124070203	0,383
Nutrients and hydropton							
Distributor to home (local transport)		0,03	20	cars sold in Europe in 2015 should emit 130 grammes of CO2 per kilometre on average	0,1300	2,6	8,031
USE PHASE							
type	*hours*	*energy (kWh)*	*energy (MJ)*				
electricity							
Water Pump (4W)	2928	11,71	42,1632	Idemat2014 Electricity Low Voltage, domestic use Netherlands	0,1879	7,922483707	24,472
LED light (15W)	1952	29,28	105,408	Idemat2014 Electricity Low Voltage, domestic use Netherlands	0,1879	19,80620927	61,180
	volume(L)						
Tap Water	125			http://oco-carbon.com/metrics/the-carbon-footprint-of-tap-water/	0,00079	0,09875	0,305
Nutrients							
END of LIFE							
type	*weight (kg)*	*process step*					

Total kg CO2	32,37358439	**100**
kg CO2 per kg tomato produce	**6,474716878**	

▲ Figure 6.7 Life Cycle Assessment for growing 1 kg of tomatoes in the flatfarm with help of artificial Lighting and a water pump

Scenario 1kg tomatoes off the grid								
DWC sytem with one tomato plant. Expected (average) yield= 5 kg and 5*25 = 125 L water required (25-40 liter water per kg tomato produce)								
					*LCI name in Idemat, Ecoinvent or CES or other source**	*carbon footprint (kg CO2 equivalent)*	**result**	**percentage**
Material								
Part	*type*	*weight (kg)*	*area (m2)*					
Pot	Terra Cotta	2,4			Idemat2014 Stoneware	0,3	0,72	15,501
Flatfarm laser cut	Wood	0,429			Idemat2014 Poplar	0,17	0,071973371	1,550
Hydroton	*Clay*	0,03			Idemat2014 Rockwool	1,5	0,045966633	0,990
Nutrients								
PVC Tube 9mm	*PVC*	0,04			Idemat2014 PVC (Polyvinylchloride, market mix)	2,1	0,084160856	1,812
PVC Tube 12mm	*PVC*	0,01			Idemat2014 PVC (Polyvinylchloride, market mix)	2,1	0,021040214	0,453
Waterpump	*PP*	0,25			Idemat2014 PP (Polypropylene)	2,1	0,519994259	11,195
PRODUCTION								
Part	*type*	*weight (kg)*	*area (m2)*					
Pot		2,4						0,000
Flatfarm laser cut			0,2625		Idemat2014 Cutting Al. laser	0,17	0,043765198	0,942
Hydroton								
Nutrients								0,000
PVC Tube 9mm		0,04			Idemat2014 Extrusion PVC	0,39	0,01568004	0,338
PVC Tube 12mm		0,01			Idemat2014 Extrusion PVC	0,39	0,00392001	0,084
Waterpump		0,25			Idemat2014 Injection moulding	1,1	0,2725	5,867
TRANSPORT								
		m3	*km*					
pots	200 pots/m3							
Production to Distributor (Italy to delft)		0,0005	1600		Idemat2014 Truck+container, 28 tons net (max weight/volume ratio 0,41 ton/m3) (m3.km)	0,0288	0,023070629	0,497
Distributor to home		0,0005	3		cycling	0	0	
Waterpump and tubes								
Production to distributor (shanghai to R'dam)	1200	0,000833333	22.000		Idemat2014 Container ship (max weight/volume ratio 0,84 ton/m3)	0,0068	0,124070203	2,671
Nutrients and hydropton								
Distributor to home (local transport)		0,03	20		cars sold in Europe in 2015 should emit 130 grammes of CO2 per kilometre on average	0,1300	2,6	55,975
USE PHASE								
type	*hours volume(L)*	*energy (kWh)*	*energy (MJ)*					
Tap Water	125				http://oco-carbon.com/metrics/the-carbon-footprint-of-tap-water/	0,00079	0,09875	2,126
Nutrients								
END of LIFE								
type	*weight (kg)*	*process step*						
						Total kg CO2	4,644891414	**100**
						kg CO2 per kg tomato produce	**0,928978283**	

▲ Figure 6.8 Life Cycle Assessment for growing 1 kg of tomatoes without any electronic appliances.

Conclusion

Besides the total amount of CO_2 equivalent, the LCA also provides the percentage of CO_2 per factor of influence. Thereby the LCA also gives insight into which factors have the biggest influence, and which factors have such a small influence so that they can be neglected.

An interesting insight from the LCA of figure 6.3 is that the consumption of electricity accounts for 85% of the total emission (25% for the water pump and 60% for the LEDs).

The LCA of figure 6.4 shows that for the scenario where no electricity is used (Kratky setup), the transport of mail order goods accounts for 55% of the total emission.

Focus points for further improvements would be the efficiency of transportation and power supply.

Figure 6.2 shows that growing tomatoes in the Flatfarm can reduce the carbon emission compared to tomatoes that are bought from the supermarket. However, this is only the case when the tomatoes are grown with the Kratky method, without electricity. Growing tomatoes with the Flatfarm in the summer may thus be beneficial to the environment. Growing tomatoes in the winter have the opposite effect. Therefore it should be encouraged to grow tomatoes in winter. Herbs and lettuce for instance can be grown in winter without the necessity for artificial lighting and heating. Stimulating this kind of behaviour would ensure that the maximum potential, in terms of sustainability, of the Flatfarm is used.

The consumption of electricity accounts for 85% of the total CO_2 emission of the drip system setup.

For the Kratky setup the transportation of mail order goods account for 55% of the total CO_2 emission.

The total CO_2 emission of growing tomatoes year round is 13,93 kg CO_2 per 3 kg of tomatoes compared to 14.37 kg for organic tomatoes from the supermarket.

RECOMMENDATIONS

This paragraph will explain the future planning of the project and which topics will need specific attention in bringing the project to a further level. Up to this point the Flatfarm has been elaborated up to the point that it could be shared as a beta version. However, improvements on the design still have to be made before a commercial version can be launched. In the next phase the product will be elaborated further by making use of online DIY communities.

Sharing the instructions of how to build a Flatfarm beta version together with the vector cutting files of the design could be the first step to get feedback from a group of early adopters and eager DIYers. This could be done by sharing the instructions on the Flatfarm website as well as sharing it on DIY platforms such as Instructables or Ponoko. Sharing the design on DIY platforms first will ensure the product will be shown to a large audience. It also ensures the product is seen as a DIY or beta version instead of a commercial product. Possible flaws in the design will thereby do less harm to the Flatfarm brand.

Sharing the design on a website like instructables.com will hopefully result in the emergence of a community of enthusiasts. These are the people that can provide valuable insights into the flaws of the system. Even better, since we are dealing with a group of DIYers, these people might build and share improvements to the system. Thereby these people will be involved in the R&D process from bringing the DIY beta version into a commercial version.

Already, from testing the first prototype, a list of points of improvements has been made. These points will be explained in further detail here.

Solar power

The drip system Flatfarm setup will require a power supply to control the water pump. In the current system this power is delivered from the grid. From the life cycle assessment it became apparent that the consumption of electricity holds a large percentage of the total carbon emission of the system. If the power could be delivered from the sun instead of the grid, the emission could be reduced drastically. However, the water pump runs at intervals of 30 minutes during day and night. Whereas solar energy can only be collected during the day. This means a battery might have to be integrated. Further analysis and development is needed to examine the possibility of powering the system with solar energy.

Add on modules

The modularity of the Flatfarm allows for different add-ons to be added to the system. One example of an add-on that has been developed is the LED light module. However, more modules could be developed to make the overall system more complete. Examples of add-ons are accessories such as supporting structures for vegetables that grow on the ground such as cucumbers and zucchini, as well as heavy plants such as tomatoes and beans. Glasshouse modules and (arduino) electronics modules are more examples of add on modules.

In the next phase the product will be elaborated further by making use of online DIY communities.

Evaporation

From the first tests of the prototype it became apparent that the reservoir has to be refilled every two days. As well as in the Kratky setup, water was evaporating since there was no lid that was closing of the system. Within the drip system setup the problem of evaporation of nutrient solution may be due to the absorption of water by the porous terra cotta pots. This was solved by placing plastic bags in the pots that prevent the pots from getting wet. For the prevention of evaporation of water from the bottom reservoir and the Kratky modules a lid has been designed. Both solutions are being tested at the moment and may need further improvements later.

Algae growth

The combination of water with nutrients, plants and light will result in growth of algae on the wooden parts of the Flatfarm system. The algae do no harm to the efficiency of the system but do not improve the aesthetics of the design. A solution to prevent the growth of algae would be to replace the wooden material by a plastic, this however brings challenges for making a design that requires no glue for assembly. The wooden parts of the Flatfarm can be assembled without the use of glue, through means of clamping. Plastics are less flexible compared to wood, and will break with the tight tolerances required. Another solution would be to examine the possibility of a varnish, however this will have to be a varnish that is food safe. Another solution might be to design the system in such a way that the wooden parts will not come in contact with either nutrient solution or (sun) light.

Cost reduction

The production costs of the laser cut parts are estimated around €30 plus €10 material costs. Efforts to reduce the cost price of the Flatfarm have to be made in order to have a competitive advantage within the market.

Kratky method

The test setup where the two types of hydroponic methods have been compared with traditional soil based growing provided an interesting insight. The difference between the Kratky method, that does not require any electricity, and the drip system method, that requires an water pump seemed relatively small. The question became apparent whether the addition of electricity to the system was worth the extra effort. This will have to be examined further. The advantages of the drip system might become more apparent at a later stadium or when growing fruiting plants such as tomatoes and bell peppers.

Commercial version

As explained above, the current Flatfarm will need some improvements before it can be launched as a commercial version. More research and development is needed to do so. These improvements may steer the Flatfarm in a different direction than its current shape. Therefore the development of a commercial version will have to wait until the flaws of the beta Flatfarm are solved.

The development of a commercial version will have to wait until the flaws of the beta flatfarm are solved.

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APPENDIX

1. ASSIGNMENT

IDE Graduation Assignment (version 2013.12.06)
incl. the student's study progress (Appendix 3)

TU Delft

To be filled in by the student
Please save your assignment as (format): IDE Graduation Assignment_family name, name_student number_dd-mm-yyyy
Place the proper document name on each page of your assignment in the headline, number the pages

Name student	Malik Ivan Tas	
Student number	1390406	
Address	Raamstraat 107	
Zip- code, City	2613RX	
Telephone	0616521759	
E-mail address	m.i.tas@student.tudelft.nl	
Start at IDE ..... (2007)	Start at TU Delft ..... (2007)	

Bachelor [1]	**Master** [1]	**Specialisation** [1]
▪ TUD Bachelor IO	▪ IPD	☐ Medisign
☐ TU/e or UT Bachelor IO	☐ DfI	☐ Advanced Automotive Design
☐ TU Delft non-IO BSc	☐ SPD	☐ Retail Design
☐ Other Dutch University Bachelor	☐ ..... = 2nd non-IDE master	**Annotation** [1]
☐ HBO Bachelor	☐ Individual programme, date of approval [2]	☐ Techn. in Sustainable Design
☐ Foreign Bachelor	☐ Master Honours Programme	☐ Entrepreneurship

Name Chair .....

1. Check study progress

To be filled in by the Shared Service Centre O&S after approval of the assignment by the chair. The study progress will be check for a 2nd time just before the green light meeting.

Bachelor degree:	☐ Yes	☐ No	☐ N.A.

Missing 1st year Master courses	1. ..... 2. ..... 3.	4. ..... 5. ..... 6. .....

Master electives, no. of EC credits accumulated: .....

Name:	Date: ..... / ..... / 20.....	Signature:

2. Formal approval Graduation Assignment by the Board of Examiners

To be filled in by the Board of Examiners

Approval of the content of the Grad. Assignment:	☐ Approved	☐ Not Approved
Procedural approval:	☐ Approved	☐ Not Approved

Comments:

Name:	Date: ..... / ..... / 20.....	Signature:

[1] *Tick where appropriate. As per 1-9-2013, for Advanced Automotive Design and Retail Design transition regulations are applicable, see the Implementation Regulations to the IDE Teaching and Education Regulations.*
[2] *Fill in: Date of approval of your individual programme by the Board of Examiners.*

IDE Graduation Assignment

GENERAL INFORMATION

Title Graduation Project [3]	**Designing a sustainable vegetable garden for urban farmers striving for self sufficiency.**		
Chair of Supervisory Team [4]	Han Brezet		
Department / Section			
Mentor of Supervisory Team [5]	Jotte de Koning		
Department / Section			
Project commissioned by [5]	☐ Faculty	☐ Company	☐ Other
Project type [6]	☐ Design	☐ Research [6]	☐ Other
Company name, if applicable			
City & Country			
Company Mentor			
Start date			
End date			

CONTENT

Ascertain that the text of your Graduation Assignment clearly meets and reflects the general and specific requirements for your specific IDE master. [7]
Write your assignment in the neutral, third person.
When inserting images or schedules in colour, make sure a print in black and white is still readable.

Introduction

Give a sketch of the context of your assignment. Historical developments, if applicable relevant published scientific research results, new trends, status quo; materials, technologies, usage, etc. If it is a faculty project: describe how your assignment reflects the research portfolio of the IDE Faculty. If it is a company project: provide Company information. If other, e.g. entrepreneurial: describe your future enterprise and how your assignment will be of value to the enterprise.

The growing world population is expected to stagnate at a number 9 billion people somewhere around midway of the century (2050) (Godfray et al, 2010), which is double the ammount of people since the 1980's and an increase of 2 billion people compared to today. At the same time, taken into account the increase in welfare, caloric and nutrition demands of crops are expected to increase with 100-111% from 2005-2050 (Tilman et al 2011). Global food demand is increasing rapidly. At the same time, by some estimates, world grain production has stabilized or even decreased since the late 1980's (Rees, 2005). Ground water tables are falling in over half of the world agricultural area's (Rees, 2005) and soil erosion is rampant. As well, since the current system of agriculture is largely depending on (depleting) fossil fuels, food security is insecure. Last but not least; agriculture contributes a substantial ammount to environmental impacts such as global warming and environmental pollution (Brower and Leon, 1999).

Developments in food production have made life easy for us today. In the supermarkets of the western world we have all the food imaginable available throughout the whole year. However, at the downside of this, there is a growing health problem regarding obesity and vascular diseases as a result of these unhealthy processed foods (Kelly et al, 2008). The relation between us and the food we eat has become poor along the way. For some people that relation has only become the time their food has to spent in the microwave. Many people have no idea anymore,

[3] *Keep the title compact and simple.*
[4] *Avoid team members from the same section.*
[5] *Tick where appropriate.*
[6] *See webpage http://www.io.tudelft.nl/onderzoek/onderzoeksprogrammas/*
[7] *For general master specific requirements, consult paragraph 4 of the Master Teaching and Examination Regulations, and paragraph 2.4 and 3.1.4 of the IDE Graduation Manual.*

what ingredients are in their food, where they come from and how they are made. The whole food chain, with genetically modified crops, chemical fertilizers, and food additives is developed around the profits of the food industry. The way food is produced today is both harmful to us and our environment.

The question of how to feed the future's world population, specifically in a healthy and sustainable way, will be one of the biggest questions of the coming decades.

Therefore, the way we produce the food we eat is under development. With movements for slow food, organic food, home growing, permaculture and technological innovation. One potential solution that meets both the requirements derived from a growing population as well sustainability demands is hydroponic agriculture. Hydroponic argiculture, or hydroponics in short, is a modern technology involving plant growth on inert media in place of the natural soil, in order to uncouple the performance of the crop from problems associated with the ground, such as soil-borne diseases, nonarable soil, poor physical properties, etc.(Savvas, 2003) Hydroponic agriculture has many advantages over traditional soil based agriculture. Increases in yield can go up to a striking 4-10 times compared with conventional outdoor soil culture (Resh, 2011). It requires much less water, is easier to treat for pest and diseases and excludes potential fertilizer pollution. Another great advantage that relates to the increasing scarcity of arable land is the possibility of higher density planting (Resh, 2011). Combined with the potential of vertical argiculture, where growbeds are stacked on top of eachother, hydroponics maximizes the efficiency of space and yield per space unit. This brings possibilities to grow food at the place of consumption, namely; in the cities. By 2050 it is expected that 70% of the world population will live in urban areas (WHO, 2014). The large part of environmental pollution due to transport of food would be reduced drastically when food is produced locally(Sim et al, 2007).

Mistrust of consumers towards processed supermarket foods and awarenes of sustainability have boosted the popularity of growing vegetables at home. Hydroponics are yet largely implemented in commercial greenhouse fruit and vegetable production and also slowely start to find their way towards the hobbyist home grower. They offer many advantages above traditional soil agriculture that are specifically beneficial for space limited urban areas. Therefore hydroponics is part of the answer of how to feed the 9 billion people in 2050 and besides it is a fun and rewarding activity of producing food.

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Problem definition

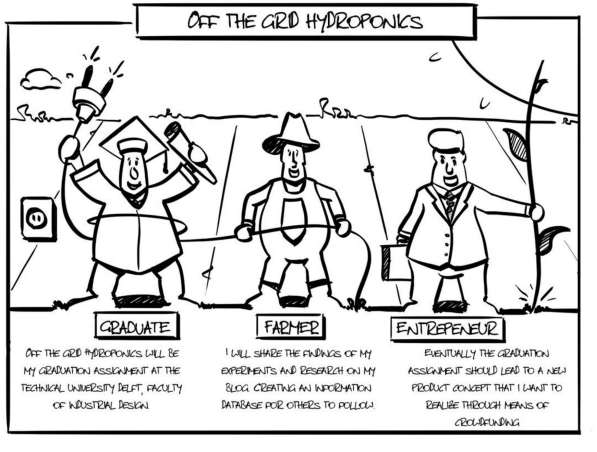
Indicate clearly, what is should/could be improved in the present situation. When executing a research project: indicate the knowledge gap. What opportunities exist, what contradicting demands should be addressed, etc.

Agriculture should develop towards a more sustainable system. Therefore it is important to educate people where and how their food is made and to stimulate them towards a richer interaction between them and the food they eat. By the current trend food production is shifting from the large corporations towards local production and home growers (ofcourse still being a fraction of the total), some of them striving for self sufficiency. Hydroponic food production is commercially implemented as the next step in the solution towards a more sustainable system. Besides commercially however, it also brings along great possibilities for home growers especially in urban areas. With the technique being relatively new and unknown to this audience the challenge is to find the way to adapt the system to their specific needs and behaviour.

Assignment

Briefly and to the point, describe the assignment to solve (part of) the problem for your 'client', i.e. Company of Faculty.

The assignment is to design a hydroponic system for home vegetable growers in urban areas. The system makes use of vertical space rather than horizontal to maximize the yield per square meter. Ideally this system enables self sufficiciency of fruit and vegetables (200 grams of each per day) for at least one person throughout all the four seasons. Energy consumption should be minimized and preferably the system makes use of natural energy sources such as solar power. A selection of specific crops is made to provide a rich variety of food and a even spread of moments of harvest throughout the calendar. The system should be modular in order to adapt to individual preferences and allow to easily increase production as well to spread investment costs over a larger ammount of time. Focus points are sustainability, ease of use and low maintenance in order to make it accesable for hobbyists.



Research Questions

- Is the current system of traditional agriculture maintainable for the future regarding increase in population and welfare?
- What are sustainable alternatives for traditional agriculture? How about Hydroponics?
- Is (food/vegetable) self sufficiency a feasable and sustainable alternative for people living in urban areas?
- What combination of crops allow for maximum efficiency and low maintenance (high yields and spread of harvest throughout winter and summer season)?
- How sustainable is growing vegetables indoors with help of artificial lighting compared to growing outside under sunlight?
- How do you stimulate consumers into urban farming? More specifically with new farming technologies?

Approach

What will be the approach to deal with the complexity of the assignment? What has to be done to meet the challenges? Indicate the steps within your project. If one or more extra parties are involved in your project, indicate which role they play.

Research
Trend Analysis
Experiments
Ideation
Concept development
Prototyping
Testing
Evaluation
Embodiment
Entrepreneurial

Graduation Project results

Describe the expected results or outcome of your Graduation Project for your (imaginary) 'client', i.e. the Company or the Faculty. Describe what you intend to design, create and generate. E.g. a product, a product-service combination, a strategy illustrated through product or product-service combination ideas.

A product or product service combination. As well a list of product ideas/concepts related to the context of the assignment. Production plan and cost price calculations. A brief business plan and crowd funding campaign set up.

Deliverables

List the mandatory graduation deliverables here, being the thesis report, annexes if any, the poster and the representative pictures. Furthermore, you may want to mention specific deliverables, such as a working prototype or a paper.

Report
Poster
Prototype
Crowd funding campaign (goals, marketing, promotion video)

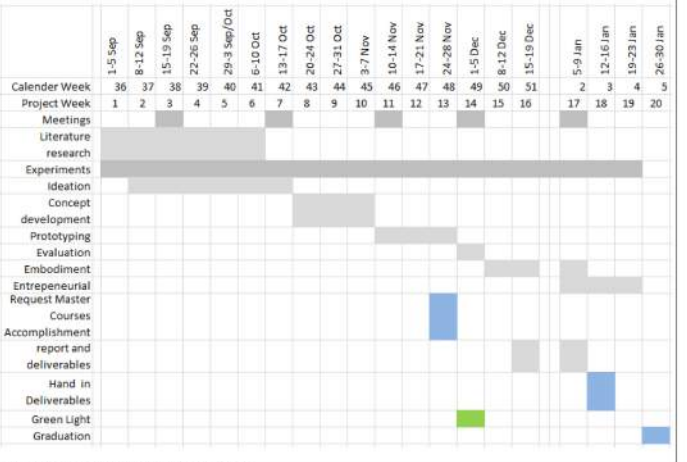
Relation and relevance to the domain of Industrial Design Engineering and the chosen master direction

Explain (as indicated/required in the graduation manual): 1) What is the relation of your project with the domain of Industrial Design Engineering and your master direction? 2) What is the relevance of your project to the mission of the IDE faculty? and 3) Explain the touching points of your project with each of the pillars of the triangle Human-Business-Technology. Indicate the scientific and/or societal significance of the outcome of your project.

Sustainable food production is one of the big questions of the 21st century. As a designer, through the means of good design, we can influence and change the behaviour of people and thereby contribute to solve this question and make the world a better place. As this being a university graduation project, the approach towards new product development will be systematic and methodical. As the specific master direction being IPD, the goal of changing people's behaviour will be achieved through the means of interaction with a physical product/product service system.

Planning

Present your planning in a Gantt Chart, which can easily be made in Excel, see example underneath. Make sure a print in black and white is still readable.
Mention the main phases of the project + number of weeks. Indicate only main activities, milestones, meetings.
Take notice: 33 EC = 22 full-time weeks! 30 EC are to be gained in the fulltime semester 4, 3 EC in the previous semester (part-time). Indicate periods of part-time graduation project activity and/or periods of not spending time on your graduation project, if any, e.g. because of holidays.



Brief explanatory remarks on the planning, if any.

The project starts with 6 weeks of literature planning combined with ideation and conduction experiments. Halfway the project the process should have lead towards the development of a concept which is prototyped in week 11 to 13. This prototype will then be evaluated before starting the embodiment phase. The final weeks of the project are reserved for entrepeneurial activities such as setting up a crowdfunding campaign.

Further comments and information

As far as you are of the opinion, that your Assignment needs further comments, please add any information you think is relevant.

[Text]

APPROVAL BY CHAIR

Date of approval	
Signature of Chair	

2. TRANSCRIPTION

Transscriptie interview Frans Spierings, Stadssocioloog

I
Mijn afstudeeropdracht gaat over het thema duurzame landbouw. Je ziet op dit moment een trend waarbij er veel landbouw naar de stad toe gaat. En dat mensen zelf aan het verbouwen zijn. Voor mij is het interessant er achter te komen waarom mensen nu zo bezig zijn met stadslandbouw. Ik ben benieuwd wat uw visie, als zijnde stadssocioloog, op stadslandbouw is. Of wat de achterliggende motieven van uit sociaal oogpunt zouden kunnen zijn volgens u?

R
Je ziet allerlei trends in de samenleving, een daarvan is de gezondheids cultuur. En dan zie je dat mensen graag goed eten. Gezond eten. En een jaar of veertig geleden dan draaide heel veel om meer eten, goedkoop eten. en nu zie je allerlei tegentrends van het mag allemaal meer kwaliteit hebben, mag best wat langzamer zijn, liever on bespoten biologisch. Lijkt een beetje een cultuurtje te worden en daarin past dat mensen het gevoel hebben dat ze controle hebben over voedsel. Daarnaast zie je dat heel veel jeugd helemaal niet meer weet waar voedsel vandaan komt en volwassen zijn daar soms vol onbegrip over. Heeft met verstedelijking te maken maar dat hebben we natuurlijk al heel lang dus het heeft ook te maken met dat de landbouwsector steeds kleiner is geworden, steeds onbelangrijker is geworden en de dienst sector steeds meer gegroeid. Veel kinderen denken dat een kip uit een supermarkt komt in plaats van daarvan daarvoor op een kippenfarm. En daar lijkt ook een soort tegen beweging gaande te zijn dat sommige mensen het leuk vinden om te laten zien waar voedsel vandaan komt ook aan hun eigen kinderen door daar mee bezig te zijn.

Dus kwaliteits besef, educatie... mensen hebben ook veel vrije tijd, heel veel mensen in Nederland hebben hebben een anderhalf verdieners model, dat houdt in dat de vrouw 3 dagen werkt en de man vijf en hoger opgeleiden zie je dat ze alle twee vier dagen werken daardoor hebben ze meer vrije tijd gekregen en zie je dat mensen die tijd ook willen besteden aan kwalitatief goede dingen.

I
Is dat iets dat nu iets meer van de laatste tijd dat de mensen nu meer vrije tijd hebben en dat je daarom ziet dat stadslandbouw nu zo een trend is.

R

Nee dat is al heel lang gaande ik denk gewoon dat er vanuit dat soort trends vele kleine deelinvloedjes doorspelen

I
Ja en dat dat nu allemaal samen komt op dit moment?

R
Ja, dus de behoefte aan voedsel kwaliteit, de behofete aan voedsel educatie in combinatie met vrije tijd maakt dat mensen die in de stad leven geneigd zouden kunnen zijn maar dat is allemaal hypotetisch he... dat ze het leuk vinden om daar mee bezig te zijn....

Verder staat in de stad de sociale cohesie altijd onder druk en je ziet dat dit soort initiatieven soms ook samenvallen met sociale cohesie initiatieven... dat ze in de buurt gaan farmen. En je ziet dat.. soms zijn er stukken grond die braak liggen die dan in de tussentijd benut worden voor sociale cohesie activiteiten, dat een woningcorporatie zegt dat... we hebben nog geen bestemming.. we zijn bezig om de wijk aantrekkelijker te maken... dit stuk grond daar kunnen we een pand neerzetten maar dan blijft het zo steen... we kunnen het ook even in de tussentijd laten zitten en kijken van wat we er mee gaan doen. En in die tijd stellen we het ter beschikking aan de buurt... en als de buurt dan een plan heeft dan zie je soms dat op die kleine stukjes grond wordt soms een ijsbaan neegelegd of soms gefarmd of soms een activiteit eromheen dat mensen uit de buurt gekookt hebben en dan een soort buurtfeest organiseren. En soms komen die dingen samen dat mensen uit de buurt zeggen we verbouwen hier wat groente en we gebruiken die groente voor het buurtfeest en dan koken we van wat we zelf geplukt hebben.

I
En is dat dan ook een stukje... dat wat u over de telefoon vertelde... Rotterdam ambitieus is op het gebied van urban farming en daar een voorloper van wil zijn?

R
Nou ik had er dus eigenlijk heel zelden van gehoord. Ik had wel van sociale cohesie projecten gehoord en ik had van daktuinen gehoord. Maar dat mensen bezig zijn met farming dat was nieuw en en ik zie de laatste tijd ook restaurants die bijvoorbeeld op het marconiplein die dat implementeren die gebruiken dan.... er is toch nog wel wat grond en soms brengen ze dat restaurant naar de grond toe en daar omheen wordt er wat zelf verbouwd en dat tapt natuurlijk in op die behoefte van mensen naar authentiek eten en gezond eten en weten waar het eten vandaan komt... Want er zijn natuurlijk heel veel verhalen in omloop over ongezond eten... water wordt toegevoegd of middelen worden

toegevoegd aan voedingsmiddelen waardoor mensen het gevoel krijgen wat krijg ik allemaal voor rotzooi binnen... en dat is een cultuurtje aan het worden van minder eten beter eten de tijd nemen om te weten weten waar het vandaan komt en in de stad is dat dan niet voor de hand liggend want de stad is vol.... maar op die braakliggende stukjes grond omdat daar dan te ontwikklelen zie ik wel dat dat iets ineens van de laatste twee drie jaar is.

En ik zag nu ook bij seismic, zal ik even voor je opzoeken dat is een onderzoekers netwerk dat krijg ik vandaag langs, moest ik aan je denken en een van de thema's was stadslandbouw. Ik zal hem ook voor je printen. Maargoed zo komen een aantal dingen samen en dat is wat ik er van weet.

I
En over dat stukje stimulering van de overheid om sociale cohesie te bevorderen op dit soort braakliggende tereinen, zijn daar programma's voor vanuit de overheid.

Ja er zijn altijd programma's geweest voor sociale cohesie, rotterdam had bijvoorbeeld het "opzomeren" en vervolgens de stadsetikkete ofzo.... "Mensen maken de stad"... dat zijn allemaal welzijns programma's om de cohesie in de buurt te verstevigen.... en dat heeft er mee te maken dat er allerlei nieuwe groepen in de samenleving komen en de overheid had de veronderstelling dat die groepen niet goed integreren... en dat er spanningen ontstaan en de mensen elkaar niet meer kennen dus het "opzomeren" was een soort veeg programma waarbij de mensen in de straat... die kregen wat geld en gingen de straat aanvegen en plantjes neerzetten en later werd dat "mensen maken de stad" konden ze geld aan vragen om een straatfeest of een bbq aan te vragen en dat programma's... dat hebben we al een jaar of vijftien en dat kwam voort uit de sociale vernieuwing... dus dat er behoefte was in de stad aan vernieuwing op het social vlak dat mensen elkaar weer gingen kennen... gingen groeten... bezig waren met normen en waarden en activiteiten organiseren om om elkaar beter te kennen... En de veronderstelling is dat die groepen met verschillende etnische achtergrond niet integreren en elkaar niet kennen... en door elkaar te groeten in de straat je elkaar kan leren kennen en daar zijn verschillende programma's voor die in de laatste jaren steeds meer zijn afgebouwd ...en je ziet dat dat soort programma's zich eigenlijk verschuiven naar bezig zijn met samen veilig of samen sporten of bezig zijn met samen werken aan je gezondheid of idd misschien wel verschuift naar stadslandbouw... dat er samenwerkingen ontstaan die dan budget kunnen aanvragen en dan op een stukje braakliggende grond kunnen gaan verbouwen... en dat in combinatie met wat coorporaties dus met braakliggende grond doen.

Ja en je ziet dat dat ook bij scholen is… het is misschien ook interessant om ook een keer met Henk Oosterling te praten dat is een stad filosoof en hij doet op een heleboel scholen in rotterdam zuid het programma heet “ecosofie” en dat gaat uit dat het denken en het bewegen en de voeding geintegreerd moeten zijn en dat doet hij op een basischool…. en hij zegt een gezonde ontwikkeling van een kind is als die zijn denken zijn voelen en zijn doen integreerd… dus hij heeft daar bij die school een schooltuin en daar worden groenten in verbouwd door de ouders en die worden ook gebruikt om daar tussen de middag te koken… dan krijgen alle kinderen op de Bloemhof school gratis eten… dat programma van “ecosofie” dat zit dat is dezelfde manier van denken als die denk ik achter die stadslandbouw zit. Voor een goede balans tussen lichaam en geest heb je goede voeding nodig en kinder moeten worden opgevoegd… en moeten weten waar eten vandaan komt, wat het waard is en hoe je het klaar maakt… en dat je het niet weggooid enzovoorts.

I
Ik heb een publicatie van u gelezen dat heette de stad als gevaar en daar zeg u in dat stadbewoners maar niet staan te popelen om de problemen van de stad op te lossen terwijl je bij stadslandbouw toch ook wel initiatief ziet dat de bewoners zulke problemen aan pakken?

R
Wat ik daarmee bedoelde was dat veel mensen uit de stad wegtrekken naar de buitenring dus die gaan in Capelle wonen of in Nessselande wonen omdat ze zich ergeren aan de sfeer in de stad en last hebben van gevoel van onveiligheid in de stad….die publicatie was van 12 jaar geleden.. en je ziet tegelijkertijd dat mensen in de stad dingen organiseren die weer aan sociale samenhang bouwen. dus je hebt het denk kader van Hierschman dat heet exit, loyalty ,voice… Heel veel hebben die exit optie gekozen… mensen trekken uit de stad want ze zijn niet tevreden over de leef kwaliteit. Dat is wat we in Rotterdam Zuid hebben gezien met de vlucht van de mensen naar de buitenwijk toe… dat heet selectieve migratie dus daar hebben we al bijna tien jaar een programma op gehad dat heette toen… nu heet het “nationaal programma rotterdam zuid”… maar toen heette het “pakt op zuid”. En het pakt op zuid zij eigenlijk wij willen de selectieve migratie van Rotterdam Zuid terugbrengen naar nul dat niemand meer uit de stad vertrekt omdat zij daar geen passend leefmilieu of passende sfeer kunnen vinden… dus dat heb ik niet verzonnen maar de selectieve migratie kon je gewoon aanwijzen in de cijfers… dus de middenklasse vetrok en de huizen kwamen vrij en daar kwamen mensen met een lager inkomen in terug… langzaam maar zeker werden de problemen daar in Zuid steeds groter want ze hadden minder geld en misschien minder capaciteiten en dat zie je ook in alle monitors terug.

En toen wilde de corporatie samen met de overheid daar heel hard aan gaan werken.. die zei de selectieve migratie die moet naar nul. Dus die exit optie, mensen betrekken... Dan heb je loyalty en de voice. De voice optie is... mensen gaan zich verzetten en spreken zich uit... we zijn ontevreden en dat doe je bijvoorbeeld via stemgedrag of via allemaal discussie ... of stukken in de krant... Er is een periode geweest dat het stemmen op Leefbaar Rotterdam door heel veel mensen werd gezien als het uiting geven.. het voice geven... het stem geven aan ontevredenheid... men was ontevreden over hoe de stad werd aangestuurd over wat er gedaan werd aan veiliheid aan sociale samenhang... en mensen spraken dat uit door te stemmen op leefbaar rotterdam... en die heeft ook altijd een vrij rechts imago gehad en intolerant imago dus dat is de veronderstelling dat dat met elkaar samenhangt... dat is het begrip voice en je hebt ook het begrip loyalty... dus exit komt uit de economie... je bent ontevreden dus je gaat weg... Voice komt uit de politiek, je bent ontevreden en je spreekt je uit... en loyalty dat komt uit het sociologische dus mensen zijn niet tevreden maar ze blijven wel loyaal aan de stad..... en ze gaan van binnenuit door zelf betrokken te zijn proberen die stad te verbeteren. In dat denken over stadslandbouw als instrument om sociale cohesie te bevorderen zit dat op het begrip loyalty... Mensen denken hallo ik kan wel weg gaan maar misschien heb ik helemaal geen keus.... mijn hypotheek... dus die crisis heeft er ook aan bijgedragen dat een heleboel mensen niet wegkunnen... ze hebben meer geleend dan dat hun huis verkoopt dus dan blijven ze en hebben ze zo iets van ik ga daar gewoon zelf voor knokken door bijvoorbeeld me meer te bemoeien met de buurt

I
Dus je kan daar verschuivingen in zien in de jaren?

R
Ja en dat kan door allerlei invloeden komen. Dat kan door culturele verandering komen dat kan door economische veranderingen dus het kan best zijn dat stadslandbouw door sommige mensen ook wordt gedaan om in kosten te besparen... door de tijd die ze over hebben te besteden aan het verbouwen van je eigen groente.

Er komen trends samen.. economische trends... mensen die zijn on tevreden over de sociale samenhang, samenwerken aan groente verbouwen kan een manier zijn voor mensen die het belangrijk om gezond te eten en daar tijd aan besteden.

I

Ik vond het interessant dat u zei dat door de crisis mensen zeggen dat ze niet weg kunnen.. Daardoor de loyaliteit gaan op zoeken en zulke initiatieven doen dus voor mij is het interessant om te zien of stadslandbouw iets is dat blijft of is het iets dat als de economie aantrekt dat mensen weer minder loyaal worden en dat het dan overwaaid?

R
Ja dan ga je uit van een factor he... van de economische factor dus wat je vaak ziet is dat het begrip familie verwantschap... doordat een aantal trends samenkomen... sociale trend economsiche... culturele trend dat iets ineens op komt en als er een trend dan weer veranderd en de andere twee zijn er nog dan is de kans groot dat het nog wel wat langer blijft dus als mensen nog steeds als mensen wel weer weg kunnen en wel weer meer geld hebben maar het nog steeds belangrijk vinden om te weten waar hun voedsel vandaan komt... en nog steeds belangrijk vinden om in de buurt te werken aan sociale cohesie dan heb je kans dat die trend langer voort duurt... en dat heeft natuurlijk alles te maken met ruimte en je hebt nogal wat ruimte nodig voor stadslandbouw en met klein schaligheid denk ik want ik neem aan dat je kleinschalige stadslandbouw bedoeld.

I
Ja meer eigen inititieven van buurtbewoneners hoewel je nu ook ziet dat er bedrijven zich toespitsen op het verbouwen van groentes in de stad

R
Nou ik denk dat de trend van duurzaamheid er eentje is die nog heel lang blijft. en uhm dit past wel in het duurzaamheids denken groene daken dat helpt weer om je huis te isoleren... dat is nog een vierde trend denk ik die erbij komt ...ik denk dat de kleinschaligheid ervan dat het nog wel eventjes zal voort duren maarja het is ook nieuw, ik was er ook door verrast.....Maarja er is ook heel veel vervuilde stadsgrond als ik een stukje land koop een huis met een tuintje in blijdorp dan denk ik nou is dit wel heel gezond als ik daar een moestuintje bouw... maarja je hebt ook nieuwe producten he dat je een vierkante meter zak kunt kopen dat je daar wat groente in kunt zetten en je zet twee vierkante meter zakken tegen elkaar aan en je hebt een volkstuin en sommige mensen stoppen daar nog een druppelaar in ook voor als ze op vakantie zijn.

I
Zelf verbouw ik met hydroponics een techniek waardoor je geen aarde nodig hebt om planten te verbouwen

R

Ja dat is in het Westland hebbn ze natuurlijk ook heel veel technologie, groeiprocessen inzet van bijen, voor bestuiving eigenlijk lalle processen die we vergeten

I
Ik ben ook wel benieuwd wat daar in gebeurd omdat je aan de ene kant ziet dat mensen een stukje kwaliteit terug willen en terug gaan naar de natuur, een stukje groen en aan de andere kant zie je de introductie van nieuwe technologie.

R
Ik heb niet het idee dat stadslandbouw technology-driven is ik heb het idee dat het traag sociaal gedreven is want technology driven dat is meer voor grootschalige en innovatieve werkwijze waarin.... uhm die opkomen omdat de concurrentie moordend is maar dit is juist om het tempo te vertragen lijkt het...

I
En de andere trend is, we hadden het over sociale cohesie. Is dat dat de laatste tijd meer verschuift naar het digitale, social media?

R
Ja dat denk ik wel dat mensen elkaar makkelijker kunnen vinden... gemeenschappelijke hobbys kunnen vinden via facebook. Dus via de ict en sociale media worden een hoop dingen laag drempeliger en minder specialistisch en veel sneller verspreid.

I
Wat is uw visie daarop als socioloog?

R
Ja ik zie dat wel als vooruitgang. Bij kinderen zie je wel dat er veel pesterijtjes zijn, maar de dingen met elkaar delen die je leuk vind en dingen uitwisselen, plaatjes zien, ik heb het idee dat dat meer samenhang genereerd en dat ze elkaar daardoor makkelijker vinden en elkaar helpen... want wat je ook ziet dat heel veel stadskeukens dat is een website waarbij mensen zeggen... mensen zijn aan het koken en die weten ik ga te veel koken ik ga voor twaalf mensen koken en dat zetten ze een advertentie en dan kun je daar bij mensen eten. En dan hebben ze gezellig mensen over de vloer ik heb het idee dat die dingen allemaal heel laagdrempelig worden en mensen dat leuk vinden en mensen nieuwsgierig

zijn naar elkaar omdat soort dingen te doen... En daarmee ook dat het veel minden vanuit de overheid gestimuleerd hoeft te worden. Nou dat is een beetje een gevaarlijke uitspraak. Ik denk dat dat nog steeds dat dat vanuit de overheid gestimuleerd moet worden maar ik denk dat ook veel burgers zelf het initiatief nemen dat noemen ze ook burgerkracht dat is een belangrijk begrip van “van der lans”... en burger kracht moet ik wel zeggen is vooral voor de mensen die al een netwerk hebben en niet zozeer voor de meer kwetsbare groepen ...mensen die een hoge status hebben die vinden het makkelijk om andere uit te nodigen en die hebben al kapitaal om dingen te organiseren dus mensen die dat niet hebben die er raar uitzien of andere problemen hebben die hebben dan is het netwerk eerder iets waar ze last van hebben

I
Zou je kunnen zeggen dat dat toeneemt die burgerkracht, dat mensen zelf het initiatief nemen?

R
Ja ik denk dat bij hoger opgeleiden, mensen met meer kapitaal die tijd hebben dat burgerkracht enorm toeneemt dat ze behofte hebben om meer ruimte te hebben en het ook leuk vinden om dingen te organiseren... omdat ze met een leuke hobby bezig zijn maar het is wel een beetje voor de middenklasse... Iemand die in de schoonmaakbranche zit die verdiend echt geen fluit en werkt zich echt kapot dus die heeft er helemaal geen tijd voor dus het is een beetje elitair

I Zou je dat kunnen toe praten naar een stukje, dat we meer individualiteit willen, dat we dat meer willen uitbeelden en dat we vanuit daar gaan zoeken naar eigen initiatieven ipv dingen die door bedrijven of de overheid georganiseerd worden?

R
Ik denk dat mensen wel meer behoefte hebben aan authenticiteit en tegelijk gedeelde interesse. Mensen vinden het leuk om elkaar te ontmoeten op iets wat ze met elkaar delen. en ict maakt dat mogelijk... en zeker als je genoeg kapitaal hebt. financieel kapitaal economisch of sociaal of cultureel kapitaal, makkelijk communiceert dan liggen er geen drempels.

I
Aan de ene kant wordt er gezegd dat stadslandbouw kan zorgen dat het de arme voedt in de stad. Maar volgens mij zijn het idd wat meer initiatieven die vanuit de middenklasse worden georganiseerd.

R
En het is wat dat betreft ook heel rijkdom gedreven. ik zeg altijd maar iedereen heeft het gereedschap in huis. maar niemand doet dat. Sterker nog ze hebben allemaal een zaagmachine en een decoupeerzaag en een metaalslijper en een boortol een boormachine ....allemaal in huis en die gebruiken ze 1 keer per jaar, volstrekte verspilling allemaal twee televisies, drie toiletten twee autos, enorme verspilling in de economie omdat we zo rijk zijn hebben we dat allemaal. Ik heb niet het idee dat het echt dat het de onderkant van de samenleving voorruit gaat helpen ik het het idee dat het een speeltje is van de rijken, als ik het zo zwart wit tegen elkaar mag uitzetten.

3. INSTRUCTABLES

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Food | Living | Outside | Play | Technology | Workshop

IKEA HACK MODULAR STACKABLE HYDROPONIC WINDOW GARDEN

by Maliklvan on December 1, 2014

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Step 7: Nutrient solutions

UNDER CONSTRUCTION

Here I share my method and knowledge of providing my plants with a nutrient solution. I learned this by checking information on the internet myself. Be aware that this is just one of the many possibilities and that a lot of other information is available on YouTube and other sources. Still I hope it provides you a basic overview of the topics involved.

I am using the 3 component FLORA SERIES nutrient solution from General Hydroponics. Plants need nutrients to grow. Nutrients can be divided into Micro and Macro nutrients. The separation of these different nutrients within the 3 component FLORA series allows to provide the plants with just the right amount of nutrients according to the growth stage of the plant.

Keeping things simple, there are three things important to consider when preparing your nutrient solution. These are the mixing ratio of the 3 different nutrient components, the pH level of the nutrient solution and the EC (electric conductivity) level of the nutrient solution which indicates the amount of particles dissolved in the water.

Mixing ratio

The second image above shows a growing chart provided with the flora series nutrient solution. The chart distinguishes different growth stages, such as: Seedlings, General purpose, vegetative and blooming. As explained before, to get optimum yields, the plant needs different nutrients at these different stages. The Kratky method however, which is the simplest method of hydroponics, allows you to grow without the necessity of changing the nutrient solution. For herbs, lettuce and other crops that do not consume lots of water to grow, an initial filling of the 5L container with a nutrient solution should be enough for the entire cropping period. For fruiting crops that require a bigger amount of water such as tomatoes and peppers it will be necessary to refill the container with nutrient solution. Keep in mind that for the Kratky method (that does not include an air pump) an air gap within the container will be necessary to provide the roots with oxygen. So only refill the container half way.

Conclusion
Beginners

The "general purpose" mixing ratio (see grow chart) of 1:1:1 for the three components is used. This means mixing 1,32 ml of each of the components per liter water.

More advanced growers can vary the mixing ratios according to the different growth stages of the plant. See the grow chart for instructions.

PH

The ability of the roots to uptake nutrients from the solution is depended on the PH value of this solution (see third picture, pH chart). The optimum pH range, where the plant is able to uptake all the nutrients, lies between a value of 6 to 7. The pH of tap water varies regionally. Also the amount of nutrients dissolved in the water will influence the pH value. Therefore it is important to check and adjust the pH value of your nutrient solution before the solution is provided to the plant. A liquid pH test kit can be ordered (cheap but less practical option) or an electronic meter (expensive option) can be purchased for checking the pH. When the pH value is either too high or too low you can adjust it with a pH up or pH down solution that can be ordered. An overview with specific pH values per crop is given in the images above.

EC

The EC value tells you something about the amount of particles dissolved. Sometimes this can also be provided by a cF of PPM value. Plants need nutrients to grow, a shortage or excess in the amount of nutrients provided can restrict this growth. Therefore it is important to check the EC value with an EC meter, and adjust to the optimum value if necessary. See the table provided in the images above for the specific EC value of different crops.

Basic Applications Table	FloraGro tsp/gallon	FloraGro ml/100 liters	FloraMicro tsp/gallon	FloraMicro ml/100 liters	FloraBloom tsp/gallon	FloraBloom ml/100 liters
Cuttings and Seedlings	1/4	33	1/4	33	1/4	33
General Purpose - Mild	1	132	1	132	1	132
Vegetative Growth Stage	3	396	2	264	1	132
Transition to Bloom Phase	2	264	2	264	2	264
Blooming and Ripening	1	132	2	264	3	396

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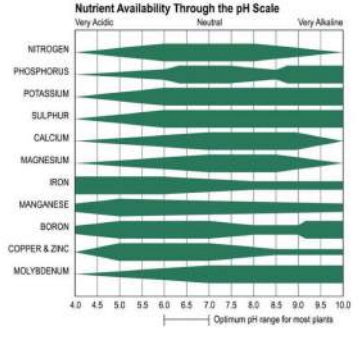
Basic Applications Table

	FloraGro		FloraMicro		FloraBloom	
	tsp/gallon	ml/100 liters	tsp/gallon	ml/100 liters	tsp/gallon	ml/100 liters
Cuttings and Seedlings	1/4	33	1/4	33	1/4	33
General Purpose - Mild	1	132	1	132	1	132
Vegetative Growth Stage	3	396	2	264	1	132
Transition to Bloom Phase	2	264	2	264	2	264
Blooming and Ripening	1	132	2	264	3	396



Plants	pH	cF	EC	PPM
Ambra radicchio	5.5-6.5			
Artichoke	6.5-7.5	8-18	0.8-1.8	560-1260
Asparagus	6.0-6.8	14-18	1.4-1.8	980-1260
Bean (Common)	6.0	20-40	2-4	1400-2800
Beans (Italian bush)	6.0-6.5			
Beans (Lima)	6.0-6.5			
Beans (Pole)	6.0-6.5			
Beetroot	6.0-6.5	8-50	0.8-5	1260-3500
Broad Bean	6.0-6.5	18-22	1.8-2.2	1260-1540
Broccoli	6.0-6.5	28-35	2.8-3.5	1960-2450
Brussell Sprout	6.5-7.5	25-30	2.5-3.0	1750-2100
Cabbage	6.5-7.0	25-30	2.5-3.0	1750-2100
Capsicum	6.0-6.5	18-22	1.8-2.2	1260-1540
Carrots	6.3	16-20	1.6-2.0	1120-1400
Cauliflower	6.0-7.0	5-20	0.5-2.0	1050-1400
Celery	6.5	18-24	1.8- 2.4	1260-1680
Collard greens	6.5-7.5			
Cucumber	5.8-6.0	17-25	1.7-2.5	1190-1750
Eggplant	5.5-6.5	25-35	2.5-3.5	1750-2450
Endive	5.5	20-24	2.0-2.4	1400-1680
Fodder	6.0	18-20	1.8-2.0	1260-1400
Garlic	6.0	14-18	1.4-1.8	980-1260
Leek	6.5-7.0	14-18	1.4-1.8	980-1260
Lettuce	5.5-6.5	8-12	0.8-1.2	560-840
Marrow	6.0	18-24	1.8-2.4	1260-1680
Okra	6.5	20-24	2.0-2.4	1400-1680
Onions	6.0-6.7	14-18	1.4-1.8	980-1260
Pak-choi	7.0	15-20	1.5-2.0	1050-1400
Parsnip	6.0	14-18	1.4-1.8	980-1260
Pea	6.0-7.0	8-18	0.8-1.8	980-1260

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Peas (Sugar)	6.0-6.8			
Pepino	6.0-6.5	20-50	2.0-5.0	1400-3500
Peppers	5.8-6.3	20-30	2.0-3.0	1400-2100
Bell peppers	6.0-6.5	20-25	2.0-2.5	1400-1750
Hot Peppers	6.0-6.5	30-35	3.0-3.5	2100-2450
Potato	5.0-6.0	20-25	2.0-2.5	1400-1750
Pumpkin	5.5-7.5	18-24	1.8-2.4	1260-1680
Radish	6.0-7.0	16-22	1.6-2.2	840-1540
Spinach	5.5-6.6	18-23	1.8-2.3	1260-1610
Silverbeet	6.0-7.0	18-23	1.8-2.3	1260-1610
Sweet Corn	6.0	16-24	1.6-2.4	840-1680
Sweet Potato	5.5-6.0	20-25	2.0-2.5	1400-1750
Swiss chard	6.0 6.5			
Squash (Summer)	5.0-6.5			
Squash (Winter)	5.0-6.5			
Taro	5.0-5.5	25-30	2.5-3.0	1750-2100
Tomato	5.5-6.5	20-50	2.0-5.0	1400-3500
Turnip	6.0-6.5	18-24	1.8-2.4	1260-1680
Zucchini	6.0	18-24	1.8-2.4	1260-1680

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Intro: IKEA HACK MODULAR STACKABLE HYDROPONIC WINDOW GARDEN

This modular hydroponic garden allows you to customize your system by choosing the components according to your personal demands. You can decide yourself whether to grow off the grid with the Kratky modules or to add modules that require electricity such as the Air pump and Light module. The different modules can be stacked on top of each other to make efficient use of your space. The majority of components are available at IKEA.

The different modules are:

Kratky Module (1 plant side), (1 plant middle) and (2 plants side)

The Kratky module allows to grow plants hydroponically without the use of electricity. The water uptake of the plant creates an air gap in the container which enables the roots to take up oxygen. If provided with a large enough container the initial application of nutrient solution should be enough for the entire cropping period, which is the case for crops that have low water consumption such as herbs and lettuce. Fruiting vegetables such as tomatoes and peppers have higher water consumption and thus require refilling the nutrient solution.

DWC Module

DWC stands for Deep Water Culture. It is a method of plant production by means of suspending the plant roots in a solution of nutrient-rich, oxygenated water. An air pump with air stone oxygenates the water. Providing the roots with high amounts of oxygen will result in higher yields.

Glasshouse Module

This Module allows to sprout your seedlings before transplanting them into the hydroponic system.

Light Module

With the light module, artificial light can be added if needed. It allows to give your plants a little extra or extend the growing season.

Arduino Module

The Arduino module implements smart sensors into your garden that make it possible to monitor and control your garden with some help of smart technology.

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Step 1: Kratky Module

Parts Needed

IKEA SAMLA 5L with lid
Net Pot 2 inch
Scotch Tape

Tools Needed

Drill with 2 inch drill bit (51 mm)
Stanley knife
Spray paint

Instructions

Lid with one plant on one of the sides

1. Use a Net pot and a marker to mark the area where the net pot will be placed on the lid. Make sure the net pot is placed just on the inside of the SAMLA box below, taking into account the wall thickness.
2. Use the drill with the 2 inch bit to drill out the hole for the net pot.
3. Place a small strip of masking tape +/- 5 cm on one of the sides of the container.
4. Cover the SAMLA lid and box in spray paint. This prevents algae growth from light reaching the nutrient solution.
5. After one hour, when the paint is dustdry but still flexible, remove the masking tape. Now leave the objects dry for 24 hours or according to the instructions on the spray can.
6. Preparing the net pots.Make a cut at the bottom of the net pots, disconnecting the side ribs from the bottom. Do this for five of the ribs. Cut off the two bottom ribs. This allows the net pot to fit in the Samla box.
7. Use scotch tape to connect the side with the bottom again to close the net pot. This is easiest done when the net pot is placed inside of the SAMLA box, since the shape of the box will force the net pot into a closed position.

Lid with two plants on each side

Follow the steps above but now drill two holes for the net pots on each side.

Lid with one plant in the middle

This module can be used at the top of your setup. Follow the instructions above but now drill a hole for the net cup in the middle of the lid. No adjustment to the net cup is required.

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Step 2: DWC Module

Parts Needed

2x IKEA SAMLA 5l with lid
Air pump that fits in the SAMLA box (28x20x14 cm), with 1-4 outlets
PVC tube that fit with the outlets of the air pump (6mm outside- 4mm inside diameter)
Airstone

Tools Needed

- Drill
- 2 inch bit
- 0.25 inch bit (6-6.5 mm)
- Spray paint (optional to camouflage the air pump)

Instructions

Airpump module

1. Drill a 2 inch hole in the middle of the lid. This creates the opening for the plug and cable to enter the box through the lid.
2. Drill a 0.25 inch hole at one of the sides of the lid. This is the opening for the PVC tube to enter the box.
3. Optionally you can paint the lid and container to camouflage the content of the box.

DWC plant module

You can choose to have a planter module with one plant on one of the sides, two plants on each side, or one plant in the middle, similar to the lids in the Kratky modules. The only difference is the necessity of a hole in the lid to allow the PVC tube to enter the container.

1. Follow the steps of preparing the lid and net pots as described in the instructions of the kratky module above.
2. As an extra step, drill a 0.25 inch hole in the side of the lid as the opening for the PVC tube.

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Step 3: Glasshouse Module

Parts Needed

IKEA SAMLA 5L with lid
Towel paper

Instructions

Fold the towel paper A few times until it has a few layers and fits the dimensions of the box. Make the paper towel wet and place the seedlings on top.

Step 4: Light module

UNDER CONSTRUCTION

Parts needed

- IKEA SAMLA 5l with lid (€ 1.99)
- IKEA KOPPLA socket (€ 3.99 / 2 st.)
- IKEA TÅNDA clocktimer (€ 3.49 / 2st.)
- 2x IKEA Kvart clamp spotlight (€ 4.99)
- e14 CFL or LED growspots

Tools needed

- Drill with 2 inch bit
- Spray paint (optional for camouflaging the content of the box)

Instructions

1. Drill a 2 inch hole in the lid of the SAMLA as an opening for the cable plugs.
2. Plug the spots into the clock timers and the clock timers into the socket. Place the whole in the container. The cables can exit through the hole.
3. Clamp the spot on the front side of the SAMLA box.

Step 5: Arduino Module

Under construction

Step 6: Additional lighting

Parts Needed

- IKEA FOTO pendant 25 cm (€ 9,99)
- IKEA FILLSTA tablelamp (€ 14.95) or plug cord with e 27 fitting
- IKEA TÅNDA clocktimer (€ 3.49 2st.)
- LED or CFL growspot e27 fitting
- IKEA Torkis Clothespins (€ 2,49)

Instructions

1. Remove the lamp shade from the IKEA FOTO pendant lamp.
2. Remove the e27 fitting with cord from the IKEA FILLSTA tablelamp.
3. Place the e27 fitting with cord from the IKEA FILLSTA tablelamp in the IKEA FOTO lampshade.
4. Drill a hole and mount a hook in the ceiling or windowsill for the fixation of the lamp.
5. Clothespins allow to re-position the height of lamp according to the growth of the plant.

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4. LCA IKEA HACK

Scenario 1kg tomatoes with LED light and Airpump

DWC sytem with one tomato plant. Expected (average) yield= 5 kg and 5*25 = 125 L water required (25-40 liter water per kg tomato produce)

				*LCI name in Idemat, Ecoinvent or CES or other source**	*carbon footprint (kg CO2 equivalent)*	**result**	**percentage**
Material							
Part	*type*	*weight (kg)*					
SAMLA box with lid	polypropeen	0,3		Idemat2014 PP (Polypropylene)	2,1	0,623993111	1,97979792
Net Pot	polypropeen	0,002		Idemat2014 PP (Polypropylene)	2,1	0,004159954	0,01319865
Hydroton	*Clay*	0,03		Idemat2014 Rockwool	1,5	0,045966633	0,14584239
Nutrients							
PRODUCTION							
Part	*type*	*weight (kg)*	*process step*				
SAMLA box with lid		0,3		Idemat2014 Injection moulding	1,09	0,328255844	1,04148624
Net Pot		0,002		Idemat2014 Injection moulding	1,09	0,002188372	0,00694324
Hydroton		0,03					
Nutrients							
Spray paint		0,005		Idemat2014 Acrylic varnish white , liquid, water based	2,2	0,011168209	0,03543436
TRANSPORT							
from-to		*m3*	*km*				
	700 samla/m3						
Production to IKEA (Poland to Delft)		0,0015	1300	Idemat2014 Truck+container, 28 tons net (max weight/volume ratio 0,41 ton/m3) (m3.km)	0,0288	0,056234658	0,17842066
IKEA to home		0,0015	3	cycling	0	0	
Production to distributor (shanghai to R'dam)	8000	0,000125	22.000	Idemat2014 Container ship (max weight/volume ratio 0,84 ton/m3)	0,0068	0,01861053	0,05904727
Production to distributor							
Distributor to home (local transport)		0,03	20	cars sold in Europe in 2015 should emit 130 grammes of CO2 per kilometre on average	0,1300	2,6	8,24924908
USE PHASE							
type	*hours*	*energy (kWh)*	*energy (MJ)*				
electricity							
Air Pump (4W)	2928	11,71	42,1632	Idemat2014 Electricity Low Voltage, domestic use Netherlands	0,1879	7,922483707	25,1363621
LED light (15W)	1952	29,28	105,408	Idemat2014 Electricity Low Voltage, domestic use Netherlands	0,1879	19,80620927	62,8409053
	volume(L)						
Tap Water	125			http://oco-carbon.com/metrics/the-carbon-footprint-of-tap-water/	0,00079	0,09875	0,31331283
Nutrients							
END of LIFE							
type	*weight (kg)*	*process step*					

Total kg CO2	31,51802029	**100**
kg CO2 per kg tomato produce	**6,303604057**	

Scenario 1kg tomatoes of the grid

Kratky sytem with one tomato plant. Expected (average) yield= 5 kg and 5*25 = 125 L water required (25-40 liter water per kg tomato produce)

					*LCI name in Idemat, Ecoinvent or CES or other source**	*carbon footprint (kg CO2 equivalent)*	**result**	**percentage**
Material								
Part	*type*	*weight (kg)*						
SAMLA box with lid	polypropeen	0,3			Idemat2014 PP (Polypropylene)	2,1	0,623993111	16,4671209
Net Pot	polypropeen	0,002			Idemat2014 PP (Polypropylene)	2,1	0,004159954	0,10978081
Hydroton	*Clay*	0,03			Idemat2014 Rockwool	1,5	0,045966633	1,21305523
Nutrients								
PRODUCTION								
Part	*type*	*weight (kg)*	*process step*					
SAMLA box with lid		0,3			Idemat2014 Injection moulding	1,09	0,328255844	8,66264161
Net Pot		0,002			Idemat2014 Injection moulding	1,09	0,002188372	0,05775094
Hydroton		0,03						
Nutrients								
Spray paint		0,005			Idemat2014 Acrylic varnish white , liquid, water based	2,2	0,011168209	0,294728
TRANSPORT								
from-to		*m3*	*km*					
	700 samla/m3							
Production to IKEA (Poland to Delft)		0,0015	1300		Idemat2014 Truck+container, 28 tons net (max weight/volume ratio 0,41 ton/m3) (m3.km)	0,0288	0,056234658	1,48402747
IKEA to home		0,0015	3		cycling	0	0	
Production to distributor (shanghai to R'dam)	8000	0,000125	22.000		Idemat2014 Container ship (max weight/volume ratio 0,84 ton/m3)	0,0068	0,01861053	0,49113019
Production to distributor								
Distributor to home (local transport)		0,03	20		cars sold in Europe in 2015 should emit 130 grammes of CO2 per kilometre on average	0,1300	2,6	68,6137614
USE PHASE								
type	*hours volume(L)*	*energy (kWh)*	*energy (MJ)*					
Tap Water	125				http://oco-carbon.com/metrics/the-carbon-footprint-of-tap-water/	0,00079	0,09875	2,60600344
Nutrients								
END of LIFE								
type	*weight (kg)*	*process step*						

Total kg CO2	3,789327312	**100**
kg CO2 per kg tomato produce	**0,757865462**	

Conclusion

HOME GROWING

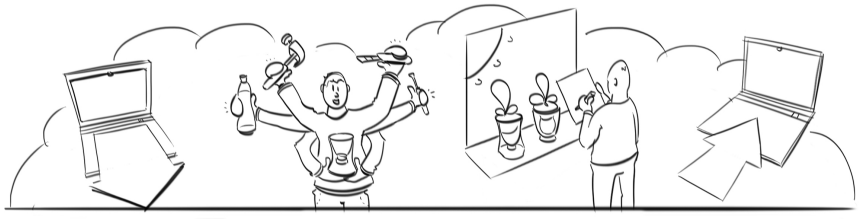
Scenario of growing 2 indoor periods and 1 outdoor	periods	kg CO2 per kg tomato produce		Total
Outdoor 1 period with natural resources	1		0,758	0,758
Indoor 2 periods with artificial resources	2		6,3	12,6
		total co2 for GROWING tomatoes year round		13,358

BUYING FROM SUPERMARKET

	3			
Idemat2012 Tomato, organic			4,79	
		total co2 for BUYING tomatoes year round		14,37

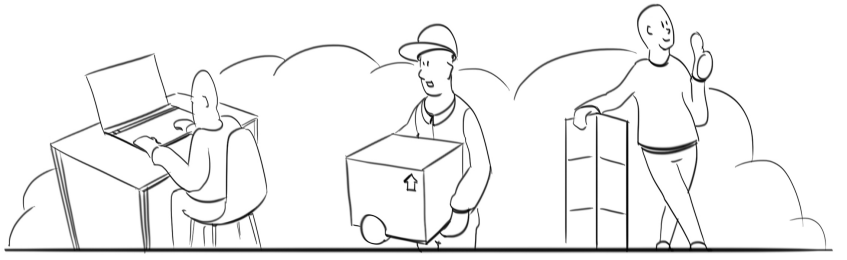
	3			
Idemat2012 Tomato, standard			3,28	
		total co2 for BUYING tomatoes year round		9,84

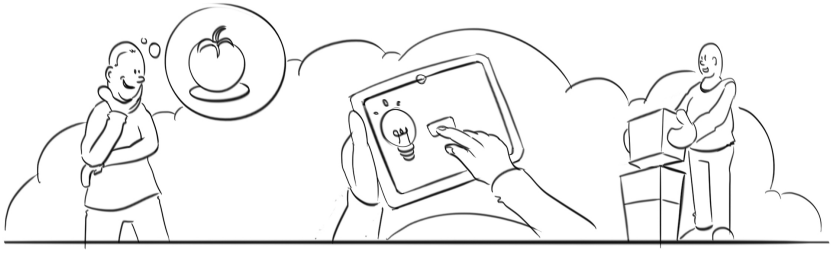
5. SCENARIOS



The DIY-er likes to build his own.He gets his inspiration on the internet on websites like pinterest and instructables. There he downloads the instructions. He evaluates and if necessary he makes adjustments to improve the product. He shares his recommendations to improve the product with the online DIY community.

The first buy customer may not have the time or skills to build his own. He therefore orders a pre-assembled model on the internet which is delivered at his home. Setup and maintenance are easy.

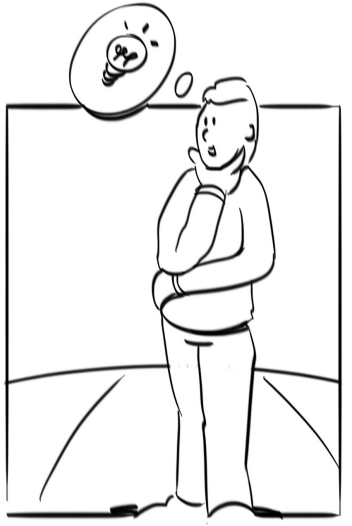




The first buyer can turn into an upgrade customer later. His initial setup may no longer fulfill his demands. Therefore he researches the internet for an upgrade package to his existing setup. After ordering online the package will be delivered at his home and he can easily install his new configuration by adding a module.

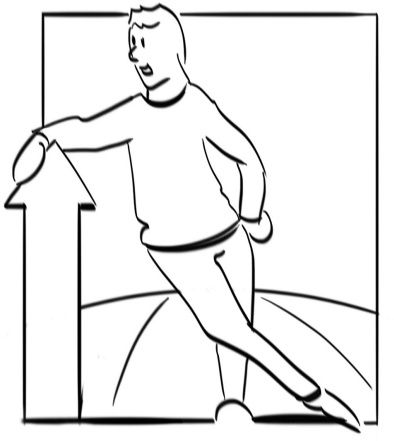
DIY-er

The DIY-er prefers to build his own rather than to buy pre-defined end product. It allows him to make adjustments and improvements according to his own insights. The DIY-er likes to make his products personal by this way.



First Buyer

The second segment is defined as the segment of “first buyers”. They may not have the skill or time to build their own. Or they prefer to have a “sophisticated” product that does not require a lot of installation and maintenance. The prefer a plug and play product and are willing to pay some extra for it.



Upgrade Buyer

The upgrade buyer may have been a DIY-er or first buyer. After experimenting with his initial setup he wants to upgrade. By adding new modules to his setup, the product can grown along with his changing demands.