Virtual X Water

A ROADWAY TO CIRCULAR CONSTRUCTION AND DEMOLITION SECTOR IN SOUTH HOLLAND

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Delft University of Technology - MSc Urbanism (Architecture, Urbanism and the Building Sciences)

Third Quarter of the academic year 2020/2021 - AR2U086 - R&D Studio: Spatial Strategies for the Global Metropolis

Coordinators of the course: Verena Elisabeth Balz and Lei Qu

Tutors: Daniele Cannatella, Nikos Katsikis and Remon Rooij

Inputs from the Research and Design Methodology for Urbanism course, with coordinators Roberto Rocco de Campos Pereira and Marcin Dabrowski

Authors: Daria Beliavskaia, Jorg Hogerheijde, Rosalie Moesker, Isabella Trabucco and Nando Versteeg

Thank you Daniele for always keeping us in check on the complex data handling, Nikos for thinking along with us on how to enhance the project even more and Remon for making sure we work together with an open mind.

VIRTUAL X WATER

0. Abstract

To achieve a circular economy in South Holland by 2050, the construction and demolition sector must use resources efficiently, close materials loops and work with fewer emissions.

Currently recycling building materials is already the approach. Yet, since this costs a lot of energy and results mostly in downcycling, it is not ideal as a long term solution to achieve a durable circular economy. Adding to this, is the space limitation within the continuous growth. The usage of the existing space and infrastructure has to be optimized.

This research is answering what is the best strategy to close material loops in South Holland while reusing the existing water infrastructure, amplifying it with integrated (data) networks and improving socio-spatial justice with circular hubs.

The research is being executed by analysing the most efficient waterways to use in the area, defining transformation locations according to a data-driven matrix and designing the most efficient circular hub network possible.

The waterways will connect circular hubs on 3 scales, a regional processing hub, a city storage & purchase hub and a flexible last mile hub. Transporting materials and goods in between the circular hubs helps in reducing CO2 emission and it can substantiate traffic on the roads. This leads to less busy highways, safer city centres and efficient use of transport. All the logistic flows and used-material flows come together in the Virtual realm, where all used-material data is accessible and a twin-region is ensuring spatial justice. Therefore the concept of Virtual X Water is the answer to define the transition towards a circular economy in 2050.

1. Introduction

CURRENT SITUATION

PROBLEM STATEMENT

RESEARCH QUESTIONS

METHODOLOGY

CONCEPTUAL FRAMEWORK

1.1 Current situation

THE ROAD TO 2050

VirtualXWater is a project focused on designing a new spatial strategy to transition towards circular economy within construction/demolition sector for the province of South Holland.

The Netherlands is aiming to transition to a circular economy by 2050, with an intermediate step of 50% reduction in raw material consumption by 2030 (Government of the Netherlands, 2016). This is a response to a global increase in consumption of raw materials as well as the climate change – as advised in the The Circularity Gap Report 2019 (PACE, 2019), transition to circular economy maximises the chance to meet the goals of the Paris Agreement on Climate Action.

The ambition to drastically reduce the raw material consumption is especially important in the light of an ongoing urbanisation. The Netherlands is struggling with the growing demand for affordable housing in the limited space of the country – by 2035 it is predicted that around half of provinces will experience a growth over 5%, with major cities faced with even higher population increase of 15%-20% (CBS, 2019).

As stated by the WWF's "Living Planet Report Nederland 2020", the state of Dutch nature on land is "worse than ever" (WWF, 2020). The urban growth cannot continue at the cost of the nature, and one of the ways to ensure it is densification of existing urban areas rather than expansion.

Not only do new buildings need to be constructed, but also a large stock of post-war buildings that do not meet the energy criteria are due for transformation or renovation Image 1.

The combination of these factors presents a challenge – Dutch cities need to grow, while staying within their borders and reducing the raw material consumption.

The province of South Holland, which is the focus of this report, is the most densely populated in the country (CBS, 2020b), has the highest percentage of built-up area (CBS, 2020a) and is likely one the most material intensive provinces in the country (Drift & Metabolic, 2018).

It is therefore a region with a high urgency to take action, and a potential to become an example for other provinces to learn from.

PORT OF ROTTERDAM

The Port of Rotterdam, located in the province, is the largest European port, with the annual freight throughput of 436,8 mln tonnes. With the ongoing growth, the port has a long-term commitment to changing the modal split: less cargo on road and instead more utilisation of inland waterways and railways (Port of Rotterdam et al., 2019).

The real significance of the Port is not just the material flow - 6.2% of the added value of the Netherlands is due to the Port of Rotterdam and its economic activities (Kuipers, 2018). This important stakeholder is actively working with the Province of South Holland towards more sustainable operations. The future Port will be looking to transition into a "Waste-to-value hub" (Port of Rotterdam, 2019), where valorisation and utilisation of a wide range of residual flows can happen.

Image 1.
Buildings with the construction year 1945 to 1980, based on geodata from Province South Holland

CONSTRUCTION SECTOR

As can be seen in Image 2, construction sector in the Netherlands has a high negative impact on the environment and is therefore one of the focus industries in transition towards circular economy.

Apart from the material production and demolition, construction-related logistics take up the largest volume on the Dutch market, and 70% of all transport is done via road (Buck Consultants International, 2020), leading to more emissions, noise pollution and traffic blockage.

From 2021 the EU regulations on the new construction state that all new buildings must be (almost) energy-neutral (European Commission, 2020). This is stimulating the use of sustainable materials in newly built areas and creating demand for the re-use of existing materials and buildings.

The current system is already able to put all materials from building demolitions to use. Unfortunately, 97% of those are prone to be downcycled (Circulaire Bouweconomie, 2017), shortening the lifespan of the materials and decreasing the value.

If buildings are disassembled rather than demolished, many materials could be applied again in new buildings. One of the steps being taken by the government is introducing material passports to ensure reliability and help identify potential of these materials in new construction . Government-formed “Platform CB’23” is busy with developing specific regulations towards the material passports and will be introducing them by 2025 (Platform CB’23, 2020).

As identified by Circulairestad , the main challenges for construction industry at the moment are lack of clarity on circular economy and the controversy between the need for innovation in construction and the risk-averting government strategies (Circulairestad, 2018).

If one were to start research circular construction, a multitude of companies, NGOs and NPOs would come up with lack of clear structure, making it more complicated to work out the best action plan.

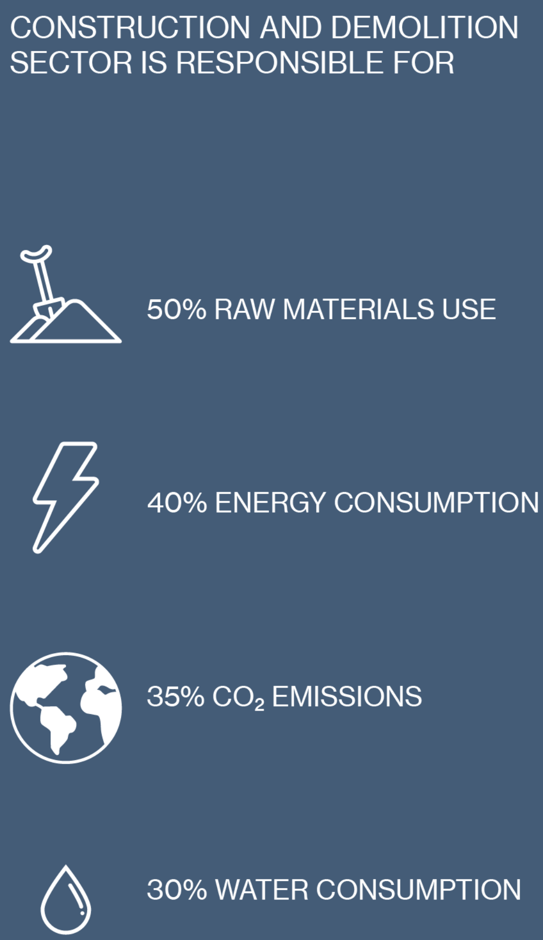

Image 2. % of total country use.
(Rijksoverheid, 2016)
Drawing by author

1.2 Problem statement

2 main issues that slow down the process into achieving a circular system are elaborated into problem statements. Designing solutions for these problems is the needed foundation into working towards a circular construction and demolition sector.

1. LIMITED SPACE AND HIGH DENSITY

South Holland being the most densely populated and built up province, with almost no land left for new developments, makes it a challenge to achieve results on the way to a circular economy. In order to sustain the growth needed, the current use of the existing infrastructure does not seem sufficient.

The logistic aspect of the current system involving multiple separated material flows from a number of suppliers largely contributes to CO_2 emissions. It is logistically not efficient to have contractors placing several orders from several locations for different materials (Duurzaam gebouwd, 2017). A shared logistic system is fundamental since there is a limited amount of re-usable materials, which results often in mixing new and reused materials in the same building (Densley Tingley, D., 2014). In the meantime, cooperation between the new material suppliers and reuse materials is necessary to avoid separate orders and deliveries. The high urgency for new construction in the province does not allow for a timely process of looking for suitable materials to be reused. This means that there is a need for transparent and clear communication and data flow among the construction, demolition and logistic sectors. There is already the needed knowledge in the industry related to innovative materials that are easier to re-use and are circular, yet this knowledge is not shared and openly available on a large scale. Overall, the urgency caused by the space limitation within the continuous growth means that a completely new approach to old processes is needed, not only to become circular, but also to simply sustain the quality of life.

2. DOWNCYCLING

The current linear approach leads to a general trend to introduce finite and non-renewable raw materials in buildings (e.g. concrete and ceramics) (Metabolic & Drift, 2019). The use of these types of raw materials initiates consequently a considerable waste flow. This is not because it is not possible to recycle the materials, but probably due to lack of knowledge and techniques on how to extend their lifespan. The issue is in the recycling itself, which has been on the rise because of governmental restrictions on waste disposal (Rijksoverheid, 2016).

This means there is mainly being recycled already, yet the biggest amount of recycled materials are still downcycled, losing their material value. Recycling is not the final goal that should be achieved. Since it involves processing, which needs space and energy and can also produce waste. This makes the reuse of materials a preferred approach for a truly circular system. (DuurzaamMBO, n.d.)

However, reuse of materials is hard to achieve in a system with multiple spatially shattered organisations that do no have an efficient way to collaborate in identifying the supply and demand of reusable materials. Furthermore, the materials and their qualities need to be properly documented in order to be applied in the design and construction process. One of the common ideas is an introduction of material passports - "a qualitative and quantitative documentation of the materials composition of a building" (Honic, M., Kovacic, I., & Rechberger, H. 2019, p2). However, this has not yet been integrated into the Dutch construction and demolition industry.

In conclusion, recycling was a short term solution in the transition towards the circular economy. Yet, since it takes a lot of energy and results in downcycling, it is not the ideal approach for the long term solution.

1.3 Research questions

MATERIALS
How can material flows be inventorized, shared and accessible for reuse?

WATER
What are the possibilities to use the existing water infrastructure for a macroscale transportation network in South-Holland?

What is the best strategy to close material loops in South Holland while reusing existing water infrastructure, amplifying it with integrated (data) networks and improving socio-spatial justice with circular hubs?

DATA
How can the use of Big Data amplify the transport and hub material network?

HUBS
What kind of material hub network is needed to reach the circular economy?

1.4 Methodology

C

Virtual fieldtrip
- Current 2050 strategy of SH
- Current phasing untill 2050
- Transformation locations
- Analysis cityhubs and logis-tics
- Port of Rotterdam

B

Literature review
- Regional vision SH
- Growth agenda SH
- Circular opportunities SH
- Current urbanization SH
- Material flows SH
- Circular indicators SH
- National circularity in 2050

A

Theoretical framework
Group dynamics
- Peer production
- Process management

Circular economy
- Systematic approach
- Example projects (international)

Spatial justice
- Methodology lectures + readers

Conceptual framework
- **Virtual X Water**
- **3 HUBS**
  - Flexible droplet: Micro
  - Stream: Meso
  - Source: Macro

Analysis
Hubs
- Trends of hubs
- Functioning
- Benefits

Materials
- Kinds of materials
- Material flows - M
- Ways of using exis
- From product to s

Water
- Rediscovery of wa
- Water transport a
- Problems of wate transition
- Inland water netw

Data
- The opportunities
- Virtual approach
- Data amplifying lo
- Automated water
- Transparency of B

Assignment

Circular demolition and construction sector in 2050

Pitch

Methodology conceptual framework and vision statement

Base story document

Problem statement
Limited space and high density
- Spatial limitation and ongoing growth require a drastic change of current approaches

Downcycling
- The life of materials ends in downcycling or waste

Initial findings
- Using waterways
- There is already no waste in SH
- Making a matrix to find locations

Research questions
- **What is the most efficient way to close material loops in South Holland by reusing the existing water infra-structure, creating material hubs and amplifying it with integrated (data) networks?**
- How can material flows be inventoried and accessible/shared for reuse?
- What are the possibilities to use the existing infrastructure for a mac-ro-scale transportation network?
- What kind of material hub network is needed to reach the circular economy?
- How can the use of Big Data amplify the transport and hub material net-work?

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service

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of Big Data

gistics network
transport
Big Data

Design strategies

Spatial justice
• Jobs
• Public space
• Educational functions

Circular hubs
• Functions and flexibility
• Urban revitalisation
• Visual aesthetics

Assessment: Matrix

• Multi-criteria assessment tool matrix based on data
• Determine development areas by neighbourhood based on criteria

Criteria hub locations

• Identify areas for the strategically located circular hubs
• Write criteria scheme for hub-locations

Midterm

A break:
Where we are now
What is next

F

Final presentation
Final report

Present VxW

Conclusion

• Evaluation
• Reflection
• Discussion

2050: Virtual X Water

• Easy for all stakeholders to access second hand materials on the all-encompassing database
• Transport by interconnected regions and cities in a CO_2 friendly way
• Connect the existing networks of waterways, roads and train tracks
• The circular hubs are located on the most efficiënt locations
• 3 hub scales to create new nods, which is intended to improve logistics, communication and knowledge flows
• The digital connection allows SH to be efficient and helps integrate the re-use of materials in the design process.

• **The virtual and water flows combined make the circular economy a reality.**

2

G

Phasing

• From 2025 to 2035 - Initiation phase
• From 2035 to 2040 - Spreading phase
• From 2040 to 2050 - Integration phase

1.5 Conceptual framework

To have an in-depth understanding of the forming of Virtual X Water, in this chapter the project is elaborated into a conceptual framework. The conceptual framework is providing a visualisation of the relationship between the most important components of research (Grant & Osanloo, 2014). This differs from the theoretical framework, which is a guideline of the used research methods (Grant & Osanloo, 2014). The theoretical framework is elaborated into the methodology scheme in the following chapter.

Virtual x Water combines two separate systems and looks through this "lens" to find new ways of construction industry becoming circular. The goal is to enhance opportunities present in the region and solve the problems by adding connections to the existing qualities - advancements in data management and the historical water transport network. We included both elements to create a complete strategy where the spatial and digital realm meet each other.

TRANSITION TO A CIRCULAR ECONOMY

The shifting towards a circular economy can be classified as a transition of one socio-technical system (linear economy) to a new one (circular economy) (Ministerie van Infrastructuur en Waterstaat, 2020). A

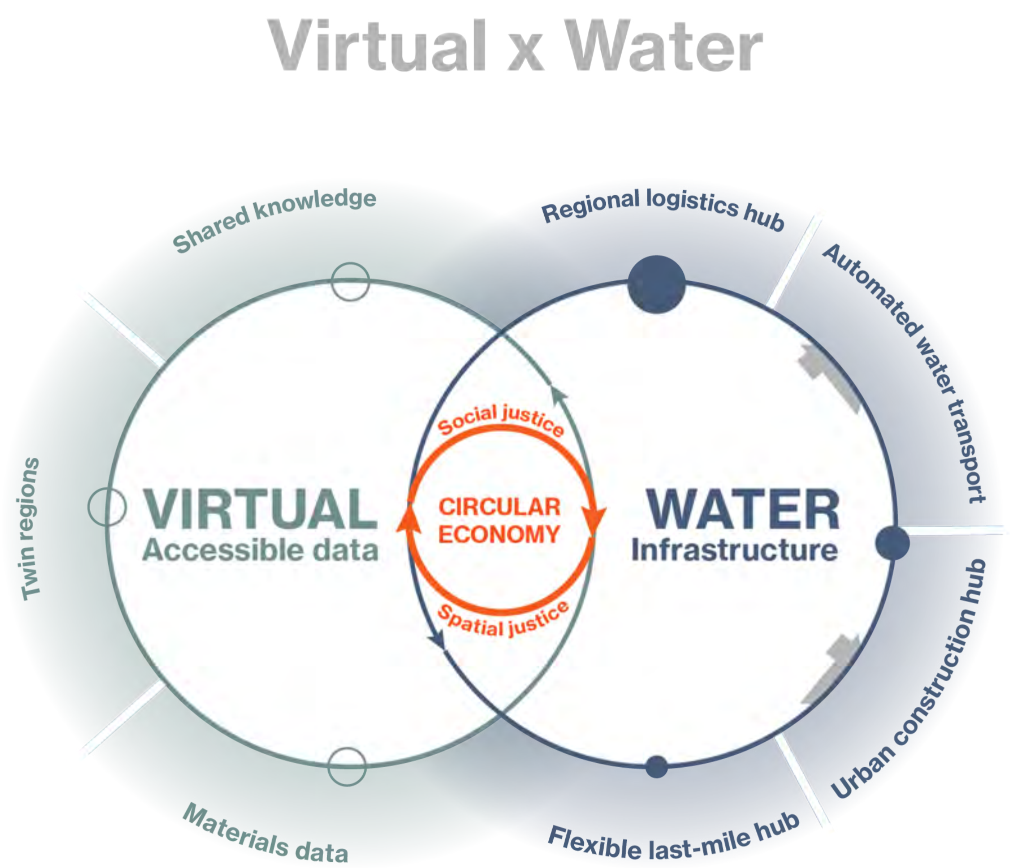


Image 3.
Conceptual framework Virtual X Water,
drawing by author

transition is a process of fundamental and irreversible changes in culture, (institutional) structure and working method at the system level (Transities, Drift, 2020). Transitions at the level of societal functions consist of a change from one socio-technical system to another, requiring inclusion of multiple actors (Geels, 2006). This multi-actor process involves interactions between many social groups, e.g. commercial transactions, political negotiations, power struggles and the creation of coalitions (Geels, 2006).

In the centre of the conceptual framework, the circular economy is illustrated as the conclusion of the strategy Virtual x Water. When the 2 circular constructions of Virtual and Water collide, together they intersect as the X into a circular economy. The Virtual and Water circles are fueling and accelerating the rotation of the circular economy on and on.

VIRTUAL: ACCESSIBLE

Shared knowledge

A lot of initiatives and innovations are occurring regarding the circular economy. The key is to share the knowledge and not spend time and money on reinventing the wheel while other organisations have found a solution. Including the available and suitable actors in the process of creating a circular construction and demolition sector. Especially in the new era of increasing possibilities due to the availability of Big Data (Philbeck & Davis, 2019).

Materials data

Data and the related processes will enable us to audit what kind of materials will come from demolished buildings. The data availability about materials will enable the circular system to reuse the material at the justified location and at the right time. Therefore can be concluded that material data is vital for the reuse of specific construction materials.

TWIN REGIONS

A twin region has the ultimate purpose to make better-informed and transparent decisions. The system can be used extensively for monitoring and structuring the material flows between circular hubs and construction sites. Technical innovations and concepts must be people-centred and improve the quality of life of all its inhabitants rather than achieving process or economic efficiency.

WATER INFRASTRUCTURE

Regional logistics hubs

The regional logistics hubs are a key element in a circular system. The logistics hubs are the time-related link between the offer and demand for circular materials. Furthermore, in a circular economy, it could be possible that construction materials will be reused in a different location and will be transported. Thus, the logistics hubs can be seen as spatially related links as well. The Regional logistics hub is a physical centre to easily connect the involved actors to reusable materials, data, knowledge and communication on a regional level.

Automated water transport

Transport is necessary to get reusable materials towards and from a logistic centre. Due to its many benefits such as sustainability, safety and time reduction scholars believe that all transport modes will eventually be automated (Hancock et al., 2019, p. 7687). Over time, automated transport will enter the transportation network and connect the logistics hubs. To further elaborate on the vision of South Holland, the focus is on water transport. Navigable waterways are well represented in South Holland (DRIFT, 2015).

City storage & purchase hub

As a sequel to the large regional hub where the demolishing materials will be stored and repurposed, the City storage hub is used as a storage facility on the city level. Via the logistics system, these city hubs are supplemented with materials from the Regional logistics hubs.

Flexible last-mile hub

The Flexible last-mile hubs are the smallest hubs of the system. These hubs form the bridge between the large storage facility and construction sites where the materials will be reused.

2. Analysis

CONSTRUCTION HUBS

MATERIALS

WATER

DATA

Transitioning towards a fully circular economy for the construction sector is a challenge. The four topics highlighted in our research questions are analysed in this chapter, forming our background knowledge and leading us towards the vision and strategy.

Firstly, there is a missing link in having an integral chain management that controls all logistic flows (TNO, 2018). The results are large amounts of logistic failures, imbalance in supply and demand, and unclarity in deliveries. In addition, connecting construction and demolition is necessary for a circular economy, but the existing framework does not provide this link (Yvonne Ton, 2019). Construction hubs facilitating the logistics for construction sites seem to provide a solution for these issues.

Secondly, an understanding of the materials - the amounts, sizes, shapes and kinds, is crucial to transform the current system and economy. In 2014, 17.600 kton of materials flowed through the sector of construction in The Netherlands (Metabolic, 2020). However, this is very general, it does not tell us what kinds of materials they are and in what form. In the same year, only 13% of all materials usage in The Netherlands came from secondary resources (CBS, 2019). In order to understand where the usage of secondary and circular materials and products can be improved, a deeper analysis of materials is needed.

Furthermore, water and specifically water transport have potential for new opportunities, especially in the province of South-Holland, 18 percent of which is water. The province is not only well connected through the Rhine-Meuse-Scheldt delta, but also the cities have great amounts of canals and rivers. The province calls itself the inland shipping province of the Netherlands, with the biggest port of Europe - port of Rotterdam, 50 inland harbours and 6 container terminals (Zuid-Holland.nl). In addition, 41% of all goods in the province are transported by water (Van de Geest, 2016). The use of waterways shows great potential and further analyses will help in finding the opportunities and possibilities.

Lastly, Big Data can bring the system and emerging technologies such as the internet of things, artificial intelligence, 3D printing, automated transport and robotics, together and make everything work as efficient as possible (Dragicevic et al., 2019, p.199). All these relatively new technologies are capable of harnessing big data that could help to reuse, recycle and reduce the use of materials (Modgil et al., 2021, p.1), given that the data is available and accessible. Therefore Big Data is often seen as the (essential) missing element in obtaining a circular economy

These four topics will form the following analyses.

2.1 Construction hubs

TRENDS

To be able to overcome the housing shortage of an estimated one million homes an enormous amount of houses needs to be realized. Some of the houses will be constructed in greenfields. However, brownfields in city centers are an important part for the realization of new housing. Densification of our cities is part of the solution of housing shortage. The effect is that there is and will be a large pressure of transportation and construction logistics in dense cities. Transport of goods can have negative effects, for example traffic jams on highways, harmful emissions, fatal road accidents and blockades in city centers. In the meantime, construction sector is using 25% of all transport (UFEMAT, 2008). In terms of emission within our urban regions, construction transport contributes to 34% of the CO2 emissions (CE Delft, 2016).

The combination of high demand for construction and reduced side effects of construction transportation creates a huge challenge. Research institute TNO conducted a research on construction logistics (TNO, 2011). They looked into the trends and challenges of the construction logistics and identified the following:

1. Sustainability is the main topic of our current world. Sustainability in construction and transport is a part of that. Within construction logistics, this results on the one side in a need of usage of renewable energy, energy efficient transport and cleaner fuels, and on the other side in the urgency for more efficient planning and execution of construction materials, machinery and workers.

2. Industrialisation of the construction process is on the rise, due to reaching higher quality standards when constructing in a regulated environment, one that can barely be obtained at a construction site. This results in the need for prefabrication at factories and manufacturers, which again results in the demand for transportation of more complex products and just-in-time deliveries in order to gain the highest quality standards.

3. The shift in the construction task translates to an increased amount of renovation, densification, downscaling, and reconstruction mainly in existing urban areas and dense city centres. This results in more complex and less standardized projects which means more traffic and transport for smaller products and specialized craftship.

4. Collaboration of contracted parties in construction is much more needed. Due to sustainability regulations and in order to gain qualitative standards and optimization of construction processes, new collaborations between competing and supportive parties are needed. These are also required to work efficiently, profitably and qualitatively with prefabrication and joint transportation.

5. Digitization of logistic and informational flows can help reduce failure costs and improve coordination and alignment between stakeholders. The improving ICT-systems are there to be implemented, but a collaborative approach to designing, planning and construction materials is still missing.

The concept of a construction or logistic hub can provide the solution for the discussed trends.This chapter will further discuss the concept of such hubs.

CONCEPT OF A HUB

The construction hub is a broad concept with many different designs. Radboud Nijmegen provides a clear basic definition of such a hub that can help us understand what it entails (Radboud Nijmegen, n.d.). A construction hub is a transfer point. This point is placed in a location that has good and direct accessibility for suppliers on the one hand, and on the other one location that is of least disturbance to the city. The hub takes in the deliveries from suppliers and provides temporary storage. (Image 4)

At the other side it regulates the packages going to the construction site. The hub can improve efficiency by reorganizing the packages and deliveries and thus creating a higher loading rate, reducing the amount of transport in the city and downsizing the transportation to smaller and sustainable modes of transport.

The report also provides terms of condition for the hub:

> Proper accessibility for suppliers and to construction sites

> Expertise on controlling construction logistics

> Standardized knowledge sharing including connection to planning

> Possibility for prefabrication

> Regulating the mandatory use of the hub

> Regulating the costs and benefits over all stakeholders to create an equal share of profits.

These conditions are partly in line with the trends discussed in the previous chapter. The concept of a construction hub can facilitate current trends. In the past decade, multiple hubs were realised and closely studied at the same time to investigate if and how beneficial these hubs can be, compared to the traditional logistic planning. A couple of these examples will be examined further to see how the concept can be implemented.

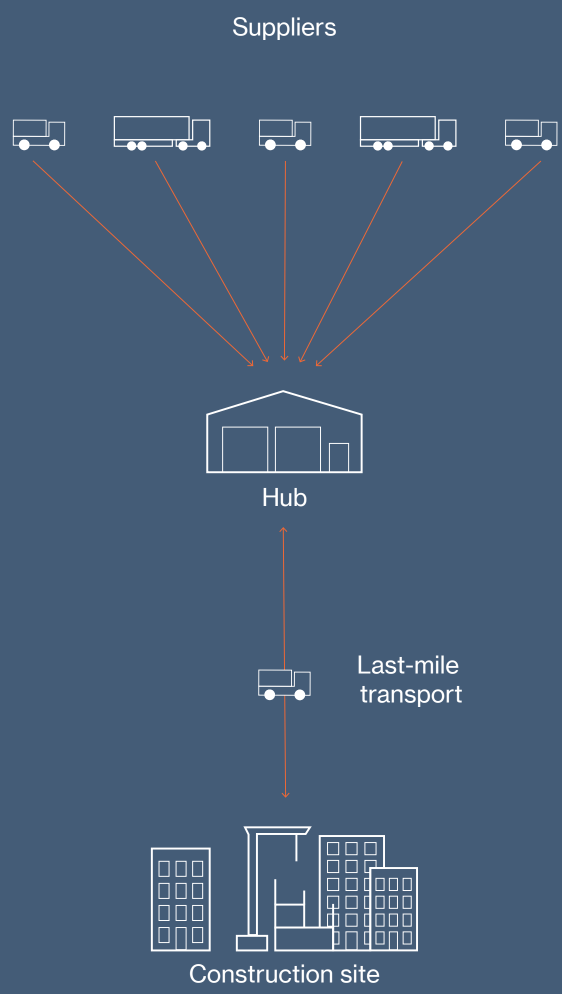


Image 4.
Operation of construction logistic hub
Drawing by author

HUB EXAMPLES

CONSTRUCTION CONSOLIDATION CENTRE, LONDON	VOLKERWESSELS BOUWHUB UTRECHT	LOGISTICS CITYHUB AMSTERDAM
The city of London started a pilot in 2005 with a construction consolidation centre three miles from the city of London. All logistics for four pilot projects were managed through this logistics hub.	VolkerWessels construction company started a built hub in 2015. They wanted to experiment with a new concept of logistics for construction. All construction logistics are monitored and coordinated.	This hub is meant to facilitate and shorten the last mile of deliveries. The hub is strategically located at the economic heart of the city in the harbour next to the water.
FUNCTIONS		
Delivery management: > material handling > inventory tracking > storage management	> delivery collection > storage > repackaging > transfer to construction site > refabrication > waste collection > parking	> storage > assembly > prefabrication > distribution via small scale water transport > office space > loading docks
REACH		
5 km from the city center servicing four nearby projects.	4 km from the city center servicing three projects.	15-20 km from the city center servicing whole city of Amsterdam
SIZE		
5.000 m^2	5.500 m^2	220.000 m^2
STAKEHOLDERS		
Government, businesses, association: > Transport of London > Wilson James Ltd. > Stanhope Plc. > Bovis > Construction Excellence	Businesses: > Woele & van Eesteren > Dura Vermeer > Wessels Zeist > de Mors BV > van Stokkum > Hilti > BMN Bouwmaterialen	Government and businesses: > VolkersWessels > Beelen Next > ParkBee > Port of Amsterdam > Rijkswaterstaat > Municipality of Amsterdam

BENEFITS

The concept of construction hubs and its influence on construction logistics has been a topic of interest for many companies.

The hub of VolkerWessels has been researched and investigated by research institute TNO and the academy of Rotterdam and Utrecht (VolkerWessels, 2017). The research was conducted on the use of a logistic construction hub at the construction of the building De Trip, in Utrecht. The research took 28 weeks and followed the whole construction process.

Image 5 summarizes the most significant positive effects that align with the trends and needs of current construction logistics. These results are quite stunning. The benefits itself are very positive, but the differences are also great. This could mean the concept can be very effective and valuable.

Additional benefits that occurred as well, but are harder to measure are, for instance, social benefits.

Due to the implementation of a hub there will be a significant reduction in construction traffic in the city and around the construction site. Given that the biggest amount of future construction is going to be reconstruction, transformation and densification, the projects will mainly be in dense urban areas. By reducing the amount of transport and planning transport at specific time slots will reduce the negative impact on the direct surrounding. The construction site can be smaller and time of construction will be shortened.

The hub also creates possibilities for green and smaller modes of transport, which again also reduces the impact on the surrounding. The people living around the construction site will have less hindrance from the construction site.

The hubs can also fulfill a social role for people with a distance at the labor market. Processing used materials in order for them to be used again is a perfect job for these people to get reintegrated in the labor market or for a permanent workplace. They can learn a craft that is needed, but hard to be automated.

Image 5.
Operation of construction logistic hub
Drawing by author

2.2 Materials

KINDS OF MATERIALS

The construction sector contributes to a usage of 5,6 Mton of materials. Apart from the petrochemical industry of the port of Rotterdam, this is the largest material flow in the province of South-Holland (Metabolic, 2018). The sector is also responsible for 23% of waste production in the whole of the country (CBS, 2019). However, the construction sector does score highest in the use of secundar materials, with 38%.These numbers show the scale, importance and power of the industry. However, it is important to get an insight in these numbers, starting with materials used.

Metabolic conducted a research in collaboration with Drift to investigate the material flows in the construction of housing and utility buildings. The report provides an overview of the kinds of materials used in new construction.

The materials that are used at higher quantity are concrete, steel, brick, wood and glass. Because of their great usage it is interesting to take a closer look at these materials in order to get a better understanding of the kind of material, its use and its production.

CONCRETE

Concrete is the most used material in the construction sector. The raw materials of concrete are limestone, silica, minerals, chemicals, sand, gravel, alumina and iron ore. (Petek Gursel, 2014) Concrete can be used as mortel, cast on site, in prefabrication or used in fabrication of products.

STEEL

Steel is the second most used material. Just like concrete, the material is strong and durable. In addition, steel can be used te make great spans. Steel is made from iron ore, coking coal, limestone and sometimes scrap metal.

BRICK

Brick is very common in the Netherlands, mainly due to an abundance of raw material for it. Bricks are made from clay, with addition of water, some metals or other additives for colour differentiation. Bricks used to be a structural building element, nowadays it is mainly used as nonbearing facade.

GLASS

Glass is crucial for the construction sector, as every building has got windows. Glass is produced with from sand(silica), soda ash, limestone and sometimes cullet. Glass is mainly used as flat glass for windows, however innovations present possibilty to use glass as the constructive material.

WOOD

Wood is a sustainable and renewable material. The most used type of wood is coniferous, hardwood, tropical wood and sheet material. Only 7% of the wood used in the Netherlands is not imported. The Dutch wood does not come from harvest, but as rest product from site preparation.

PRODUCTS

MANUFACTURING

> street bricks
> tiles
> sewage pipes
> foundation poles
> building blocks

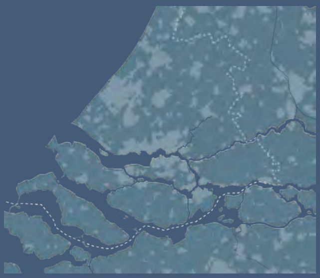
Currently there are 18 concrete mortel facilities in the province of South-Holland (de Kort, 2017). An additional 15 facilities produce prefabricated concrete products. These facilities are most of the time located along the shore of a waterway.

> beams
> profiles
> sheeting
> tubes
> railing

The biggest manufacturer is Tata Steel located in Ijmuiden. They also have a large location in dordrecht for piping. There are an additional 40 companies that work with steel and produce steel products.

> facade brick
> street brick
> pavement
> roof tile

There are no manufacturers of brick in the west of the country. The clay is mined from the inland rivers and most brick factories are in Limburg, in the south.



> windows
> railing
> walls
> doors

There are a few companies in the Netherlands that do primary processing of wood, as most imported wood is already processed. There are approximately 100 companies that produce wood products.

> **beams**
> **sheets**
> **slats**
> **roof tile**
> **doors, windows**

There are two factories that produce glass, one in Ridderkerk and one in Spijkenisse. The remaining companies produce products with glass, like windows and doors.

Image 6.
Maps of manufacturing locations,
Drawing by author,
based on Regiobedrijf.nl

MATERIAL FLOWS

Now that there is a better understanding of the most important materials in the construction sector, it is interesting to look at the amount that flows in and out of the sector. There is a lot of extensive research on the flows of materials, on which the chart below is based (Metabolic, 2019). However, they are very complex and also project specific. That is why only the five main materials that contribute for the largest part are taken into account here.

The whole construction sector used a bit over 80 billion kilos of material in 2016 (CBS, 2019). An additional 25 billion kilos went into the production of construction materials. These numbers are very general and need to be broken down. The flowchart below tells us the amounts of the five main materials used in. Concrete is significantly the most used material, especially for the constructive structure of buildings. After that brick is second most used material, followed by steel, wood and glass.

Now on the other side of the 80 billion kilos of materials going into the construction sector it also produces 18 billion kilos of waste (CBS, 2019). The flowchart also shows the specific amounts per material. As can be seen, the ingoing and outgoing amounts are not in balance at all. This makes sense, as a building often stays up for 50-100 years, or even longer. This means that the needed materials for construction can never be covered by the materials coming out. However, it is imported to actually use this amount, thus wasting as little amount of materials as possible. The next step is investigating how the waste materials can be used to reintroduce them back in the material flow for new construction

Image 7. Material flows in concstruction industry.
Drawing by author,
based on (CE Delft, 2015), (CBS, 2019), (Metabolic, 2020)

CIRCULAR STRATEGIES

The research by Metabolic discussed in the previous chapter showed the previous common ways of dealing with waste; dumping and burning, recycling and downcycling. However, there are more ways of dealing with waste materials. There is a long history of discunssions about the methods of circularity. For instance in the 1980's various concepts of waste hierarchies were established (Vermeulen, 2018). The concept was based on 3 R's; reduce, reuse and recycle (Srinivas, 2021). However, Srinivas also states that there are many more R's. Therefore, Vermeulen has tried to resolve the confusion and develop the concept of 10 of the most important and relevant R's, a method that is now widely used and implemented (Vermeulen, 2018). The first step are short loop strategies: refuse, reduce, reuse and repair. In the medium long loop there is refurbish, remanufacture and repurpose. The long loop strategies consist of recycle, recover and re-mine. A clear definition of the strategies is shown in table 1 below. The Dutch government also implements this theory on circular strategies (Potting, 2017).

Another upcoming marketing technique that focuses on circularity is the transition from a product to product as a service. Instead of selling a product, the the value that comes from whole period of usage is sold (Aubertin, 2019). This leads to a shift in ownership, from the customer to the producer (Rombouts, 2020). The shift in ownership means the biggest cost factor for the producer will be the material costs. The incentive for the producer is to decrease the material cost to stay profitable (Matschewsky, 2019). This can be a stimulus to reduce the use of materials, therefore implementing the circular economy model. However, the product-as-a-service business model can only contribute to a circular economy when taking into account two aspects (Matschewsky, 2019). One aspect is efficiency - the narrowing of flows and reduction in material use and pollution. The other is the effectiveness, focused on retaining the material value and optimizing the benefits of ecological and economic systems. Only by taking into account these aspects a product-as-a-service model can actually contribute to a circular economy.

Circular

	R	Strategy	Description
Smarter product use	R0	Refuse	Make physical products redundant by offering the same function or combined functions, usually enabled by radically different product, technology or both.
	R1	Rethink	Extend the life of materials or products in a manner that exploits their residual value and becomes a significant part of the offering of the business. May involve providing new forms of value.
Extend lifespan product	R2	Reduce	Improve circularity potential and process efficiency through consuming fewer natural resources or energy, aim for 'gentani' (the absolute minimum input required to run a process).
	R3	Reuse	Extend to new use cycle by reusing a part/product (discarded/not in use) that is still in good condition and can fulfil its original function in a different use context (new customer/user).
	R4	Repair	Extend existing use cycle by countering wear and tear, and correcting faulty components of a defective product/part to return it to its original functionality.
	R5	Refurbish	Extend to new use cycles by returning a part/product (discarded/not in use) to a satisfactory working condition that may be inferior to the original specification.
	R6	Remanufacture	Extend to new use cycles by returning a product (discarded/not in use) to at least Original Equipment Manufacturer (OEM) performance specification and quality.
Useful application materials	R7	Repurpose	Extend to new use cycles by using a product (discarded/not in use) or its parts for different functions.
	R8	Recycle	Extend material lifespan by processing them in order to obtain the same or comparable quality.
	R9	Recover	Recover energy or nutrients from composting or processing materials.

Linear

Table 1 - 10 R's of circularity
Based on (Vermeulen, 2019), (Potting, 2017), (Blomsma, 2019)

2.3 Water

REDISCOVERY OF WATERWAYS

Regarding water management, the Netherlands is often seen as one of the most unique countries in the world (Schwab, 1993, p.150). Water performed a huge role in the development of the Netherlands (Provincie Zuid-Holland, nd). A large section of the country is artificially made and reclaimed from water (Schwab, 1993, p.150). Over 25% of its surface is below sea level and approximately 65% of the total land surface would be flooded if the infrastructure and water management system (dikes, sluices etc) are not well maintained (Rijksoverheid, 2015, p.5). This constant struggle required perseverance, cooperation and ingenuity and at the same time resulted in shifting towards an egalitarian society (Mostert, 2020, 312). The egalitarian society is maintained via democratic institutions such as water boards (Mostert, 2020, 312).

Collaboratively, over time Dutch water boards shaped the Netherlands often guided by the need for agricultural land or as a result of the drainage of low and high moor areas for peat production (Rijkswaterstaat, 2019). This unique Delta situation generated possibilities and ensured that water transport became a dominant mode of transport (DRIFT, 2015). The ever-growing network of maintained waterways (6.300 km of navigable waterways) created a huge potential for water transport (Rijkswaterstaat, 2019).

Nowadays, the potential for water transport does not seem to have disappeared (DRIFT, 2015). Due to development, the province of South Holland became an international transport hub (Canon van Nederland, 2020). Flows of goods, industrial materials, agricultural and horticultural products enter and leave the province from multiple ports (Provincie Zuid-Holland, nd). The majority of goods are loaded and unloaded in the port of Rotterdam. Although, there are a number of product groups that are to some extent loaded and unloaded in inland ports such as fertilizers, raw minerals & building materials and agricultural products, livestock and food products (Provincie Zuid-Holland, nd). The province is committed to an optimally functioning infrastructure that consists of easily accessible nodes that form the arteries of both provincial and national economy (Provincie Zuid-Holland, nd). Between 2007-2014 the total throughput by water (inland shipping) increased by 11.7% (Provincie Zuid-Holland, nd). The province intends to use this momentum and explores inland waterway shipping as an alternative for other transportation modes (Provincie Zuid-Holland, 2018) (Geest & Leeuw van Weenen, 2016).

WATER TRANSPORT AMBITION

The highlights of cargo transport via water are elaborated in Image 8. The focus is established on the shipping of building materials (Geest & Leeuw van Weenen, 2016).

Panteia stated an expectation of the transhipment volume for South Holland in the longer term: the cargo flows by any kind of transport mode will further increase due to large-scale infrastructure projects, reduction of housing shortage and the circular economy initiatives (Geest & Leeuw van Weenen, 2016).

The province of South Holland has the ambition to use inland water transport as a sustainable counterpart to other transport modes and further develop inland waterway transportation using existing infrastructure (Image 9). In total there are 73 transhipment ports in the province of South Holland, the 22 largest are displayed below. The total volume in the province was 113,890,618 tons in 2014.

The ambition resulted in the 2019-2048 Outline Agreement composed by the provincestating that efforts will be made to increase water transport and sufficient business locations alongside the water (Provincie Zuid-Holland, 2018). This includes both provincial, non-provincial and national waterways. The intensification of water transport can be done via promoting, using Big Data (2.4) to organize the flow of goods and by facilitating companies (Provincie Zuid-Holland, 2018). In addition, hubs could be used to transfer goods between road, rail and water (2.2).

The stated ambition is a good start. However, there are some challenges to deal with which make it difficult to further develop and increase inland shipping (DRIFT, 2015).

Image 8 - Statistics on water cargo flow,
Drawing by author,
based on (CBS, 2019), (Geest & De Leeuw van Weenen, 2016)

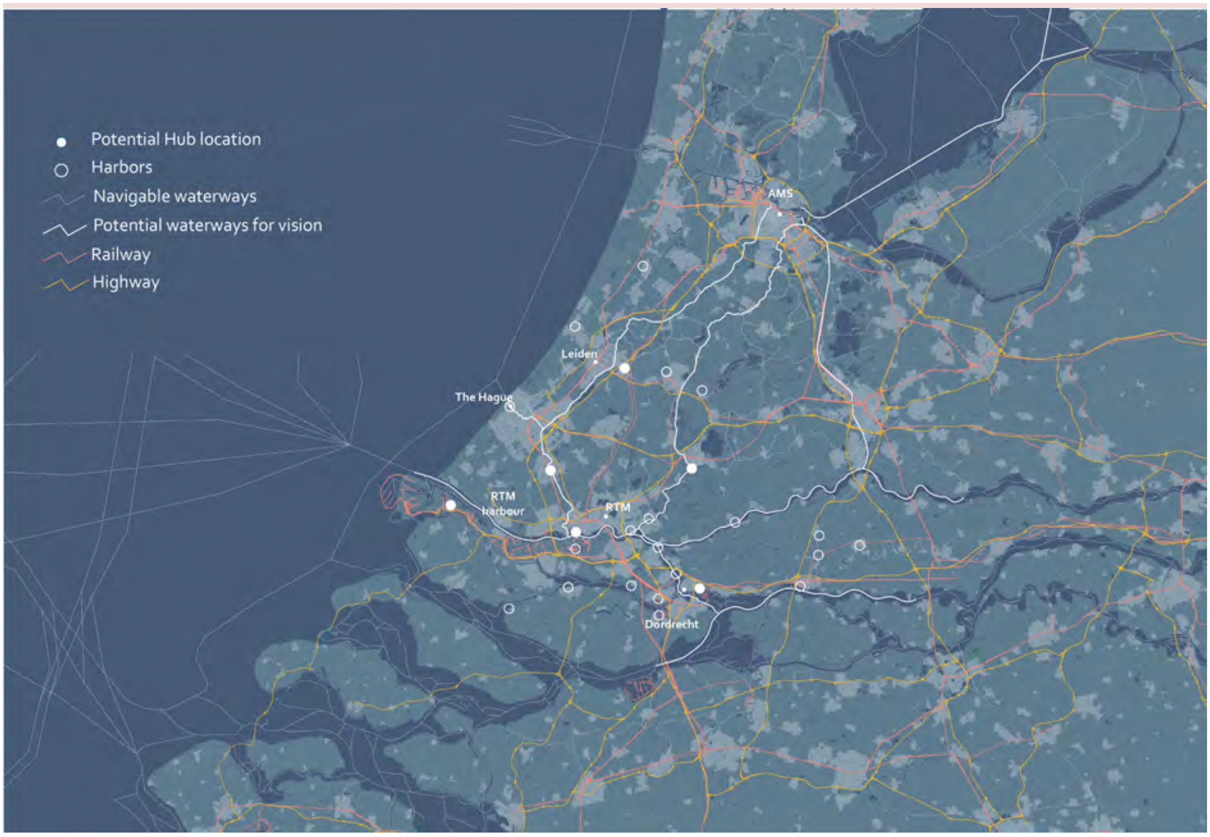


Image 9 - Navigable waterwats,
Drawing by author,
based on (Rijkswaterstaat, NWB, 2019)

CHALLENGES AND TRANSITION

Multiple challenges have made it difficult to intensify and create a sustainable inland shipping environment. This can be traced to the following facets (DRIFT, 2015):

1. Water transport is often characterized by many small companies that specifically focus on one type of transport (or one ship). On the sector level there was a fragmented picture and despite mergers, there is no unified sector: a shared culture and pride have an “everyone for himself” mentality. There is an ideal of a well-integrated logistics system, but it already proves difficult to obtain existing information to share and provide a platform for this. On a technical level, fragmentation in the form of a lack of standardization: ships are the same, but the functioning is not the same (An IT on the quayside could lead to a revolution of much more standardization).

2. On the public side, there is also not one powerful government actor for water transport. Development of business parks, wet infrastructure, technological innovation, the interest of shippers, price incentives against road transport, it is divided among several governments that all give some importance to inland shipping.

3. Finally, there is a fragmentation of benefits: where ‘thick’ cargo flows often clearly have parties involved which benefit strongly, there is not one party for “thin” flow that has the potential to gain a lot from transport across the water: shipper, sector and consumer together have a lot to gain, but individually it seems the profit often marginal.

This results in a standstill. Therefore, a transition to overcome these challenges is necessary according to Drift. The transition task can be conducted as follows:

Water transport continues to have inherent benefits over road transport and has potentially new ones tapping into markets. But then the discussions should go further than survival in today’s markets. And not only focus on the growth of “thick” container flows but on the much wider winning new markets. New markets, new logistics concepts, service-oriented organization of water transport, connection with other modalities and indisputably better environmental performance than road transport will require. In other words, it requires a fundamentally new culture, structure and working method to fulfil the great sustainability potential of water transport, a transition. Such a big change does not arise from the existing structures and interests or from planning and control, but must be done through experiments, innovation networks and administrative perseverance are given direction and speed. According to Drift, the challenge is:

Exploiting the economic, ecological and social potential of water transport from a strong belief in the future perspective of water transport, through new markets, develop logistics concepts and organizational forms; radically green (DRIFT, 2015).

FUTURE OF INLAND WATER TRANSIT

There is a transition task beyond the borders of South Holland to reach the full potential of the fragmented inland water transport sector. Although, South Holland could play a vital role in this sector. There are multiple reasons to further explore and expand the water transport sector.

It is expected that South Holland will have a more prominent role in construction logistics according to (Geest & Leeuw van Weenen, 2016). Construction producers and concrete manufacturers, given the short distances to the market and proximity to seaports for the landing of raw materials, are already established in South Holland (Geest & Leeuw van Weenen, 2016).

Furthermore, it is expected that the inland water transport sector due to the circular ambitions of South Holland will further develop (Geest & Leeuw van Weenen, 2016). In recent years the recycling, refurbished and remanufactured sector has already increased. Resulting in demolishing/building materials being collected, recycled and transported to other locations. The desired recycling centre is already located in the harbour of Rotterdam (Geest & Leeuw van Weenen, 2016). Transportation is essential and this relatively new market will strengthen the position of South Holland as an (international) transport hub.

Also mentioned in the transition task is that water transport has inherent benefits over road transport:

> Water transport produces substantially less in terms of CO2 emissions compared to road transport (DRIFT, 2015). For instance; to transport 110 million tons of materials we would roughly use 22 trucks or 1 barge boat. The efficiency of water transport is indisputable.

> Water transport can (partly) replace road transport. Causing that trucks don't have to travel between cities and locations. Resulting in less congestion (DRIFT, 2015).

> The local hubs as explained in 2.2 can be located alongside the waterfront in local areas and directly transported to and from reconstruction or demolishing areas (Geest & Leeuw van Weenen, 2016).

> New data-driven approaches (explained in 2.4) will create more opportunities. The Blue Wave is an example of this, ensuring better coordination between road traffic and shipping traffic on the water. By obtaining better insight into the distribution, more efficient traffic management on road and water can be done (Provincie Zuid-Holland, 2018).

There is also an important challenge that has to be taken into account. In the second half of 2018, inland shipping suffered from low water levels due to the prolonged drought (CBS, 2019). This meant that ships could load fewer goods and it was not possible to sail everywhere. This mainly affected international transport, which decreased by almost 6% in 2018 (CBS, 2019). In 2019, domestic transport by inland vessels decreased. Compared to a year earlier, the transport decreased by 1.6% to 120 million tons (CBS, 2019). It is expected that prolonged drought will more occur due to climate change and can therefore be seen as a serious threat to water transportation (Droogte KNMI, nd).

In order to further increase water sustainable transportation, it is essential that there will be alternatives as well. A combination of different transport modes which will work collaboratively and use hubs as transport nodes will create a resilient transportation system.

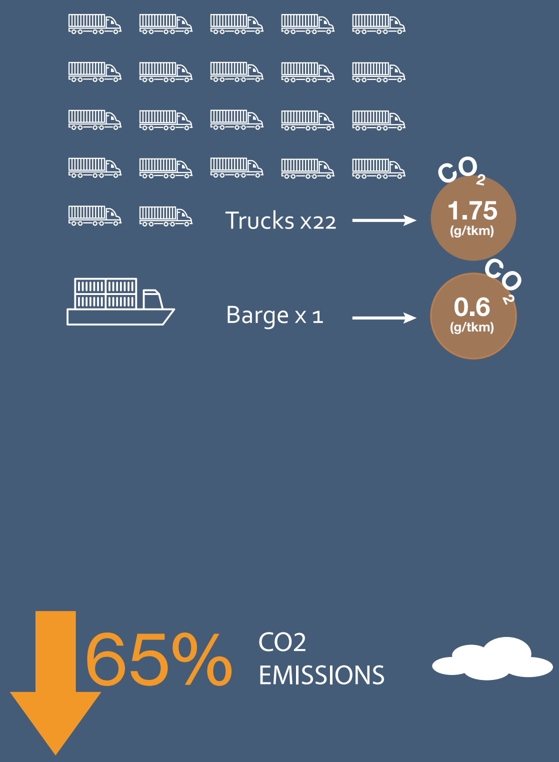


Image 10. Benefits of water transport,
Drawing by author,
based on (Ommeren, E. B., ND) & (CE Delft, ND)

2.4 Data

OPPORTUNITIES OF BIG DATA

In continuation of the third revolution, Industry 4.0 has appeared (Modgil et al., 2021, p.1). Industry 4.0 is characterized by an intertwined digital, physical and biological world (Philbeck & Davis, 2019). Based on emerging technologies such as the internet of things, artificial intelligence, 3D printing and robotics (Dragicevic et al., 2019, p.199). The efficiency of these new technologies is based on the use and availability of Big Data. According to Oracle, Big Data can be seen as "larger, more complex data sets, from especially new data sources such as devices and objects advent of the Internet of Things (IoT). These devices and objects are connected to the internet and can be used to gather real-time information and analyse patterns (ORACLE, nd). These patterns are essential to machine learning to predict all kinds of different events (ORACLE, nd). The available data sets are so voluminous that they can be used to transform into useful information for decision making and predicting activities (Matthey, 2020). In Image x a schematization of the Big Data process and related terms is created.

All these relatively new technologies are capable of harnessing big data that could help to reuse, recycle and reduce the use of materials (Modgil et al., 2021, p.1). Therefore Big Data is often seen as the (essential) missing element in obtaining a circular economy. The Construction and Demolishing sector could be a good start of introducing Big Data due to the tangibility of material flows and the urgency towards a circular economy.

Big Data can offer multiple benefits over contemporary approaches:

1. The Big Data generated by diverse platforms can help ecosystems such as the construction and demolishing sector on a real-time basis by providing a wide variety of data and provide insight into the real-time and spatial bounded locations (Dubey et al., 2019, p.534) (Modgil et al., 2021, p.1)

2. The use of Big Data analysis insight in the decision making of various processes, resulting in the opportunity to conduct multi-constrained and well-informed decisions (Saggi & Jain, 2018, p. 759).

3. The use of Big Data enables large-scale group decision making (LSGDM) because it displays the problem from the perspective of each decision-maker differently (Liu et al., 2019, p.737). LSGDM refers to the most suitable option from a set of feasible alternatives and predicted on the preference of an often large number of decision-makers (Liu et al., 2019, p.737). LSGDM offers refined and optimized solutions to a circular economy (Power, 2014, p.222)

Image 11 elaborates the interaction between multiple aspects that are related to the Big Data system. Furthermore, the Image describes the gains that could help a circular building and demolition sector.

Big data or other framed terms are not the end goal, they are a tool to amplify a virtual approach

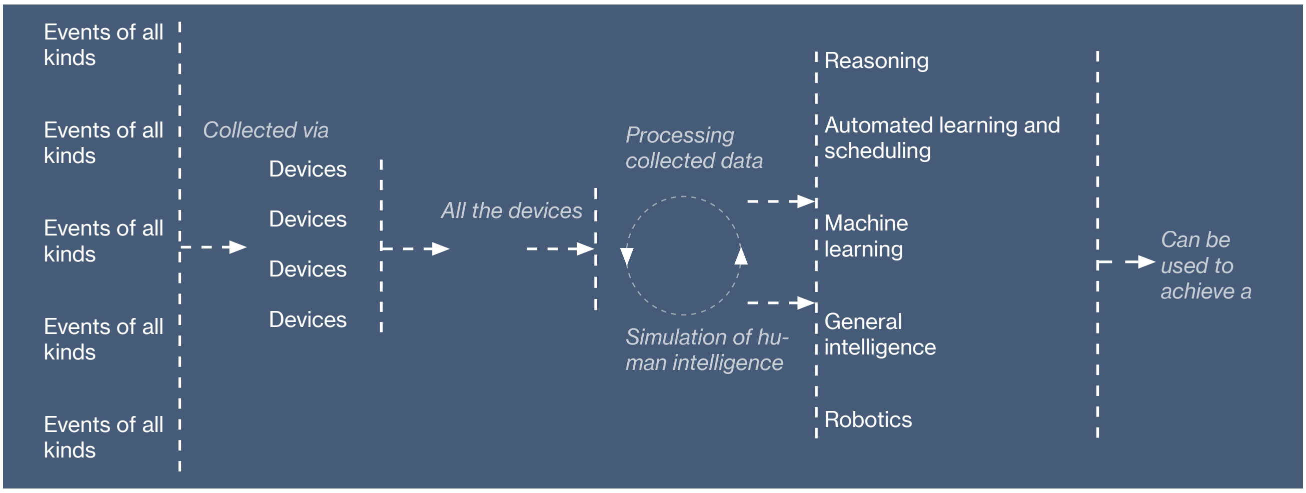


Image 11. Big Data system
drawing by author,
based on (Dubey et al., 2019, p.534) (Modgil et al., 2021, p.1)

of the strategy toward a circular construction and demolishing sector. The next subchapter is elaborated on how the use of (Big) Data could be intertwined within obtaining the aforementioned goals.

VIRTUAL APPROACH

To achieve a provincial (or national) circular construction and demolishing system, will require transportation, remanufacturing and refurbishing of goods and materials. In 2.3 it is explained that the current water infrastructure has the potential to be used as a logistic network to transport the materials between construction and demolition nodes across South-Holland and beyond. The hubs, as explained in subchapter 2.2, are the essential link between the construction and demolition sites. The hubs enable the system to intercept huge amounts of flows and subsequently store the materials. Because of the storage capacity in hubs, the system will be able to connect the offer and demand of materials over certain periods and locations.

The hubs consist of cascade transport use; the source, the stream and the droplet are connected via water. It is expected that different kinds of materials (2.1), the physical flow, coming from existing buildings and is intended to be refurbished/remanufactured in hubs to be reused again in a new building site. Simultaneously, a virtual flow, which contains the information of material that is being transported and reused will be monitored. To manage both the physical and virtual flows, use them in the most efficient way and monitor the entire system a data network/management system will be created.

A tool that is capable to manage the entire system and use the available Big Data sufficiently could be a Digital Twin Region. Digital twins are considered the key information management technology of the era (Gartner, 2019). It can be used as the continuation of the digitisation in projects, where physical objects have counterparts that are digital and mirroring the properties of the real-world objects (Gartner, 2019). Besides, the system is capable of managing all the information.

To create a tool that could help in achieving a circular construction and demolition sector a number of preceding steps are necessary:

1) The first step consists of an assessment of material data. Material passports are key to the transition. The government put up a framework, platformCB23, together with stakeholders from the sector to push on the implementation of a material passport.

2) The next step is BIM designing; BIM is a term used in the construction sector, which stands for Building Information - Model, Modelling, or Management (Bouwinformatieraad, 2020). BIM could be used to visualise and provide information about a 3D object in empty space and does so independently of time.

BIM provides 3-dimensional geometries and manages information. (Kahlen et al., 2017) states that a digital twin is an addition to BIM and provides a dynamic, time-dependent nature, described as both 3D drawings and system behaviour, simultanesously improving information management (Kahlen et al., 2017).

3) Finally, the Digital Twin Region. The main purpose of creating Digital Twins for the construction and demolition sector is to make better-informed and transparent decisions (Tijs, 2020, p.7). While using the help of data integration and visualisation from across the urban space (Hemetsberger, 2020). This virtual doppelgänger of urban environments promises to make cities more resilient (Hemetsberger, 2020).

It is adjusted that a twin region has the ultimate (sole) purpose to make better-informed and transparent decisions. Nevertheless, the system can be used extensively for monitoring and structuring the material flows between hubs and construction and demolition sites as well.

A digital twin region could be used to predict the number of materials that are needed in a certain location at a specific moment of time. Because of the inter-connectedness, automated vehicles will be packed automatically and sent to the streams and droplets. The construction materials can be delivered on time and in a sustainable way. Besides we have to take into account that technical innovations and concepts must be people-centred and improve the quality of life of all its inhabitants rather than achieving process or economic efficiency. Therefore, citizens must be able to use the data to order and deliver the materials at any place that is wished for.

DATA X LOGISTICS

Big Data has much to offer to the world of logistics. Sophisticated data analytics can consolidate this traditionally fragmented sector, and these new capabilities put logistics providers in pole position as “search engines in the physical world”. Nowadays the digital universe is expanding at a rate that the data volume doubles every two years. Over the next coming decades, data possibilities will steadily grow.

In the world of logistics Big Data and related analytics could have value in three dimensions:

1. Operational efficiency: use data to make better decisions, optimizing resources and consumption and improve process performance and quality.

2. Customer experience: increase customer loyalty via optimized customer service and precise customer segmentation.

3. New business models: complement revenue streams from existing products and additionally create revenue from new data products

Big Data analytics can provide a competitive advantage because of five distinct properties. These five properties highlight where Big Data can be most effectively applied in the logistics industry.

Big data increases the efficiency of logistic operations. This is nothing new, IT always had the purpose for improving business operations. Multiple optimizations using big data results in an efficient logistic system

The essential element in the Big Data optimizations of the logistic network is the role of Artificial Intelligence (AI) (Vashistha, 2020). The sudden increase of digitization in the fourth Revolution opposes a huge pressure concerning energy, manufacturing or transportation (Vashistha, 2020). AI is the essential element that enables machines to simulate human behaviour (Java Point, 2018). Machine learning can be seen as a subset of AI which allows a machine to learn from past data automatically (Java Point, 2018). Therefore playing a pivotal role in:

> Saving time

> Reducing costs

> Increasing productivity and accuracy with cognitive automation

> Demand forecasting

> Route optimization

An interesting element that could make a start in the fourth revolution is the use of automated transport. Regarding chapter 2.3 inland water transport is and can become the essential mode of transport. 2.4.4. Will further elaborate on the possibilities of creating an automated water transport system.

AUTOMATED WATER TRANSPORT

The transport sector is one of the sectors which holds the greatest potential for contributing to the European Energy Union goals regarding greater efficiency, competitiveness and decarbonisation (EUROPEAN COMMISSION, 2017). The European Commission initiated the Strategic Transport Research and Innovation Agenda (STRIA) which focuses on the deployment and development of low-carbon transport technology solutions encompassing at the same time safety, security and digitalisation (EUROPEAN COMMISSION, 2017).

CAT, Connected and Automated Transport, is part of STRIA. CAT and related technologies are introduced as the technology for all transport modes to obtain the Energy Union Goals (EUROPEAN COMMISSION, 2017). Furthermore, CAT technologies have more benefits regarding decarbonisation:

> Removing the human element from vehicle operations resulting in optimum performance parameters. Besides, the human factor remains the most important underlying cause of marine accidents.

> Minimising the headways or spacing between vehicles through implementing moving block principles

and automated control connectivity

> Efficient vehicle utilisation for freight transport

CAT can be used by improving the interconnectivity between modes and ports to make the transport system and vessels more efficient and reliable (EUROPEAN COMMISSION, 2017). Especially regarding waterborne transport, there are objectives stated for the next coming decades:

> Thirty per cent of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50 % by 2050.

> Reduce CO2 emissions from maritime fuels by 40% by 2050

> All core seaports connected to the hinterland via rail freight and inland water system

> Increasing the use of inland waterways due to its large potential to reduce road congestion and emissions

The Ship and port Automation and Autonomy are seen as the aspects which could lead to an Automated Water Transportation Network functioning the Hubs System. New technology is under development which will create a fully autonomous system. Based on this new technology and with the use of Big Data we create a system that consists of the following approaches (Valentine, 2020):

Automated vessel operation along navigable inland waterways - Includes vessel navigation and the use of automated cranes that makes it possible to self-load and self-unload. These automated inland vessels transport from the source to the stream and droplet location.

The automated self-driving trucks - These trucks will interline with the automated vessels at the stream and droplet hub locations if the construction locations cannot be reached via water.

Automation increases efficiency, reliability and safety due to using Big Data and AI. Although, the use of Big Data often goes hand in hand with the threats of Big Data. It enables one company or organisation to have it all. Therefore, Big Data Transparency is essential to maintain a 'fair' system

BIG DATA TRANSPARENCY

Big data often uses cases that are built upon a smart combination of individual data sources, these sources combined will provide new perspectives and insights. Vital for creating a twin region. Although, to ensure successful implementation and transparency three major challenges must be addressed and overcome.

Full transparency of information assets and ownership

Data attributes must be cleared structured and explicitly defined across multiple databases

Maintenance of strong governance on data quality to ensure the validity of mass queries.

Furthermore, in each project where Big Data is being used, it is essential to consider data protection and privacy issues. Contemporary personal data is generally revealed when exploiting information assets. Especially when there is an attempt to gain customer insight. Despite that Use cases are typically elusive in countries with strict data protection laws, legislation is not the only constraint. With the use of large-scale collection and exploitation of data to e.g. forecast the supply chain or last-mile optimization, it will often stir towards a public debate which could subsequently damage the reputation of the essential Big data process towards a Circular economy (Jeske et al., 2013).

To conclude, simultaneously with creating a Digital twin region with the use of Big Data it becomes vital to include the three aforementioned major challenges within the process. And moreover ensuring data privacy via transparency towards all included stakeholders.

3. Vision

Virtual

The efficiency of the new technologies is based on the use and availability of Big Data. All relatively new technologies are capable of harnessing big data that could help to reuse, recycle and reduce the use of materials. Therefore Big Data is often seen as the (essential) missing element in obtaining a circular economy. It is essential in the Virtual approach with the use of digital material passports, BIM designing and Digital twin region. Additionally, it has a lot to offer in the logistics sector. Although, it is important to maintain the transparency of Big Data.

Water

Due to historic development South Holland has huge potential for inland water transport. The province has the ambition to use this momentum and further explore the possibilities as a sustainable counterpart to other transport modes. Exploiting the economic, ecological and social potential of water transport with a focus on the future perspective of water transport, through new markets, develop logistics concepts and organizational forms; that are radically green.

Circular hubs

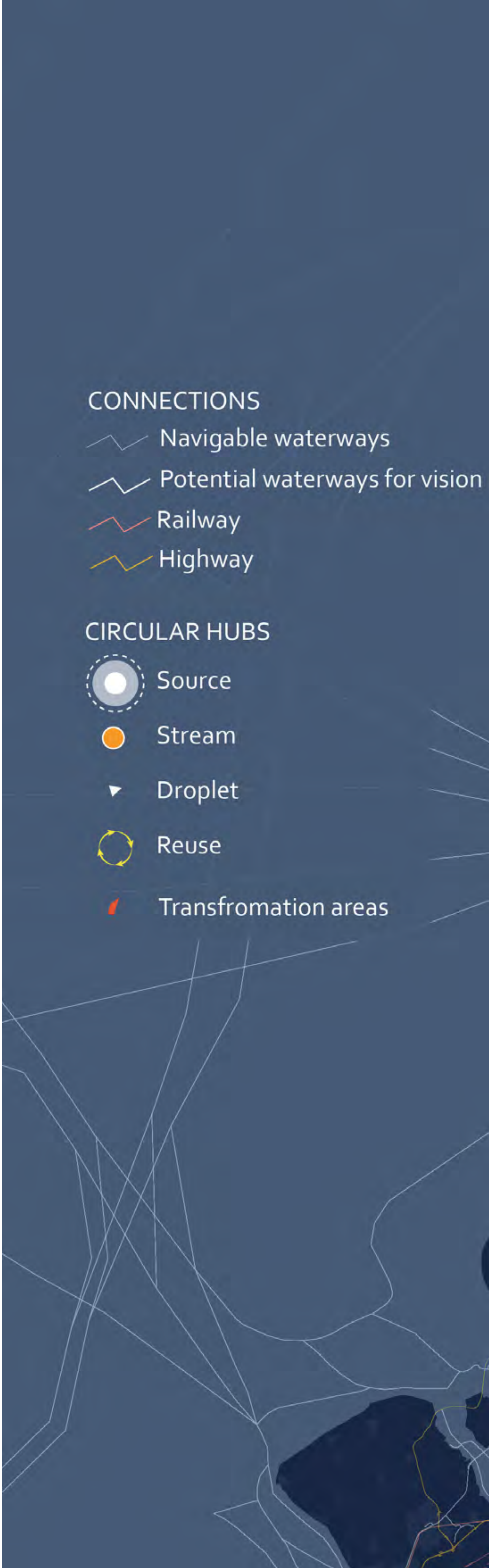
Housing shortage and redevelopment caused a large continuous pressure on transportation and construction logistics in dense cities. Besides, as stated in 2.1 construction logistics there are multiple negative impacts. A construction hub is seen as a concept to solve this challenge and a relief to pressure on cities and transportation. Due to its many advantages, a circular hub can be the key node towards a circular construction and demolishing sector.

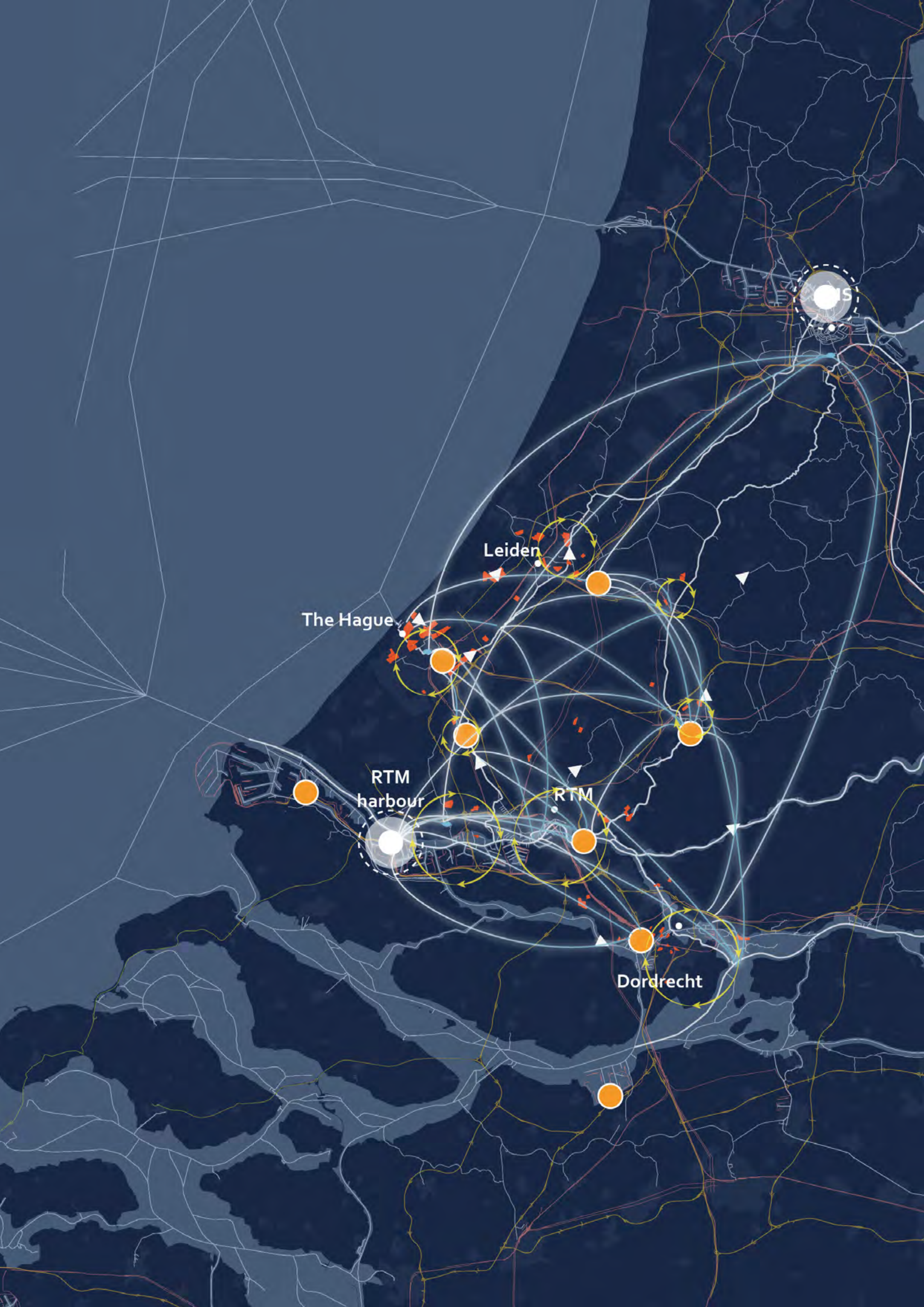
Vision 2030

To strive for a circular economy in 2030 and implement an entire new strategy on logistics and flows, a period of transition is needed. The 2030 vision plays an important role in this period of change.

2030 is a milestone, since the first puzzle pieces have been placed. Yet, these are mainly small scaled interventions. The material flows are starting to be digitized by the introduction of the material passports and innovations for reuse have been established.

The first locations of the stream have been placed and water transport has been introduced in between several locations. The first droplet locations are used to provide material distribution for transformation areas. We can conclude that the base for Virtual X Water is standing. From here, 2030 and on, it is all about the introduction of the new strategy and connecting the small scaled interventions on the macro scale with Virtual X Water.




Leiden
The Hague
RTM
harbour
RTM
Dordrecht

Vision 2050

In 2050 it is easy for all stakeholders to access second-hand materials on the all-encompassing database, which are being transported by interconnected regions and cities in a CO_2 friendly way. We embrace the existing networks of waterways, roads and train tracks. The circular hubs are located on the most efficiënt locations. The creation of different hub scales to create new nods, which is intended to improve logistics, communication and knowledge flows. The digital connection allows us to be efficient and helps integrate the re-use of materials in the design process. The virtual- and water flows combined make the circular economy a reality.

By 2050 we are ambitions to achieve the following goals:

> To use the current well maintained infrastructure to transport with the least CO_2 emissions while relieving the city and highways from construction transport while giving attention to public life.

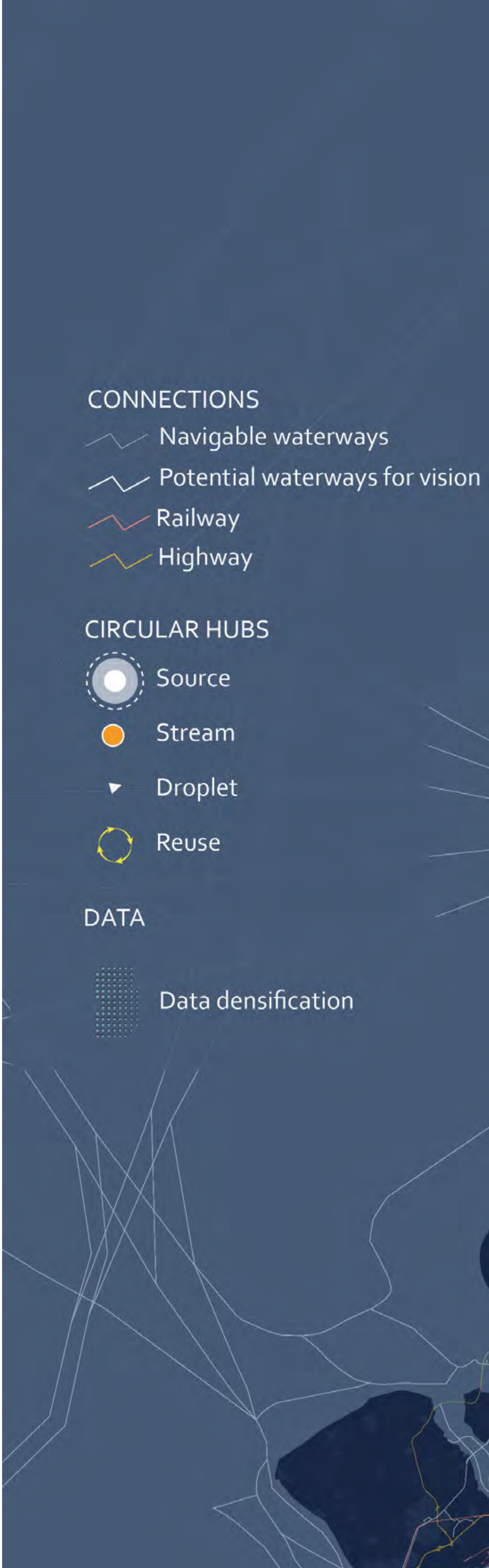
> to use Big Data to amplify the designing process and logistics network and obtain higher efficiency.

> to create a framework to preserve and enhance the material value by reusing the existing ones.

> to give the chance to everybody, to live in good quality and eco-friendly environment by providing a structure for construction sector to build circular.

The Virtual X Water has a potential to work beyond construction, therefore an overarching ambition is as follows:

*To **inspire** the approach of creating **cross-industry solutions** that result in a **transparent system** and **high quality spaces** for government, companies and people.*

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4. Design strategies

THREE SCALES

THE SOURCE

THE STREAM

THE DROPLET

THE MATRIX

4.1 Three scales

The proposed integrated network is based on the implementation of hubs on three different scales. Savy discussed the different levels of logistic hubs in his literary study on the hierarchy of logistic facilities (2005). ''In the first level we find single establishments such as depots, warehouses, and sorting centers. The second level comprises specialized facilities in a logistics zone, also called platform if it is a formal organization. Logistics hubs encompass several zones or platforms in a given area and are situated in the third level. Lastly the author defines the logistics area, which corresponds to a large scale agglomeration in a metropolitan/regional scope.'' This hierarchy is used in the hubs on three scales; the regional source, the urban stream and the local droplet.

Image 12 further elaborates the way the three hubs operate among each other.

THE SOURCE

The source is the origin of the integrated hubs network. Here, large scale import and export is coordinated. This is the place where stakeholders from all sectors crossover and work together on sustainability and circularity. It is the inspiration centre where market parties, government and knowledge institutions work together on innovations and new technologies on circular economy and sustainable development. Rest flows from all sectors can come in here and enter as a resource in another sector. The source on its turn feeds the stream.

THE STREAM

The stream is an urban hub that flows between the source and, in the end, the construction site. This consolidation centre coordinates and facilitates all construction logistics. Deliveries come through the hub, are reorganised and delivered just in time at the construction site. The hub also assesses and processes return and waste flows, making sure no material loses its potential value. It links waste materials directly to its new user of the initial manufacturer. All day packages are distributed to the droplets.

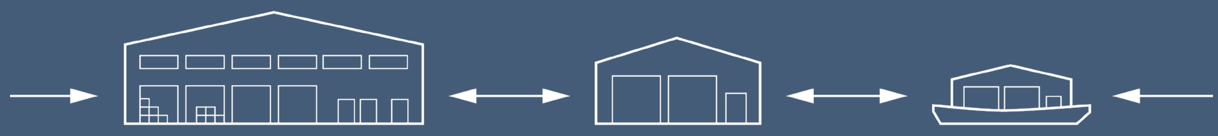
THE DROPLET

The droplet is a flexible floating logistic terminal for the construction site. It is wherever construction is happening and will move to wherever transformation is needed. The droplet has a direct link via water with the stream as facilitates the last-mile delivery of supplies and return flows. This is the first checkpoint for the assessment of used materials and clean waste material flows are created to be returned to the stream.

The Source

The Stream

The Droplet



The Source

- Regional scale
- Fixed
- Leader in crossovers
- Showcase methods of recycling, reusing, refurbish, remanufacture
- Large scale recycling processes
- Innovation centre on all-sector-wide approach on circularity

The Stream

- Urban scale
- Fixed
- Strategically positioned at skirt of the city along waterway
- Coordinates material flows from and to construction site
- Direct connection and distribution of the droplet
- Connects suppliers to waste/recycle flow
- Storing used materials
- Recycle waste materials

The Droplet

- Local scale
- Flexible on water
- Temporary
- Cover construction site logistics
- Create clean material flows
- Assessment on reuse, remanufacture, recycle
- Last-mile site delivery with green mobility

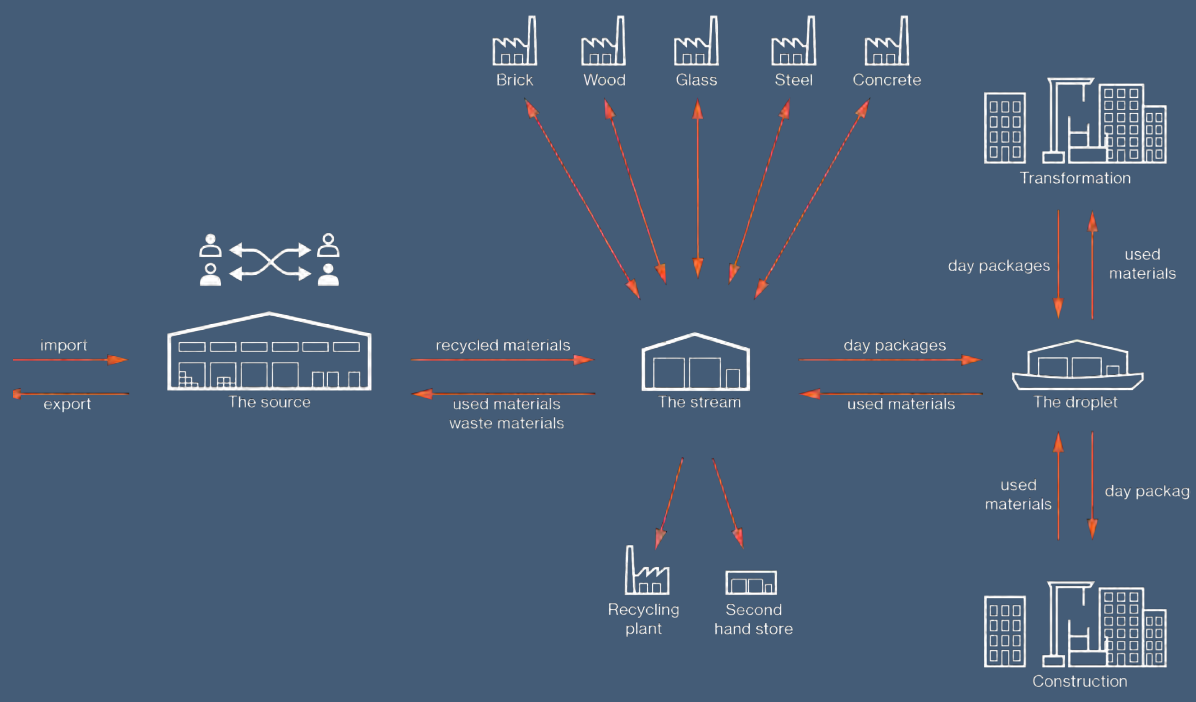


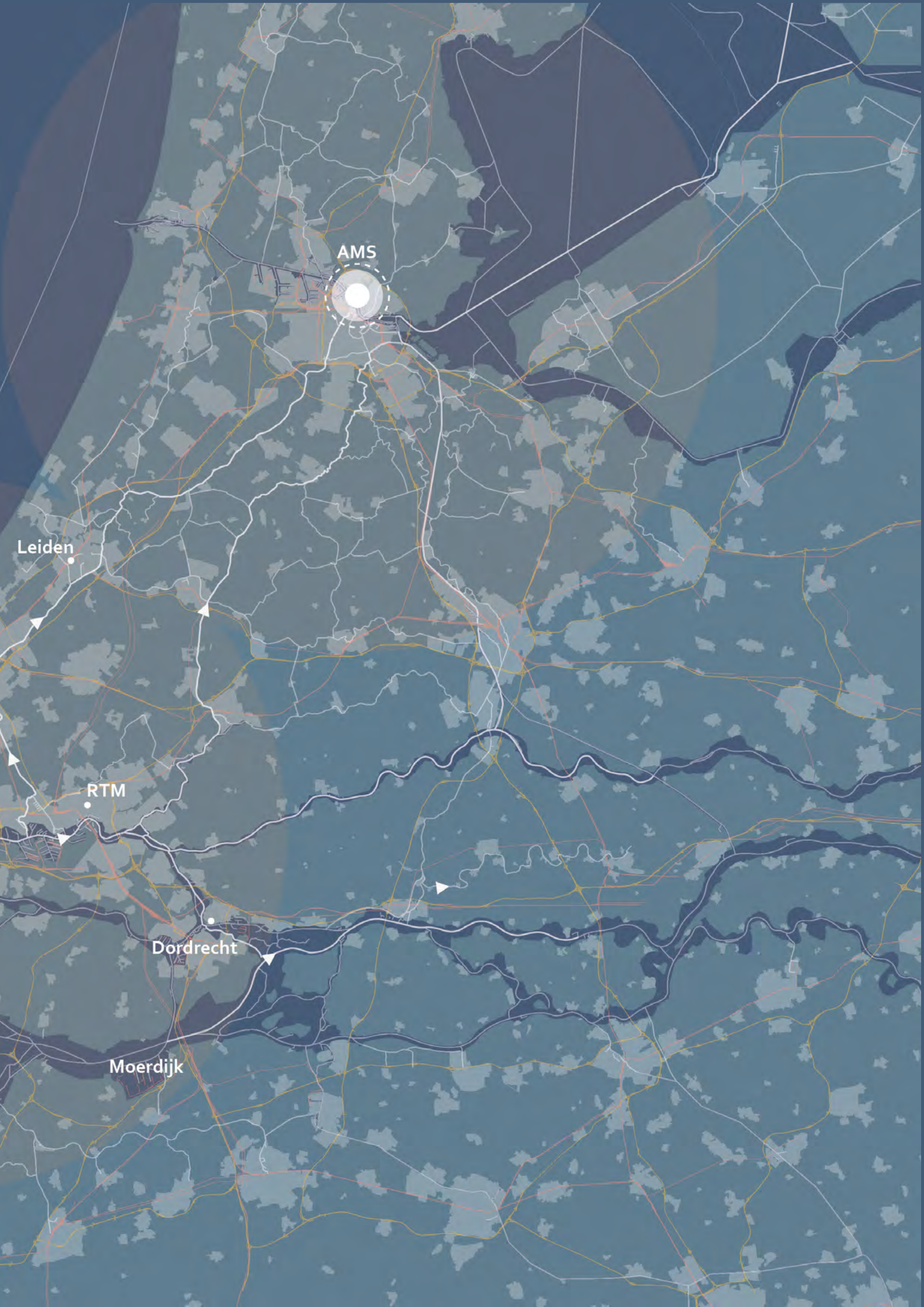
Image 12. Three scales of hubs explained, drawing by author

4.2 The source

As discussed before, the source functions a whole metropolitan region. This means its reach can be as far as the distance from Rotterdam to Amsterdam. In addition, the export and import flows contribute to a world wide reach. However, its main focus is on a metropolitan scale.

Following the Port of Rotterdam ambition to become a Waste-to-Value hub the source is placed there, allowing for multiple stakeholders and different industries to collaborate in one place.

Image xx. Reference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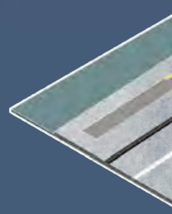
SCALE

The source is the largest scale of the three hubs. It is meant to create sector crossovers and stimulate collaboration between market parties, governments and knowledge institutes. This is also a place where large scale logistics can be organised for all sectors. This innovation and crossover centre is partly in compliance with the project of Amsterdam Logistic Cityhub. They have a total surface of 220.000 m2 for storage, processing, office space and docking space. The size of the source can be in the same range, however if experiment, innovation and development research will be conducted, this can even enlarge.

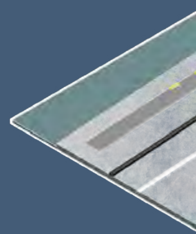
FUNCTIONS

The source's main function is initiating crossovers between different sectors and bringing together market parties, governments and knowledge institutions to develop new methods on sustainability and circularity. This means that there will be a research department and office spaces for working on crossovers. In addition, public functions will be added in order for the public to also learn about circularity and sustainability. Therefore the source gets an educational role as well. The processing side of the source focuses on the import and export on a large scale, as well as recycling, remanufacturing and upcycling of materials. Here there is also the possibility for sector crossovers.



REGIONAL SCALE

- Processing materials (upcycling, recycling)
- Big scale import
- Crossovers with other sectors
- Public function (learn, inspire)
- Big scale recycling



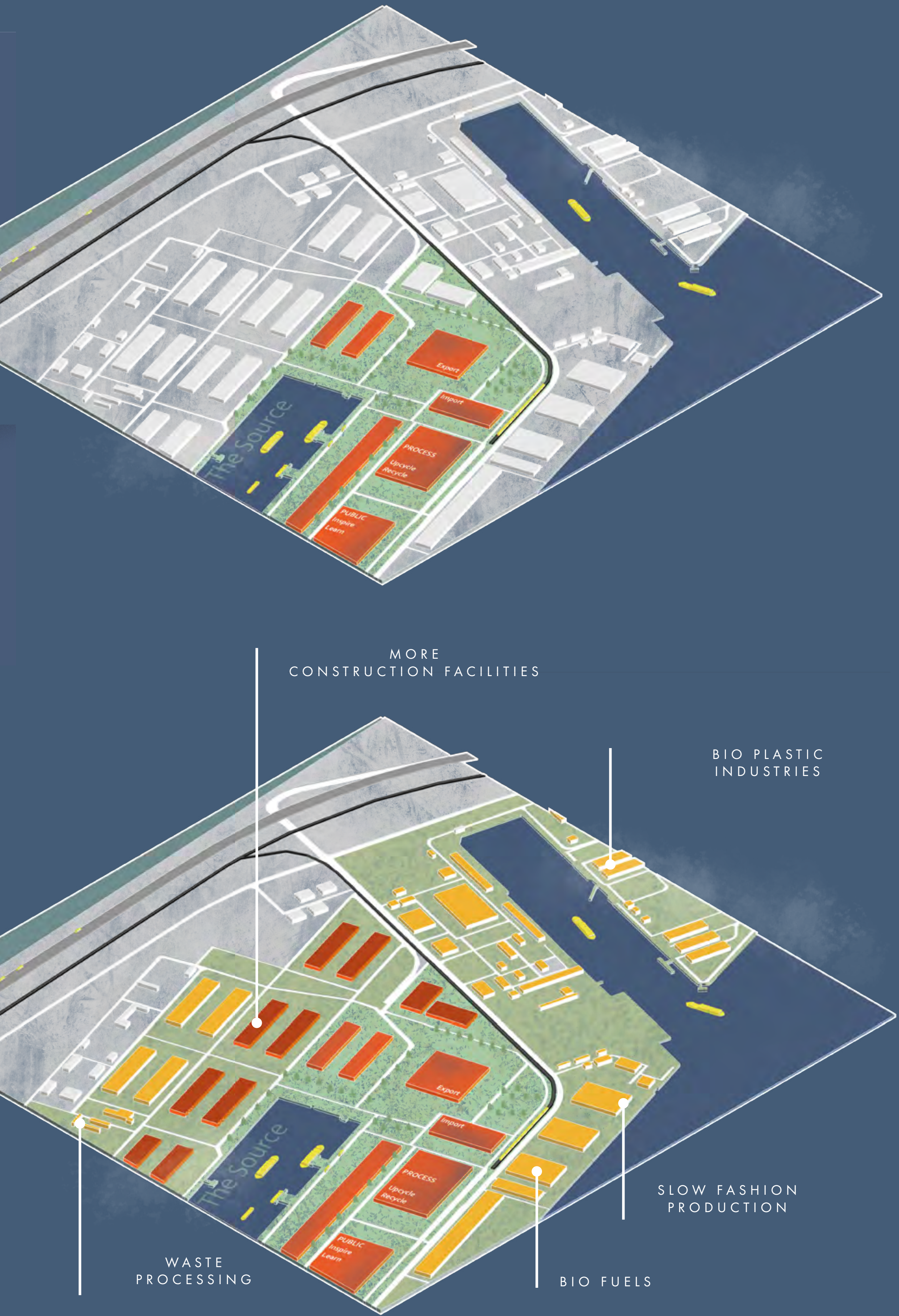


Image 13. The source,
drawing by author

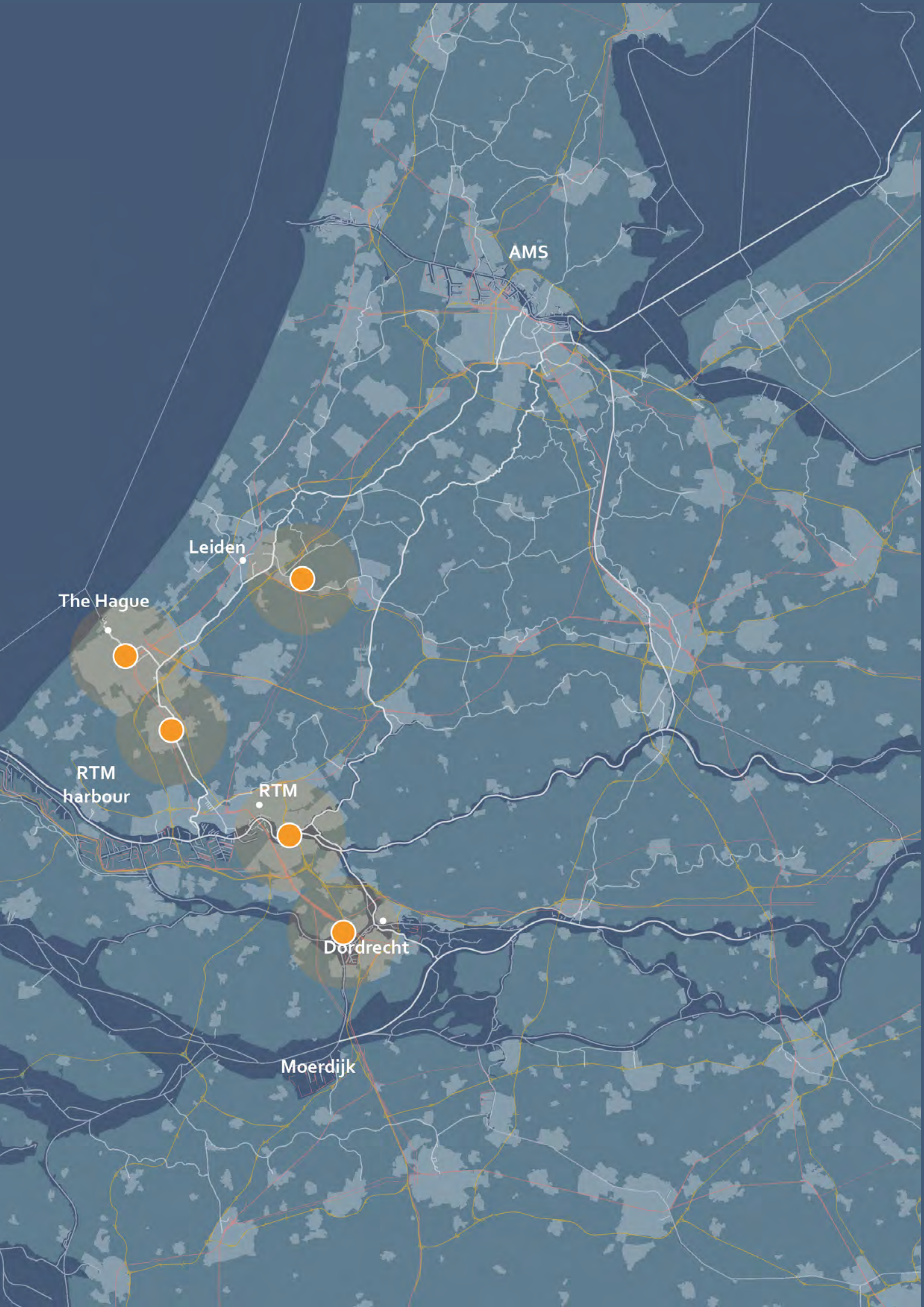
4.3 The stream

The stream is the middle sized hub but also the most frequent in the region. The current plan has 5 stream locations but this number can grow and if needed, a stream could be placed in each main urban area. It acts as a catalyst for the urban core where it is placed in. The design of the stream is flexible, meaning it is not a standard product which can be placed anywhere. It is an object which reacts to its surroundings and evolves with it. Therefore each stream is going to have a different identity and each function within the hub is

Goal	Interests	Sub-interests
Select a suitable site for stream	Functions cooperation	Square meter Zoning plan Redevelopment area Beneficial projects
	Accessibility	Waterways Highways Public transport Skirts of the city
	Spatial feasibility	Manufacturers Construction materials Social functions

→ STREAM LOCATION

Image xx. Reference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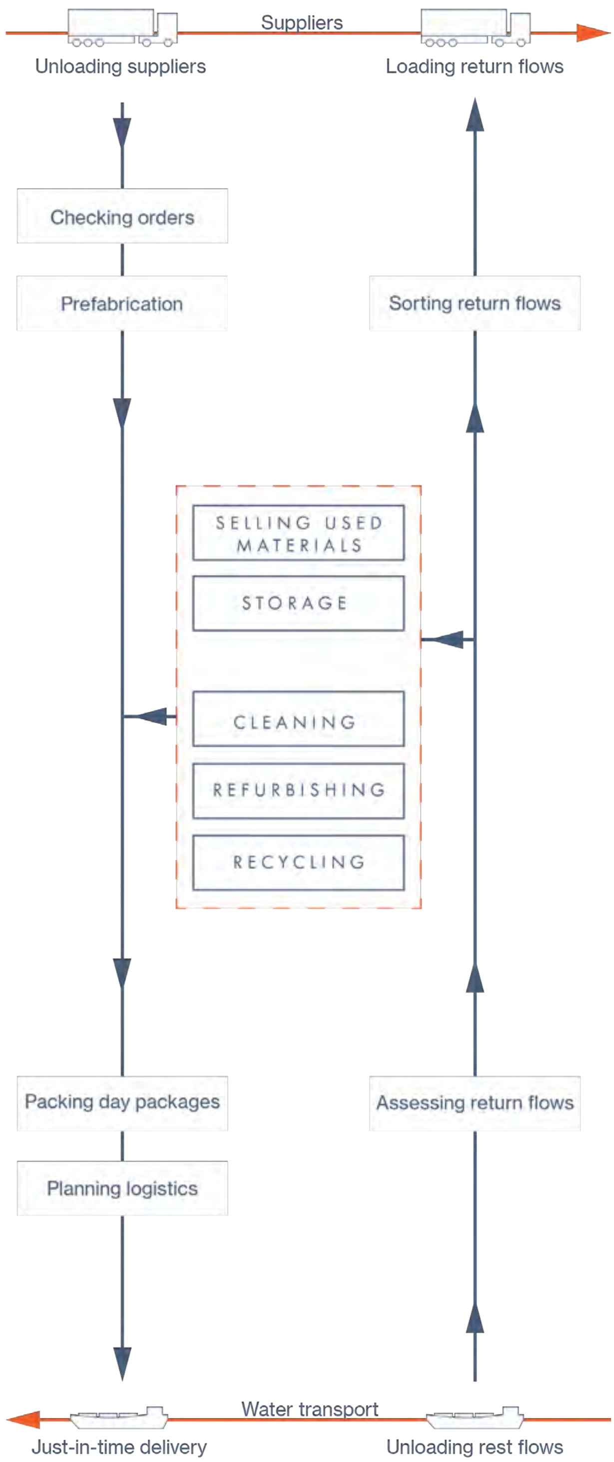
SCALE

The size of the hub is based on the design of construction consolidation centre in London and the Bouwhub in Utrecht, discussed in chapter 2.2.1. The area of the stream is approximately 5000 m2. On average, a minimum of 15-20% of this area needs to be sheltered for storage of materials that cannot be stored in open air and for processing materials. If desirable, it could be possible that over 80% is sheltered. The storage space has to take up a maximum of 75% of the area. This space needs to be fitted according to the type of material, taking into account its shape, size, weight and packaging. Every stream should have a quay for delivering of materials and goods and for the distribution of day packages to the droplet. The desired minimum quay length is 80 m, but should be decided according to the location possibilities.

FUNCTIONS

The stream facilitates, coordinates and organizes the construction logistics. It stands in between the suppliers and the construction site. It receives, checks and temporary stores the deliveries, after which they are reorganised in day packages specific for construction projects. It is also possible to conduct prefabrication.

The stream is connected to a water transporter to deliver the day packages to the droplet. After that, the stream receives waste and return material flows. The materials are assessed and planned to be processed. There is possible small scale processing and recycling at the stream, for example a mobile concrete recycling plant. In other cases the materials are loaded by the manufacturers after they dropped their deliveries, thus directly connecting return flows to manufacturers. The stream can also have a public workshop, used material marketplace and sheltered workplace for people



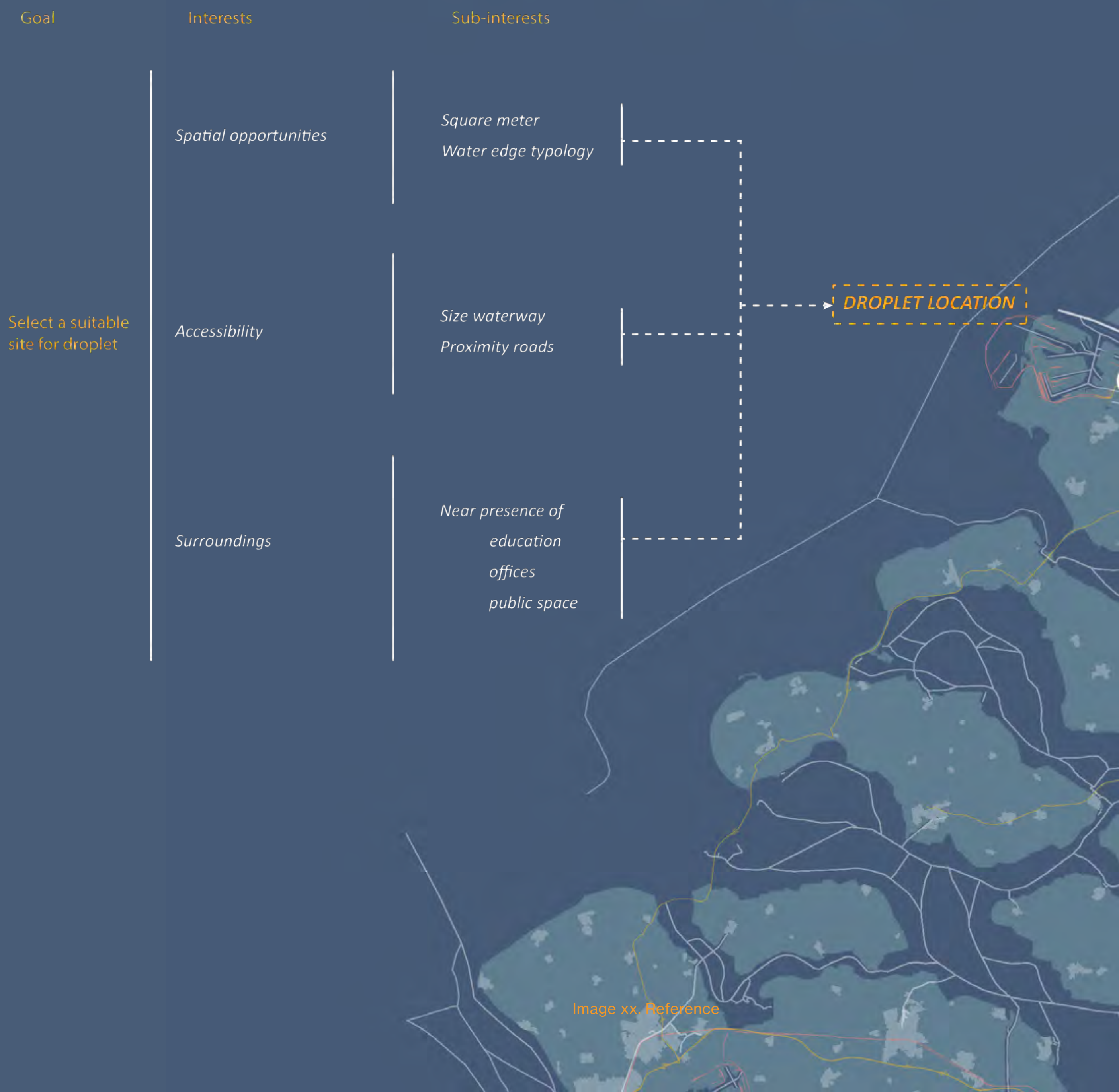
LOCAL SCALE

- Showcase
- Local distribution between droplets and distributors
- Reuse
- Repurpose
- Small scale innovation
- Storage of materials

Image 14. The stream, drawing by author

4.4 The droplet

The droplet functions as a terminal for the construction site, so it should be as close to the construction site(s) as possible. Preferably, this distance is not more than one kilometer, fitting with the last-mile function. The supply of the droplet has a larger reach. The supply comes directly by water from the stream, which can be in a range of 20 km.



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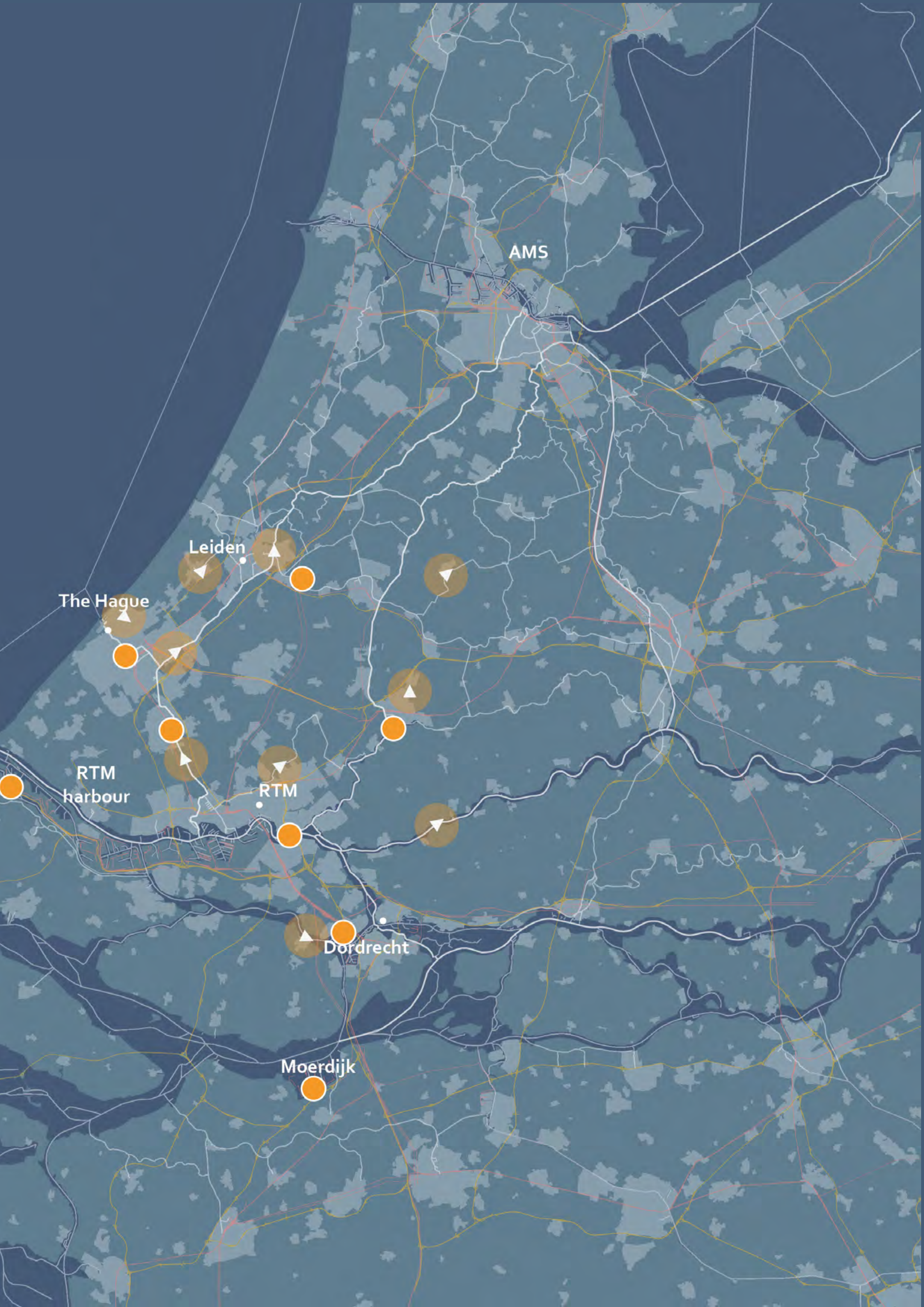
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SCALE

The droplet works on the local scale. It is a flexible floating terminal for the last-mile distribution of goods to and from the construction site. The droplet has resemblance of a barge boat; a shoal-draft flat-bottomed boat. Its average size is approximately 75m long and 12 m wide. For certain large scale construction projects there is the possibility of combining more than one boat. The droplet is flexible and can be moved from one construction site to the other. Its flexible design makes it possible to dock at any kind of bank, hard, soft or shallow.

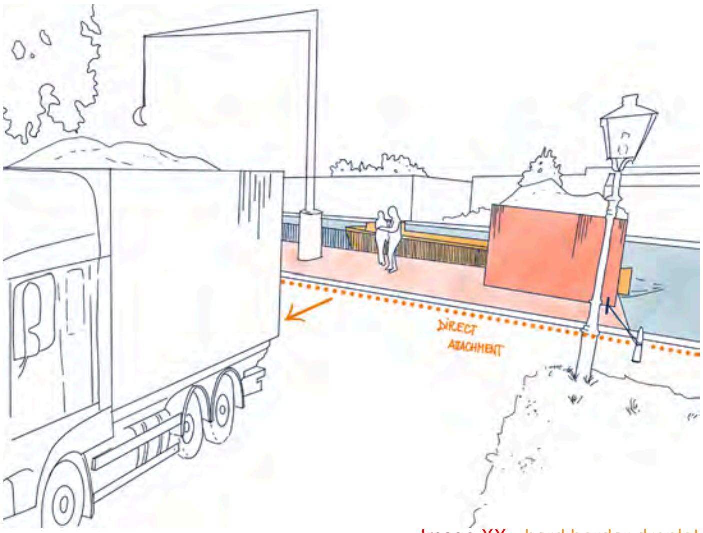


Image XX - hard border droplet
Drawing by author,

FUNCTIONS

The supplies from the stream lastly go through the droplet. From there, the droplet facilitates the last-mile delivery to the construction site. The last-mile delivery is always a green and sustainable mode of transport, for instance hydrogen powered trucks, electric vans, electric bikes, etc. These modes of transport also return with rest and waste flows from the construction site. At the droplet, these materials are assessed on their strategy of processing, for instance reuse, refurbish, remanufacture, recycle, etc. After that, clean material flows are created that can be delivered back to the stream. Where possible, the droplet can also have a mobile concrete recycling plant (Circuton by Strukton).

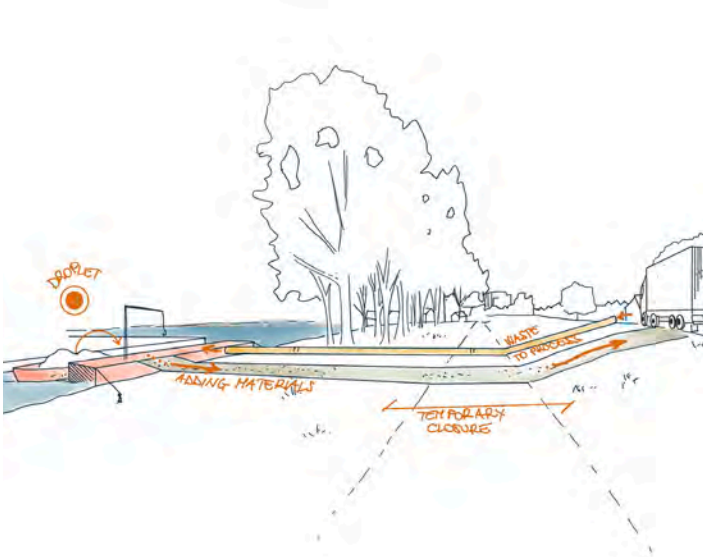
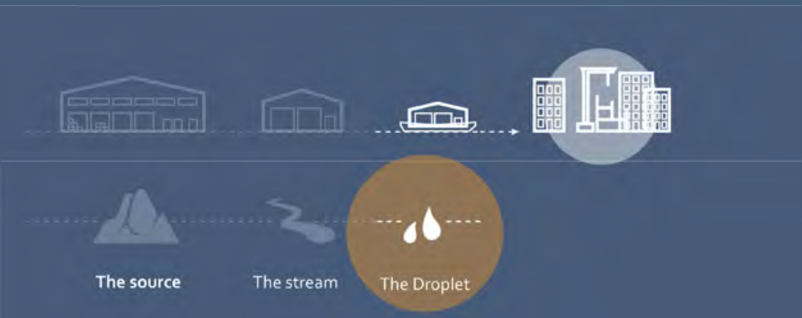
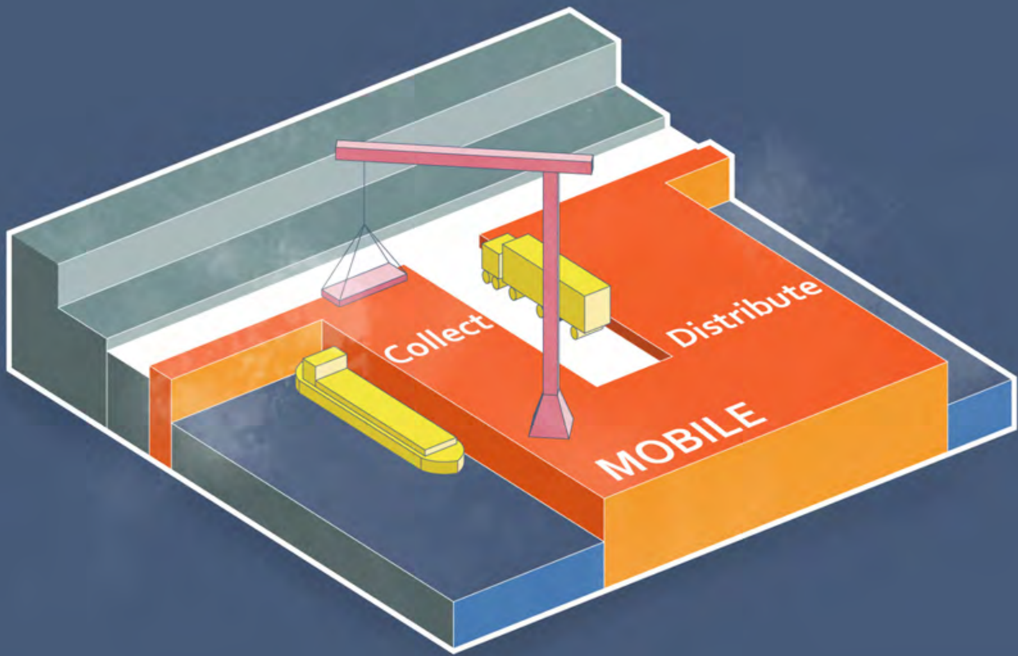


Image XX - soft border droplet
Drawing by author,





FLEXIBLE

- Distribution construction sites
- Material collection
- Creating clean material flows
- Mobile recycling facility

Image 15. The stream,
drawing by author

4.5 The Matrix

As a result of the hub system in Chapter 4, this chapter will elaborate how we can deal with an unchangeable and intangible element, time. Over time, redevelopment areas will be realized and the focus will shift towards new redevelopment areas bounded to other spatial locations. This will cause that over time the hub system will be less efficient due to the fact that it is less close to redevelopment areas. This will concern the droplets. To persevere the efficiency of the hub system over time we created the Matrix.

FUNCTIONING

In order to identify the interesting areas for new-developments, re-developments and where to strategically place the droplets, we create an assessment tool. This tool consists of a multi criteria matrix which takes in consideration various aspects of the built environment. Through the evaluation of each neighbourhood of the province, it will be possible to arguably define a selection which are the most interesting areas for the strategically located droplets.

The defining of these areas is done through evaluation of criteria. The criteria are subdivided to three types of evaluation: Construction, Climate and Qualitative evaluation.

Image xx.

Observation
Year of construction
Energy label
Demolition permit
TRANSFORMATION
Flooding risk
Subsidence
UHI sensibility
Clustering of business
Water proximity
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RTM harbour
RTM
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USAGE

Construction assessment, regards the practical and quantifiable aspects of current building stock.

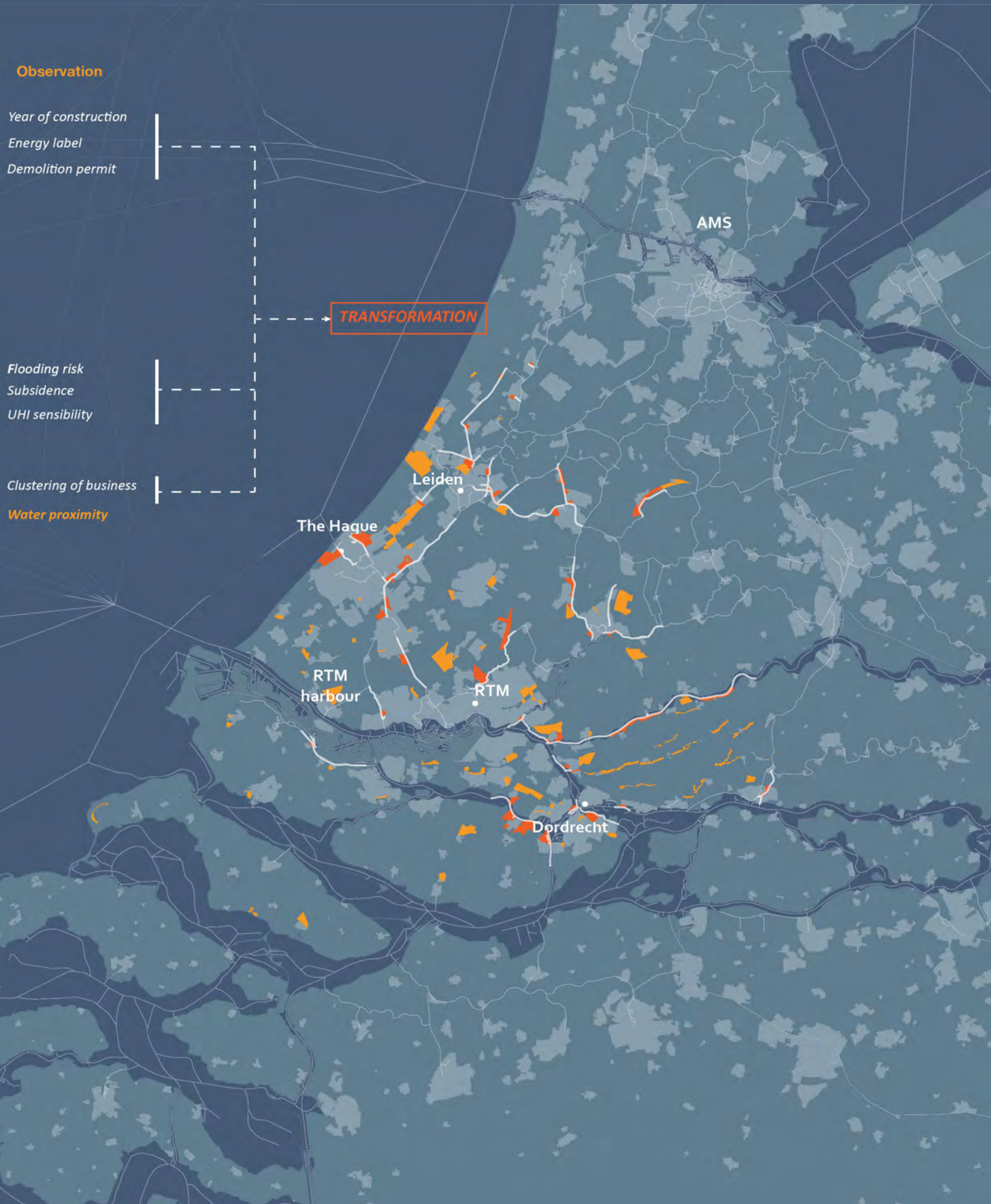
The climate assessment takes into account current protection of areas and future risks that climate change and landscape changes could cause the current and new building stock.

The qualitative assessment highlights the influence on the social condition that certain aspects cause to a neighbourhood.

Through evaluation of construction and climate criteria we can indicate that certain neighbourhoods need or are going to be redeveloped in the coming decades. Besides, based on the qualitative assessment it becomes possible to define a selection of areas which are suitable for droplets locations due to favourable spatial & economical benefits.

The matrix is flexible, criteria can be added or removed when it seems necessary. After for instance time periods of 5 years it becomes reasonable to determine which areas will be redeveloped and where to locate the new droplets. The matrix will help to determine the redevelopment areas and which locations are most efficient to locate a droplet. This resulted in the matrix being applied through time in different scenarios.

Image xx.


Observation
Year of construction
Energy label
Demolition permit
TRANSFORMATION
Flooding risk
Subsidence
UHI sensibility
Clustering of business
Water proximity
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5. Socio-spatial justice

SPATIAL FAIRNESS

SOCIAL FAIRNESS

To achieve a fair distribution of space and functions, the socio-spatial aspect is crucial for the Virtual X Water strategy. Using a schematic matrix, theories and macro scaled research has a danger of overlooking a fair distribution of spaces and burdens.

In such a macro scaled sustainable strategy, the equal avilability of resources and facilities for corporates, governances, local residents and other vulnerable parties is crucial. Not only to make the plan resilient for the future, but also to consider the small scaled externalities on the public space and most important: people's everyday lives.

Spatial justice involves the fair and equitable distribution in space of socially valued resources and opportunities to use them (Soja, E. W., 2009). While social justice is a fair distribution of opportunities along class lines, contribution to common good and merit (Harvey, D., 2010). According to the Methodology lecture of Roberto Rocco at Delft University of Technology (R. Rocco, personal communication, February 18th, 2021), this chapter concerns a distributive and a procedural dimension. Distributive justice is about the fair distribution of resources and procedural justice is about how and by whom the decisions are being made. The interventions of Virtual x Water concerning socio-spatial justice are elaborated further.

5.1 Spatial fairness

Spatial fairness in Virtual X Water manifests itself mainly in distributive spatial justice. The locations of the Source and the Stream are placed in industrial areas to avoid bothering residential areas or city cores. Furthermore, the circular hubs are inolving companies of all scales into the process, giving a chance for smaller businesses to transition to circular economy on even grounds with their larger competitors. Lastly, the circular hubs are a place for all parties to share their knowledge.

AREA REVITALIZATION

Visual quality plays an important role in the realisation of the circular hubs, making them attractive not only to businesses involved but also to local stakeholders. Using existing research by such urbanists as J. Gehl, the hubs will transform industrial areas into attractive areas with the use of open facades, various functions and interesting details (Gehl, J., 1996, p.33). Image 16 represents an environment of the urban scale Stream hub.

Besides using research for achieving an attractive environment, citizen participation will help shape each location. The circular hubs will not only serve the goal towards a circular economy, but also create qualitative public space with access to water, activities for hobbies and meeting each other.

ALLEVIATING THE TRAFFIC

The traffic will be alleviated on the macro and meso scale. The city by shifting construction logistics towards industrial areas instead of city centers, which reduces the impact of construction sites. As well city traffic, by using waterways instead of trucks. (transport/infrastructure used mostly by the people by shifting to water). On the macro scale, the highways will have less trucks. The weakness of this is that more often bridges will open, which can cause uncomfort for citizens. This will be avoided due to the Twin Region. This is a digital copy of the region predicting all the flow, which will help to plan the driving times the boats pass by.

"Spatial justice is the fair distribution of burdens and benefits of development, and the fair distribution of resources in the city, including urban space."

(Rocco, R., 2020)

Image 16. Impression of the Stream hub, collage by author

5.2 Social fairness

Social justice is a fair distribution of benefits and burdens of opportunities along class lines, contribution to common good and merit, depending on individual needs. (Harvey, D., 2010) Social justice in planning seeks to alleviate and end unfair distributions without rejecting the promises of a more environmentally friendly or economically vibrant city (Gilbert, L., 2014).

Virtual x Water introduces social justice with a fair procedural distribution. Firstly, the droplet is located in the least burdensome place as opposed to the most efficient one. Therefore criteria have been created for the locating of the droplet. For the design and actual functions of the stream, also a participating design process is very important in order to connect the citizens to the strategy and make sure they will actually feel invited to use the public space they helped to design.

NEW (SOCIAL) JOBS

Given the fact that jobs will be lost, like truck drivers, new logistic jobs will be available. Even workplaces for people with a distance to the labor market will be implemented on the stream locations. This is interesting to accelerate the use of the public space around, yet also an important commercial reason lies behind this. By more and more people feeling familiar with these locations, the commercial function of buying second hand materials will be promoted.

PUBLIC FUNCTIONS

The second hand materials database is not only used for a used materials marketplace, it will also be used as a public workshop. This will as well accelatere the public space created around the Stream. The circular hubs will open up for the public and create a shift in functions. Again this is promoting the commercial function of the hubs as well.

THE SILENT STAKEHOLDERS

Another important topic in the strategy Virtual X Water are the silent stakeholders that will be listened to for assuring a durable and working plan on all scales. Firstly, Virtual x Water is a resilient plan with a matrix evolving through time to choose the best development locations while ensuring the adaptability for the needs of future generations. Secondly, the nature/planet is taken into account, since Virtual x Water is avoiding new infrastructure veins through the green heart at all costs. Only the existing infrastructure is being used to make sure biodiversity and the nature of the green heart is not being disturbed. Lastly, the vulnerable, for example children and elderly. By moving the major traffic to the water, Virtual x Water removes loads of traffic from the city, resulting in a safer living environment with fewer trucks with blind spots creating unsafe situations. Also, traffic at certain times, for example when children cycle to school, will be avoided due to the Twin Region a digital copy of the region predicting and improving all the flows.

6. Phasing

STAKEHOLDERS

CATALIST PROJECTS

PHASING SCHEME

6.1 Stakeholders

In the process to shift from the linear economy to a new socio-technical system, multiple actors will have to be involved in the process (Geels, 2006). This multi-actor process involves interactions between many social groups, e.g. commercial transactions, political negotiations, power struggles and the creation of coalitions (Geels, 2006). A way to approach the challenge of listening to all stakeholders is using the method of communicative planning. This connects all stakeholders, helps them to communicate and make decisions that value all present viewpoints. According to the Methodology reader "It's a deal" of Roberto Rocco at Delft University of Technology (R. Rocco, personal communication, March 20th, 2021), narratives and storytelling are central in communicative planning because they are more readable to most of the stakeholders than opaque technical reports.

The following actors will have the power to change the approach, progress or create policies:

> Larger municipalities (Rotterdam, Leiden, Delft, Den Haag, Gouda & Dordrecht)

> Province of South Holland

> Rijksoverheid

> Water institutions such as Waterboard and Rijkswaterstaat

The larger municipalities are the important link between policy/ambition and the translation on a local scale. Based on this approach the smaller municipalities are important as well, although they will have less power to influence the process. The waterboard and Rijkswaterstaat are included because of the importance of the water system in the logistics hub system. Rijksoverheid is important due to the power this organisation has on plans and policies.

Moreover, there are multiple knowledge institutions & universities included in the region. Via these institutions and universities, multiple initiatives and innovations are occurring regarding the circular economy. The key is to share this knowledge and not spend time and money on reinventing the wheel while other organisations have found a solution. The above stated knowledge can be shared with the commercial sectors such as the logistics and storage. The companies are vital to include due to their progessive approach in the market ecosystem what could stimulate broad implementation of the new innovations.

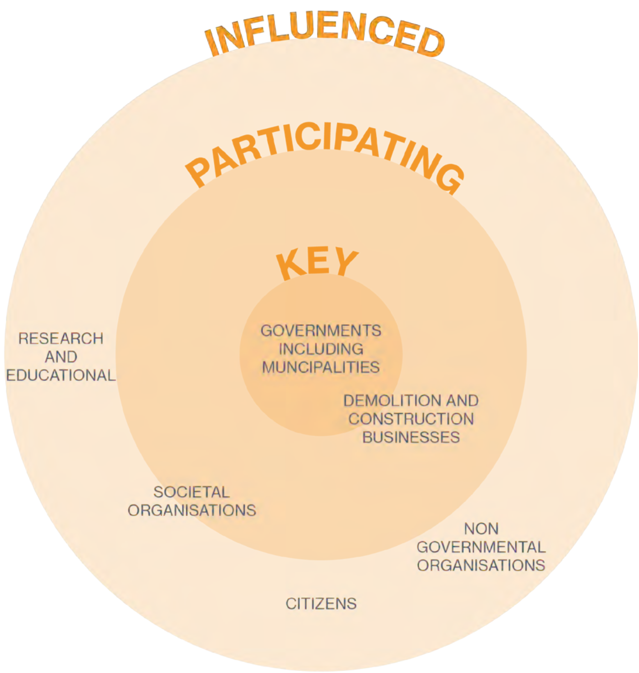


Image 17. Stakeholder overview, drawing by author

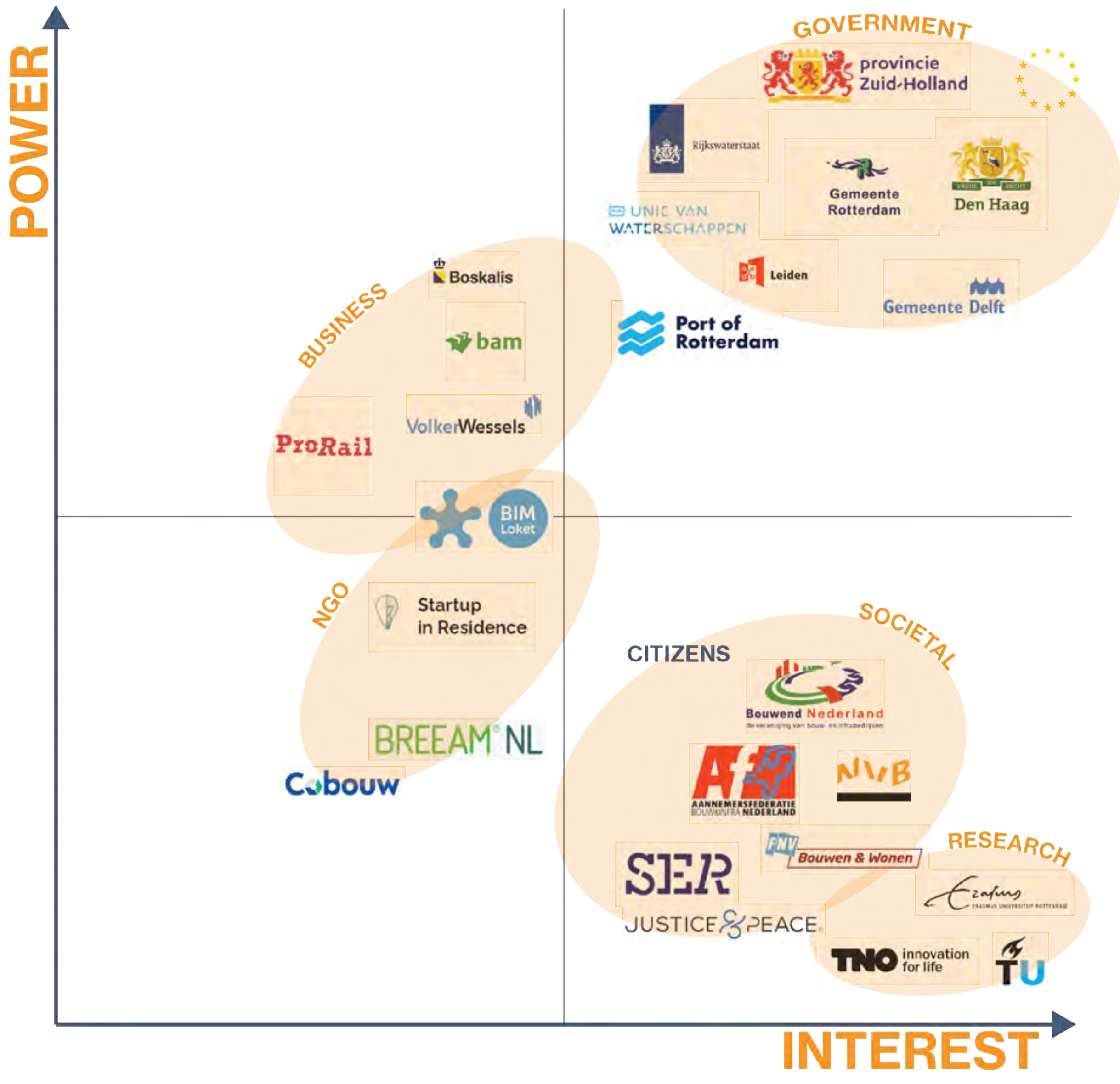
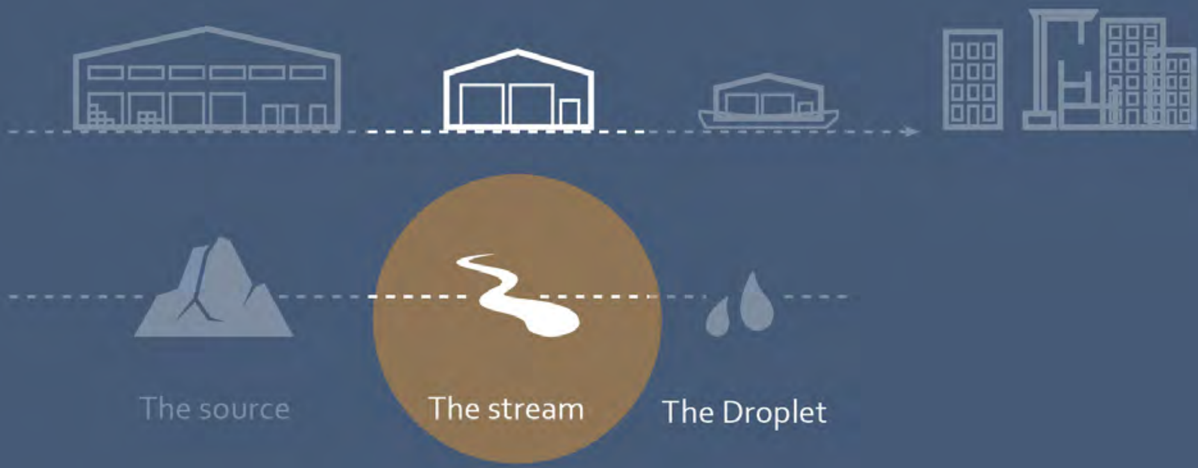


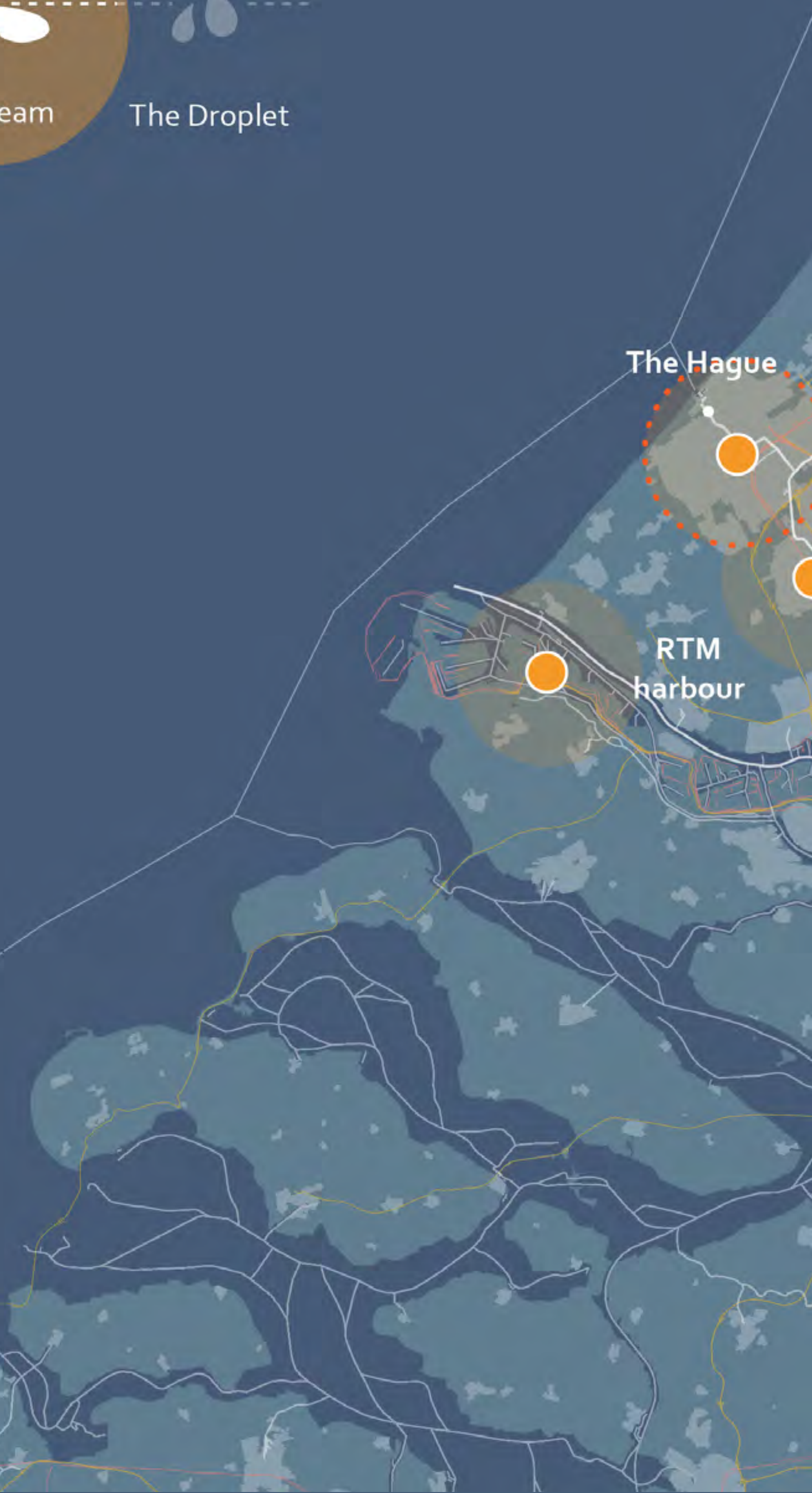
Image 18. Stakeholder matrix, drawing by author

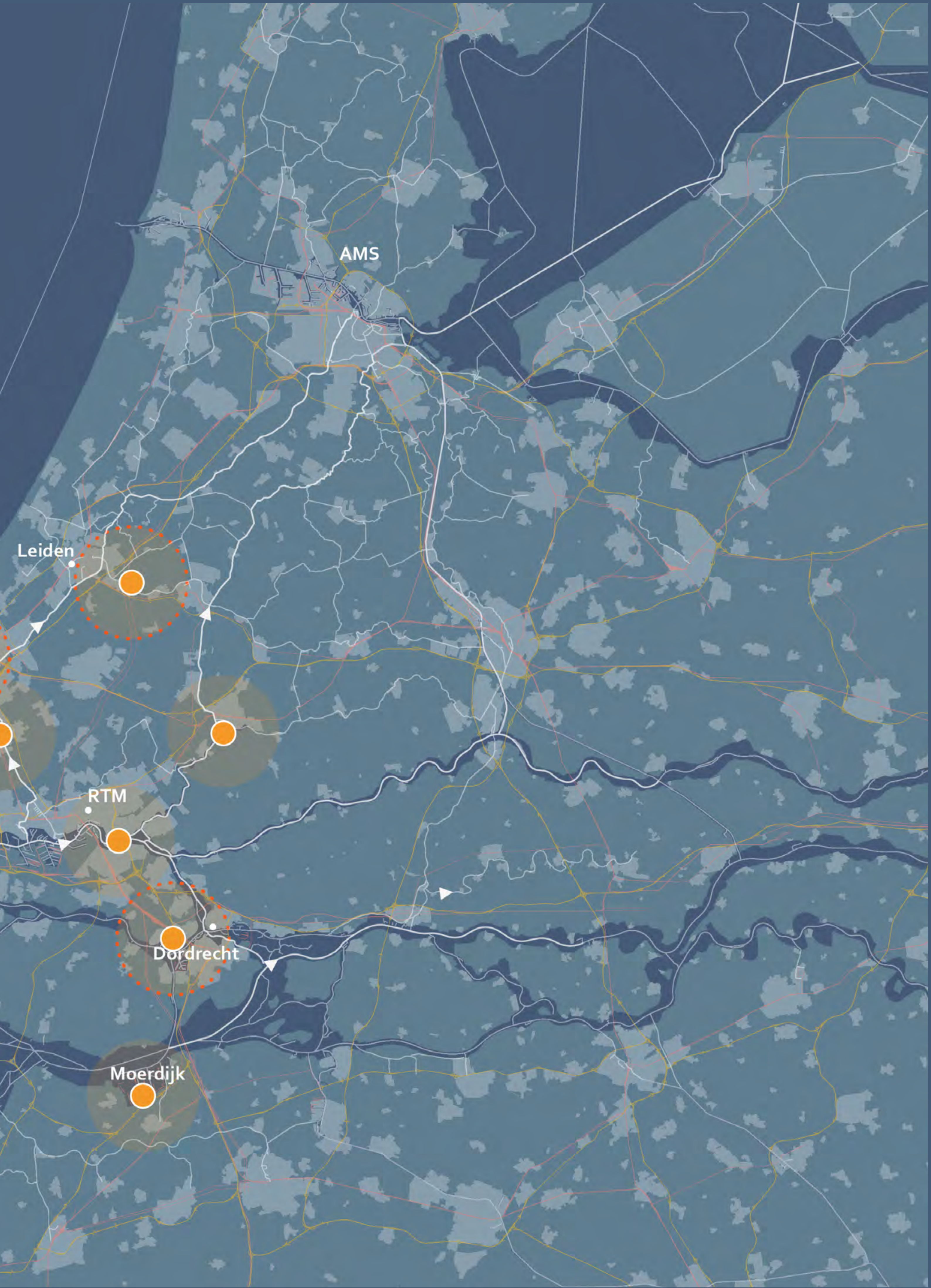
6.2 Catalyst projects



Each stream location will be different - that depends on the location, the stakeholders involved and the specific needs of the city.

As an example, three different locations were picked and will illustrate the multiple approaches to hub design and functions.

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6.3 Makers space

The first proposed location for a stream is the Binckhorst area in The Hague. This area is close to the city centre and being redeveloped at this moment.

This urban area asks for a location specific design of the stream. While the stream facilitates material distribution to the many construction sites in the city, there is less space for the processing of materials. This space is designed for the public aligning with the makers space redesign of the area. The makerspace can be part of the stream through public workspaces, educational workshops and a local used materials hardware store. The area around it is designed for public use as a unique public space where people can enjoy the harbour, urban greenery and loading of the ships. Because this location is in the middle of the city, it can have a great impact on the distribution of goods through the hub. Although storage space is limited, data can help to organize and regulate an efficient flow that can process the large amounts of construction materials needed in the area.

The stakeholders involved in the current redevelopment plan can get in on the action of the stream. The stream can provide the opportunities and space for the current industrial parties to partially proceed their work, while transitioning outside of the area. On the other hand, public stakeholders can find their place here and start the shift to an urban area designed for the local public.

Image 19. Impression of makers space at Binckhorst, collage by author, images

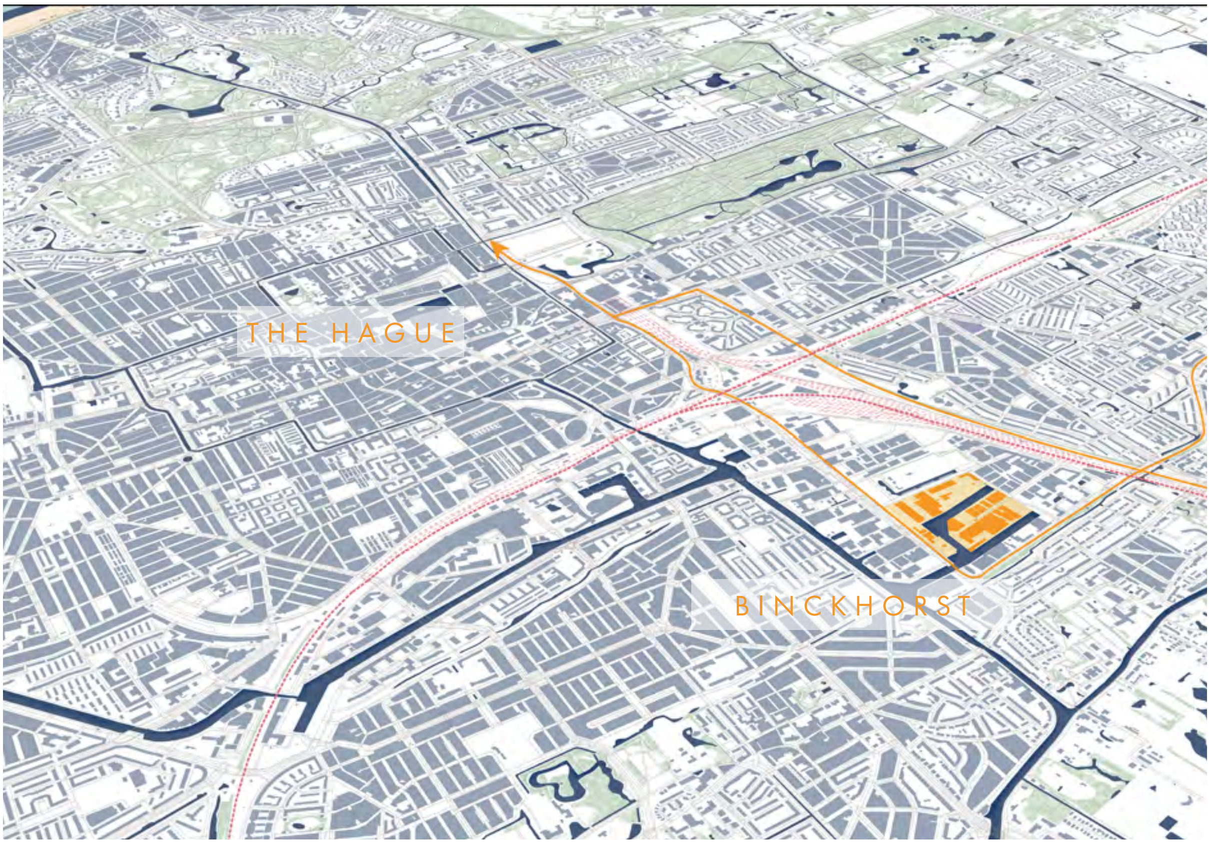


Image 20. Aerial view of Binckhorst, the Hague
drawing by author

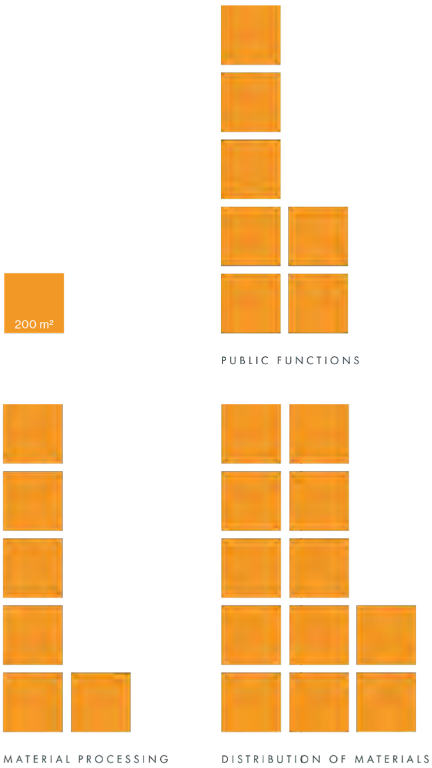


Image 21. Function mix,
drawing by author

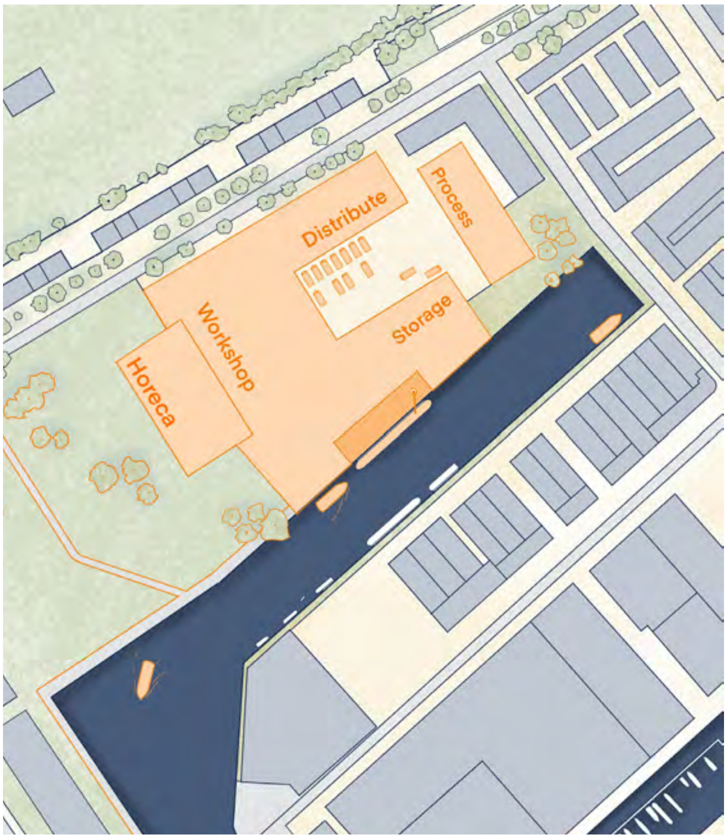


Image 22. Makers space hub,
drawing by author

6.4 Bridging the gap

The second proposed location can be found in Zwijndrecht, across the canal from Dordrecht. The stream is located in an industrial area with harbours connected to the canal. The industrial area is clearly bordered off from the city.

The characteristics of the area makes way for more functioning on the processing and storing of materials. The neighbouring stakeholder is TataSteel, a big powerful stakeholder that can create a crucial and interesting collaboration. The harbour has enough space to transport large amounts of materials that are processed at the stream, for instance through recycling, remanufacturing and refurbishing. Besides the material processing and distribution, there will always be a part specific for the public. In this case, there is a balance and in both functions. The stream connects to a park that breaks the border between the urban and industrial area. This makes it possible for the public to enjoy the livelihood and public functions of the revitalized industrial area, bridging this gap between both areas.

Tata Steel can be an important partner in the initiation of the stream at this location. It can provide the platform and opportunities for the industrial processing, beside also inviting the public to get inspired and work on innovative local circular solutions.

Image 23. impression of the hub at Zwijndrecht, collage by author

Image 24. Aerial view of Zwijndrecht, the Hague
drawing by author

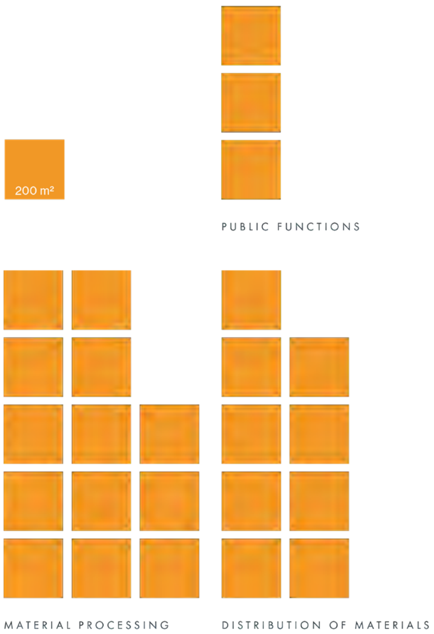


Image 25. Function mix,
drawing by author

Image 26. Bridging the gap hub,
drawing by author

Image xx. Reference

6.5 Revitalization

The last proposition for a location for the stream is near Leiden. The dense and smaller city of Leiden uses its industrial areas that are on the skirts of the city, at Zoeterwoude. It is on the border of the city and the agricultural landscape.

This location is most suitable for the industrial functions. It can work together with the local industrial stakeholders to process waste and rest materials to be put back in the production chain. The current mortel plant fits perfectly and can provide the city of Leiden with construction concrete. The wide waterway is ideal for the transportation of larger amounts of material goods. Even at a stream that is focussed mainly on industrial functions, every stream will implement public functions. It can provide workplaces and public spaces overlooking the beloved Dutch landscape.

The stakeholder involvement in this case is mainly between the municipality and local companies. The city of Leiden will ask certain service form the stream, while it has to satisfy the need of the existing companies. In addition, Zoeterwoude also wants to please its citizens and the introduction of the stream should fullfill certain needs while respecting its surrounding.

Image 27. impression of the hub at Zwijndrecht, collage by author
Image xx. Reference

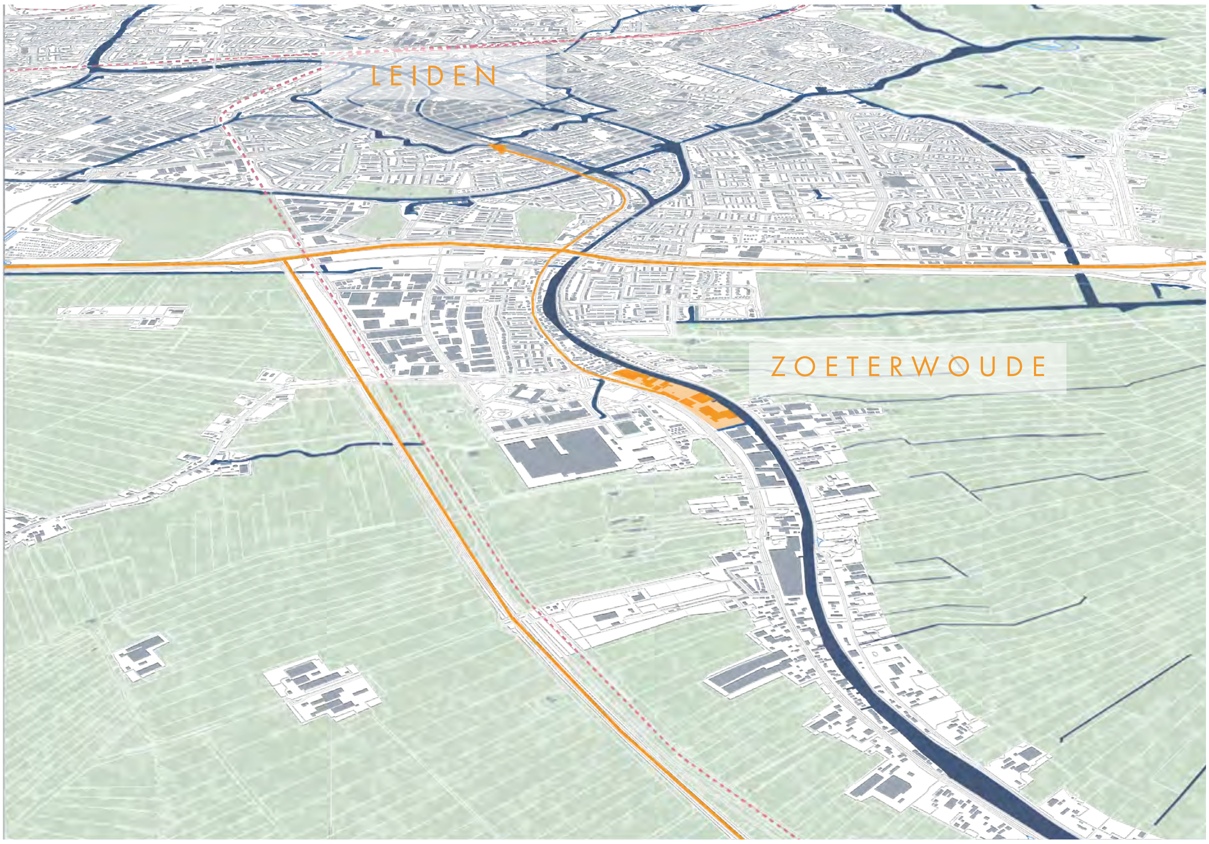


Image 28. Aerial view of Zoeterwoude, the Hague
drawing by author

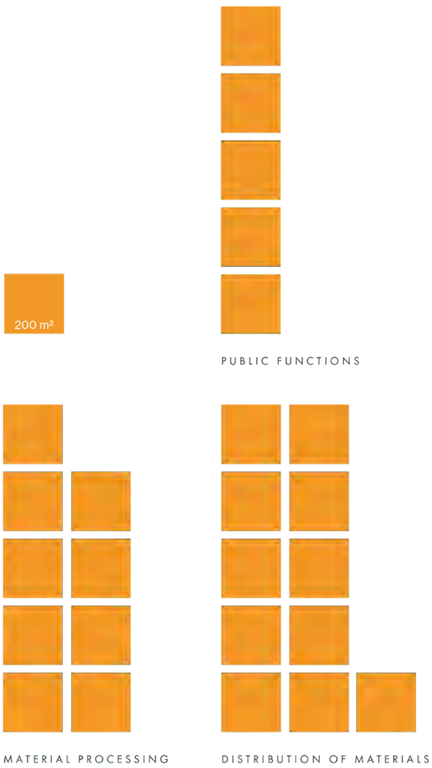


Image 29. Function mix,
drawing by author

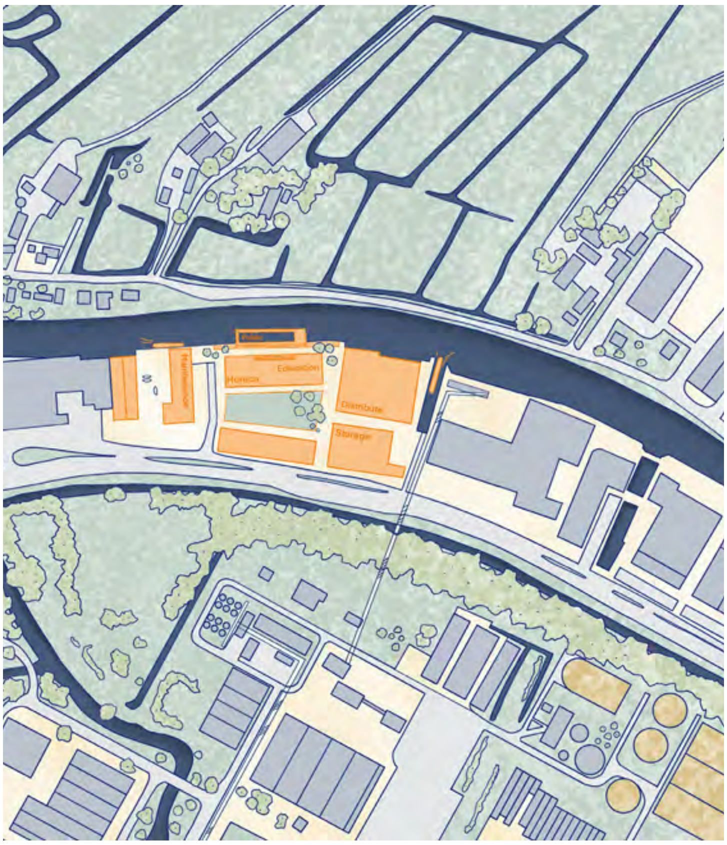


Image 30. Revitalising the industrial area,
drawing by author

6.6 Phasing scheme

A circular construction and demolition sector cannot be achieved at once due to its vast amount of interrelated processes, stakeholders and the necessity of new innovation. A certain shift of socio-technical system will take time. The proposed strategy will need guidance as well. The phasing enables a certain guidance towards the aforementioned end goal; circular construction and demolition sector.

The proposed phasing will consist of three 'hard defined' periods. Each period will have a clear purpose.

INITIATION

The initiation phase will start in the end of 2021 and will last till 2030. The purpose of this phase is to implement small scale interventions throughout the province. The interventions have the purpose to create a foundation for further implementation of the strategy. The interventions can be seen as pilots / best practises, a playground for new innovations. Below multiple goals for this phase are elaborated.

G1: Shape integrate navigable water logistic system

G2: Align actors for hub system & logistic system

G3: Introduction of material passports assessment

G4: Initiate the digitized material flows inventory into redirecting the flows

G5: Create the first amount of stream locations

G6: Introduction of material passports assessment

G7: Create citizen participation to increasing reusing of the material flows

We can identify multiple stakeholders that are crucial for succeeding in this phase and accompanied goals. It can be categorized to:

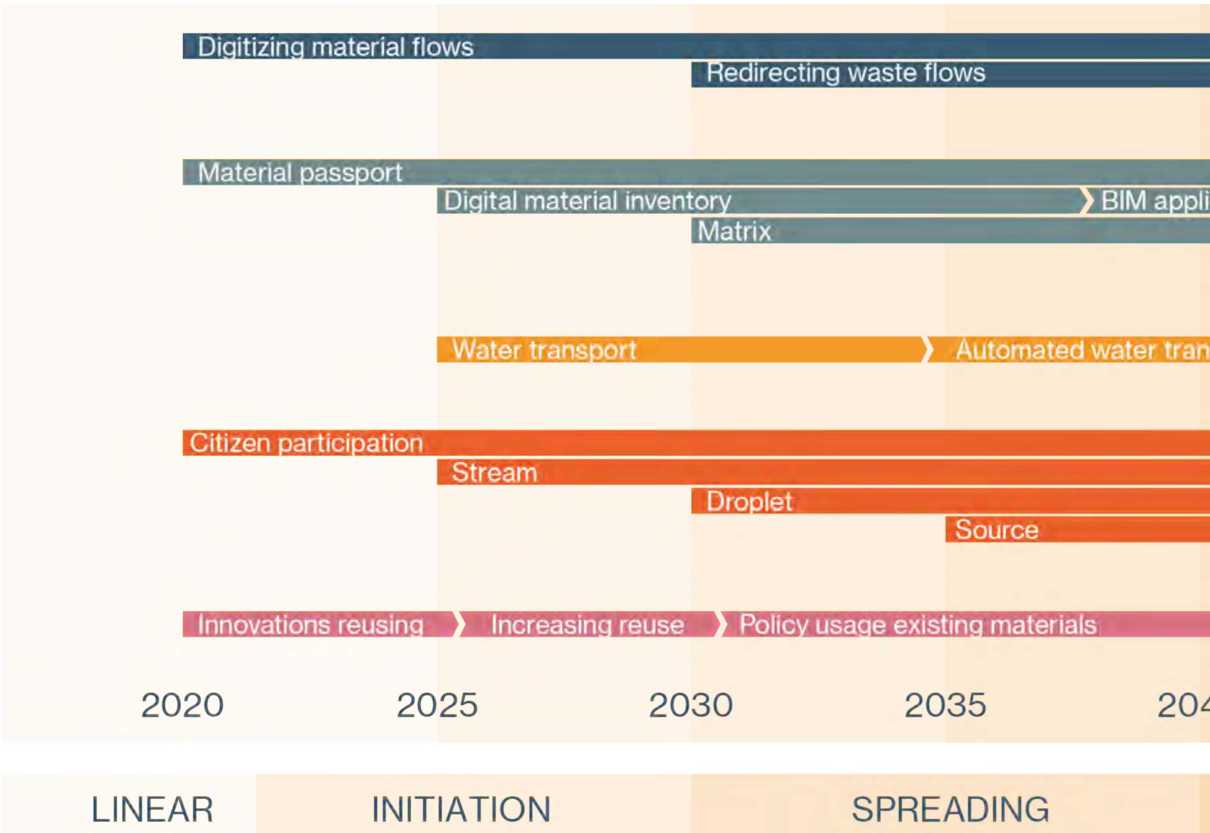
> Government

> Business

> Research

SPREADING

in the continuation of the rather explorative phase the spreading phase will proceed. In this phase the best practices are evaluated and based on this evaluation further expansion of innovative initiatives can be



obtained. The purpose is to further expand on the created foundation in the previous phase. Systems have been explored now it is time to use them extensively and include data as well.

G8: Integration of automated water transport system into material handling

G9: Create droplet locations

G10: Connect the droplet hubs with the expanding amount of stream hubs

G11: Redirect all the material waste flows via the hubs

G12: Matrix is being used to determine redevelopment locations

G13: Policy usage is to shift from niche market to landscape changes.

We can identify the following categorized stakeholders

> Government

> Business

> NGO

> Societal & Research

INTEGRATION

In 2050 a circular economy is achieved. The spreading of the previous phase resulted in a fully integrated system. A connection has been made between all the initiatives, innovations, systems (data) and structures (hubs). After the achieving of a circular construction and demolition sector in 2050 the progress will go on. To strive for maximal efficiency and further elaboration between all the actors.

G14: Sources will be fully developed and connected within the hub system

G15: Digital twin region is 'online' and represent the real word in a virtual way

G16: The matrix is upgraded and connected to the Digital twin region

We can identify the following categorized stakeholders

> Government

> Business

> NGO

> Societal & Research

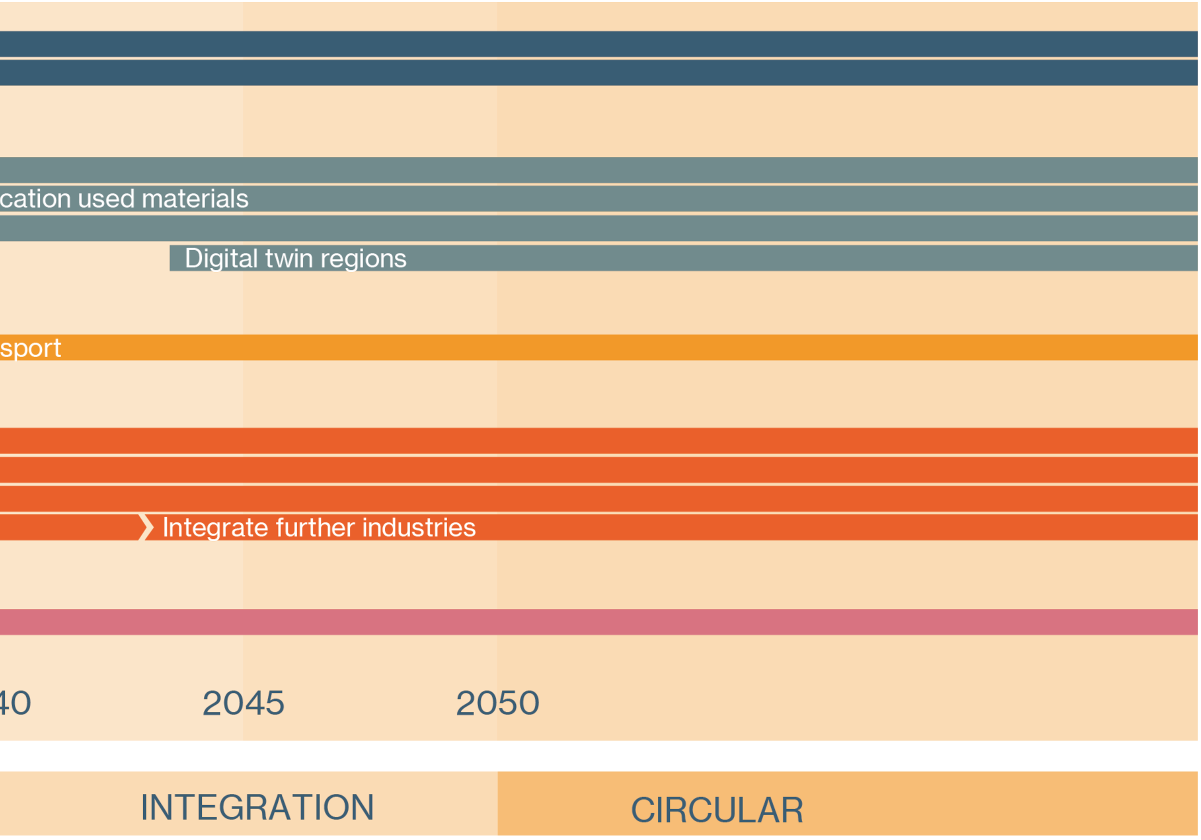


Image 31. Phasing scheme, drawing by author

7. Conclusion

The goal of Virtual X Water is to transition the construction and demolition sector in South-Holland towards a fully circular system. We identified the relevance of both the virtual and water systems. By combining both systems and implementing physical hubs where these system come together a network unfolds that can be used by all stakeholders to achieve a fully circular economy. The construction hubs on three scales form an integrated multidimensional network for a new method on construction logistics, while at the same time reducing the loss of materials value. They will also inspire circularity for the people. Public workplaces, educational workshops and creative workspace will stimulate the circular approach on the public scale.

The network of construction hubs is supported by a virtual system. The virtual system uses shared data of materials flows in order to create efficient flows moving via water between the hubs. The advancements of Big Data will provide the increased efficiency for construction logistics as well as the use of existing materials. The virtual network will evolve into digital twin regions, where all data is combined. The great water network of the province is used for the transportation. The water network can provide a sustainable counterpart to road transportation, as it experiences excessive use, both in the cities and on the highways. Water transport will relieve the stress on the roads, while providing large scale distribution and flexible movement throughout the city and the region. Automated transport will in the end make the network more efficient by reducing the negative impacts of human errors and delays.

Virtual X Water will strengthen the economy and regional wide agglomoration by increasing efficiency, sharing knowledge between stakeholders and maximizing the province's strongest characteristics. The project presents great flexibility which is of great importance. We cannot predict the future, however we can steer it. While the project pushes for transitions in physical, logistical and digital systems, it creates opportunities for a flexible approach that fit with future needs that are different from now. Virtual X Water will create a better future in which we upgrade the logistical network and improve our urban regions. Our approach will lead to future-proof and sustainable cities.

8. Evaluation

The elaborated vision of 2030 and 2050 describes how the province of South Holland could obtain a circular construction and demolition sector. Although, the group acknowledges that due to limited amounts of time and limited knowledge the vision strategy has a couple of limitations. In this subchapter the most important limitations according to the groups knowledge will be elaborated and suggested as follow-up research.

BLACK SPOT MAP

Water transport is the prominent transport mode in the vision strategy. Main reason for this approach is that the Province is predominantly accessible via navigable waterways. Hence, the strategy neglects the fact that there are certain areas not accessible via waterways. The so called black spots visible in figure XX. These black spots will need a different approach to be accessible in a sustainable way. A solution could be the use of alternative transport modes, likewise, an aspect that was not part of the conducted research.

CHANGING WATERWAYS

It is expected that periods of prolonged drought will increase due to climate change and can therefore be seen as a serious threat to water transportation (Droogte KNMI, nd). Extensive periods of heavy rainfall are also a part of our changing climate. Both these aspects affect the waterways heavily. The conducted research did not look into the future scenarios of changing waterways. In order to create a solid and future-proof implementation of the water transport network, additional research needs to be done on the state of the waterways, currently and in the future. This also complies the possibility of adding alternative modes of sustainable transport on land. A combination of different transport modes which will work collaboratively and use hubs as transport nodes will create a resilient transportation system.

Image 32. Zones inaccessible by water transport, drawing by author

LAST MILE TRANSPORT

In the vision strategy the last mile transportation is overseen. The transport from the droplets towards and from the construction and demolition sites is not included while the last mile is the most costly and polluted mile according to (Brown & Guiffrida, 2014, p. 513). There are many innovations on green urban mobility, such as hydrogen-powered trucks, electric vans and electric delivery bikes. However, topic was not in the scope of the project. Therefore, additional research will have to be conducted to amplify the last-mile strategy to obtain a sustainable transportation system.

POLICIES

During the designing of the vision strategy existing policies that could function as a barrier are not taken into account. The report mentioned the importance of the government in realizing our integrated network. However, more research is necessary to get a better understanding on the current policies that need to be adapated, as well as future policies that ensure correct use of the network. If this part is excluded, the achievability of the vision can be misjudged. Hence, to further extend the feasibility of the strategy more research is necessary.

These are the highlights of the limitation to the current vision strategy according to the project group.

ETHICAL REFLECTION

While looking for a more efficient solution to achieve a circular economy, we have to take into account the well-being of the population who are going to live there everyday using those planned structures. They are the first users and will have to carry the burden of an inefficient and poorly made plan that is only achieving the climate goals.

As our conceptual framework stands, societal and spatial justice are an integral part and a circular economy is not fully circular if it is at the cost of justice which one of the main parts. The following aspects have been integrated into the strategy that improve public good:

> - An increase in quantity and in safety of spaces in the city cores due to relieving the city from most materials and goods transportation.

> - By lowering CO_2 emissions by shifting the transport to the water and using less trucks, the air in South Holland will be cleaner. The breathing air is a public good and the quality of it is being improved by using the waterways.

> - Public spaces to swim or use a canoe are designed on the water borders at the Stream, we see the water as a recreational feature also as a public good. The usage of this water is being improved by adding public space.

These environmental goals correlate with those mentioned by the European Green Deal (European Commission. (2020) - starting from the main topic of the project, circularity. However, Virtual X Water also includes social justice goals.

Making sure that the interventions are producing more (social) work opportunities as well as education, especially for people who might have lost their job because of technological advancements that this project promotes. This is also related to the general societal awareness and possibility to be part of the change towards a more sustainable future.

Despite all the best efforts, it is inevitable to have externalities from the proposed actions.

Some of those are easier to anticipate and negate, whereas many would come up as the time goes by.

It is therefore essential for the success of the project that instead of having a stiff strategy, the planning and decision-making is constantly keeping in mind the possible side-effects and ways to minimise them.

Personal reflection

NANDO VERSTEEG

The topic of spatial planning is not that close to me. I was interesting and intrigued to work on it and explore how spatial planning on such a large scale works and what it entails. At the same time, I expected it to be very complex. Compared to urban development, spatial planning is more implicit and it has more to do with strategies instead of actual urban designs. When I look back, I think my idea on the subject was correct. Spatial planning is a complex topic that connects many different subjects and stakeholders. At first, it was very difficult to grasp how systems on a metropolitan scale work and what actual the current problems are. However, through group discussion we were able to combine our personal research and together paint this picture of the region and find a topic that works as the solution for us. The group work on such a topic is similar to the characteristic of spatial planning, complex and difficult. But this comparison also provides the solution, which is long and intense discussions on current issues and possible solutions. This can be tough, especially in our online environment, but it is the solution to work together on creating our project.

I learned a lot on spatial planning, especially on the types of interventions and strategies. The vision and strategy is about providing the tools and concept on how to come to the proposed goals. Especially creating a storyline to be able to explain all the decisions was something I found joy in doing so. On the part of phasing, combined with stakeholder participation I can still gain more knowledge. I found it hard to understand everybody role within the strategy and the relation between them.

Working on the theme of circularity however caught my most attention. I am very much interested in the topic and I share the values of circularity. The solutions companies and people find for circular and sustainable interventions is astonishing and it shows how feasible it actually is to change our approach. However, it is also still a shady subject. Remon mentioned the documentary on NPO3 of the garbage man, where the topic of sustainability abused. It shows that even with the most creative and innovative circular ideas we come up, for instance in this course, there will always we stakeholders abusing the system for their own benefit. It teached me to always think critically on how people present their ideas and define my own answer on the question of how circular the idea actually is.

However, the extensive research I did throughout this course has led to embedding the circular approach in my lifestyle. I think it is not only fascinating, but also stimulating for my creativity to find a new use for an object I don't use anymore. This also works the other way around, meaning if I want to create something I want to see what existing materials I could use. I hope that I can work on sustainability and circulariy throughout my professional career and start a concrete change.

DARIA BELIAVSKAIA

Having a background in busines and marketing through my first degree, this project became a dive into the past experiences of business analysis and strategies combined with my urban design education. However, spatial planning has shown to be incomparably more complex than any business task could be.

It was a journey of panic, meditation through analysis and re-birth through groupwork. The questions posed on the regional scale are striking with the urgency - looking at every topic I know that I will face it again in my career as an urbanist, no matter on which scale I work. It is a valuable experience to look at the topic of circularity on a larger scale and see some of the challenges behind this topic that are not often coming up in smaller projects.

As in any design process, having a clear concept and direction helped narrow down the research and gain speed towards a final strategy. Despite that, throghout the project more research would be found that contradicted our previous ideas or simply nullified the work we did - it has all been done before already, we just have not found it on time. For me the amount of information and the way to handle it in multiple languages became the hardest task. Even spread across 5 teammates it never felt enough, and it was a feeling I had to get used to for a successful delivery - there will always be more information that you missed.

This project would not have been successful without the well-formed team we created. I believe it was an effort from everyone to listen, help and support, and that was the key element in moving forward. The final project is truly a collaboration - and that is also something that is the basis of our concept. The greatest things can only happen when different people find a way to work with each other - truly work, and listen even when you do not want to hear a different opinion.

I am proud of the way we have gone through the project and of the final result, and feel like I will look at many processes happening around me and in project I work on differently.

ROSALIE MOESKER

We envisioned a new strategy towards the future of South Holland, an approach for the transition of the circular construction and demolition sector: Virtual X Water. After the field trip and the literature review we started with, many shattered strategies arose. Virtual X Water came as the connection to get all these ideas together into one logic strategy. While the group felt like Virtual X Water is a showcase of how the closed systems can be broken into open inclusive networks - where cooperation between different industries, professionals, governments and residents can create a new boost for circular development. To me Virtual x Water is all about making sure that the province is circular in 2050 while at the same time the comfort of the citizens is improving. According to me, the goal of Virtual X Water is to connect the existing infrastructure into a logistic system with the least CO2 emission to reach the climate goals and achieve a durable high spatial justice while relieving the city and highways from construction transport while giving great attention to public social life. The attention we gave to spatial justice actually shaped the whole strategy into the direction of using water more efficiently.

Coming from a bachelor in interior architecture, this small scale thinking is something I will never be able to let go. Choices being made in a project on macroscale and the impact on people and how it makes them feel is extremely important in order to make a plan durable and future resistant. In the beginning, it was quite confusing to not have the overview anymore on the microscale impact. I listened to several podcasts on circular economy strategies and these actually filled the gap and relieved my stress on missing the link to the microscale. I learned how the macroscale of regional design on this subject is mainly about connecting micro scaled interventions and elaborating these logistic connections in between them. I believe we really catched this by already starting to think on the micro scale since the first weeks and this resulted in relieving the cities and regions from transport traffic on the roads and making the cities safer and the public space more comfortable, while at the same time improving the logistics and creating a circular economy. I really believe Virtual X Water succeeded in reaching my goal for the project and it will actually improve living in South Holland while reaching a circular economy.

It was challenging to work in a team with such a different educational background. Besides all the heated discussions we learned a lot from each other's great qualities. Our team was a perfect match to tackle the technical and design approach of this course. Besides this challenge, online education has been tough throughout this quarter. Even though we already study like this for a year now, we will always miss working together on the faculty. Once we went to work on the faculty for an afternoon and it was improving the workflow a lot. This inspired us to work more as a team on zoom as well. Together as a team, we also followed the Capita Selecta series and the SDS workshops. These have been very beneficial for our process of this project and made us able to integrate, mainly what we discovered during the SDS workshop, in our project.

JORG HOGERHEIJDE

When I chose this elective I had to send a clarification to the study counsellors of MADE why I wanted to participate in this elective. I stated that I wanted to obtain more knowledge/ improve my design and research skills regarding strategies. That is something this course definitely addresses. Unfortunately, I was not able to improve my design skills due to the lack of time and because I can frame my team members as an artist if it comes to designing. Moreover, I have no intention to become a designer in the future. Therefore it was a logical choice not to learn it during this course (but in my spare time). However, when working collaboratively with designers and urban planners I learned a lot of their approach towards researching challenges via a design method. As an engineer, it felt a bit uncomfortable to start with sketching and grasping innovative ideas instead of collecting data and creating 'hard evidence' in a problem description. To be honest, it still feels uncomfortable although I could use a designer approach in my own projects. It helps a lot to create out of the box/ innovative ideas. I enjoyed the conversation/ sparring session about solutions and approaches. Because one moment you're discussing and the next moment the sparring partner was drawing something. This makes it straightforward and very clear.

During the process, sometimes I felt a little bit like an outsider. Because the group members were so attuned to each other. The first few weeks were difficult to adapt to their level. Especially, behind the laptop, it is difficult to get to know one another. Over time it went better and we could meet up in Delft. That really helps to loosen things up.

At the beginning of this course, I had to write and Self-assessment and describe with respect to teamwork what is clearly outside my comfort zone. I wrote down that I will not like to let things out of my hands. I definitely did that during this course, of course, I participated in everything and gave my opinion. Although, somebody else should be the team leader/ manager. It felt again uncomfortable to not be involved sometimes and 'know everything that was going on. At the same time, we didn't have a clear team leader, we were all involved in it. Some team members more than others. I still think it is fascinating that our group dynamics made it possible to not have a distinct team leader.

During the course, I learned to deal with a designer approach. I improved my research skills as well. For instance, I performed GIS maps, water analysis and data analysis. Although, I believe that I can definitely get more knowledge regarding the creation of strategies. It is like learning how to ride a bike, after many trials you finally get an understanding of what the best approach is to execute it. But of course, then we could still fall.

I liked the multi-disciplinary approach and that we could 'compete' with for instance the chemical and agri-food sector. Their findings were inspiring to me and my group progression. There were some similarities between MADE and this course. The most enjoyable one is that in general there are no limits as long as it has a good explanation. I would definitely redo this course if I could go back in time.

ISABELLA TRABUCCO

The Urbanism Master program approaches the discipline through gradually design on small to big scale. This project, focusing on the regional scale, was the one which acted in the biggest scale in the whole curriculum.

For me is interesting to reflect on the fact that regional planning is like looking further away: we see the system in its general lines, yet we can observe the objects of the urban environment as small components of the whole.

At the beginning of the projects, it was easy for me to feel overwhelmed by the complexity of the scale and by all the synergies that happen at the same time. Understanding though the importance of those small components and the fact that is possible to work with them as a set of tools, made possible for me to get a clear overview of what regional planning, for me as designer, could mean.

We did not lose the scale of a building in the forest of road or water infrastructure connections; we did not forget the section of a canal or the local business relationships; we used these elements to integrate our vision and to tangibly build our systemic interventions in the urban fabric. Like jigsaw pieces, connecting to each other creating a full picture, we were able to change the colour or the shape of some of those to frame our vision for the province of Zuid-Holland.

This project made me feel inspired and challenged a lot my mind. Unlike previous design courses or tasks, I could understand that this type of work is the one which acts unnoticed on the background of our daily life but is deeply influential and essential. It was encouraging to see the Dutch approach and the enthusiasm of the province in each team's project. It made me think about the fact that spatial planning could be a career direction for me, especially looking at the prospect of moving back to Venice in Italy. Often, I thought about how everything I was learning could be applied to the lagoon I come from and how the collaborative approach could benefit my territory greatly.

The team was very motivating. All the different education backgrounds could bring very different aspects to the table and everyone of us had different set of skills from the others. We were lucky for this aspect; all the needed abilities were present in the workflow.

Furthermore, I felt that I could count on my team members if I could not do something, or I would lack knowledge or competence. Especially the last week, since I was injured, they showed the ability of taking the lead in a stressful situation and work effectively and with focus.

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