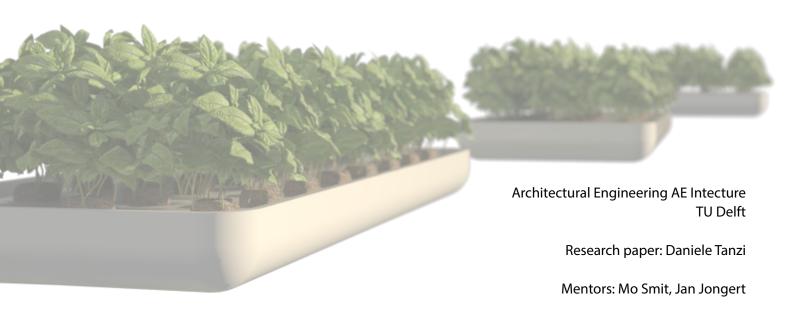


Disassemble the "Food Supply Chain"

Spaces, flows and techniques dedicated to food



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2.0_ Food introduction

2.1_ People eat

An important part of our life and a fundamental aspect of the human being existences is represented by food. People, to underline the value of the time dedicated to preparing and eat nutritional products, even started to address names to these daily actions as breakfast, lunch, dinner, snacks, drinks, puddings, aperitives and so on.

People love to eat.

Besides the need of food, people started to enjoy different tastes that are not anymore strictly connected to their life place or their proper culinary tradition. It is because they can experience the large varieties of tastes that the modern global market can offer nowadays. Unfortunately, many of these products, that are available in supermarkets, are concocted by food scientists in factories¹. Hence, it is important to underline some of the relevant issues that are arise from the modern behavior toward the food products.



2.2_ Problem statement

Due to the intricate society hierarchy and the detachment of people from rural activities, individuals have not anymore the possibility to discover the origins of food by themselves. It is because we have completely delegated the role of providing food to a chain of sellers. So, individuals became uninformed on how food is produced and brought to ours plates. On the other hand, people of the Western Countries, who are the most relevant consumers regarding the food products, are asking more and more frequently:

Where does the food we eat come from? How is it produced? Who is involved in the entire process? How is it transported to our market?

But even and more generic questions about the nature of a product:

Is this vegetable from a plant or a bush? Is this a wild product or is it from a livestock?

¹Pollan, M., (2009). Food Rules: An Eater's Manual 1°image by Tanzi, D., *Kek Delft - De Koffiebar Delft*, May 2017

Another relevant issue is possible to notice if we look closer at the "Food Supply Chain" data, about resources used in order to produce, process, transport and retail goods, it is possible to notice many wastes of resources. Materials, spaces and time are lost due to the layout of the already settled network that is spread out on the local, national and general market.

This is also because every food activity has its own role on the entire network and the companies' policies are mainly interested in the gross profit. This correspond to the overall balance between the price of the goods, the cost of processing them and the best trade the company can achieve with the next actor.

Often, the best deals are not located nearby and it can lead to several types of losses and waste due to the companies' business tendency to not paying attention on giving support over other activities and actors; they do not either interact and shear resources.

This might cause that no one has the overall picture of the food network and consequently everyone is employing more effort than the necessary.

The main problem here noticed is about two trends of the global food market:

1_ rise of the people awareness on their lack of knowledge about the products present in their diet.
2_ the tendency of the "Food Supply Chain" to stretch the path of each product in order to decrease the purchase costs and rise the companies' profits, even if it implicates a sporadic movement of the product around the globe and an enormous effort in terms of usage of available resources as materials, spaces and time.

2.2_ What is behind food

Today, when we do grocery in a shop, it is possible to find out where a product is coming from thanks to the European laws on the provision of food information to consumers of the 25 October 2011². The information written on the labels are limited to the geographical indication about the production of the product. However, it does not give any other data to the user about the intricate processes that are the background of the product.



² European Parliament, Council of the European Union, (2011). Regulation (EU) No 1169/2011 of the European Parliament and of the Council., Official Journal of the European Union.

To give a clear picture of the complexity that is behind a product, it is possible to mention, for example, the whole process of a product that is generally consumed in a European diet as the cod fish.

"The fish caught in the North Sea or off the western coast of the United States is frozen and shipped to China where it is defrosted, filleted, packed and refrozen before reaching retail shelves in Europe"³. The only reason for this complicated travel around the hemisphere is to save on operating costs, but this also brings more risks into the supply chain.

In fact, the evolution of the supply network has been driven as first by the costumers' needs and consequently by the companies' policy that moved their business from a local market toward a worldwide one, due to the cost advantages.

2.3_ Western Countries demand - 20th century "Supply Chain"

Some years ago, products as chocolate, or other abroad originals products, where not often available. Fresh fruit and vegetables were supplied by local producers and the products available, most of the cases, were affected by the season. The trades environment has changed the way food is accessible to us and it has modified our habits, diets and eating styles4.

Also, the rapid industrialization of western countries has changed the people's lifestyle and increased the consumption pattern in these countries. As the world's population continues to grow, there is an increased pressure on the food system that has to double the food production by 2050.

So, the "Food Supply Chain" companies, that are involved on the food topic, are challenged to be more efficient in production, to reduce the amount of resources loss during every process and to bring the goods as fast as possible to the consumers' fork.

From an architectural and technical point of view, the entire "Food Supply Chain" is represented by a vast field owned by various activities spread on national and international lands and often not even close to the last part of the "Chain": the consumer. This lead to an undisciplined loss of resources thought out the different phases required from each product.

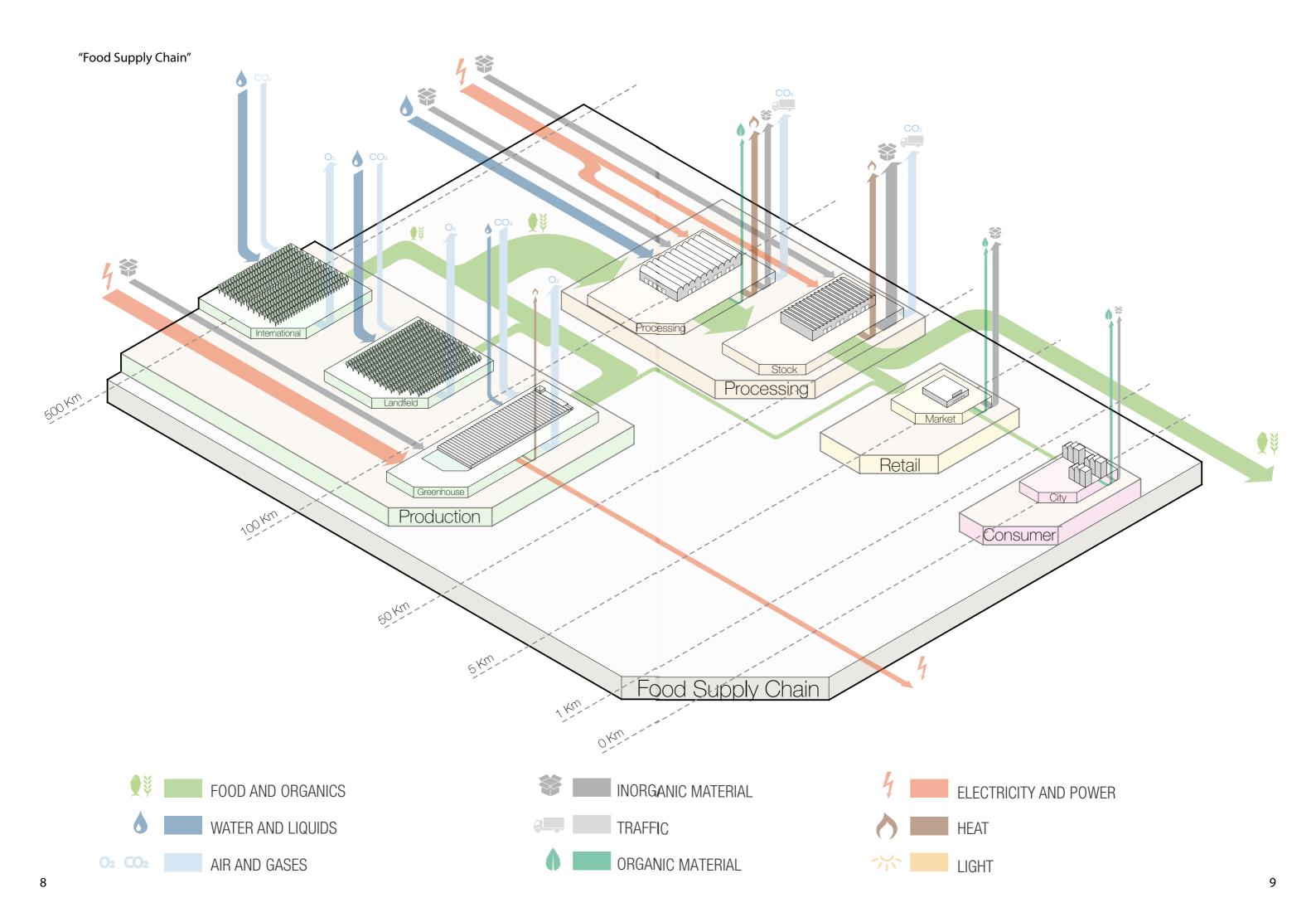
In the last few decades, the food sector changed quickly due to the movement of people as migration or working porpoise and this has led a diverse local demand of products, due to different diet styles, and the retailers followed this demand tread. Importing a product from any location of the world become possible thanks to the technological advancements in transportation, operations management and packaging.

In particular, the "Food Supply Chain" has become more complex than the other "Supply Chain" concerning to the challenge of a high efficiency of the processes, a precise quality control and freshness conservation of the products.

It is possible to define the "Supply Chain" as a network that has sequences of processes (productive, processing, retail) and flows (material, information, money) that aim to meet the final customer requirements. The Supply Chain does not include only the producers and the consumers, but also many other actors from which the chain is dependent from as logistic flows, transporters, warehouses and retailers. In a wider sense, the Supply Chain include also new product development companies, marketing, operations, distribution, finance and customer service.

^{2°} image by Urbani, R., FAO Consultant, Fish Inspector, Quality Assurance Expert., http://www.fao.org/in-action/globefish/fishery-information/resource-detail/en/c/340066/

³ Dani, S., (2015). Food Supply Chain Management and Logistics - From Farm to Fork. Kogan Page Publishers., xv 4 Ibid. xvi

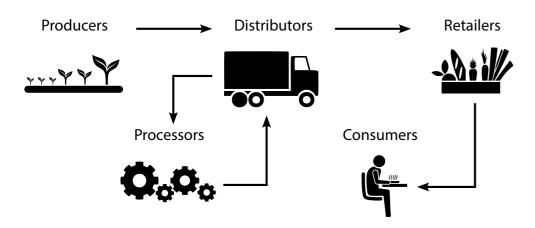


"Food Supply Chain"

The interest of this paper is on one particular network that involve food and other materials correlated with this product. The series of processes, operations and entities that help to take the food from its raw material state to our plates is called "Food Supply Chain". As mentioned before, The "Food Supply Chain" in the last half century has become a very complex network of entities and various activities that are governed by markets norms and demands of different countries. The representation above maps and tracks the flow of resources crossing different local, national and international entities. This present the overall network and it is possible to distinguish the main actors that define the path of a product.

The food supply chain starts with the producer (agricultural organization) that, through various production methods, all the year round produces an amount of nutritional goods. The produced goods are moved by facility companies as logistics and transportation. These corporates make sure that the food reaches the next phases in time and at the right quality. In between the producers and the consumers there are manufacturing companies that prepare the product in order to be transported again and be sold in the retail places.

The actors involved in a generic "Food Supply Chain" are shown in the scheme below and the next chapter will describe briefly their role in order to understand better the further specific technical analysis and the possibility to simplify and shrink the chain dedicated to food products in the further conclusion.



2.5_ Actors

Producers YYYY

The food supply chain starts at the producer end, which supplies food in its raw form – grains, fruits, vegetables, meat, fish, poultry and so on. The producers are farmers who are a part of the agriculture industry. Farming businesses range from small firms to very large corporates. Some are new to the business while others may be family farms that have been producing food for generations. Every country requires a strong food production sector as it affects both food availability for the population and economic sustainability for the food sector. There are entities in the supply chain that supply raw material (seeds, farming machinery, pesticides, fertilizers and so on) to the producers. These 'input suppliers' are generally large global companies with a lot of power in the chain⁵. The producers also have to deal with increasingly uncertain climatic weather patterns, scarcity of water, land grabbing by unscrupulous agents in developing countries and soil degradation caused by industrialization and urbanization. As margins for producers within the food supply chain are getting smaller and smaller, an increasing number of farmers are now growing what they can sell at a good price in order to have economic sustainability. Although this is fair, as long-term economic sustainability is needed for the sector, it has an impact on the availability of core food products⁶.

STAGE	PRODUCTION	PRODUCTS	
PEOPLE	TRANSPORTATION	MATERIAL transport products	
Small or industrial farmers	Agricultural tractor	carton box carton box plastic container	
Corporate management	Small production export		
Corporate carrier	Industrial production export		
OPERATING TIME 7 am - 5 pm			

⁵ Vandebelde, S., Kuijpers, R., Swinnen, J., (2017). The role of different food chain actors on setting private food standards.
6 Department for International Development (accessed 13 February 2015) Growth and Poverty Reduction: The role of Agriculture, A DFID policy paper [Online] http://dfid-agriculture-consultation.nri.org/launchpapers/roleofagriculture.pdf

Processors **Octo**

Processors are the entities in the food supply chain that transform the food products supplied by the food producers into products that meet consumer requirements. This process is also known as food manufacturing. This stage in the food supply chain will either prepare fresh food from the producer in a ready-to-eat format for consumers, or use it as a raw material to create other food products demanded by consumers. Food-processing companies are diverse in nature and will process products at various stages: for example, meat slaughtering and processing; preservation of fresh fruits and vegetables either by freezing, puréeing or juicing; milling of grains; making confectionery and bakery products; and other types of food manufacturing. Food processing is an extremely important process, as it not only sustains the food sector economy by catering to the demands and requirements of consumers, but also helps to reduce waste and increase food availability by increasing the shelf life of raw food products that cannot be immediately consumed. Food processors need to work very closely with the downstream supply chain, which comprises the entities that take the processed food to the consumer. Food processors will need technology insertion, changes to distribution channels and innovation in order to keep pace with environmental changes and changing consumer demands⁷. Another set of challenges that food processors are facing now and will face increasingly in the future is scarcity of resources such as water and energy and the availability of raw fresh food from the producers.

PROCESSING PRODUCTS STAGE PEOPLE TRANSPORTATION MATERIAL transport products Local distribution Factory carrier wood pallete metal container plastic carton container box Factory manager National distribution import - export Factory workers OPERATING TIME 9 am - 6 pm import - export

Retailers



Retailing is a process that showcases the product for the consumer. This can be in the form of local corner shops or large hypermarkets and supermarkets that deal with hundreds of thousands of stock keeping units (SKUs). The retailer stage in the chain provides the consumer with the variety of core and innovative products that the food sector has to offer. It is a highly competitive industry where food processors compete for shelf space in the retailer environments and the retailers compete among themselves to attract more consumers through their doors. Consumers have a wide choice of retailers, retail channels and formats. Retailers try to differentiate themselves from their competitors and are increasingly creating innovative business models that provide a good-value proposition to consumers based on price, quality and service. Retailers are experimenting with a variety of fulfilment channels and formats, ranging from physical infrastructure (shops) to e-retailing. As large global retailers prospect for markets in the developing world, the food supply chains in developing countries are undergoing a transformation. As the retail environment in developing countries moves from an unorganized sector (corner shops) to a more organized sector (supermarkets), the food supply chains and distribution channels have to innovate and change their processes to respond to retailer requirements. There is an ongoing debate within developing countries regarding the introduction of large-scale retailers and the impact on small shops.

STAGE	RETAILING PRODUC	OTS	
PEOPLE	TRANSPORTATION	MATERIAL transport proc	lucts
		$\overset{\sim}{\Longrightarrow}$	
Buyer manager	Local distribution		plastic ontainer
Retail manager	Forklift		
Ň			
Shop worker			
OPERATING TIME			
9 am - 11 pm supermarket			
9 am - 7 pm shop			

⁷ Cagliano, R., Caniato, F., F., A., Worley, C., G., (2016). Organizing Supply Chain Processes for Sustainable Innovation in the Agri-Food Industry., Organizing for Sustainable Effectiveness, Emerald Group Publishing, p 201

Consumers 🖡

The consumer is the final entity in the food supply chain. The economic sustainability of the chain depends upon the consumers buying the products and providing the necessary cash to travel upstream through the supply chain. Food is a staple necessity for every person on this planet and hence competition within the food supply chain concentrates on variety and value addition and not on core produce. Recently, in the UK, food supply chains have been subjected to a tussle between regular grocery supermarket chains and discount grocery retailers.

This has led to squeezing of margins and prices upstream as the retailers try to outdo each other to offer the lowest-priced food products (for example, most large supermarket chains in the UK are offering four pints of milk for £1, which is greatly affecting the returns to dairy farmers and hence their sustainability)⁸. Although this is good for consumers, it leads to another debate about food sustainability and food wastage, as food is looked upon as a very cheap resource. Ironically, as the competition to sell more within the organized sector increases, the excessive variety of food products (with little or no demand) and cheap food available in large quantities creates more food wastage at the consumer end. Reducing food wastage at the consumer end has been a major focus among governments and food-sector organizations in Europe. Food safety is a major concern for consumers and all food supply chain entities have to take the necessary steps to avoid food contamination. This can range from an excess of pesticides in produced food to microbial contamination in processing to improper food handling within the distribution and retail environment.

2.6 Distributor actors



Distributors are companies that act as the link between producers, processors and markets. The distributors source either fresh produce or processed food from the processors and then distribute it through various channels to reach the final consumer. These channels are either retailing companies or other processing companies (for example, restaurants) which provide the product to the consumer.

Distributors will generally buy in bulk and use an infrastructure of warehouses and distribution centres to deliver the products as and when required downstream in the food supply chain. Distribution companies are very important entities, especially when the supply chains are global and have to cross international boundaries, as distributors have to deal with local regulations.

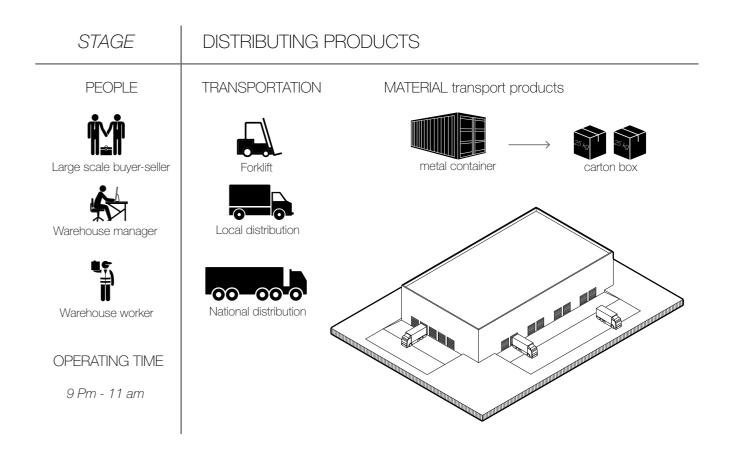
Food logistics is the movement of food through the supply chain until it reaches the consumer's plate. The flow of information from the consumer back into the chain is also an important part of logistics. "Logistics activities are the operational component of supply chain management, including quantification, procurement, inventory management, transportation and fleet management, and data collection and reporting" Pechnological advances in food processing and transportation have allowed industries to move greater quantities of food faster and over longer distances than ever before possible.

In the modern supply network, the importance of a quick movement of the products, it is as important as the rapid movement of demand information. To distribute the products through the chain, physical

infrastructure is required in the form of warehouses, vehicles, packaging boxes, crates, trolleys and so on. However, another form of infrastructure is necessary to control, monitor, track and facilitate this product distribution process. This infrastructure is the ICT hardware which increasingly uses dynamic data to drive logistics environments and organize what gets moved, when it moves and the form in which it is moved and stored¹⁰.

The food supply chains are increasingly global and logistics of food is no longer the movement of products from a local farm to the shop but includes a host of very complicated procedures to navigate across international boundaries.

Inherently, logistics is about the movement of product. The success of the system will be measured on the basis of on-time delivery. The focus of development and innovation within logistics is centered around the mechanics and details of product movement and handling, storing and packaging.



⁸ Daily Telegraph (2015) Milk cheaper than water: supermarket price war drives down pint of milk, 11 January

⁹ McKinnon, A., C., (1996). The Development of Retail Logistics in the UK: A position paper, Technology Foresight: Retail and Distribution Panel, Heriot-Watt University, Edinburgh.

 $^{10\} Dani,\ S.,\ (2015).\ Food\ Supply\ Chain\ Management\ and\ Logistics-From\ Farm\ to\ Fork.\ Kogan\ Page\ Publishers.,\ p\ 69$

Packaging

Food will be transported in several types of packaging (not retail packaging with branding) such as containers of boxes, with the aim of holding and protecting the food during distribution and transit. The operational requirements for such containers are that they should¹¹:

- hold and protect the products against climate and contamination risks throughout the journey;
- be compatible with the product;
- be easy to fill, seal and handle;
- remain securely closed in transit, but open easily when required (e.g. customs inspection) and reclose securely;
- carry information for all stages of the supply chain regarding the contents, destination, and how to handle and open the pack (smart containers will also have GPS tracking);
- be readily disposable or reusable.

The material used for some of these containers is:

- corrugated fiberboard cases;
- shrink-wrapped or stretch-wrapped corrugated trays;
- wooden or metal cases, crates, barrels, drums;
- sacks;
- intermediate bulk containers (IBCs) made from metal, plastic or corrugated fiberboard (including combi-bins, large boxes);
- large bags made from woven plastic fabric.









Temperature

Supply chain activities are either managed in-house by food and beverage retailers and manufacturers themselves, or outsourced to third party logistics providers, such as DHL Supply Chain, Wincanton and Hellman Worldwide Logistics, among others. Logistics activities in the food and beverage sector operate across four temperature bands¹²:

- ambient e.g. canned foods, jars of coffee, bags of sugar;
- fresh produce fruits and vegetables;
- chilled such as dairy products and ready meals;
- frozen frozen fresh produce, meals, ice creams, etc.

Temperature monitoring and recording is a legal requirement for the food sector. This also provides more control over the supply chain and can be facilitated by using time–temperature integrators or indicators, which connect to the IT systems, to individually monitor the temperature conditions of food products. The complexity of the food distribution will be based on the type of product, the available

modes of transport between farm and fork, legal requirements and so on¹³.

The temperature zones will differ according to whether the requirement is for frozen(-25° C; ice cream etc), cold chill ($0-1^{\circ}$ C; fresh meat, poultry, dairy, fruits etc), medium chill (5° C; butter, cheese etc) or exotic chill ($10-15^{\circ}$ C; potatoes, eggs, exotic fruit etc)¹⁴. However, when designing the supply chain and food handling it is important to understand that carrying different types of food may cause risk of product interactions.

Due to the nature of the actual "Food Supply Chain" the most high-risky role is practiced by the logistic actor that has the responsibility to transport and manage tons of products in a safety conditions. The goal is to distribute products from one process of the food chain to another within the minimum amount of time, using few resources and limit the amount of wasted material.



It is important that food and resources are not wasted during all the phases between the producer and the consumer. Improper processes and transportation or the inability to understand the needs of the market can cause this losses through the many stages the supply chain. One of the solutions to ensure that the product reaches our plates, in the right quantity, quality and timing, is a result of the use of the proper technologies.

It is the reason to disassemble the chain and investigate more carefully on technologies available today.

¹¹ Fellow, P., (2000). Food Processing Technology: Principles and practice, 2nd edn, CRC Press, Baton Rouge, FL

¹² GD (accessed 24 February 2015) UK Food & Grocery Retail Logistics Overview, 24 November 2009 [Online] http://www.igd.com/Research/Supply-chain/Logistics/3457/UK-Food–Grocery-Retail-Logistics-Overview/

¹³ Dani, S., (2015). Food Supply Chain Management and Logistics - From Farm to Fork. Kogan Page Publishers., p 76

¹⁴ Gustafsson, K., (2009). Retailing Logistics and Fresh Food Packaging: Managing change in the supply chain, Kogan Page, London

n° 3 image resource http://www.environmentreports.com/waste-not-want-not/

2.8 Research & Architectural aim

Today, especially in an academic environment, many disciplines have the opportunity to rise questions, research and participate on relevant topics. The aim is to develop different visions and strategies for a better future.

Supply healthy and enough food for the next generations seams a current work content of several professions, and it is even present on the discussion tables of architects and engineers.

Themes as "Secure and sufficient food for the world's inhabitants" and "Feeding the Planet, Energy for Life" have been topics of the last two International Exposition (EXPO Zaragoza 2008 and EXPO Milan 2015) with the intention to frame the goals of the next few decades.

Especially the Milan Expo headquarter, the architecture of several pavilions had a significant role in experimenting forms that could host advanced production and processes techniques but also diverse retail formats. The visitors had the possibility to have a closer view on available technologies and experience the food not only as tasty product but also as goods that generate forms of our landscapes¹⁵.

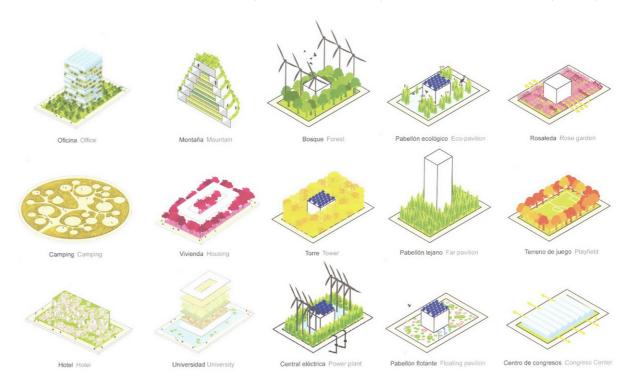




¹⁵ Linden, G., (2016). The Book of Expo Guidebooks., LuLu.

In the European Union, one of the most active countries on the food topics is The Netherlands that has been established a region called "Food Valley" where more than 15,000 international food companies, research institutes and Wageningen University and Research Centre are concentrated. These activities are intended to form a dynamic heart of knowledge for the international food industry. The intent is to settle conditions so that food manufacturers and science institutes can work together in developing new and innovating food concepts.

Due to the horticultural and economical background, Dutch government organizes every ten years a World Exposition on the impact of flowers and plants, healthy food, green innovations and ground-breaking architecture that concern our life in the future city. The exposition Floriade 2022 Amsterdam Almere "Growing Green Cities" will try to answer to the emergent question: "What can green do for you and the world?". This exposition will be related with the urgent issues arose with the global urbanization that is creating emergency on the food security, climate change and energy supply.



It has been proven that food production and consumption are the main factors that contribute to earth's ecological footprint and at this point it is necessary to point out that there exist a strong connection between food production and architectural disciplines¹⁷ (Gordon, 1990; Chimbowu and Gumbo, 1993; Greenhow, 1994).

Architecture and engineering have to collaborate in order to boost innovations in the food field, toward a different consumers' behavior, as well as companies' policy. The vision of the disciplines has to go further, using the large scale demand as a constructive starting point of new design concepts. According to Steel (2008) and Zetter (2006) Food must be locally produced and processed in order to reduce the burden of the transportations from rural to the urban environment. It must become a useful tool in building social cohesion and interactions between society's different components leading to a sustainable communities and cities¹⁸.

n° 4 image Ratti, C., Expo Coop 2015, prototype of digital supermarket, http://www.studiofmmilano.com/EN/Work/coop-future-food-district/

^{16 &}quot;Welkom in de Regio Food Valley"., Regiofoodvalley.nl., 2012-03-19. Food Valley NL is co-financed by the Dutch Province of Gelderland

¹⁷ Odeyale, T., Temple, N., Sodgar, B., (2011). Sustainable Architecture and Food Production: Impact of Modernity on the Traditional Urban Form., Lincoln School of Architecture, University of Lincoln, United Kingdom, p 3

n° 5 image, "Growing Green Cities", a project of "FLORIADE 2022 proposal for Almere / MVRDV architectural studio" resource https://evoralandscapearchitecture.wordpress.com/2015/01/29/growing-green-cities-a-project-of-floriade-2022-proposal-for-almere-mvrdv/

3.0_ Research

The presented research bases its interest and boundary in the technical and architectural aspects of the already existing "Food Supply Chain".

The survey proposed aims as first to represent an overview of the Food network, the architecture and the existing flow of resources before diving into the typological analysis that considers in specify the space necessary to produce, process and retail the food we usually consume.

3.1_ Research question

In order to understand the architecture and the technical systems behind the food products; what are the most advanced technical processes and their minimal modular elements that are necessary to compose the "Food Supply Chain" in matter of spaces, equipment and resources?

3.2_ Design question

Having the knowledge of these most advanced food processes and their minimal modular elements that are necessary to compose the "Food Supply Chain", how should they be combine in order to generate a grocery format that contribute to a stronger connection between the food processes and the costumers?

3.3_ Methodology

This study investigates into the main actors of the "Food Supply Chain" and their system techniques. The aim is to extrapolate the minimal modular elements that are essential to process food from productive to the retail activities.

The method consists in Disassembly - Analyze - Re-assembly the network that is behind the food we consume every day.

A fictitious disassembly of the "Food Supply Chain" gives the opportunity to distinguish the actors in two main categories: the "primary" and the "secondary" activities.

Subsequently, a precise analysis of the "primary" activities is directed in order to represent the spaces, systems and resources necessary to process food. The goal of the investigation is to discover the minimal modular elements that are necessary in each activity.

The end of this analytical exercise, as output of the research, represents a critical re-assembly of the analyzed activities in a more "Compact Food Supply Chain" that considers only the necessary spaces for the product phases. This will influence the architectural design proposal that brings together all the necessary technical equipment of the "Food Supply Chain" and introduces them in the urban environment close to the consumer.

3.3.1_ Literature & case studies

Since the beginning of the investigation, it has been considered literatures from various disciplines that has guided this survey through different prospective. Due to the nature of the research into innovations and technologies, in the representation of the case studies proposed has been necessary to get an opinion from scientific and technology digital newspaper that are involved in publishing the nowadays developments.

The choice the specific case studies, as shown in the next chapter, are driven by the technical systems employed by different actors that lead to efficiency of the process. They embody the most avant-garde systems today available. In fact, the following examples stand for their advanced process techniques that are compact as well as efficient in the use of resources.

The case studies analyzed are also fragment-able in single programs modules. These minimal modular elements are repeated several times based on the scale of the actors' activities.

3.3.2_Technical developments

"Sustainable development could be regarded as a process of change in which the exploitation of resources; the direction of investments, the orientation of technological development, and institutional change are in harmony and enhance both current and future potential to meet human needs and aspirations¹⁹" (Egan, 2004; Hewitt and Hagan, 2001).

During the last decades, it has been developed methods in all the food phases in order to provide sufficient and safe food to the demand of the consumer around the world. Innovation is necessary both for finding solutions to future social challenges and to sustain business competitiveness. Within the food sector researches and innovations have been the core of some activities. Processes and product development have to be considered using novel ideas to meet the challenges of feeding an ever-growing population, with rising incomes and changing lifestyles. These pressures modify where and how food products are grown, processed and distributed with the requirements of being socially and environmentally compliant.

lbid. p 342

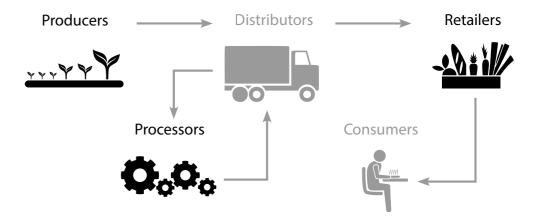
4.0_ The "Food supply chain" disassemble

4.1_ Disassembly the food network

The disassembly the chain, as a research exercise, become a tool to investigate in the places dedicated to food and to understand what are the advanced techniques used in the different activities.

The food system has been divided by activity roles underlining the main diverse processes that define different actors. It results in a simplification of the chain in five categories that, working together, bring the product from the production, through some processes, to the retailer.

This architectural and technical research sets its studies on three specific actors that are relevant for the further design approach: producer, processor and retailer.



Previously, It has been done a comparison between the different actors typologies and their architectural techniques. This prior survey has considered the efficiency of these typologies by square meter and the amount of resources consumed and produced. It has been done to select and investigate more in depth on the most advanced actors' techniques already existing on the actual market.

4.2_ Analysis case studies

The next chapters will analyze some specific spaces, tools dedicated to food and flows of resources. Production, processes and retail formats are the represented and analyzed activities that are considered as essential in the disassembled "Food Supply Chain".

It has been studied three different typologies for each category to give a wide range of techniques used in these types of activities.

The following architectural drawings describes the actors' activities considering: space, technical systems and flow of resources. The representation of the selected actors start from a short explanation at the large scale (context and building programs) and then an illustration on the minimal modular element that is the core function of each actor as the valuable meaning of this survey for further architectural and technical proposals.

4.2.1_ Production

The producers selected, as the most advanced in food production, are located in buildings that have adequate architectural qualities in where specific technologies are installed and they synergically collaborate to optimize the ratio between the use of space for the production and the use of resources. The analyzed systems produce resources as food products, but even other types of products as organic bio-mass and oxygen during a specific amount of time (conventionally 1 year).





Zoom into the system core

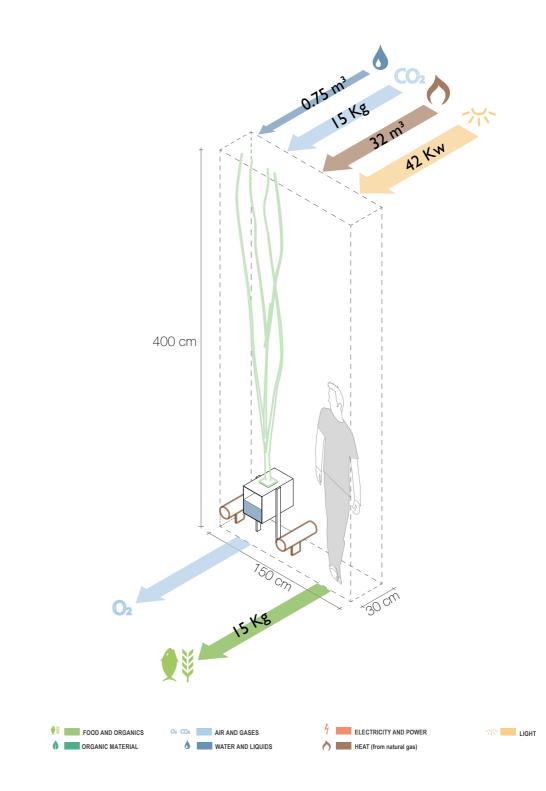
The footprint of the greenhouse is about 2.3 hectares. In The Netherlands examples of the greenhouse can even reach 12 hectares of glass shell surface.

The 10x10m scale shows the typical layout of a greenhouse building. Horizontal distribution of the production, steel structure and glass windows as roof that lets the natural light irradiate the crop.

The "minimal modular element" considers an hydroponic system for the growth of the plants, a water pipe heating system for maintain the temperature - humidity of the environment controlled all the year and the access of the workers to each raw.

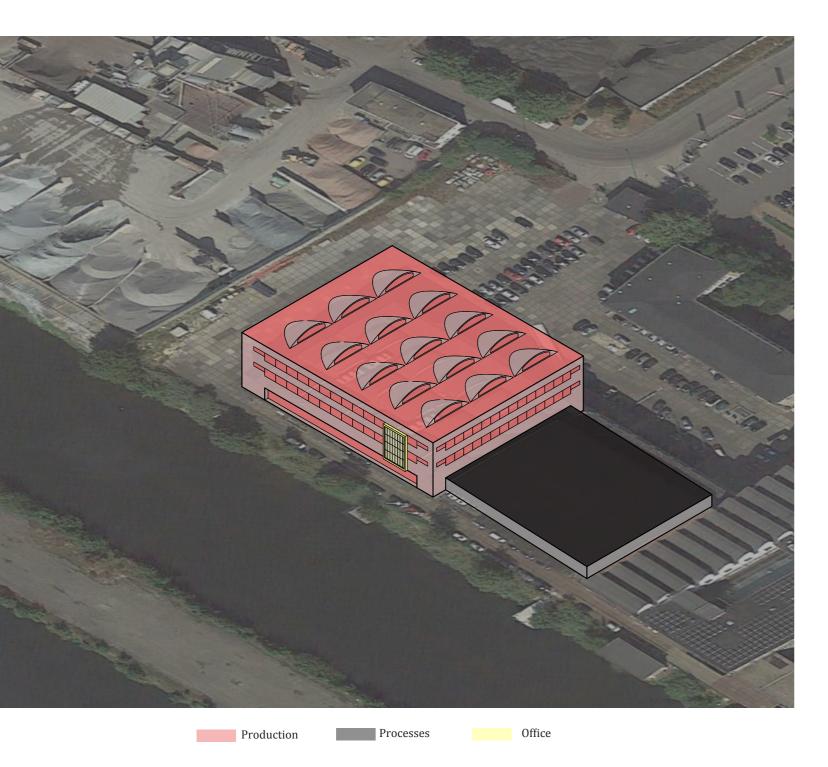
Greenhouse production "minimal modular element"

The architecture of the greenhouse module consists in three main features: hydroponic, natural light, water pipe heating systems. Each of these systems generates a flow of resources finalized to the production of food. The calculation of the flows are based on the yearly consumption and production of resources. It results that every half square meter of production can generate a production of 15 kg of edible food each year (pepper production).



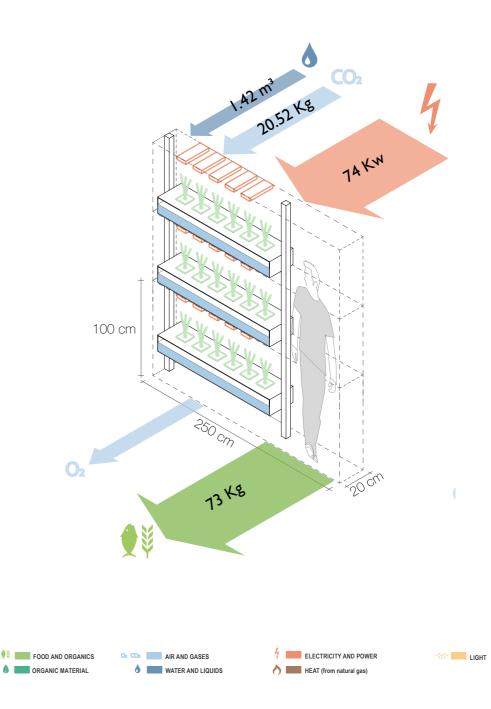
LED Farm production: building scale & context

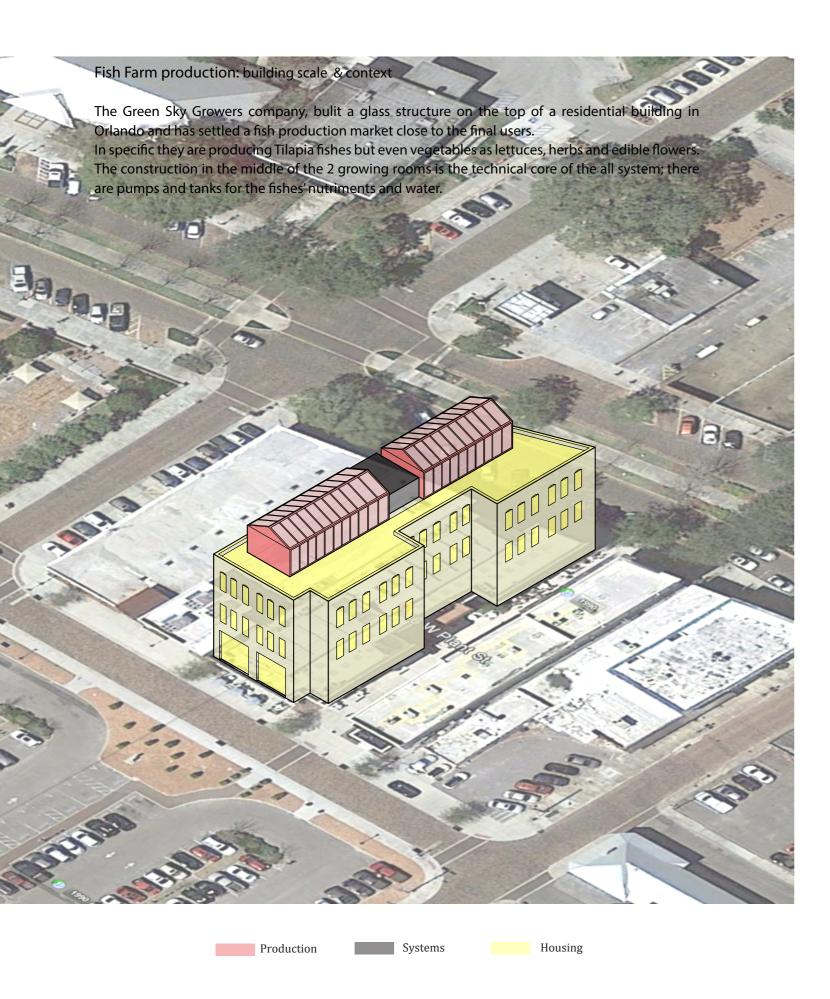
The renovated Toshiba "Floppy disks factory" in Tokyo, that in the 80s and 90s was producing innovative tools for our computers, started to grow thousands of lettuce plants in a giant indoor room. Located few miles outside the city boundaries, the company is able to produce about 10,000 salads per day. Inside the building, aside the LED production, there are also other activities correlated with the innovation in the food field as laboratories and an electronic department that experiments more efficient lighting techniques for the future productions.



LED Farm production _ "minimal modular element"

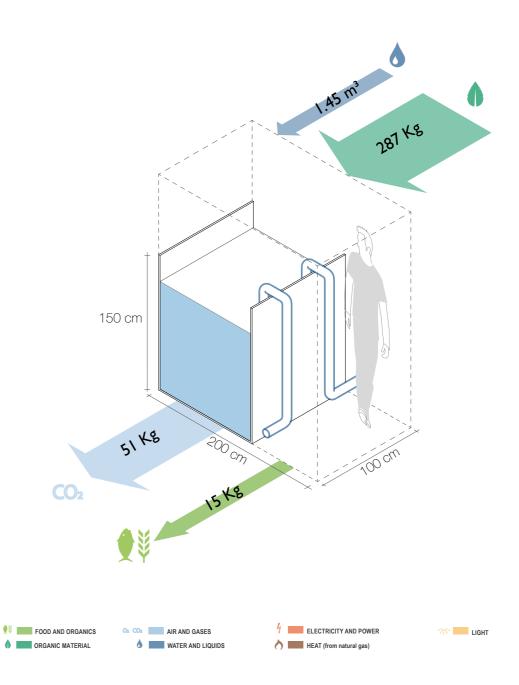
The architecture of the LED Farm module consists in many different parts that together settle a compact production on shelves. Light steel structure supports the hydroponic or aeroponic (based on a diverse quantity of water injected in the pipes) production system and the LED lights that are located above the growing product. The high power consumption is balanced by the high yield of products. In fact, in half square meter the yearly production is about 73 kg (calculated of lettuce production).





Fish Farm production _ "minimal modular element"

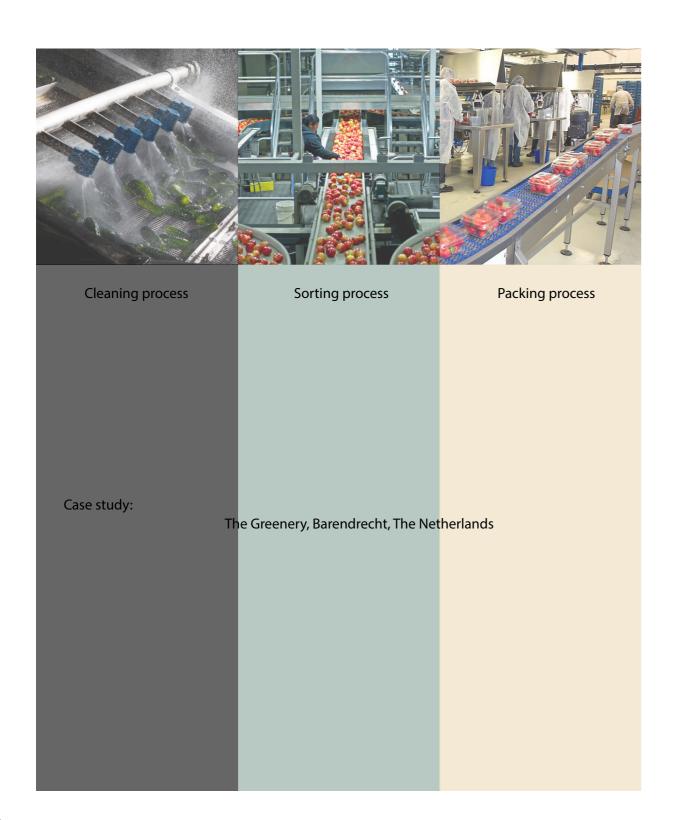
The module is based on the fish containers and pipes that distribute fresh water and nutrition to the Tilapia fishes. This technique is also used for different kind of fishes as shrimps and oysters. By controlling temperature, diet and water quality it is possible to produce 15 kg of fishes in one and half cube meter.

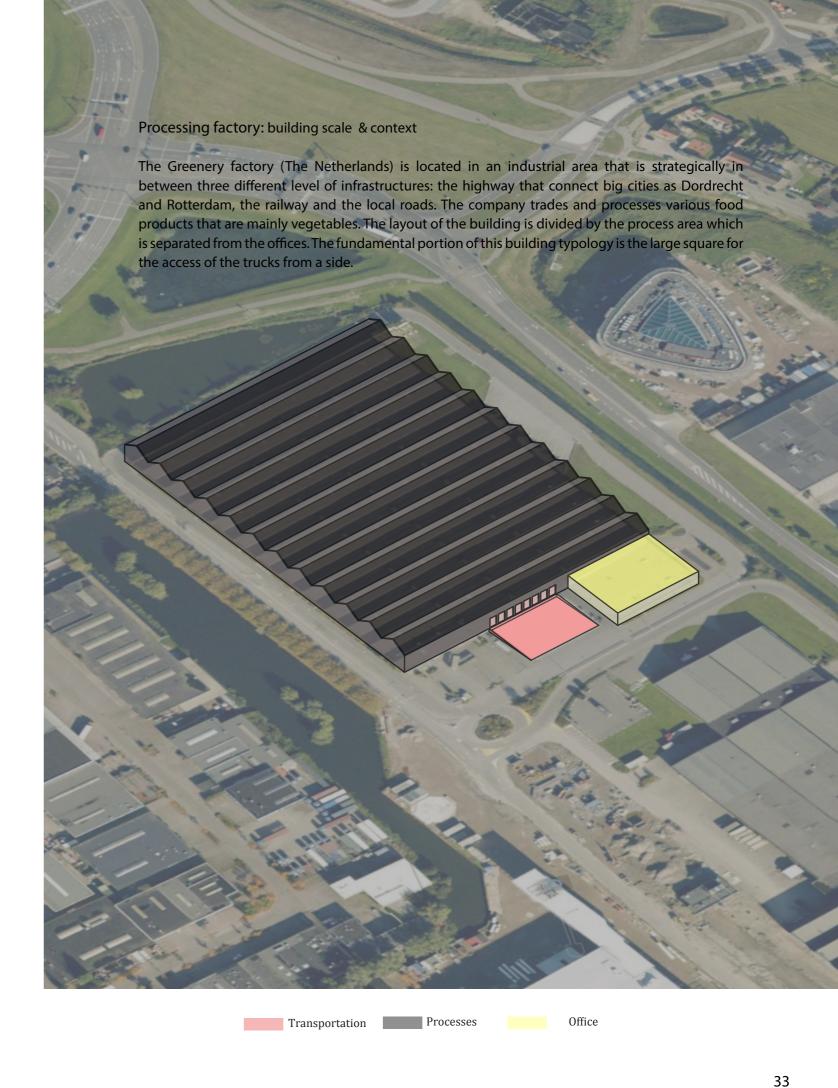


4.2.2_ Process



The processors are the fundamental actors concerning the quality control of the products. They also create the opportunity to preserve longer the food and diversify the size of the products and then the price for the final costumer. These operations are a cost-effective method of improving the quality of the raw material before the transportation and the display in various shops.





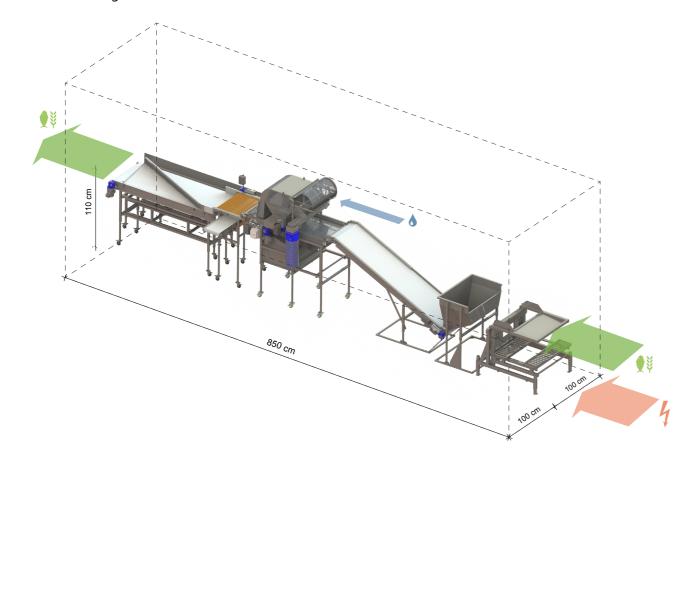
Cleaning process _ "minimal modular element"

This is the first machine that the food product meets in the processing phases.

The cleaning operation requires, most of the time, only water in order to wash perfectly all the products. The machine, as first phase, transport the product with a conveyor belt into a bubble water pool or air bubble pool that clean the surface and than it is move toward a drying chamber in order to totally remove the water or some residue left.

The products in the end of this process are moved by workers or by electronic devices to the sorting process.

Not all the companies involved in processing food are cleaning the products before packing and distributing them to the market.

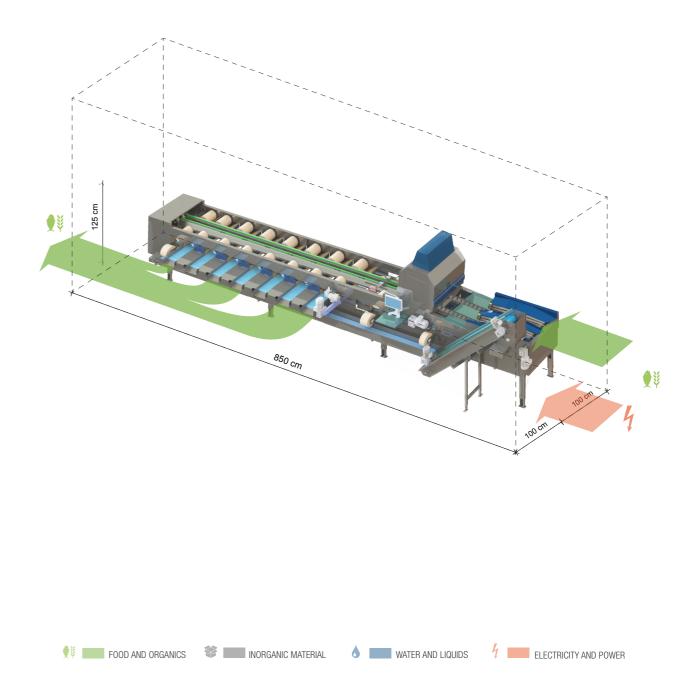


FOOD AND ORGANICS INORGANIC MATERIAL WATER AND LIQUIDS FOOD AND ORGANICS ELECTRICITY AND POWER

Sorting process _ "minimal modular element"

The sorting phase is used for determinate or the size or the weight of the products.

The goods are introduced in one extreme of the machine and than they are mechanically moved on the top of a rolling system that divide the products in front of different gates where the goods will be transported toward the packaging process or another shortage.

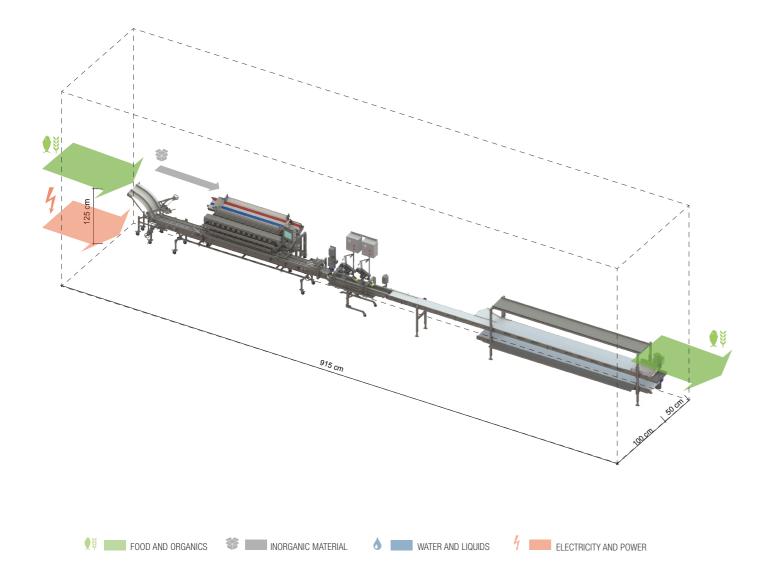


Packing process _ "minimal modular element"

The packaging is the first impression of the costumer on the product.

The large use of plastic by many companies is due to the good maintenance of the product during the travels but also because it is a transparent material and it allows the eyesight of the buyer on the product.

The machine through a sterilized process close the food products with a layer of material that is already branded.



4.2.3_ Retail



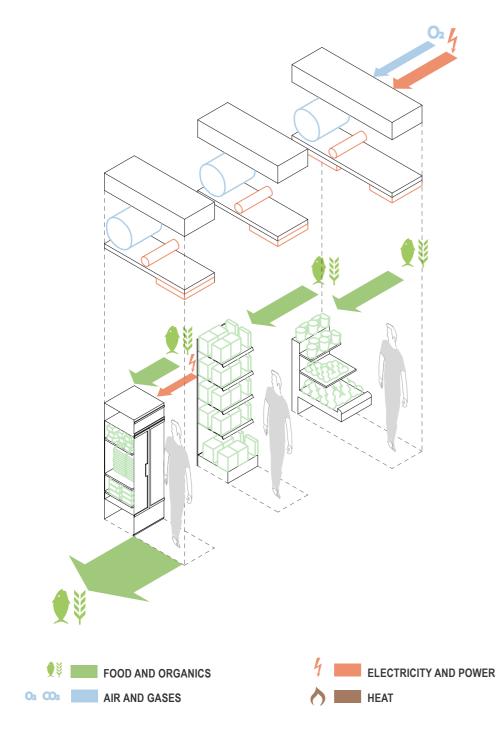
The retailers selected represent three different formats regarding to the costumers' accessibility to food products. Today, reaching a product becomes a matter of time spent. For this reason, the selection of the analyzed spaces has been defined by three diverse speed to get food and different accessibility to the goods.



Supermarket retail _ "minimal modular element"

The supermarket format offers a large variety of products to the clients. Every retail company studies in detail a strategy applicable on the layout of their stores; these study goes really in detail in order to have different techniques to display the goods.

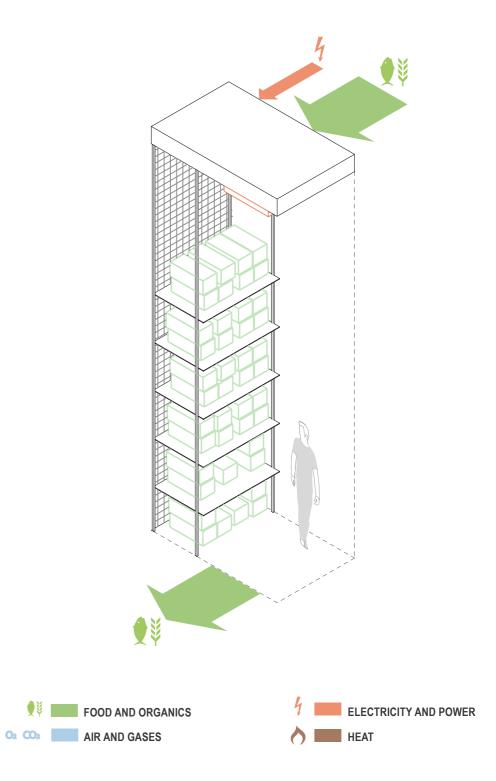
The three most used modules to display food are correlated with the product they have to exhibit. All of these techniques are lifting the product toward the hands of the consumer (height between 80 -200 cm from the floor). Light and temperature control are tool that allows a comfortable environment during the grocery time.



Self-service warehouse _ "minimal modular element"

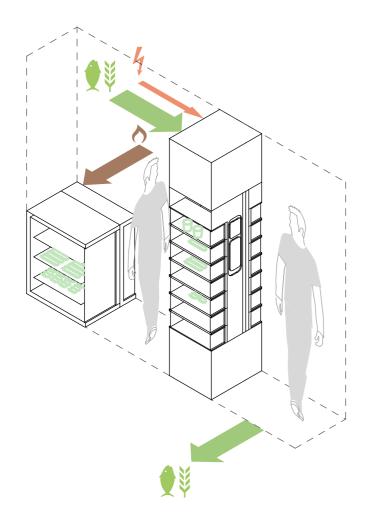
Some retail stores let the opportunity to have a different speed to access to the goods.

The shelves are larger than the supermarket one in order to offer a higher amount of products on the same height. The high ceilings leave space for tall shelves; they filled with products that are already stocked in location and employees are continuously moving them from the full higher shelves to the emptied ones.



Snack wall take away _ "minimal modular element"

The fastest retail format in order to access to food products is the snack wall. The are often present in train stations but even aside the walking paths around the city and they let to the clients a 24h access to food. The module is divided in a private space in the back of the wall, where food is continuously cooked and prepared and than inserted in the wall. This last facility is a honeybees machine filled with warm snacks. The people passing by can look inside transparent drawers, insert money and get immediately food.







5.0_ Conclusion

5.1_ Reassembly

After the analysis conducted and the representation of the minimal modules of the most advanced technologies available today for the "primary" actors which are necessary to let operative the "Food Supply Chain", it arises a critical strategy of reassembly the network in a more compact solution. It shows how can be possible to shorten the distance between producers and consumers. The strategy of creating a "Shorten Food Supply Chain" is based on three stages.

COMPACT principle takes in consideration only the necessary processes of the actual products network as the production, processes and retail modules. It removes the "secondary" activities that are stretching the distance and the time that isolate production and consumption phases. The final purpose is to diminish the use of resources for determinate products that are possible to produce and process everywhere, thanks to the available techniques today. With this scheme, there will be saved resources as space, packaging materials, energy, time, etc.

Furthermore, it is possible introduced the up-cycle technique that takes materials offered by each system and use them into another phase.

MOVEMENT principle is about linking together the essential phases of the product with a logical organization. In the existing "Food Supply Chain" the connecting role is played by the logistic actor. Transportation and movement of the goods from the producers to the processors and finally to the retailers is the fundamental factor that wisely guide the complexity of the food network toward a simple and complete picture proposed to the user.

The consumer is not anymore used to go to the production place to buy food. So, the product as to travel from the seeding laboratory to the harvesting place, throughout the shortage, cleaning and packaging processes in direction of the retail space.

INVOLVEMENT principle, the reassembled Food network has to go toward the consumer place as the urban context. This phase of the strategy considers in using architecture as a tool for constructing a diverse retail format environment. The atmosphere should drive people on the product life span during their grocery experience.

The proposed architectural principle, due to the urban food policy and demand, suggests a method that can generate competitive grocery trade approach, aiming for a new model of selling products that focuses the attention on the overall shopping experience. It creates a more intimate and innovative shopping experiences personalized to individual shoppers, emphasizing fresh, organic and prepared food options.

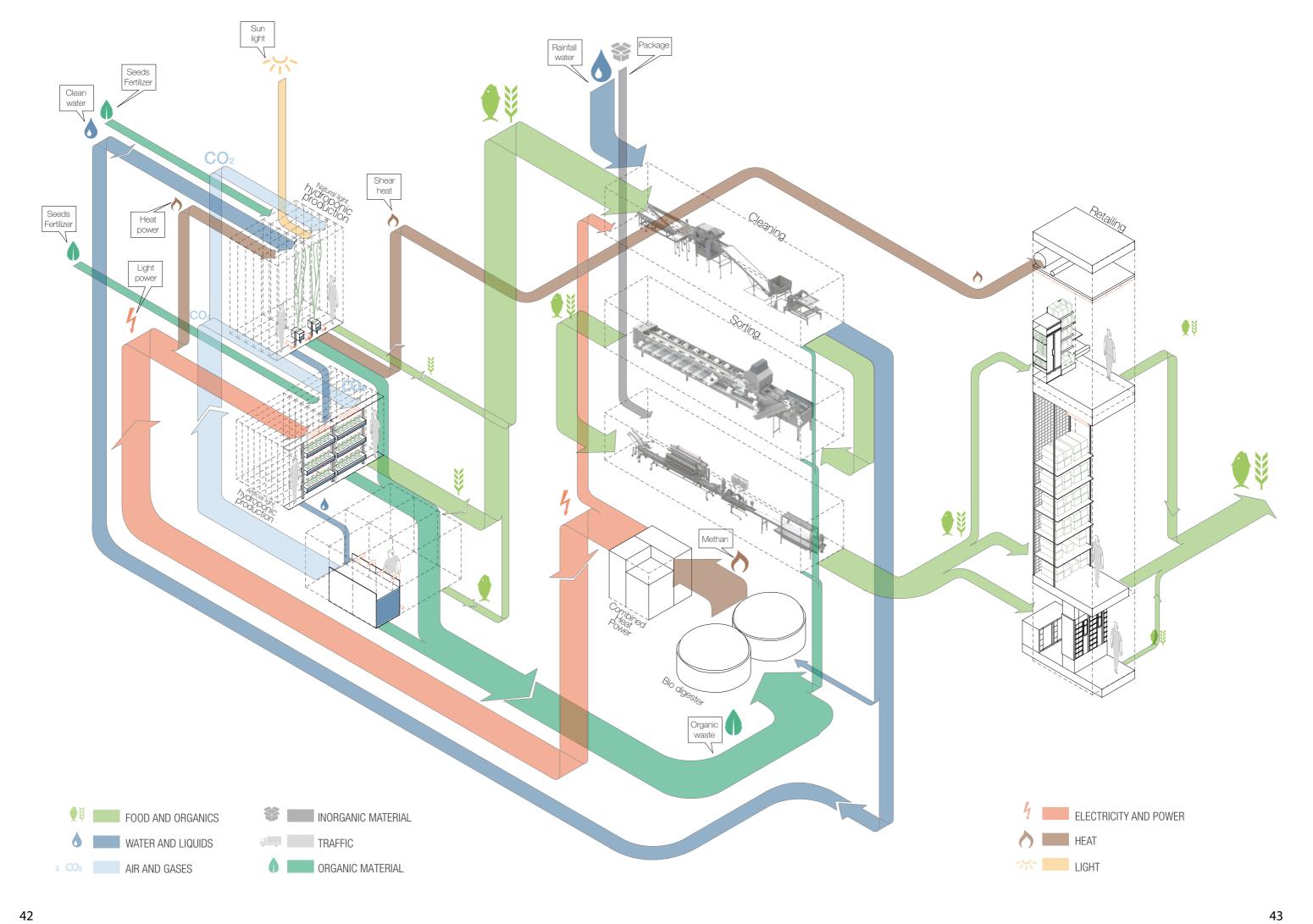
The mentioned principles represent generative points for a design proposal that reassemble the "Food Supply Chain", and its advanced techniques, in a more compact solution.

The represented modules combined within the city boundaries, aim toward a different food format that can provoke and involve people into the processes that are fulfilling our dishes.

The conceptual scheme, proposed below, shows the feasible technical flow of resources of a "compact food supply building" that aims to use the already present flows in order to reduce wastes and loss. This collaboration between food processes, It is possible only with a short distance between the different processes.

Furthermore, it up-cycle materials that in the actual "Food Supply Chain" are not possible to reuse in order to generate valuable support.

This short layout give rise to s new retail format where people can really walk through the different phases of the product they are going to eat.



6.0_ Design concept

6.1_Objective

I strongly believe that, with the nowadays technological changes, a new building typology should be developed, where all the phases of the "Food Supply Chain" should be elaborated as one: production, process and retail.

The objective is to develop a building typology that could host a space entirely dedicated to food, where all the unnecessary phases are removed, saving on time, resources and costs, and avoiding all the possible wastes related to transportation and processes. In addition to the evident economic benefits, within this new space the consumer could achieve a stronger awareness on how massive quantities of edible products are produced. The project aims indeed to create a space build up from innovations and technology, where fresh local food, respect and knowledge about health are cultivated and taught.

6.2 _Research methodology toward the design

Starting form the idea of a "Food Supply Chain" based on a complex network, the research was firstly developed by disassembling this network in single phases, and by analyzing the ones where architecture has a significant impact: production, process and retail, and the spaces related to them. For this purpose an analysis was made on the most efficient technical systems involve in the food field today, the architectural spaces that host these activities and the network of resources that are flowing between this spaces. The survey has been delineated as an investigation on the possibilities to combine different food stages under the same architectural envelop. It results in a reassembling of the this element in a more compact "Food Supply Chain", in order to lower the time spent between the production and the consumption, reducing the use of space thanks to the innovative production techniques (as hydroponic and aquaponics systems), and up-cycling the waste produced in order to generate other valuable resources.

Therefore, the used methodology consists in Disassemble – Analyze – Reassemble, and the design takes care of the third part: the Reassemble

Moreover, the research pointed out the importance of the products movement in the existing situation, mainly achieved throughout transportation and systems. For this reason a new type of movement is also introduced as a key element for the unique space designated for the new reassembled "Food Supply Chain".

6.3_ Design strategy

The design strategy takes care of the reassembly of the three element of the "Food Supply Chain". In order to achieve this goal three main principles were set as the basis and foundations to generate this new architectural typology.

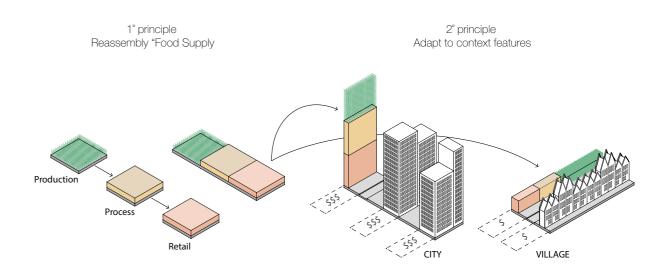
The first principle, as already stated, is to reassemble the "Food Supply Chain" fundamental phases under a unique architectural envelop. The potential of the reunion is to share spaces and resources

between the different phases. This provides a balanced overall network that reuses exhausted resources, as water, heat and biomass, for a different purpose. It result in an up-cycle flow that needs only few inputs from the external environment. This reunion leads to the abolition of unnecessary waste for transportation.

The second principle is to bring the reassembled "Food Supply Chain" envelop within the urban boundaries, where people live, work and move. This guarantees many positives aspects for the urban environment. On the technical point of view, it removes any kind of transportation, reduces the urban waste of packaging materials, lowers the carbon dioxide percentage in the air and controls greatly risks of floods. On the social prospective, it affects inhabitants' behavior on reducing the waste of food, it generates a new public space that lives in symbiosis with the greenhouse temperature effect, and it opens the access to the production process to the consumers, now, one more time, part of the process, and more aware of how his food is produced.

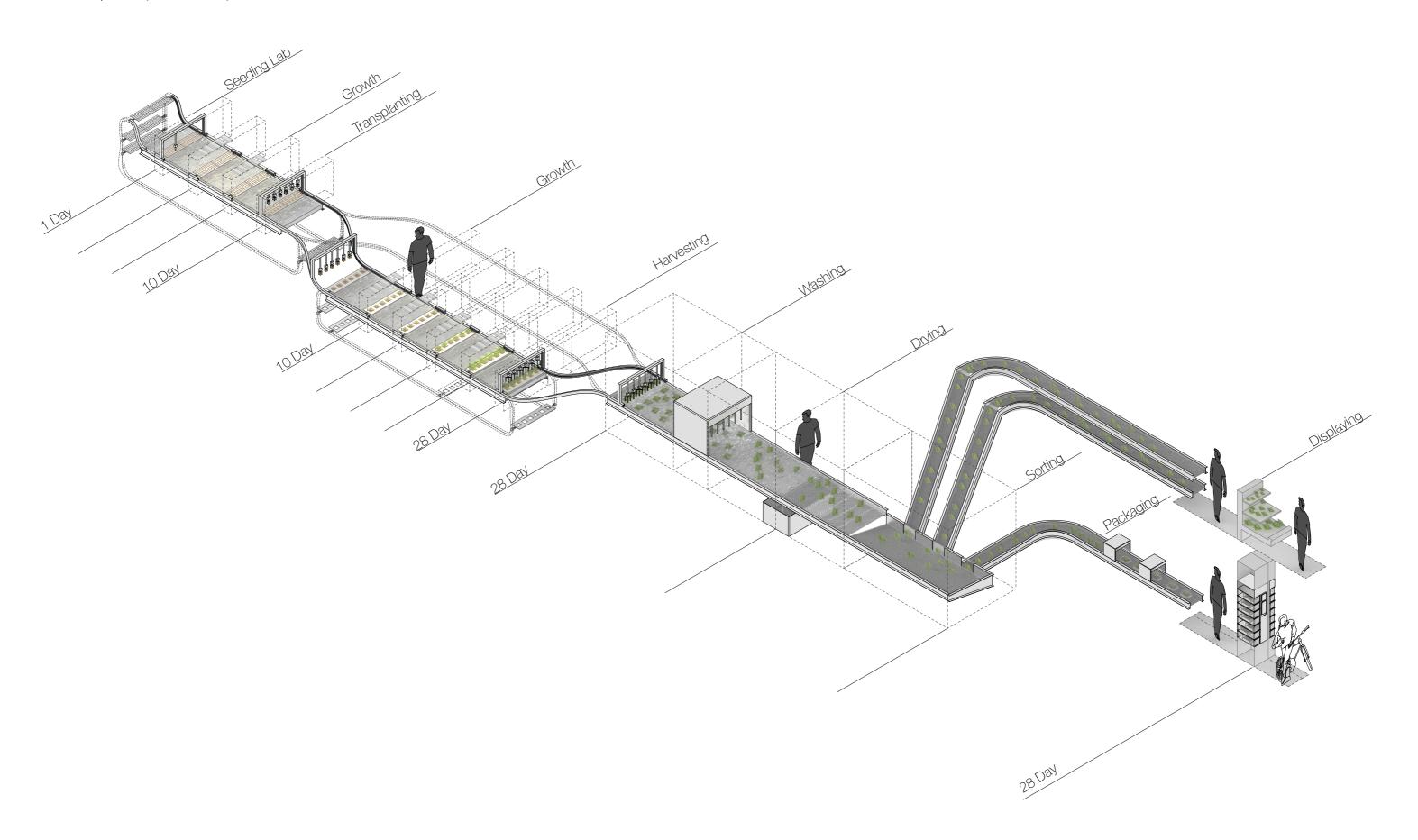
In order to achieve this new location within the city borders, the building layout has to be flexible and adaptable to any selected context. For this purpose a scalable and modular element has been designed and used as an essential tool to fulfill the resulting voids of the urban grid, where the new typology can be placed. This core element, embodied in the structure of the building, can also shape its volumes in relation to the mass demand of products for the specific urban circumstance.

For instance, I decided to choose Amsterdam as an experimental site for my project, thanks to Dutch greenhouse horticultural background. In particular, the selected site is the Marineterrein area, an urban void completely surrounded by water, where the proximity to the city center arises the value of its potential, and where the proximity to water enhances the emptiness of the site.



The third principle is to replace the transportation infrastructure that, in the actual supply network, works as connection between different phases and location. Within the new unified building, the transportation, as previously intended, has to change its face and meaning. The new needed transportation indeed acts only in the movement of the products through the building within the right time span. The facility used for this purpose is a rail system, an optimal solution to succeed in generating all of the different stages of one product at the same moment and in different positions of the building.

Rail system _ products transportation



6.4_ Project

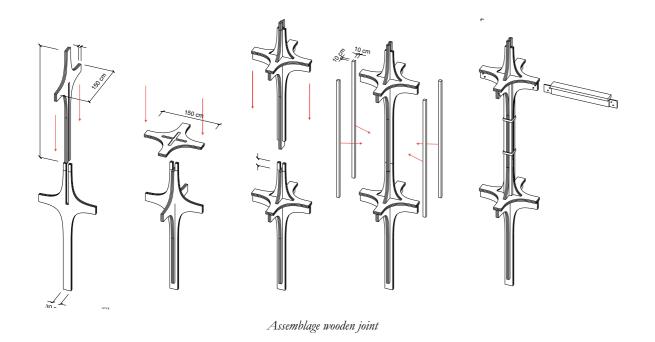
The development of the project starts from the proposal of an architectural element that can embrace the required spaces of the production, processes and retail: the structure.

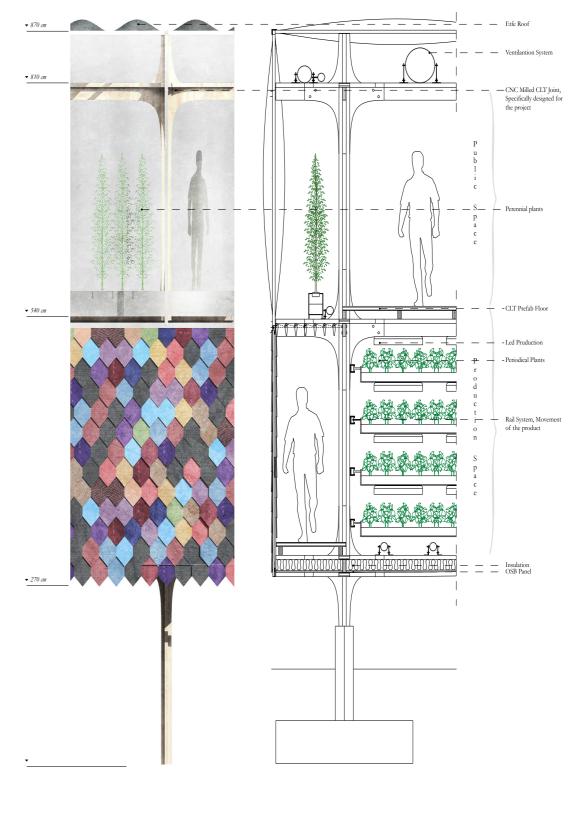
This element is composed by a CLtimber material, and is design to host and link all the technical systems and spaces required by the project, as the skeleton does for the vertebrates animals. In order to do that, it has to be modular and flexible to several different configurations, and it has been studied as easy as possible to assemble without any additional elements. This modularity also guarantees possible and future extensions.

The real potential of the structure lies in the possibility to using it as a hooker for all the other needed elements of the building, such as walkable floors, walls, systems, facades.

Moreover while the structure remains the same, the function that it host can change in relation to the spatial need.

An addition value of the structure design lies in its visual permeability, which allows the visitors to look through all the different functional spaces, and have an overall picture on how this new typology works. The possibility to watch and be part of the entire strategy is used as an important tool to increase and provide a stronger awareness about food production, and to reconcile the user with it.





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Facade 1:20 Section 1:20

As already stated, the structure represents the core of the design, and the key element for the success of a reassemble "Food Supply Chain". However, another essential element, which derives from the initial analysis, is the movement, here, embodied in the new element of the rail. The main function of this device is to move the items trough the different stages of their life and to bring them throughout the entire building toward the consumer.

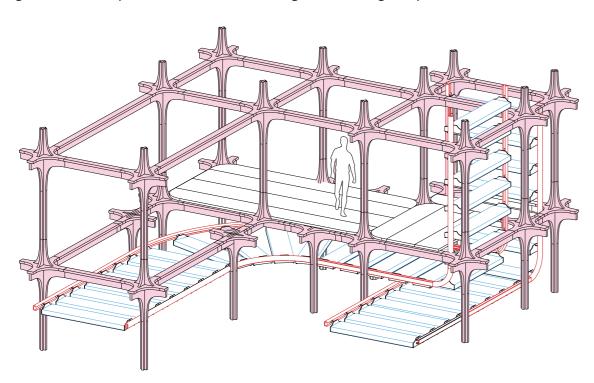
This element also acts as space boundaries, especially from a visual point of view. Its constant and rhythmic presence through the entire building make it a symbol of the new typology, and with its strong visual impact it defines spaces and functions. Moreover the rail works as a secondary structure, supporting several devices in the different part of its course, from pots for items growth in the production phase to retail display.

The rail could also be seen as the red thread of "Food Supply Chain", travelling through the different phases of production, process and retail, and acting, indeed, as the movement infrastructure that I wanted to change. With this new way of transportation also the three phases of food change their aspect and are re-elaborated within a new and unique building.

Production:

Starting from the analysis of the most innovative techniques used nowadays in food supply chain, the project starts with the design of the production phase. It is based on an "urban diet" that is composed by different products that are producible with the hydroponic and aquaponic techniques and within an artificial environment. The volumes of the production part derives from data collected by a hypothetical visitors and neighborhood demand. For this purpose a mathematical algorithm has been elaborated in order to get track of the volumes of the production and the resources needed by the demand of a certain amount of people. The parametric algorithm, in collaboration with the modular structure, allows to have an overall pictures of the first dimensions of the building but also to estimate possible scenarios of future expansion of it.

The hydroponic system, a soil-less technology, in cooperation with other systems as water, heat and lights, creates the perfect environment for the growth of the green products.



Food production Hub

Thanks to the rail device, the hydropic pots are brought within a specific time span from the seeding to the transplanting laboratories, toward the harvesting points. The growing products, depending on the travel rail length between the laboratories, travels at a certain velocity for 24 hours in order to rich a certain point of the production line at the precise maturation day. To give a production line example, a selected product as the lettuce starts its path the 1st day at the seeding laboratory where it is planted in the hydroponic pot, the 25th day will be located in the transplanting space where it is relocated in a bigger pot. The 45th day the already mature green lettuce will be at the harvesting point where it will be sold or moved to the processes sector.

The required laboratories for the production, where the visitors have the possibility to access, can be managed by specialist workers or by robotic devices that take care of the processes.

Another production device is the aquaponics system that can growth many kinds of fishes, shrimps, oysters and mussels. Working in symbiosis with the hydroponic system, the aquaponics fishes eat some nutrients that are left inside the water by the plants roots meanwhile they clean it in order to be used again.

These advanced techniques has been selected to lead a more secure, healthier and constant production, that can work for the whole year. For this purpose different climate ambiences are created, and controlled with heating systems powered by sustainable resources (heated up and powered by Combine Heat Power systems that is boosted by methane, generated by bio mass fermentation inside a bio-digester tank).

As a first action to increase the consumer awareness, within this first phase the user can already choose if being part of the production, by manual activities (seeding, transplanting, harvesting), or not, taking advantages of the mechanical techniques.

Moreover, at the end of the production phase, part of the items will be moved directly to the retail, where the user can harvest it and take it home, while the another part will be moved to the second phase, the processes.

Processes:

Sorting, cleaning and packaging are the processes present between the production and a specific retail formats. This space is dedicated to the installation of industrial manufacturing machines that processes the harvested mature products and prepare them to reach the display line. These equipment divides the items by size and quality before entering in a cleaning and packaging procedure. At last, the packages arrive in a gathering display shelve, already part of the food display retail format.

Retail:

In this new building typology, as already stated in the research conclusions, the three main themes of the food path and the technical systems are joined together with the social and public realm of the retail portion. The position of each phase settle an organized layout that guide the visitors through the life span of the products toward the access to the mature food that is gathered in the various retail formats.

Three retail experiences have been designed to let the costumer choose different ways to approach the food consumption. These spaces are fully thought to engage different human perceptions as sight, touch, smell, sound and last but not least: taste.

The only retail format that uses the industrial processing devices above mentioned is the food

display format. From this format the user can easily pick up the finished, cleaned and packed product and take it home. The display is indeed located in the end of the sorting, cleaning and packaging processes. Even if the final product is not much different from the one you could usually find in any exiting supermarket, the evident difference clearly emerge both in price of the product, way cheaper that usual, and in the possibility to see, at the same moment of the acquisition, the procedure behind it and where it comes from.

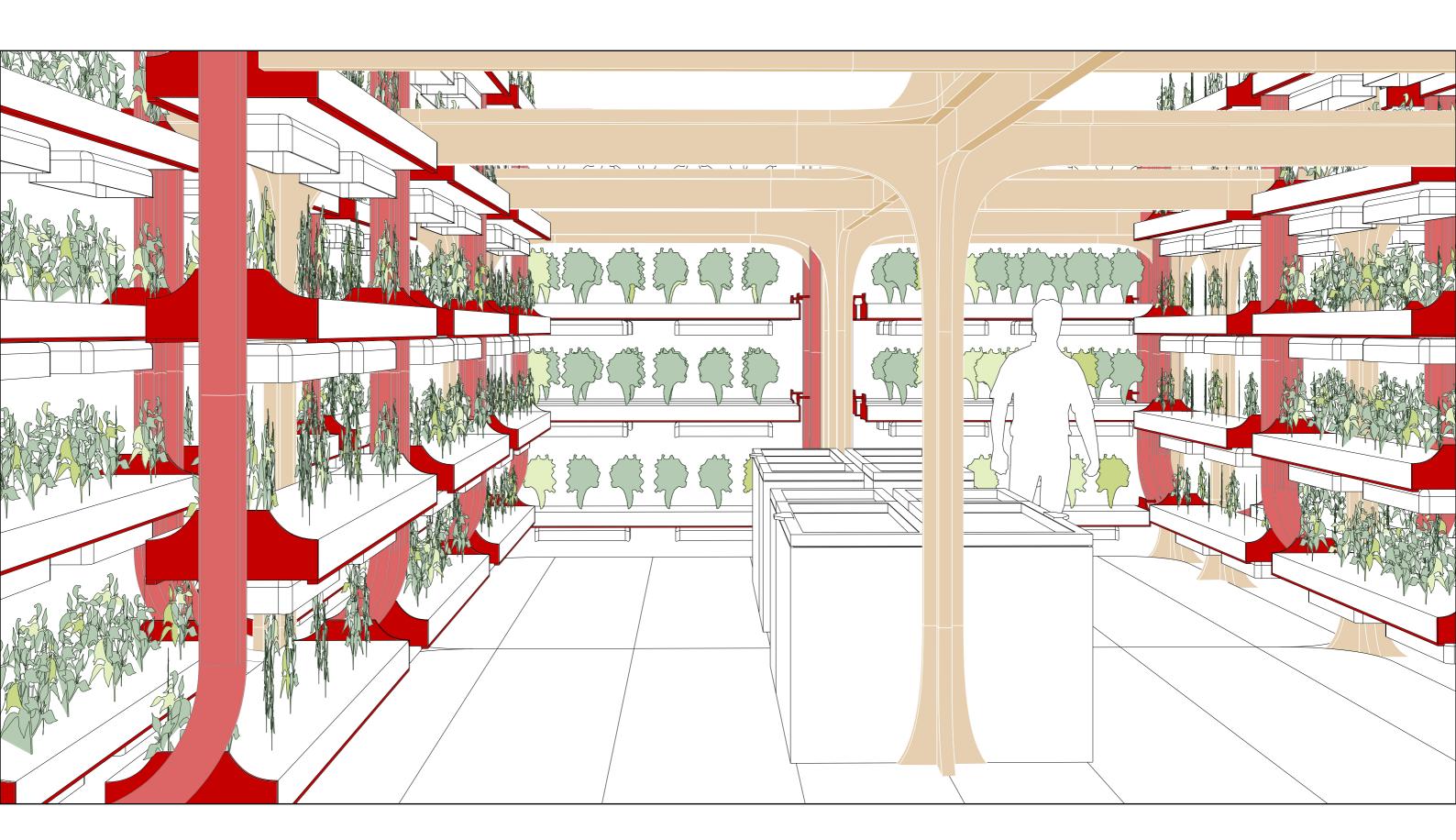
Another space dedicated to the mature food is the kitchen point format that are involving direct culinary activities as salad bars and restaurants. They are placed at the end of the production line of different products. Here the costumer can choose directly from the pots the favorite green product or from the pools the fish that is going to be cooked from the chef and few minutes later served and tasted. This retail format manually process the products.

The harvesting point format is the most direct place where the public can have a full experience in contact with the production line. It completely skips the second phase of the processes. In this precise position many mature products are ending their production path and the individuals are allowed to harvest directly the plants and fishes from the pots or the pools, buy it, and take it home. It is the most interactive retail format where people use their hands to act as tool.

With this new building typology production, processes, retail and culinary experiences are combined together in other to be part of the same atmosphere and let the visitors walking by all the phases and be informed on the products life span. The efficiency of reassembling the production phases in the unique design strategy results in a project that investigates on the strong connection between food products and the architectural disciplines. The thesis aims to develop a critical project, and as such it tries to propose an alternative scenario to an existing situation.







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