# Mycomorphosis

## Access to Tools for Urban Waste Flows

**Migration of Mycoremediation**

Thanat Prathnadi

Keywords: Mycelium, Mycoremediation, Water,
Waste Flows, Urban Agriculture

### Abstract

The migration of ideas implies the movement of ideas, thoughts, philosophy, knowledge, or other non-physical conditions from one space and/or time to another, where they are activated and manifested. As a result, this may purposefully or accidentally effect other existing conditions in a different setting, thereby giving birth to new ideas or phenomena. The thesis aims to investigate in particular the migration of mycoremediation, the method of environment decontamination through the biological properties of mycelium. The project speculates on the emergence of the mycelium industry as an autonomous mode of production within a circular economy for the Maashaven commons in the year of 2050, while investigating the utilisation of mycoremediation technology as an apparatus for confrontation against current site-specific environmental issues such as water and air pollution, and urban waste flows. Furthermore, the research aims to explore how digitisation and mechanisation in urban agriculture and waste management are manifested within Rotterdam, while seeking to unveil human's relationships with water in an urban context.

### Introduction

**"We have not been seeing our Spaceship Earth as an integrally-designed machine which to be persistently successful must be comprehended and serviced in total."**

R. Buckminster Fuller, 1969

In 'Operating Manual for Spaceship Earth', Buckminster Fuller introduced the notion that Earth should be treated as a mechanical vehicle that requires constant maintenance, whereby all humans are parts of the crew. This objectification of Earth gave birth to a revolutionary method of critiquing humans' exploitation of the planet's resources in the Anthropocentric age. Such idea was further reinforced by the term 'Hyperobjects', explained by Timothy Morton (2013) as "things that are massively distributed in time and space relative to humans". In such case, hyperobjects can be used to describe abstract yet impactful notions such as climate change, allowing new questions to be formulated around the physicality of such traditionally obscure terms.

The collage suggests and illustrates project interests and architectural qualities, such as vertical mushroom cultivation, wastewater management, and urban waste flows (made by author, 2020)



The collage illustrates the current impacts on Earth's ecological systems caused by the Anthropocene, including water toxicity resulted from wastes and resource extractions. (made by author, 2020)

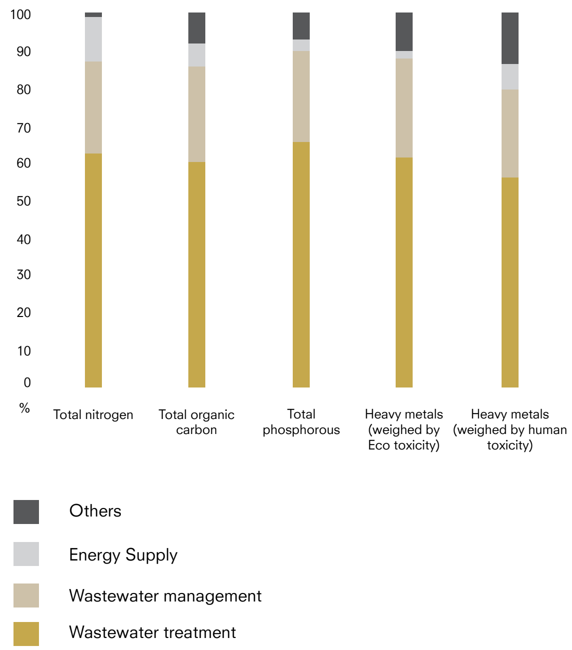
## Water Pollution

The toxicity caused by the Deepwater Horizon oil spill in 2010 still continues to affect the biodiversity in the Gulf of Mexico and its surroundings until today (National Geographic, 2020). All life depends on water, yet human activities have posed serious threats to the ecological conditions of water bodies on Earth, and the Netherlands is no exception. In addition to being the busiest port in Europe (Eurostat, 2020), the Port of Rotterdam is also home to a large industrial and energy complex, with more than 45 chemical companies and five refineries (Port of Rotterdam, n.d.). Regardless of its historical status and technological advances, such industrial activities pose major environmental issues within the surrounding waters. Data published by the European Environment Agency (2015) indicates that the Netherland's water bodies perform poorly with regards to environmental conditions, with more than 90% of classified water bodies both 'affected by pollution pressures' and 'holding less than good ecological status or potential'. Further studies also show an average of 85% of all pollutants in industrial water (nitrogen, organic carbon, phosphorous, and heavy metals) having come from wastewater and waste management industries. (EEA, 2020) Furthermore, an additional study on water quality element status has categorised Rotterdam's transitional water body as 'bad (5)', while giving the same score in the categories of 'ecological status or potential value' and 'biological quality elements'.

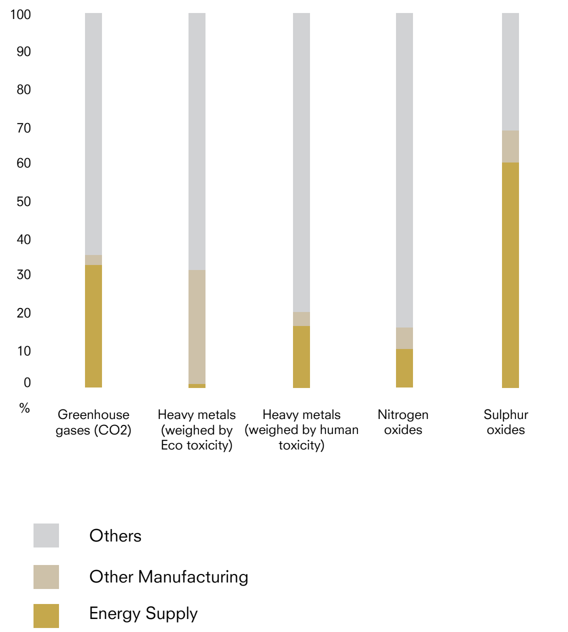
## Air Pollution

In addition to the effects on Rotterdam's water bodies, the port's industrial activities also contribute to a large percentage of air pollution within the Netherlands and ultimately the European Union. According to a similar study by EEA (2020), 33% of industrial greenhouse gases ($CO_2$ equivalents) emission can be traced back to the sector of energy supply, specifically coal, oil, and natural gas. Although port activities have moved towards the North Sea, further away from the city centre throughout the years, the emissions still have direct impacts towards the environmental conditions within the region as a whole. Moreover, the physical and visual disconnection between the port and the city also seem to allow most of the inhabitants to maintain their daily lives without constantly being aware of the port activities and its negative impacts on the environment.

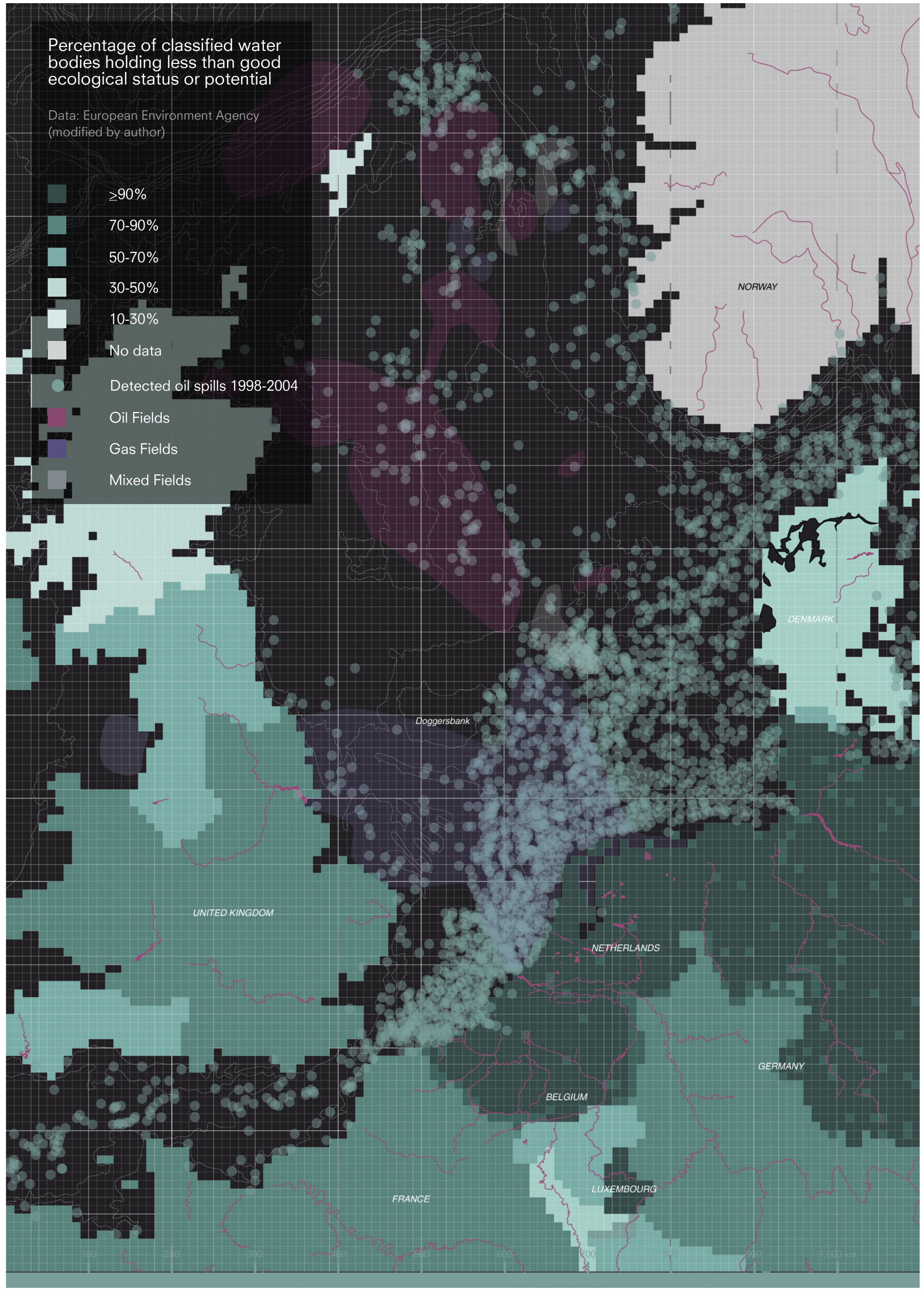
Industrial water releases as a percentage of country total by sector, Netherlands, 2017 (data: EEA, modified by author (2020))




Industrial air emissions as a percentage of country total by sector, Netherlands, 2017 (data: EEA, modified by author (2020))

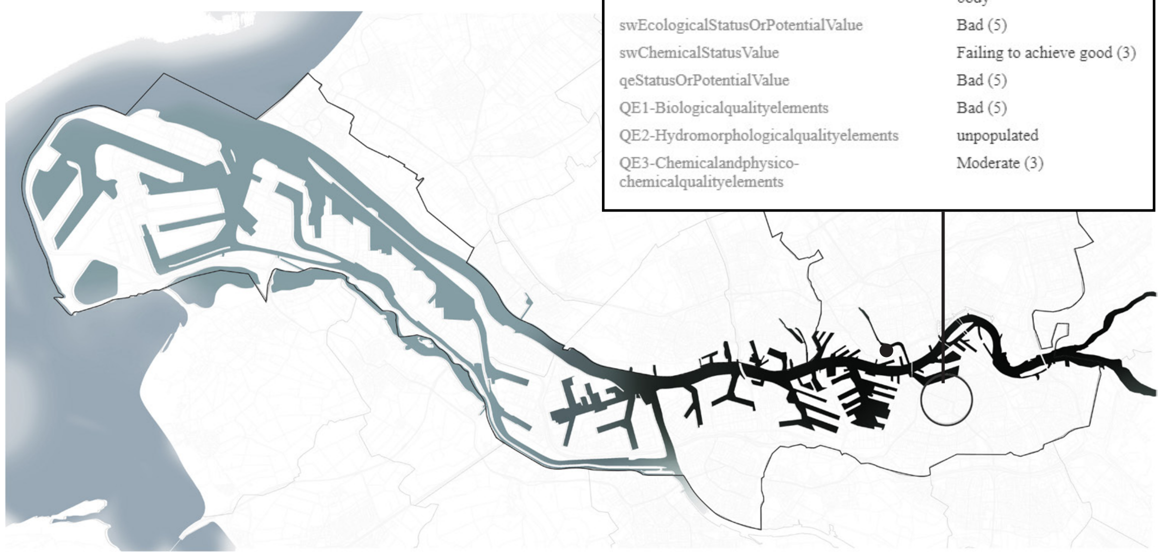





The map shows a strong corrolation between human activities (oil spills shown in circles) and impacts on ecological systems (dark green indicates areas with low ecological marine status. (data: Joint Research Centre, Ispra & EEA, modified by author, 2020)

| Quality Element Status - Bad (5) | |
|---|---|
| euRBDCode | NLRN |
| euSurfaceWaterBodyCode | NL94_8 |
| surfaceWaterBodyName | NIEUWE MAAS |
| surfaceWaterBodyCategory | Transitional water body |
| naturalAWBHMWB | Heavily modified water body |
| swEcologicalStatusOrPotentialValue | Bad (5) |
| swChemicalStatusValue | Failing to achieve good (3) |
| qeStatusOrPotentialValue | Bad (5) |
| QE1-Biologicalqualityelements | Bad (5) |
| QE2-Hydromorphologicalqualityelements | unpopulated |
| QE3-Chemicalandphysico-chemicalqualityelements | Moderate (3) |

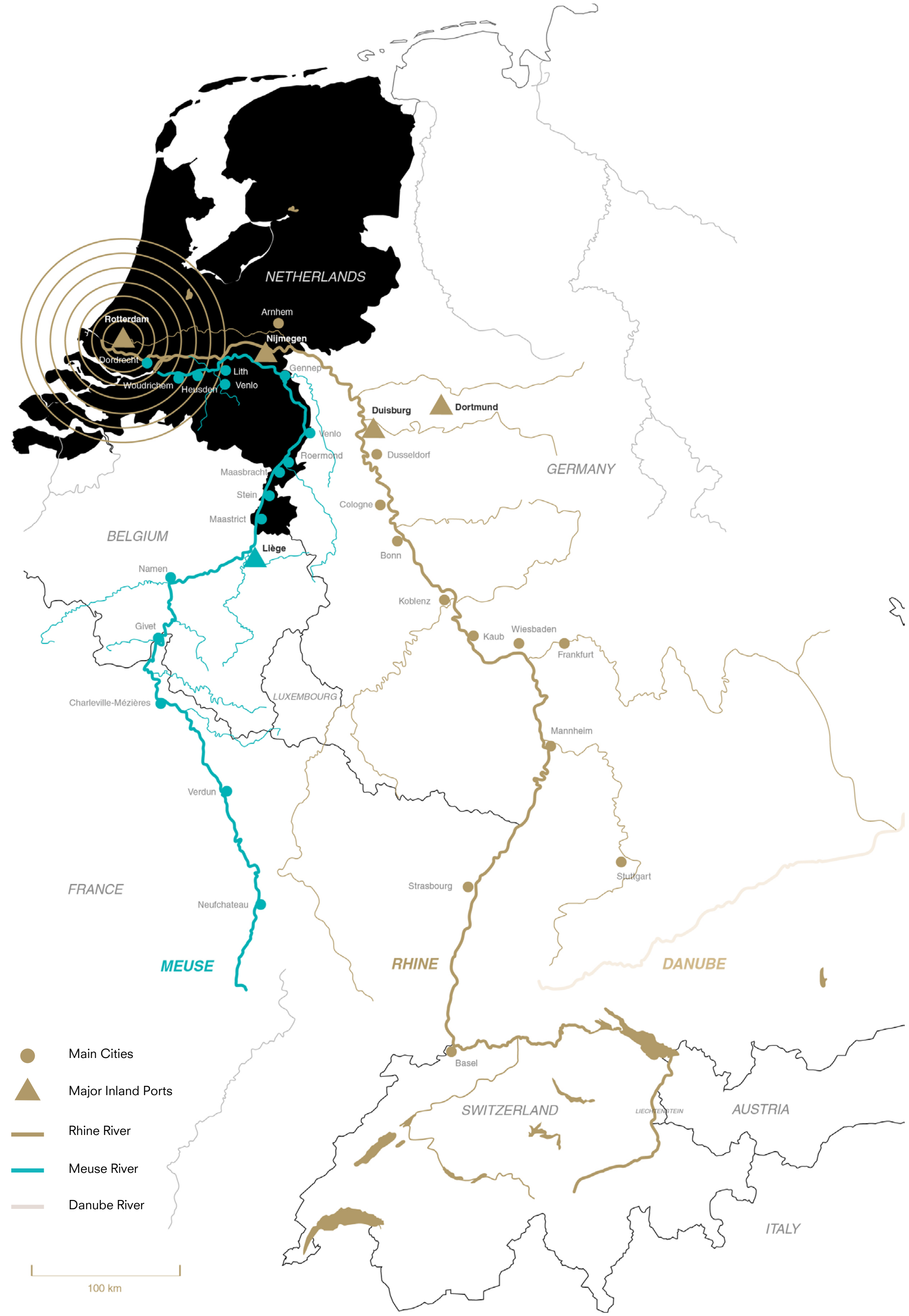


Percentage of classified water bodies affected by pollution pressures (rivers /lakes). The urban water bodies are more 'polluted' than those around the port areas.
source: European Environment Agency (modified by author, 2020)

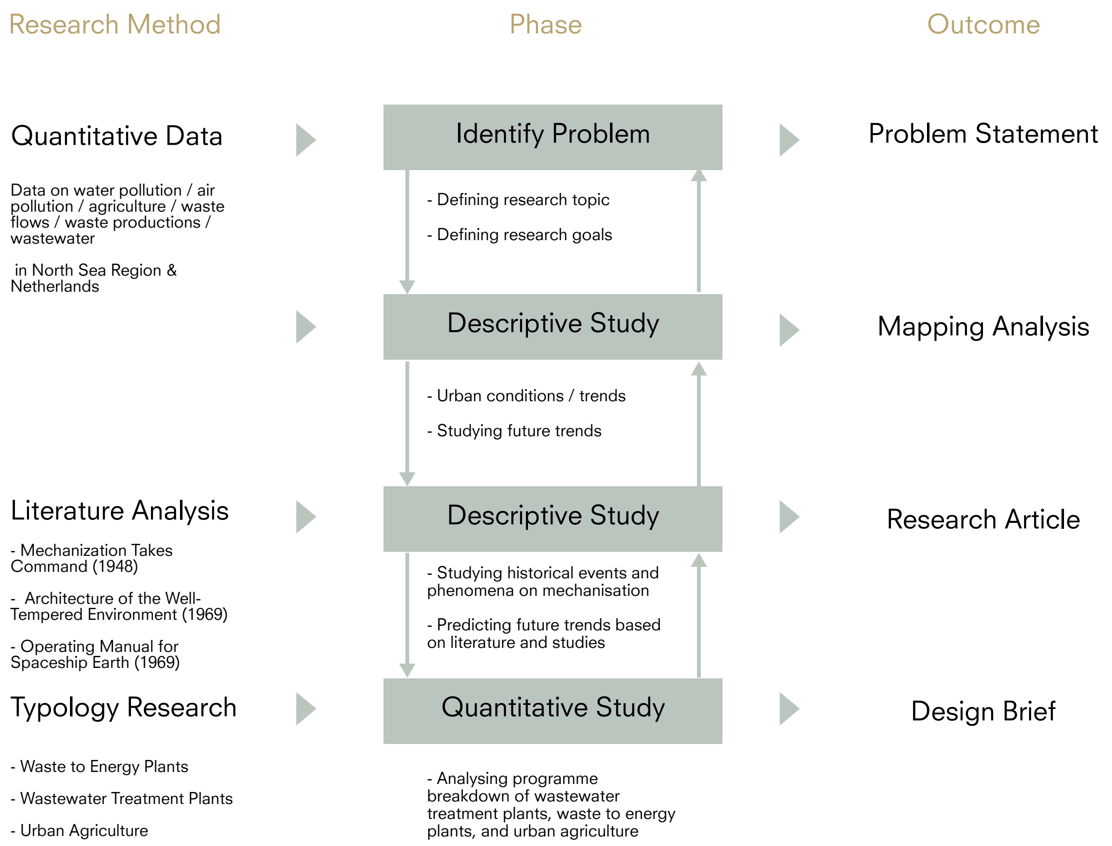
European Inland Water Network

(opposite) Corresponding to the group vision, the project location along the harbour of Maashaven which becomes a new European inland shipping hub provides an opportunity for the intervention to act as an inter-connected node with the national and international waste flows, responding to both the North Sea logistics and the eastern inland shipping routes via river Rhine, Meuse and Danube.






European Inland Water Network (made by author, 2020)




The research methodology is divided into four main stages (made by author)



## Research Question

**How can urban agriculture act as a catalyst for confrontation against urban waste flows?**

- How does mycoremediation unveil toxic water and wastes through architecture?

- How can the fourth industrial revolution be manifested within mushroom cultivation and waste management?

## Research Methodology

The research aims to explore the applications of mycoremediation in architecture and the emergence of the mycelium industry as a possible connection between urban agriculture and waste management. Therefore, the research phase is divided into five main sections: identifying the problem statements, evaluating the context's environmental conditions and issues, investigating the relationships between future technologies, urban agriculture and waste management, and understanding spatial requirements through typology research.

The first research phase will be completed through collecting quantitative data regarding the environmental conditions of the context through various online databases, such as Eurostat and European Environment Agency. The data gathered is used to identify the problem statements of the research, such as water and air pollution and urban waste flows. Then, a descriptive study will be performed through mapping and data analysis using similar sets of data in order to gain a thorough understanding of different conditions of the context and its past, present and possibly future. This includes topics such as water pollution, soil contamination, sea level rise, and urban waste flows. These studies will be supported by various literature written regarding the Netherlands and its relationship with water, and how it has evolved throughout the years.

In order to investigate the roles in which future technologies will play within urban agriculture and waste management, literatures on the relationships between humans and mechanization, and the age of the Anthropocene's impacts on Earth's geology and ecosystems will be used to inform a descriptive study. Operating Manual for Spaceship Earth by Buckminster Fuller (1969) serves as a key literature used to formulate questions around the existence of Earth as an object and how human activities should be reconsidered, while Hyperobjects (Morton, 2013) introduces a further elaboration of the objectification of abstract ideas such as climate change. Furthermore, Sigfried Giedeon's Mechanization Takes Command (1948) explores man's historical relationships with mechanization and explains in detail the gradual shift towards specialization, specifically with regards to agriculture. Such historical events and phenomena form a crucial role in the investigation in order for future trends to be predicted.

Finally, analyses and quantitative studies based on the typological research of waste to energy plants, wastewater treatment plants, and urban agriculture will inform the spatial ergonomics and distribution of each programme within the proposed intervention, allowing the design brief to be formed as an end result.

## The Next Economy, Rotterdam

Preliminary urban analysis and research suggest that Rotterdam Zuid possesses a potential to become a major district within the polycentric characteristics of Rotterdam and a major mobility node with immense potential for future development. However, the analysis also found that compared to other districts of the city, Rotterdam Zuid consists of a large number of low-skilled migrant workers with significantly low average income. Along with other factors, this set of data poses several potential economic, social, and political issues to be confronted by Rotterdam Zuid in the near future. With the city's future job trends shifting towards digitised and automated manufacturing and high-skilled workers, inhabitants with low education level are at risk of long-term unemployment. The first question posed during the preliminary research was whether or not architecture can act as a catalyst to generate a future-proof identity, education, skills, and ultimately revenue to the low-income neighbourhoods within an urban regeneration framework.

According to Cities of Making, Rotterdam City Report (2018), analyses composed by urban design researchers at TU Delft suggest that Rotterdam's next economic trends will consist of three key industrial sectors: agro-food, life science & health, and cleantech. These sectors will play a major role in supporting the city's horticulture and port industry which have been crucial in Rotterdam's economy, due to the country's natural conditions and landscapes. Shifting the attention back to the site, the second challenge was to investigate how and if there was a common denominator between the three sectors mentioned prior which could potentially act as an income generator for Rotterdam Zuid, while providing long-term high-skilled careers amongst the current inhabitants.

Through preliminary researches on the topic and its relevance to the context of the Netherlands, a unique connection was speculated with a seemingly unrelated scientific topic of **mycelium**. Essentially the vegetative part of a fungus or fungus-like bacterial colony, mycelium or mushroom production is not an unknown industry in the Netherlands. With the Dutch being the world's second largest exporters of mushrooms with over 50 million kilograms exported per year, there are approximately 5,250 mushroom species in the country. In addition its role as food, mycelium also provides a number of possibilities within its innovations. This versatility may offer Rotterdam Zuid an overlooked potential as a circular and autonomous mode of production.




Key Sectors, Cities of Making Report

**AGRO-FOOD**

Horticulture
(crop cultivations in controlled conditions)

Food production

**LIFE SCIENCE & HEALTH**

Health research & development
Medical innovations
Robotics
Pharmaceutical industry

**CLEANTECH**

Sustainability
Renewable Energy
Waste Management
Recycling

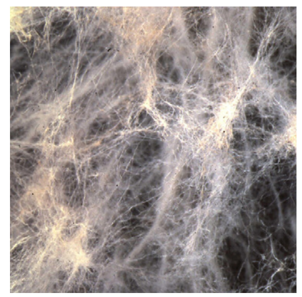
▼

**FUNGI-BASED PRODUCTION**

Mycelium-based material production

Mycelium as construction material

Mushroom plantation
plant-based meat



**MYCOLOGICAL RESEARCH**

Mycelium health research

Fungi-based medication

**MYCOREMEDIATION**

Decontamination of toxic soil/ wastewater

through fungi-based technology

Mycofiltration

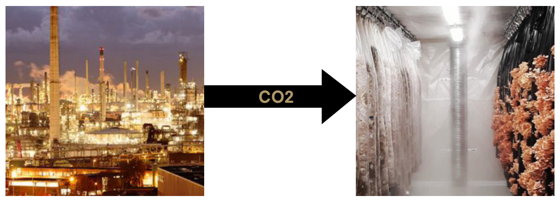
## Urban Agriculture

Not only is the Netherlands a major exporter of mushrooms, it is also an agricultural powerhouse, only ranked behind the United States in the value of world food export. (Viviano, 2017) However, the presence of such a large industry has also allowed the country to become one of Europe's biggest producers of agricultural waste, with almost five million tonnes produced in 2008 alone. (eurostat, 2020) Furthermore, regardless of the vast production scale of agriculture within the Netherlands, Foley (2014) argued that the world's crop production needs to double in order to feed the 9.7 billion population (as projected by the United Nations) in 2050. However, simply scaling up the operation may lead to more problems than solutions. Data suggests that almost 40% of ice-free land on Earth has already been used for agriculture, and the world currently comprises of less than 50% of undeveloped land. (Foley, 2014)

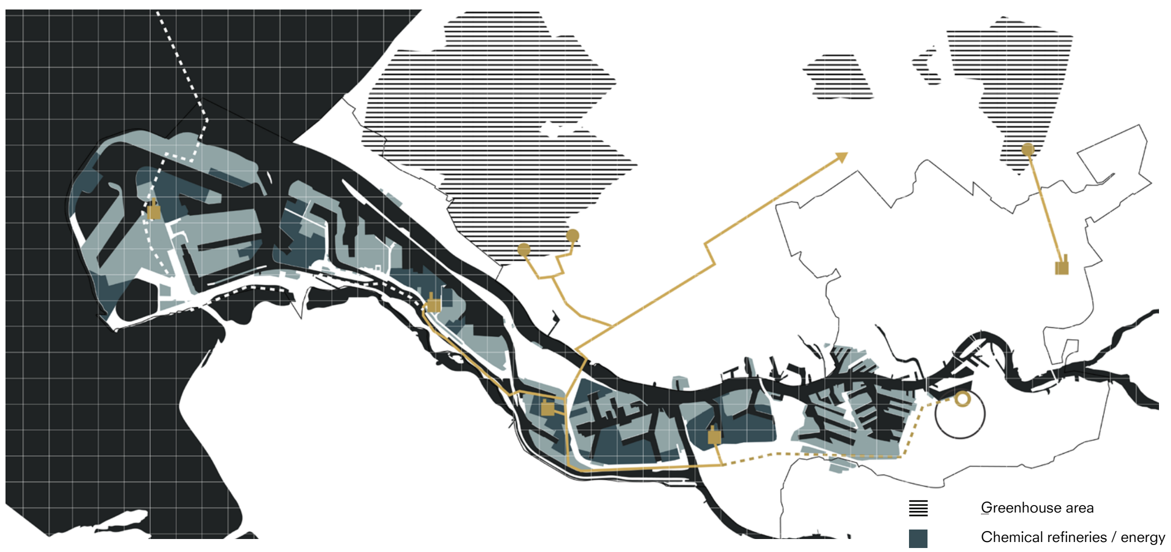
Researches on vertical farming offer an emerging alternative to traditional methods of agriculture. Relying on the verticality of space within urban contexts and hydroponic methods, the usage of space is drastically reduced, while the water footprint is minimised to 10% of traditional farming methods. (hortidaily, 2020) Additionally, the presence of vertical farming in urban settings further reduces total CO2 emissions caused by the transportation of products, a major environmental drawback of the last-mile delivery within traditional farming's supply chain. (hortidaily, 2020)

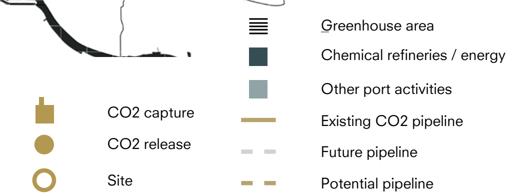
CO2 upcycling

As a response to the current issues surrounding CO2 emissions from Rotterdam's industrial activities, the research will also investigate on the possibility of transferring the released CO2 from the port areas to benefit the cultivation of mushrooms, with the growth phase requiring "a high concentration (10,000 - 20,000 ppm) of carbon dioxide" (Senseair, n.d.). As an existing initiative for CO2 emissions in 2050, Port of Rotterdam (2016) have already suggested the possibility of transporting the CO2 produced by the industrial activities through pipelines to greenhouses within and outside of Rotterdam.




Tranferring port CO2






Potential pipeline extracting CO2 from refineries to building (made by author)



## Mycoremediation

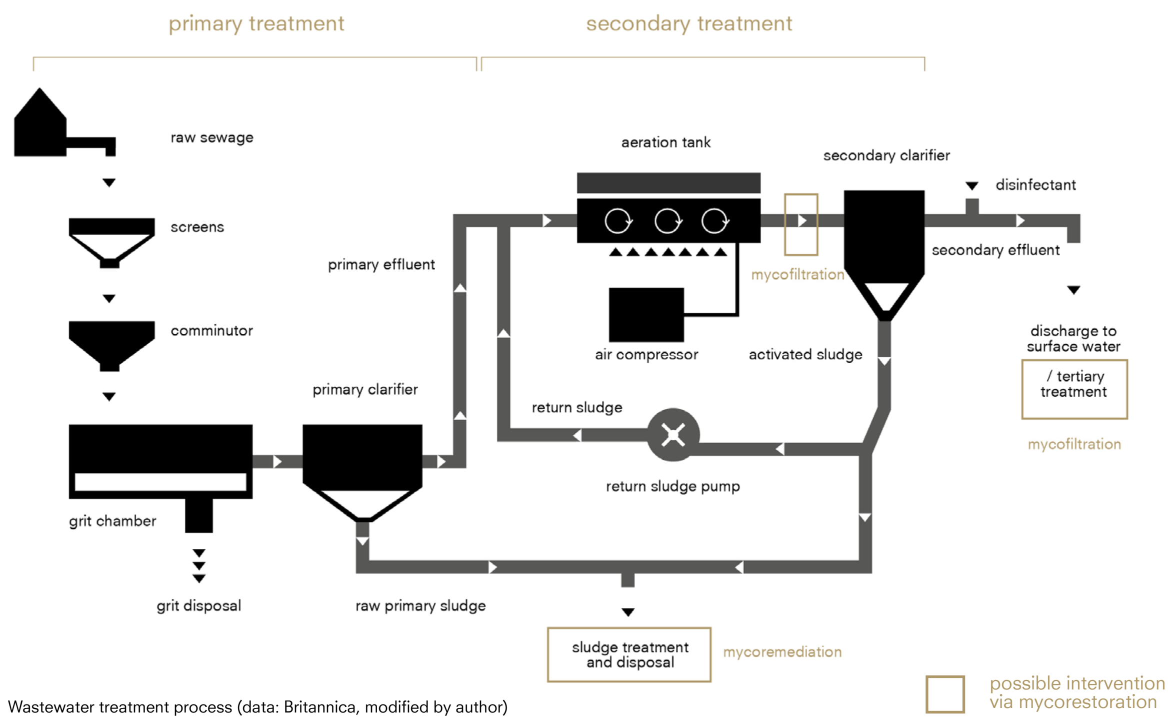
With regards to its environmental effects, data has shown that mushroom cultivation consumes a staggeringly low amount of water footprint when compared with other crops and meat productions. While one kilogram of sugar crops, vegetables, fruits, nuts, and beef requires 197, 322, 962, 1,020, and 15,415 litres of water respectively (waterfootprint.org), the same amount of mushrooms only consumes an average of fifteen litres, making it one of the most sustainable food products humans have cultivated. With topics concerning irrigation and water usage, such unique characteristics allow the focus to be shifted from finding an adequate source of water in an urban setting to highlighting environmental issues regarding natural resources. This includes water pollution, which is a highly relevant and applicable topic of concern within the context of the Port of Rotterdam, where countless industrial activities have caused direct impacts on the Nieuwe Maas and the surrounding water bodies.

As long as water remains the most crucial ingredient in the industry of agriculture, such environmental issues will be directly related to urban agriculture and mushroom farming. Current technologies for environment decontamination are often ineffective and expensive. However, supported by emerging technologies such as machine learning and artificial intelligence, perhaps humans should turn to bioremediation for possible answers. Hence, the next goal of the thesis is to explore the potential of mycoremediation, the decontamination of toxic environment through fungi, and the role it may have alongside the future of urban agriculture as a possible method of confronting water, soil and air quality issues.

Mycoremediation - chemical process

Enzymes produced by fungi break down hydrocarbon bonds in petroleum/pollutants in water and soil

Enzymes remanufacture hydrocarbons into carbohydrates to feed the mushrooms



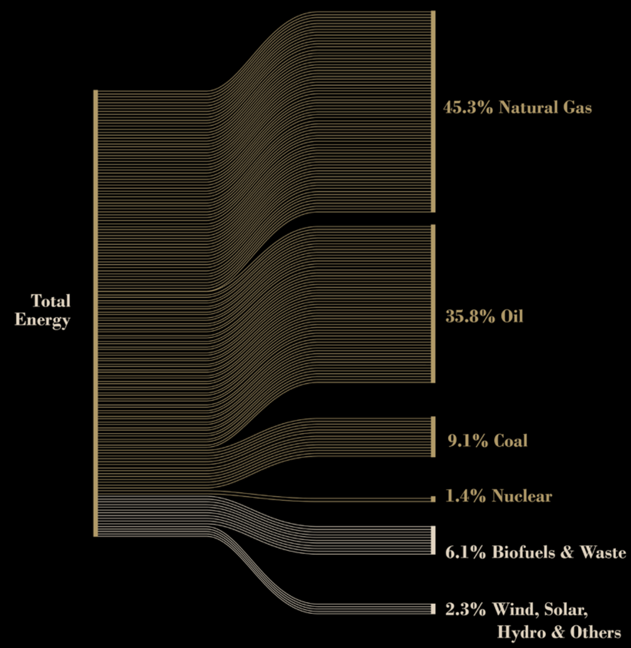

Wastewater treatment process (data: Britannica, modified by author)

## Waste to Energy

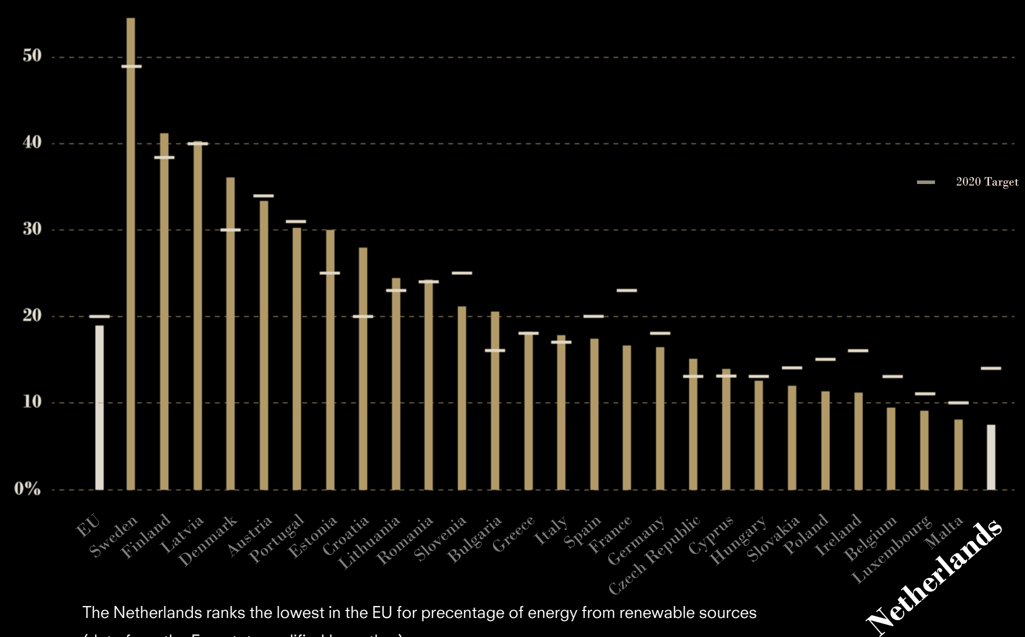
“We cannot afford to expend our fossil fuels faster than we are “recharging our battery,” which means precisely the rate at which the fossil fuels are being continually deposited within Earth’s spherical crust.” (Fuller, 1969)

According to the Rotterdam Energy Transition Plan, the city aims to become carbon-neutral by 2050. However, data from Eurostat (2018) shows that the Netherlands ranks the lowest in the EU in the percentage of energy usage from renewable sources. With less than ten percent of its total energy consumption being derived from renewables (iea, 2019), an increasing pressure lies on major port cities such as Rotterdam to transition its energy sources as soon as possible.

The United Nations (2011) estimated that one third of all food is wasted every year, resulting in ten percent of the total greenhouse gas emissions on Earth. Such wastes, along with organic wastes such as agricultural waste and manure, present a possibility of being transformed into biogas as a renewable source through the creation of methane via anaerobic digestion, or syngas through the process of gasification. In relation to the whole systems of agriculture and waste management and treatment, such production of clean energy presents a self-sustaining method of energy distribution both within the intervention and potentially the surrounding neighbourhoods.




Less than 10% of all energy usage in the Netherlands comes from renewable sources (data from iea, modified by author)




The Netherlands ranks the lowest in the EU for precentage of energy from renewable sources (data from the Eurostat, modified by author)



## Research to Design

Expanding from the aforementioned research topics and theoretical aspects discussed in the literature review, the aim of the contribution is to translate and integrate the notion of urban agriculture through mushroom cultivation to the physical aspects of urban waste flows, by establishing an architectural intervention that provides a platform for both systems. The architectural goal is to represent the possible symbiosis between waste and agriculture, while physically exposing the stages in which different processes occur. Such interactions, combined with additional layers of public functions, can be informed through the proposal of a Research Centre for Mycoremediation and Waste Management. The project serves as a set of highly conditioned spaces based on each programme’s primitive functions, exploring how various factors such as temperature, humidity, brightness, and CO2 level effect each activity within. Such urban exposures of environmental conditions establish a new set of standards for the environmental qualities of the surrounding contexts in an engaging manner. Furthermore, the by-products of wastes are transformed into valuable outputs such as fertilizers and clean energy used in the building and distributed within the neighbourhoods, allowing for a circular system to be constituted.

Giedion (1948) suggests that by the age of the agricultural mechanization in the mid nineteenth century,

**“the structural change from self-sufficiency to specialization is irresistible. To remain in competition, the farmer must narrow himself to specific products.”**

(p.131). However, Fuller (1969) also argues that “extinction in both cases was the consequence of over-specialization. [...] specialization always do away with general adaptability.” Thus, the design challenge is to investigate a balanced distribution between the specialised and exploratory programmes of the mycelium industry, and the more scientifically proven functions of waste management.

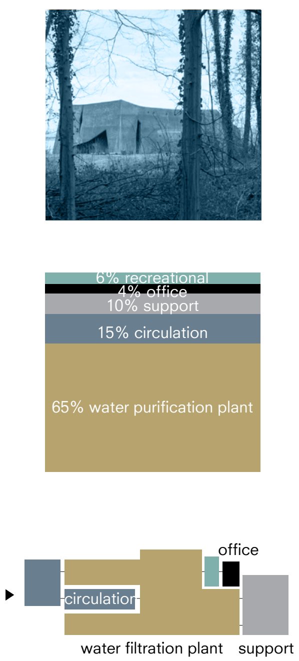
Such dichotomous programmatic division allows for a more autonomous set of systems within the architecture, where each system can function individually by itself while ultimately benefiting from each other, forming an assemblage of intricate systems. Furthermore, the architectural features within the intervention aims to intertwine the mechanical systems of the laboratories with the ecological systems of the water and mushroom cultivation, while using water features as a visual guidance throughout various programmes.

## Typology Research

Through the typological research of waste to energy plants, wastewater treatment plants and urban agriculture, a set of estimated floor areas per category was adapted based on the site-specific conditions and plot area. Upon analysing three waste to energy plants of different scales, it is concluded that the plants consume around half or more of the total floor area of the building, with a possibility of including recreational functions as a supporting programme to the building. Similarly, the mechanical systems within wastewater treatment plants also require more than half of the total footprints, however it is not uncommon to observe recent architectural interventions 'hiding' the treatment plants in enclosed spaces while covering the surfaces with public and recreational functions. Lastly, the analyses of urban agriculture projects suggest a large versatility within the nature of the programme, ranging from ten to 90 percent of the building footprints. Such adaptability allows for a freedom of supporting functions, suitable for urban contexts where a mixture of programmes is to operate within one building.

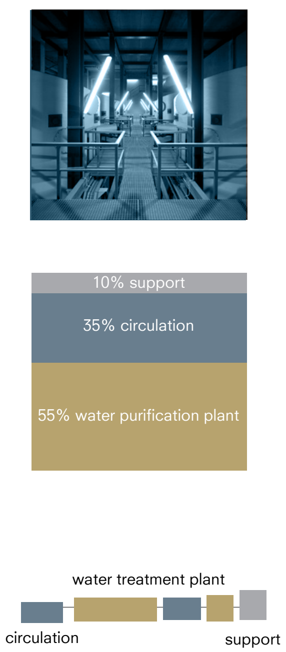
- Wastewater Treatment Plant
- Urban Agriculture
- Waste to Energy Plant

### Muttenz Water Purification Plant
Muttenz, Switzerland



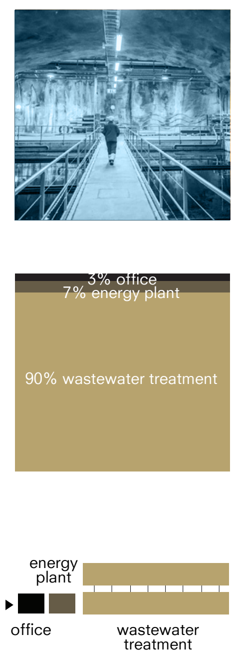

1,850 m²
N/A

### Alcantara Wastewater Treatment Plant
Lisbon, Portugal



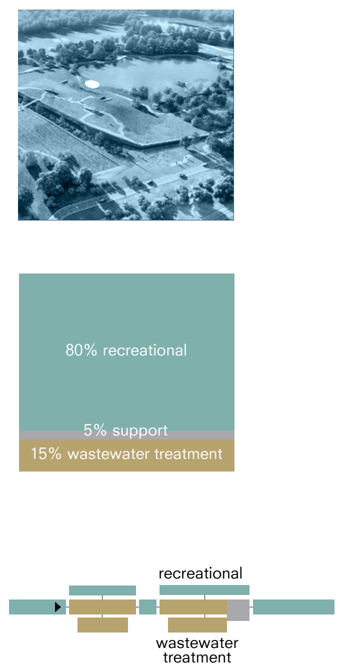

30,000 m²
800,000 households

### Käppala Wastewater Treatment Plant
Kappala, Sweden




130,000 m²
700,000 households

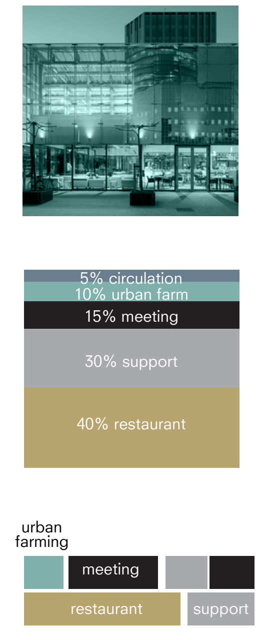
### Solrødgård Water Treatment Plant
Solrødgård, Denmark




88,000 m²
N/A

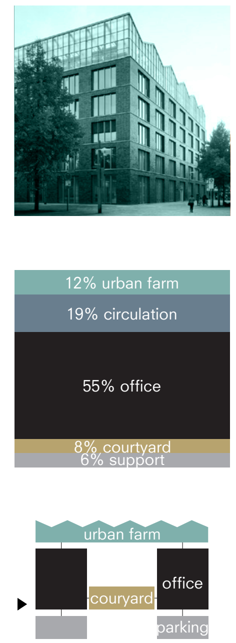


### The Green House
Utrecht, Netherlands



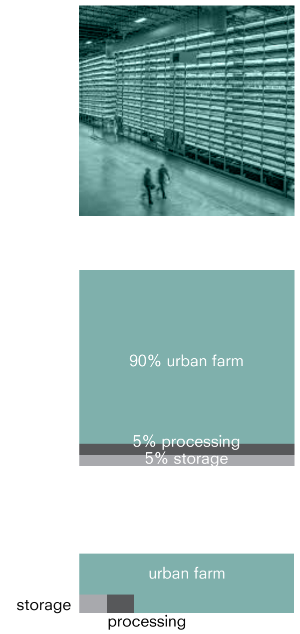

680 m²

### Oberhausen Administration Building
Oberhausen, Germany



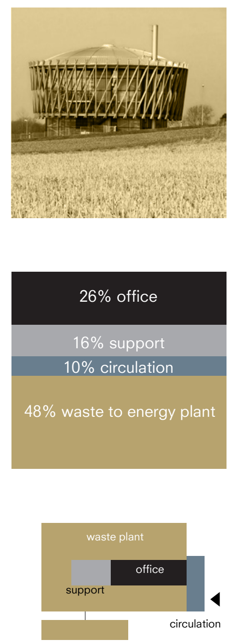

7,839 m²

### AeroFarms
Newark, NJ, USA



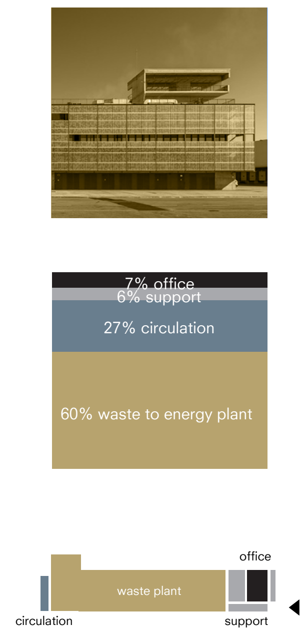

8,000 m²

### Bio Mass Power Plant
Schwendi, Germany



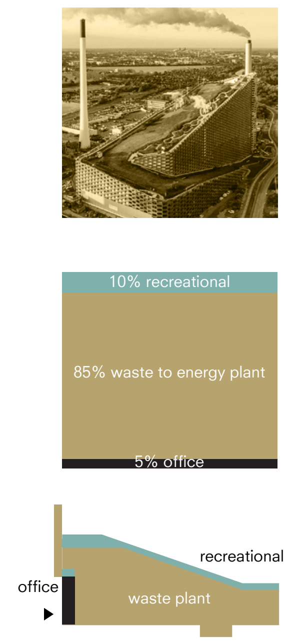

1,000 m²

### Barcelona SUR Power Generation Plant
Barcelona, Spain




3,000 m²

### Copenhill
Copenhagen, Denmark




32,000 m²

## Conclusions

During its most prosperous periods in the early 20th century, Maashaven was a major testing ground in the North Sea Region for innovative technologies such as the floating grain elevators. As port activities moved west, the harbour is left with minor shipping activities, incomparable to its past. Through mushroom cultivation and the fabrication of products derived from mycelium, the project aims to regenerate a productive waterfront as a catalyst for Maashaven and its community to regain such prosperity. The process of such industry will form a new co-operative for the Maashaven commons that revolves around the production of mushroom and the research of mycelium technology as a long-term identity, while stimulating societal integration within Rotterdam Zuid. Meanwhile, the interrelations between urban agriculture and waste flows will, through complex mechanical and ecological systems within the architecture, result in an unveiling of toxicity within Rotterdam's water, soil, and air. Regardless of whether the decontamination method through mycoremediation has proven to be successful, such physical exposures of environmental conditions will govern an assimilation of awareness in the Anthropocentric era, where humans are so disconnected from the results of their actions.

Socio-economically, the intervention serves as an opportunity to project the roles in which automation will take in agriculture and waste management, and how a low-income community should transition from low to high-skilled labour markets. As almost 200 million people are set to lose their jobs by the end of 2020 due to the pandemic (Financier Worldwide), the shift towards AI and automation will only be accelerated. The results from this architectural intervention will not only question future scenarios but also allow us to formulate the fundamental actions that need to be taken in to allow humans to work with, and not for machines in the proliferation of AI technology in such industries as agriculture and waste management.

In terms of the waterscape, the rituals through stages of wastewater treatment will allow the observers to reflect upon humans' relationships with water and portray the dynamics of each character's choreography alongside one another. The use of pools, mists and other features throughout the intervention will reimagine humans' perceptions of water and transform them into an engaging and poetic experience, where the users are no longer only observing water from afar but fundamentally become a part of the manifestation itself. As Rotterdam transitions into a water city and the inevitable 85 cm sea level rise in 2100 (Port of Rotterdam, 2020) is approaching, the idea of designing against water is becoming less sensible in a long run. Instead, allowing parts of the building to flood presents an opportunity to not only transform the architectural experiences within, but also highlights environmental issues caused by humans themselves.

### Global Relevance

In addition to the vicinity of Rotterdam Zuid and the Port of Rotterdam, the aforementioned aspects showcase a variety of mindsets that can be adopted and applied to other urban contexts where the environmental conditions are in jeopardy due to various human activities. After all, the main goal of the architectural intervention is not to solve such issues, as it will take political actions and immediate urban policies in order for the ultimate goals to become fruitful. In retrospect, the project aims to emphasise and critique the ways in which humans have treated 'Spaceship Earth' and demonstrate how it may be perceived more critically in the near future.



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## APPENDIX

### Objectives

The primary objective of the project is to portray the manifestation of the problem statement within the thesis through an introduction of the Research Institute for Mycoremediation and Waste Management. The project represents and simulates rituals through time and stages of mushroom cultivation and wastewater treatment, while constituting an international centre for fungi research and clean technology within the North Sea region. Furthermore, the project aims to formulate an apparatus for urban waste flows, resulting in a co-operative for the Maashaven commons through architecture and urban agriculture as tools. Moreover, the long-term objective imagines Rotterdam Zuid as a zero-waste community, while solely relying on renewable energy derived from organic wastes.

The research institute sets to host a number of user types, each relating to the visiting purpose of culture, education, or employment. While the public functions emphasise on regional and international visitors for cultural purposes, programmes related to education and employment are designed to cater the local communities within Rotterdam Zuid, with the long-term ambition of a shift towards a high-skilled community within a circular economy. Such architectural ambitions may be fulfilled by a number of investments through parties such as the Port of Rotterdam, Waterschap Hollandse Delta, and Westerdijk Fungal Biodiversity Institute. In terms of building construction, the project aims to explore mycelium as a circular building material while investigating building systems that react to different climate conditions, both within and outside the building.



### Agriculture

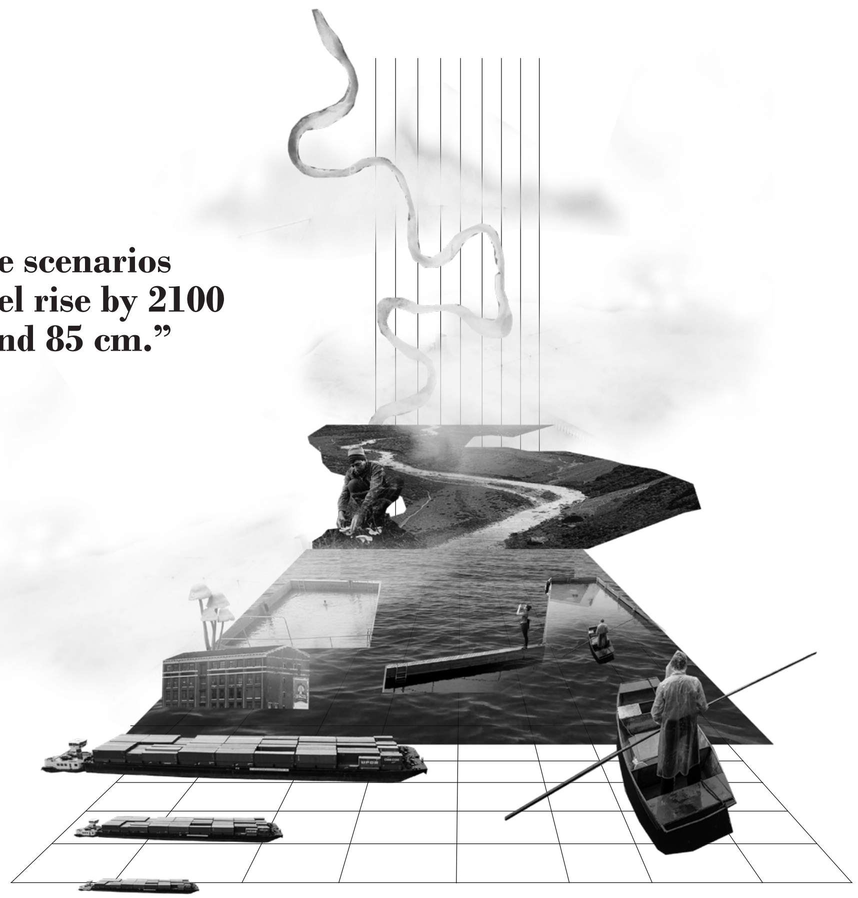
The agricultural objective of the intervention is to engage users to participate in the processes of mushroom cultivation, from the first step of mycelium spawn inoculation to the final stage of harvesting. Furthermore, the building serves as an experimental facility for fabrication technologies transforming such raw materials into sustainable products. Such activities will highlight the properties of the fungi species, which is neither an animal nor a plant, and allow more attention to be given in a global context.

## Water

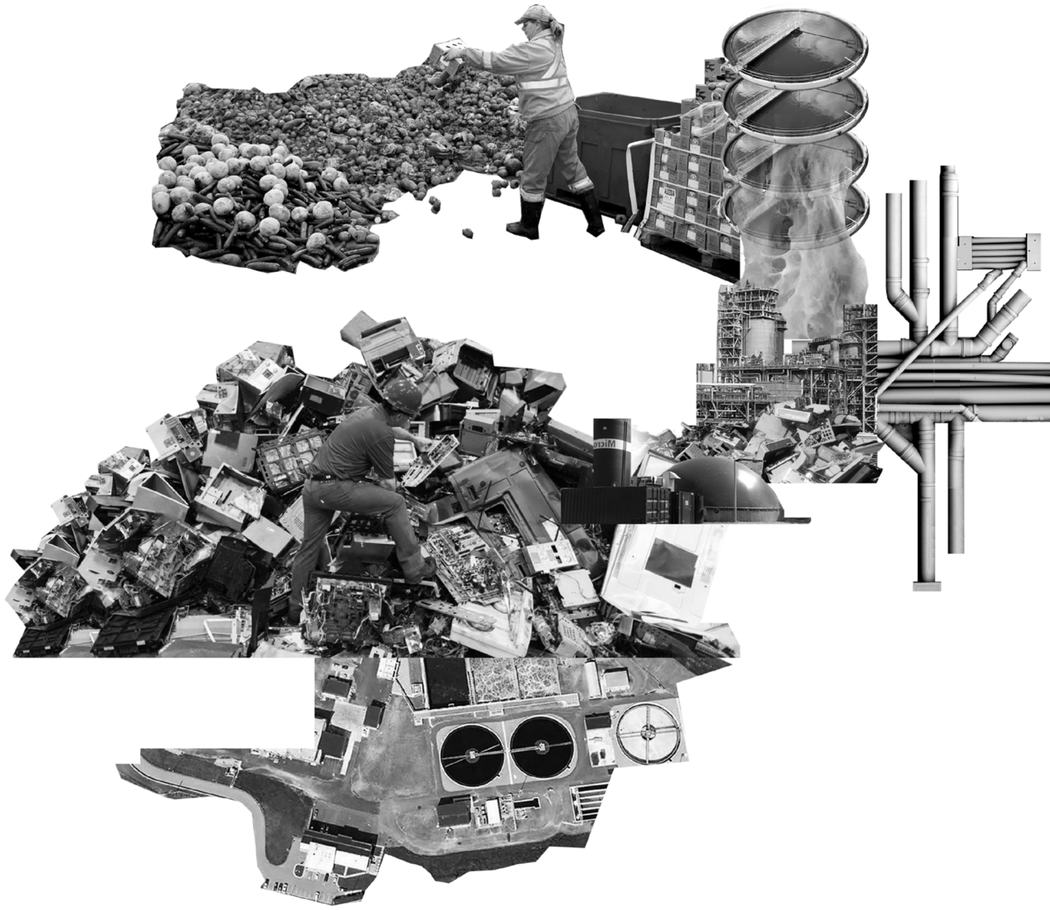
In addition to reimagining Maashaven as a productive waterfront, the intervention sets to speculate humans' relationships with water by representing each water-related programme in the building as rituals, taking the users on a journey through different stages of wastewater treatment while questioning and unveiling the negative impacts on the ecological systems in water bodies caused by the exploitation of resources such as oil and natural gas extractions. Furthermore, the building seeks to ask questions related to the inevitable sea level rise within the context of Rotterdam such as, what if the building can flood? Such questions surrounding the existence of water will be emphasised through using the same element as an architectural guidance and wayfinding tool throughout the building.

**"Current climate scenarios foresee a sea level rise by 2100 of between 35 and 85 cm."**

Port of Rotterdam







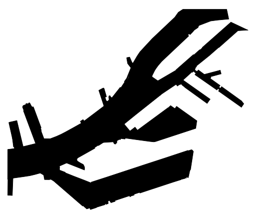
## Waste

One third of all food is wasted every year, resulting in ten percent of the total greenhouse gas emissions on Earth. (United Nations, 2011) The project seeks to expose and relocate the current waste flows within Rotterdam, while setting new energy standards through the process of waste to clean energy. Such ambitions to constitute a zero-waste community, however, will not be possible without a novel urban policy to reduce household wastes in the first place. Hence, the project will also aim to introduce a preliminary set of policies to support the goal towards a zero-waste Rotterdam Zuid.

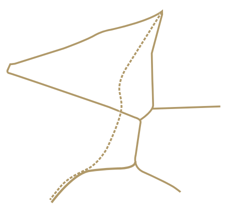
## Site

The strategic location of Rotterdam within the context of the North Sea was key to allowing its port to grow and dominate the entire region. Thirty kilometres inwards from where the river Maas meets the North Sea, however, traces of port activities are difficult to observe. The majority of shipments in the harbour of Maashaven consists of the transportation of grains to the few remaining grain companies by the waterfront, namely Dossche Mills (formerly Maneba) and Quaker Oats. At the edge of Maashaven, the underground wastewater treatment plant of Dokhaven manages the influx of wastewater arriving from most households in central Rotterdam. Such factors present an opportunity for the intervention to serve as a supporting system to the current treatment plant along Maashaven, while regenerating harbour activities in order to regain its status as a productive waterfront.

As a starting point, a list of specific requirements was made with regards to the processes of mycoremediation and mushroom cultivation, in order to determine the specific location of the intervention:

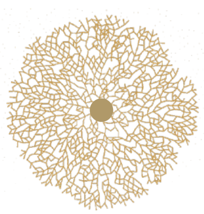


Access to urban water bodies
(water treatment)

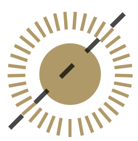


Land and water logistics
(transport of mushroom products
/ waste / food waste / e-waste)

Centre for cleantech &
agro-food, located between
North & South centres



Close to source of mycelium
spawn and substrate

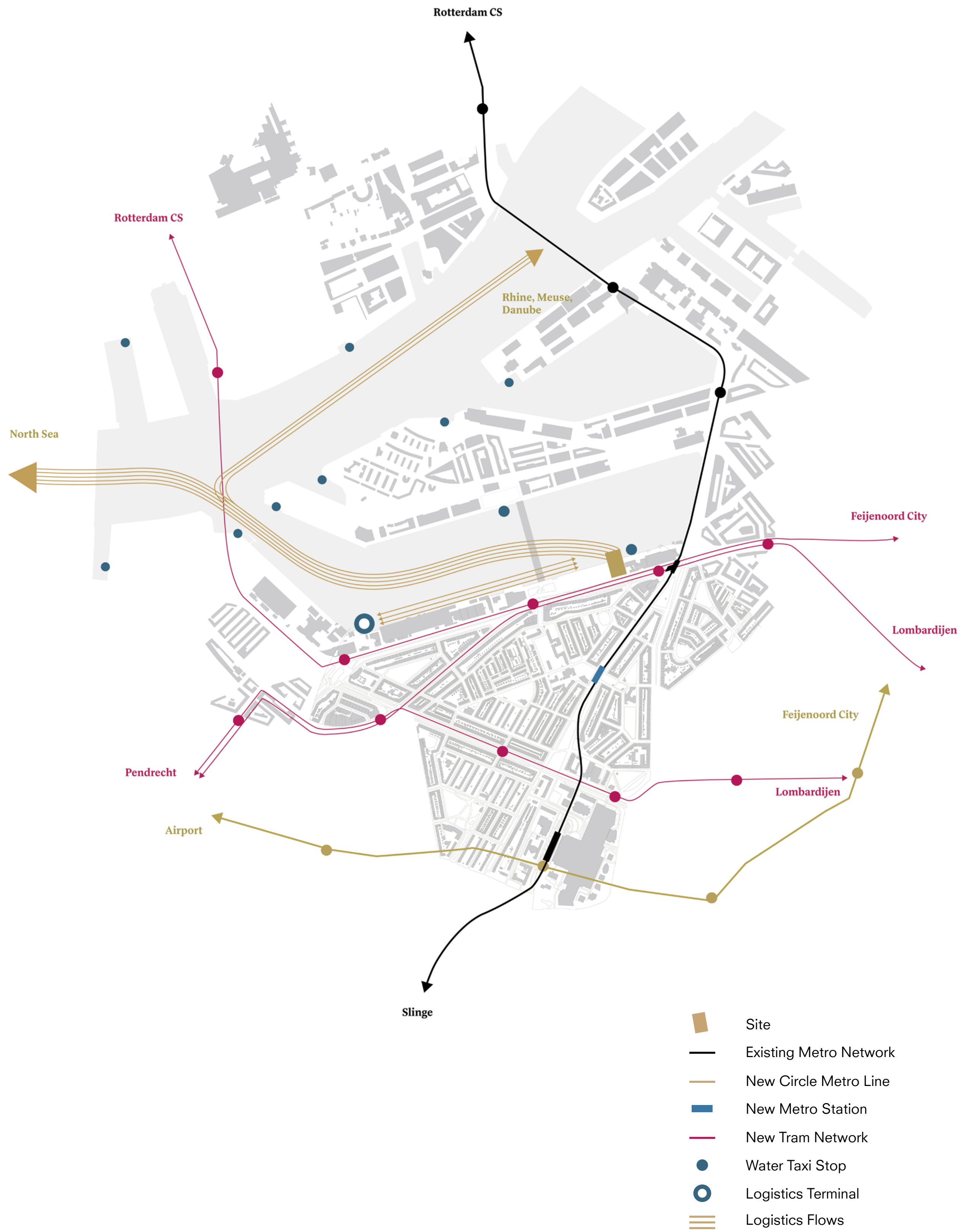


Low sunlight
(mushroom cultivation)

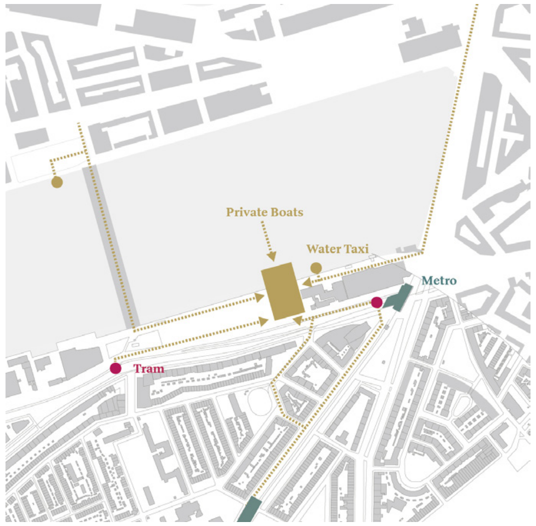
Based on the conditions mentioned above, a plot of 100 x 60 metres currently used as an extended shed for Quaker Oats factory was chosen, with the possibility of extending the architectural intervention into the water bodies of Maashaven. The site's close proximity to current grain companies allows for various grains and their biproducts such as straw to be used as mycelium spawn and substrate, respectively, ultimately reducing the carbon footprint consumed in the alternative methods of importing such raw materials from other sources.

Furthermore, the site is situated on a strategic transport node, with logistical access to an urban main road along the harbour. With the proposed future vision of a car-free waterfront boulevard, however, the logistics of the intervention will fully transition to water-only transportation, reacting to flows from the North Sea and the Maas, Rhine, and Danube rivers. Such transportations will be supported the existence of a new logistics terminal within the group visions, located at the western opening of the harbour.

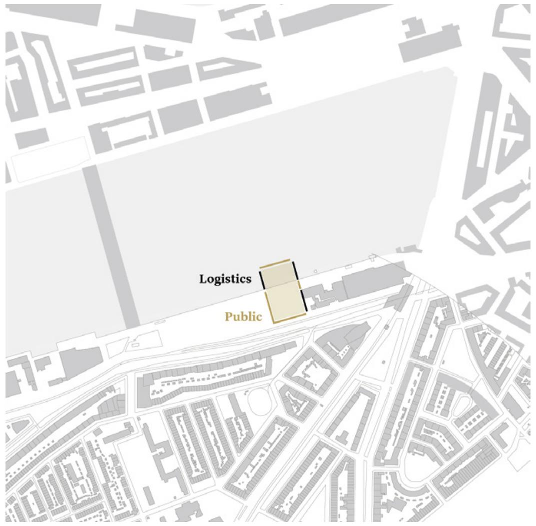




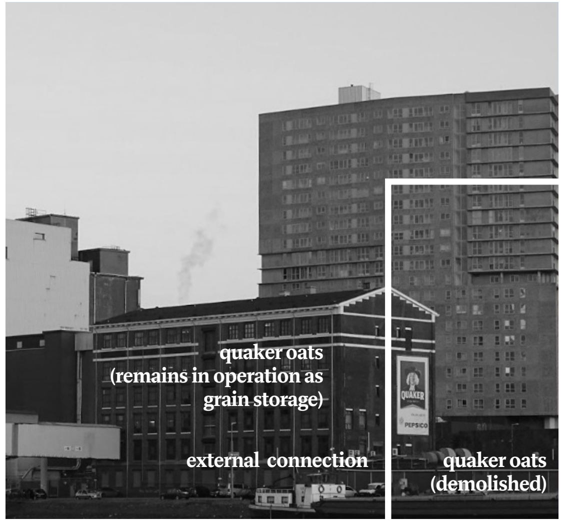
Pedestrian Approaches




Front / Back of House




Views



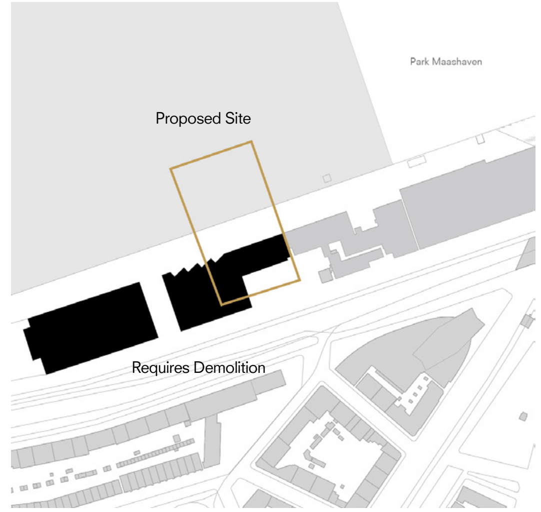

The intervention is situated next to the current Quaker Oats company, where grains used in the mycelium inoculation process are stored and supplied to the new institute. (made by author, 2020)

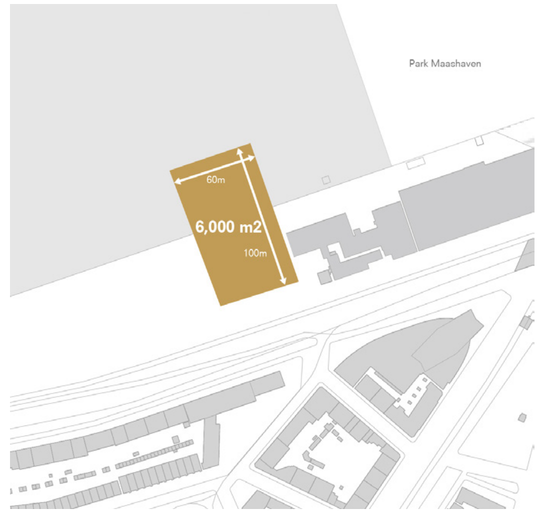


With the addition of the new Maashaven bridge within the group interventions, along with a water taxi network, a waterfront tramline, a dike park, a public waterfront, and Park Maashaven as proposed by the municipality, the site is surrounded with several possible public approaches. Being in close proximity with water allows such approaches to arrive from different levels, thus elevating the spatial dynamics of the building as a whole.

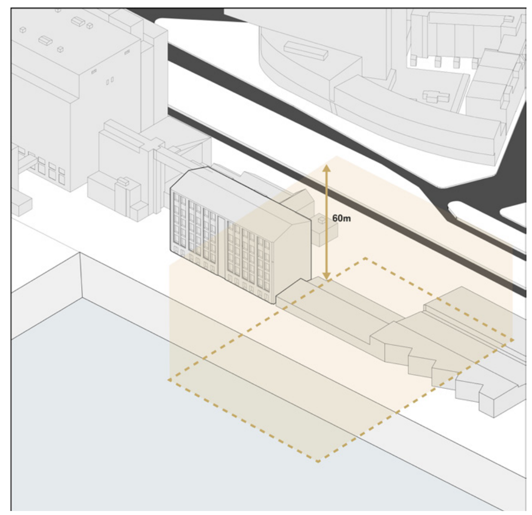
According to current regulations, the maximum buildable height of the plot is set to 28 metres, the same height as the adjacent building of the Quaker Oats company. With the average waterfront building height of 60 metres, along with the new developments of the Rijnhaven (one harbour north of Maashaven) which will include buildings of 100 to 200 metres in height, the proposed maximum height of the plot is set to 60 metres. Furthermore, the current setback rule of one meter will be expanded to ten metres from the plot line, allowing public functions within the new waterfront to surround the proximity of the intervention. Thus, the mentioned rules conclude in a maximum building volume of 360,000 m3.

The infrastructural disposition of the intervention will constitute a new zone for urban agriculture and waste management for the Maashaven vicinity, while serving as a centre for clean technology and agricultural innovations within the North Sea region. In the meantime, it will establish a locust of confrontation against urban waste flows and environmental contamination, allowing such issues to be highlighted in the middle of an ever-growing urban context.




| | |
|---|---|
| average height at waterfront | = 60 m |
| maximum building height (regulation) | = 28 m |
| + new development of rijnhaven | = 100-200 m |
| proposed maximum height for intervention | = 60 m |
| maximum building volume | = 60x 6,000 |
| | = 360,000 m3 |
| setback based on regulation | = 1 m |
| proposed setback | = 10 m |

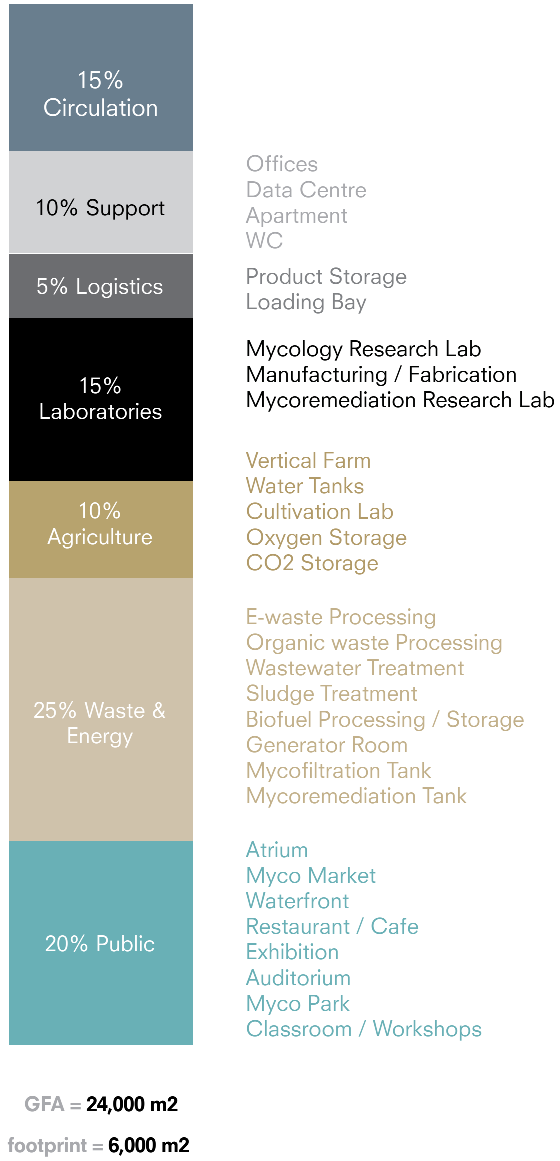


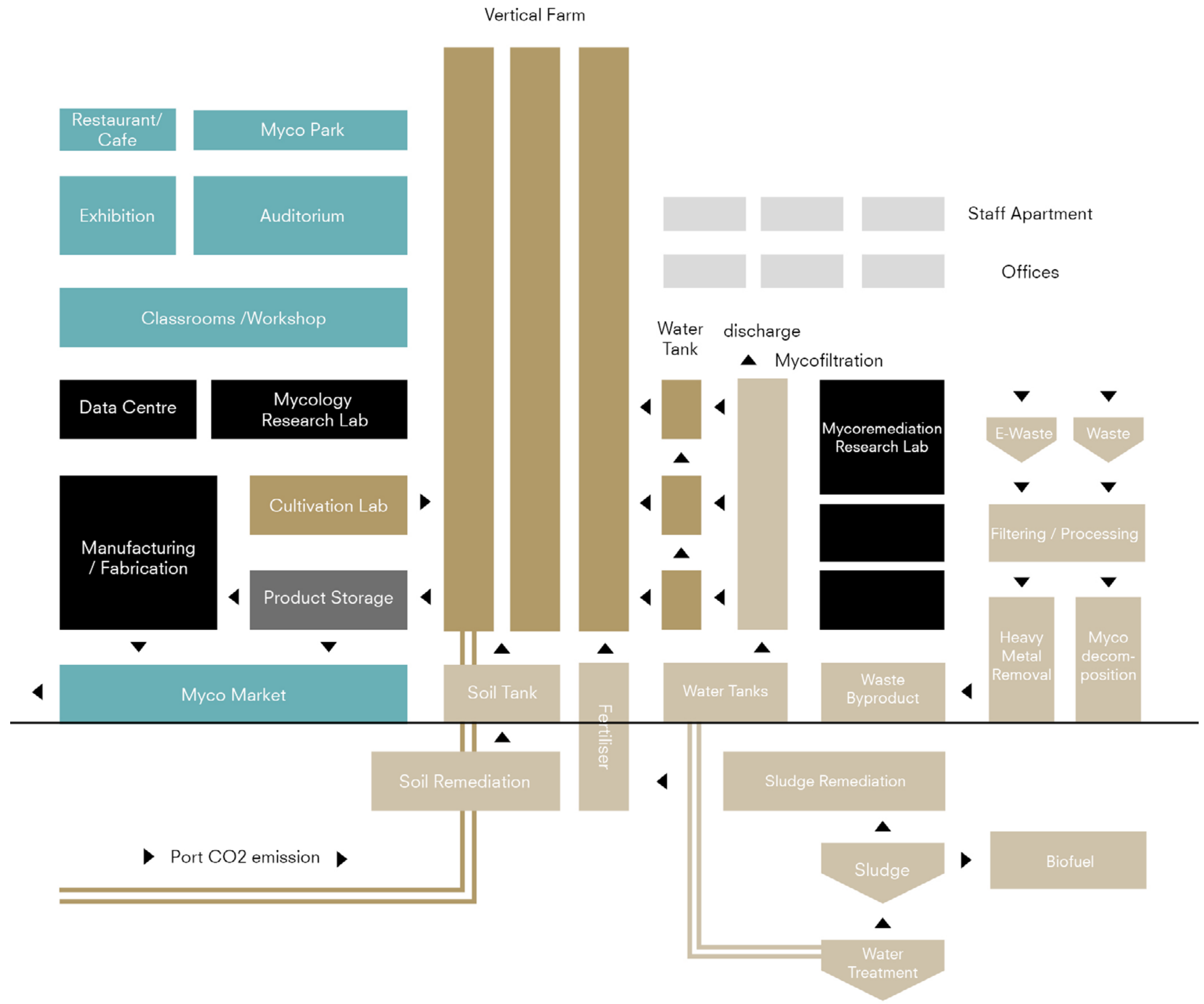
## Programme

The project aims to speculate on the emergence of the mycelium industry through the architectural existence of a research institute for mycoremediation waste management. The intervention serves as a centre of clean technology and urban agriculture within the North Sea region, while reacting to Rotterdam's current environmental issues. Thus, the proposed programme can be categorised into such sections: urban agriculture, mycoremediation, laboratories, public, logistics and support. The size of each programme was carefully considered based on the typological research of waste to energy plants, wastewater treatment plants, and urban agriculture. After having adjusted the needs to the size of the plots, it has been decided that 25% of the total floor area of 24,000 m2 (6,000 m2) will be used to facilitate the waste to energy plants, 20% (4,800 m2) for public, 15% (3,600 m2) laboratories, 10% (2,400 m2) agriculture and 5% (1,200 m2) logistics, with the remainder serving as support and circulation spaces.

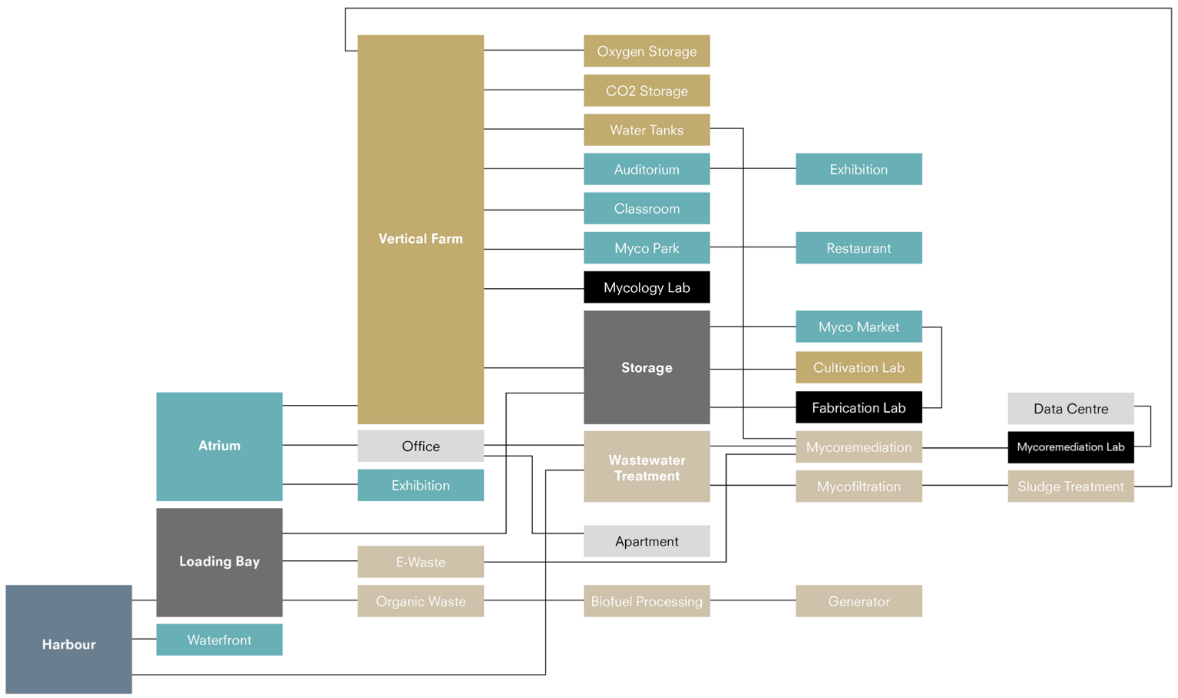
Each category performs as crucial organs within a complex system, in order create an everchanging living machine that reacts to current conditions. Furthermore, the programmes can be sub-categorised into human-centric, mechanised, and automated spaces, where the future implementations of artificial intelligence and machine learning are introduced, but do not replace certain human skills, allowing the two to coexist and fulfil the lack of certain possibilities from each side.

The programmatic diagram on the opposite page demonstrates how such systems might occur on an architectural level, with the urban farming (middle) directly benefiting from the upcycled water and soil which have been treated in different stages of mycoremediation (right). Furthermore, the products of mushroom and mycelium cultivation then inform a fabrication lab and a public myco-market which directly acts as a source of income within the neighbourhoods.




The programmatic section above demonstrates how such systems might occur on an architectural level. (made by author, 2020)

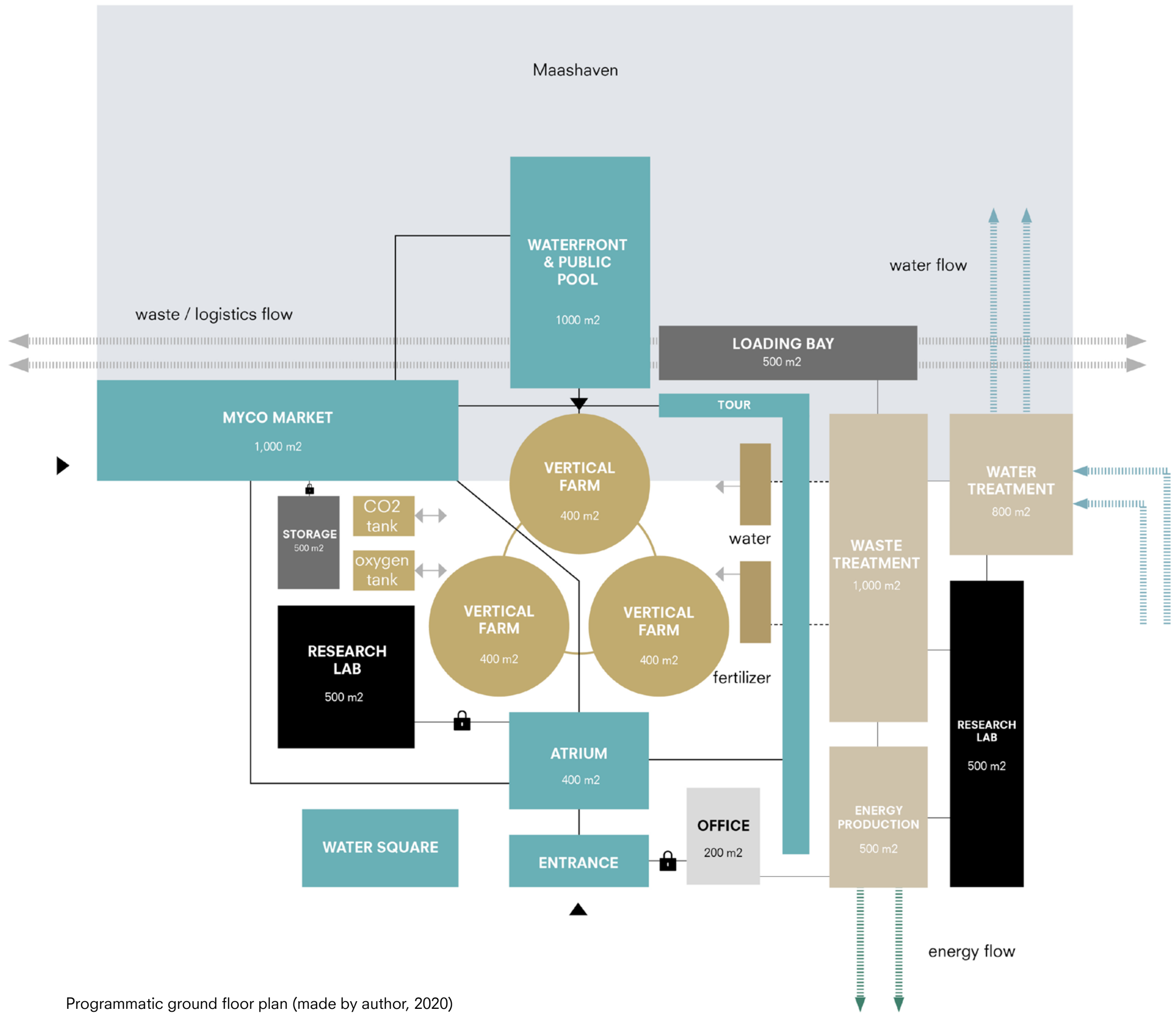



Programme connection rules (made by author, 2020)

The diagram above demonstrates the programmatic relations between different types of programmes, with the goal of constituting connection rules in the programmatic studies and understanding how each programme might functionally and spatially inform each other.

| | Area | Height |
|---|---|---|
| Offices | 800 m2 | 4 m |
| Data Centre | 600 m2 | 4 m |
| Apartment | 800 m2 | 4 m |
| WC | 200 m2 | 4 m |
| Product Storage | 200 m2 | 4 m |
| Loading Bay | 1,000 m2 | 8 m |
| Mycology Research Lab | 1,000 m2 | 4 m |
| Manufacturing / Fabrication | 1,400 m2 | 8 m |
| Mycoremediation Research Lab | 1,200 m2 | 4 m |
| Vertical Farm | 1,200 m2 | 60 m |
| Water Tanks | 200 m2 | 8 m |
| Cultivation Lab | 600 m2 | 4 m |
| Oxygen Storage | 200 m2 | 4 m |
| CO2 Storage | 200 m2 | 4 m |
| E-waste Processing | 800 m2 | 8 m |
| Organic waste Processing | 1,100 m2 | 8 m |
| Wastewater Treatment | 1,800 m2 | 12 m |
| Sludge Treatment | 300 m2 | 6 m |
| Biofuel Processing / Storage | 800 m2 | 12 m |
| Generator Room | 500 m2 | 6 m |
| Mycofiltration Tank | 200 m2 | 8 m |
| Mycoremediation Tank | 500 m2 | 6 m |
| Atrium | 400 m2 | 24 m |
| Myco Market | 1,000 m2 | 6 m |
| Waterfront | 1,000 m2 | N/A |
| Restaurant / Cafe | 400 m2 | 4 m |
| Exhibition | 400 m2 | 6 m |
| Auditorium | 600 m2 | 8 m |
| Myco Park | 600 m2 | 6 m |
| Classroom / Workshops | 400 m2 | 4 m |

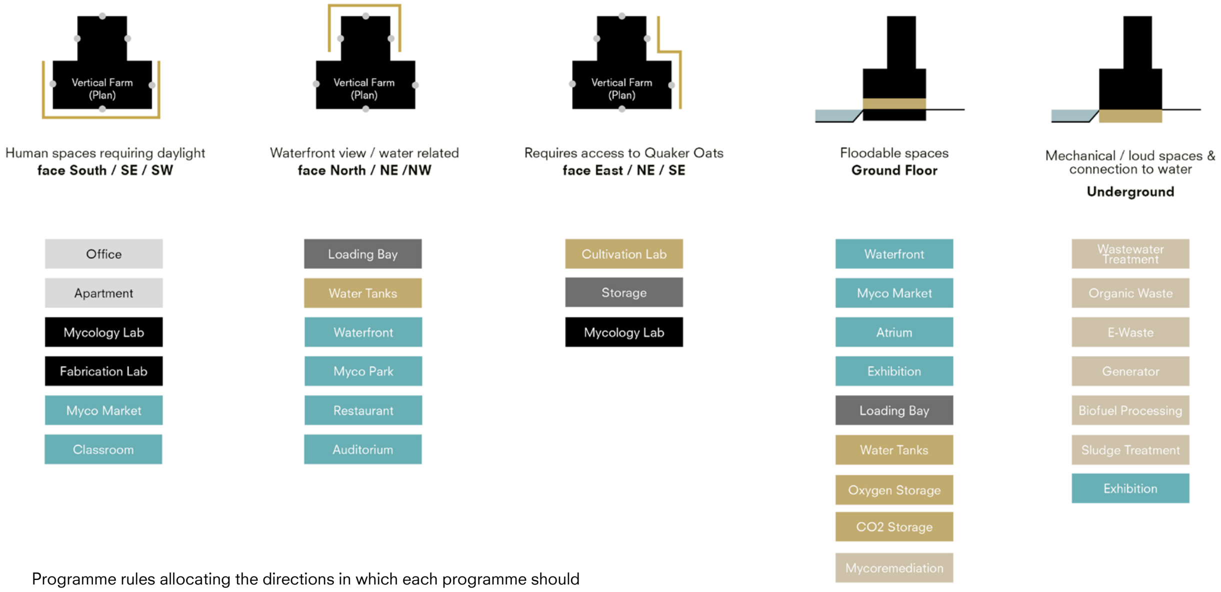




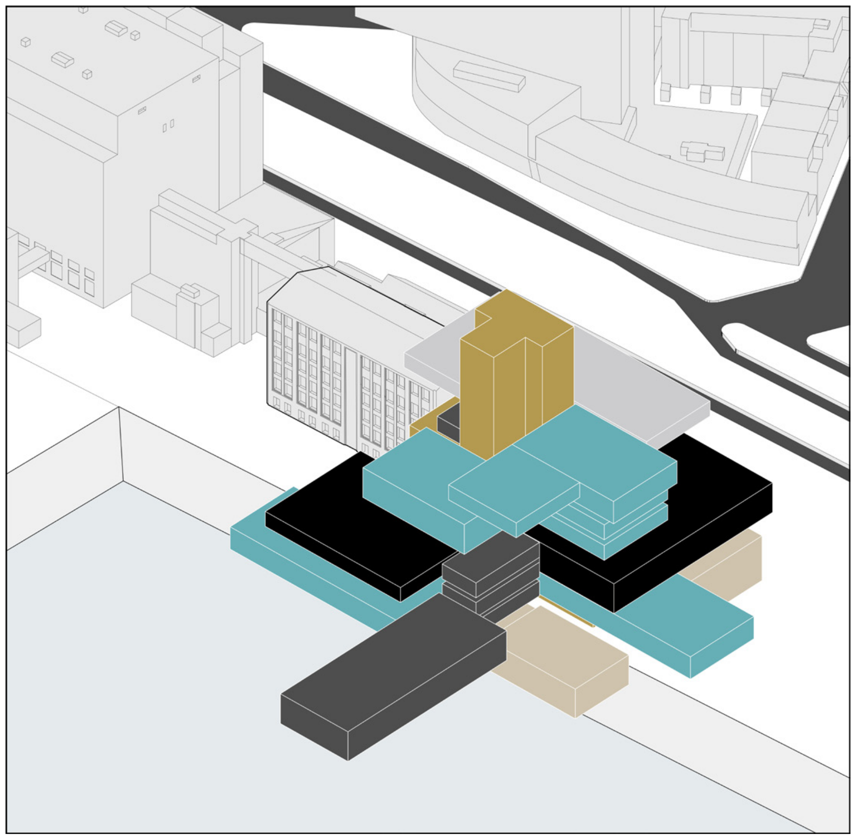

Programmatic ground floor plan (made by author, 2020)

While the waste to energy sections are seemingly separated from other programmes, the public functions are arranged in such way that different journies are created within and outside the building, providing a spatial relation between the architecture, the waterfront, and the harbour.

- Agriculture
- Waste & Energy
- Public
- Laboratories
- Logistics
- Support

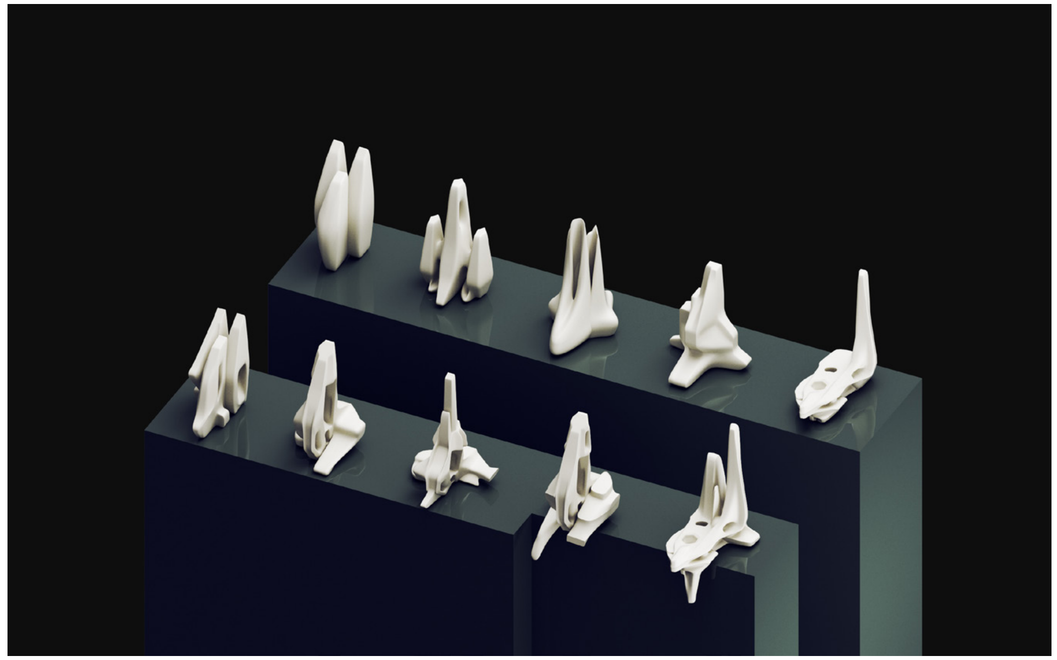



Programme rules allocating the directions in which each programme should be placed, based on its function and activities. (made by author, 2020)

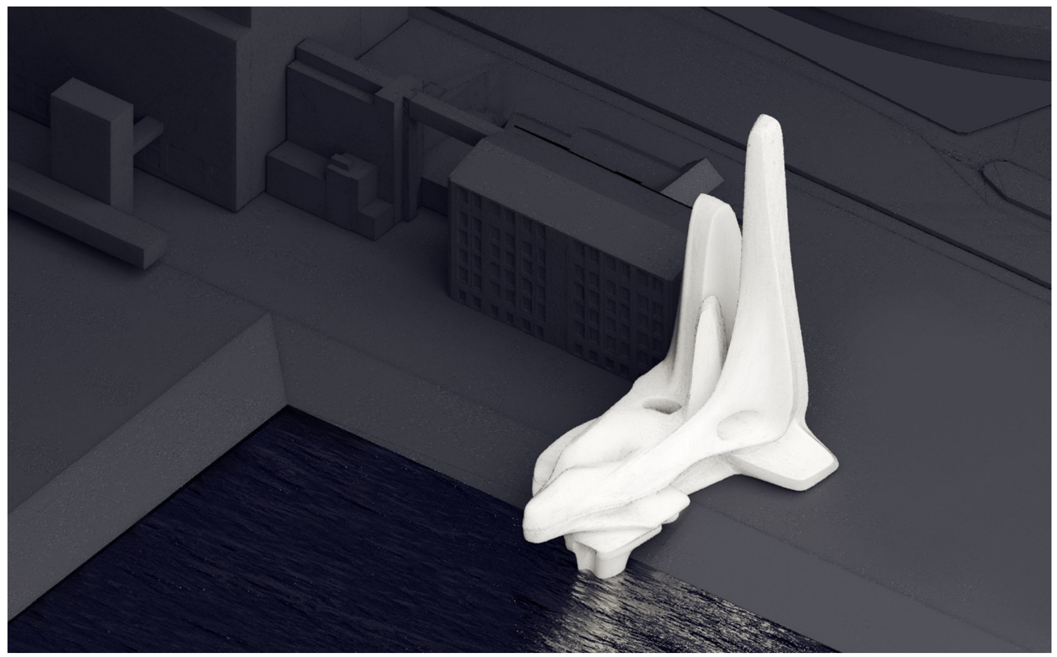


3D massing study on site suggests possible organisation of the programmes in relation to each other based on the rules mentioned. (made by author, 2020)





By sculpting three dimentional forms based on the massing studies, the programme connections and circulations are reinforced and informed by the fluidity of the building as a whole. (made by author, 2020)



The result of the preliminary massing studies inform an architecture that reacts to the surrounding contexts including the Maashaven, both reaching into the water and the sky. The structure also forms a juxtaposing dialogue with the nearby Quaker Oats building while preserving the historic building. (made by author, 2020)

## Graduation Plan

| | | | Research | Design |
|---|---|---|---|---|
| | Week 2.6 | Dec 18th | Finalising research | Finalising design brief |
| | Week 2.7 | Dec 25th | Finalising research | Massing + Collages |
| | Week 2.8 | Jan 1st | Finalising research | Massing + 3d Neufert |
| | Week 2.9 | Jan 8th | Finalising research | Massing performance studies |
| P 2 | Week 2.10 | Jan 15th | | |
| | Week 3.1 | Jan 22nd | Site analyses | Develop systems within architecture |
| | Week 3.2 | Jan 29th | Programme analyses | Programme & Circulation |
| | Week 3.3 | Feb 5th | Programme analyses | Finalise Programme & systems |
| | Week 3.4 | Feb 12th | Programme analyses | Experience design |
| P 2.5 | Week 3.5 | Feb 19th | | |
| | Week 3.1 | Feb 26th | Functional research | Plan logics + 3D modelling |
| | Week 3.2 | Mar 5th | Reference research | Plan logics + 3D modelling |
| | Week 3.3 | Mar 12th | Structure research | Section logics + 3D modelling |
| | Week 3.4 | Mar 19th | Reference research | Section logics + 3D modelling |
| P 3 | Week 3.5 | Mar 26th | | |



| | | | Research | Design |
|---|---|---|---|---|
| | Week 3.6 | Apr 2nd | Material research | Develop materials |
| | Week 3.7 | Apr 9th | Structural system research | Develop form details + 3d modelling |
| | Week 3.8 | Apr 16th | Facade research | Facade 3d modelling |
| | Week 3.9 | Apr 23th | Facade research | Integrate designs / Post productions + renderings |
| P 4 | Week 3.10 | Apr 30th | | |
| | Week 4.1 | May 7th | Finalising research | Post productions + renderings |
| | Week 4.2 | May 14th | Finalising research | Post productions + renderings |
| | Week 4.3 | May 21th | Finalising research | Post productions + renderings |
| | Week 4.4 | May 28th | Finalising research | Post productions + renderings |
| P 5 | Week 4.5 | May 7th | | |