THE INCLUSIVE SUSTAINABLE SUPERMARKET OF THE FUTURE

Social circularity and synergy with its local urban environment

Qiao-Ling Cendón Cunqueiro - June 2020

THE INCLUSIVE SUSTAINABLE SUPERMARKET OF THE FUTURE

SOCIAL CIRCULARITY AND SYNERGY WITH ITS LOCAL URBAN ENVIRONMENT

Msc thesis (Delf University of Technology)

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PREFACE & ABSTRACT

This report is the final product of my master program at the faculty of Architecture and the built environment in TU Delft. Within this master period, I was able to be closely in touch and learn a lot about sustainable innovations, new concepts, products, projects and in general, learn a different way of thinking, studying and conducting research.

At the faculty of Architecture and Build environment, the climate department was the perfect environment to further develop my ideas and expertise. What started as a project focussing on food waste flows, evolved in a new approach about the circularity of different flows and societal relevance. During the process, I could deepen my knowledge on circular principles and "urban metabolism" topic, which allowed exploring relations between flows and urban design/planning, exploring circular solutions of flows, analysing the performance of an urban system, and co-relate it with people and the built environment.

In the end, I think that the design framework developed for this thesis could contribute to the improvement of other areas in need, similar to this selected study case, and in general, this thesis could form the base for paying attention to the importance and advantages of combining environmental, social and economical aspects under one project. Moreover, this research could be helpful for companies that want to improve their sustainability operations considering Sustainable Development Goals.

I would like to thank some people who were of great help throughout this intense and unexpected year.
First of all to my two mentors, Peter Luscuere and Bob Geldermans, who have been good support for me through this whole process. My thesis has undergone some difficulties in finding data and finding the right scope and approach. Both mentors were of help during this research process, trying to guide me in the right way and letting me investigate and add my own perceptions and creative ideas. The relaxed atmosphere but intensive chats helped me to boost confidence and move forward in difficult times.
This report would not have been developed without the support of my family, boyfriend and friends. My family constitutes a great pillar in my life, who have always been there for supporting me in my decisions and progress, and what I will be always grateful of. My boyfriend Iago played a key role during this period, boosting my mood, being critical with my thoughts and helping me to rest from work in the best way. The role of my friend Joanna was undoubtedly very enriching, who gave me general insights, critical perspective and together with Francesca, many important fun times during this period.

In the end, I am very proud of the effort and amount of investigation I could perform, leading to valuable results not only for public authorities but also private companies that could be interested to go beyond the social circular economy.

I hope you would enjoy reading this report and hopefully, you could obtain some insights, new knowledge and perceptions.

· Motivation:

My personal motivation for this research came after finishing the last course of the master: SWAT, in which the assignment was focused on the exploration of new insights and directions for developing a sustainable city by implementing a design methodology that could embrace theoretical knowledge, technological merit, environmental effectiveness and create a great societal impact. I could develop an urban farming complex for Amersfoort's citizens in which not only food flows were improved but also it could contribute to a better life for the community.

For this reason, a research topic related to flows and urban design was aimed to be chosen in order to investigate further the future possibilities for the improvement of the natural environment and the social benefits for a community. Moreover, my urban background and the objective to contribute to future sustainable urban development and improve social life quality for everyone has influenced on the development of this thesis.

· Executive summary:

Current issues such as climate change or scarcity of resources, among others, make general business market and in this case, Lidl supermarket Netherlands continue searching and improving its commercial operations and services around circular economy principles (CE). However, CE carries several social limitations that this thesis is planned to solve through exploring social circular economy solutions (SCE) and synergistic potential of urban metabolism. Moreover, the influence of United Nations (through Sustainable Development Goals) and its objective to focus on the improvement of social conditions is important for the sustainable progress and social living conditions of degraded areas such as Spangen, the selected case study.
The thesis is structured around 3 steps consisting of the analysis of baseline (flows, SDGs, Lidl, social context), improvement (exploration of circular solutions routes and interrelations for achieving design options) and proposal (including an evaluation and supportive calculations). This research is mainly qualitative, comprising of literature review, case study and fieldwork.

READING GUIDE

· Notes:
-Orientation: The floor plans, drawings (top view) and maps that are presented inside this report are always with the North orientation unless otherwise stated.
-Scale: The scale will be mainly represented in the final plans of the proposal, so appeared in chapter 06 *Research by design* (avoided in other conceptual diagrams).
-References: References that are not part of the literature study are cited with the website link. Moreover, the rest of the figures that are not mentioned consist of own work.

· Structure:
This research is formed by 8 main chapters, and briefly structured into 4 parts:

- **Problem and objectives:** For facilitating the delimitation of the problem and R.questions (RQ) and objectives.
- **Theoretical and analytical study:** Detail knowledge about useful concepts, qualitative information and quantitative analysis about Spangen.
- **Design process:** Selection of certain strategies and design possibilities through design by research, choosing the optimal solution according to SDGs and improvement of urban flows criteria.
- **Evaluation:** Based on the design outcomes, being critical with the achievement of the main research question and sub-questions presented at the beginning.

Chapters:

Problem & objectives	-01: General background study and Lidl description. -02: Focused on definition of main problems, vision, research question and sub-questions. -03: Conceptual framework.	
Theoretical & analytical study	-04: All the literature review, including precedent studies and concluding with design framework. -05: Local analytical study of the area, selection of essential flows and calculations of flows.	RQ1, RQ2, RQ3
Design process	-06: Further analysis of local context, circular solution routes and design process.	RQ3, RQ4
	-07: Final proposal, calculations and benefits.	RQ5
Evaluation	-08: Conclusions, discussion, reflection.	
	-(09): Appendix with bibliography and further research data	

· List of definitions:
Several important definitions are described in order to establish a proper communication and understanding, and avoiding misreadings between the writer and readers:

- **Circular economy framework:** Limits in which circular economy definition are restricted, but in general it is all referred to circular economy principles and concepts.
- **Circular facility:** Set of amenities and services necessary for a given activity inside a certain context (industries, armies, neighbourhoods, etc), operating based on circular economy principles.
- **Halophyte:** It consists of a natural water filtration system but with a specific selection of plants that can support higher concentrations of salt and other pollutant particles than regular phytoremediation plants. Within the project, halophyte plants are destined for greywater treatment, whereas phytoremediation word is destined for the treatment of rainwater, although both are phytoremediation systems.
- **Inclusive:** It is a characteristic attitude or tendency of integrating building(s) or people into a bigger context, with the objective that they can participate and contribute to it and benefit from this process.
- **Synergy:** It is an union of several forces or causes in order to achieve greater effectiveness through collaborative actions between involved parties
- **Social circular economy:** It is a further approach of the circular economy principles and concepts, where social and local context is also considered for creating more impact and benefits in the environment.
- **Neutral dependency:** It is a connection that does not lean in favour of any of the opposing parties, resulting in a balanced and equilibrium state among parties.
- (Food surplus: Unsold products, including inedible parts of food, that are intended for human consumption including drinks. Food surplus can be generated from product damages, degraded quality, recalls, past its best before or use by date).
- (Food waste: Any surplus not redistributed for human or animal consumption and or disposed of via anaerobic digestion, composting, energy recovery or landfill).
- **Food waste:** Although the previous definitions were the correct ones, within the project, food waste will be defined as the avoidable food waste that can be recovered through circularity measures.

· List of abbreviations:
The following abbreviations will be commonly used:

- **CE:** Circular economy
- **FW:** Food waste
- **F, W, A:** Food, water, air flows
- **GH:** Greenhouse
- **LM:** Linear model
- **LSC:** Luminiscent solar concentrator (panel)
- **(Low tech):** Low technology
- **NFT:** Nutrient Film Technique (aquaponics)
- **NL:** The Netherlands
- **PV:** Photovoltaic (panel)
- **SCE:** Social circular economy
- **SDGs:** Sustainable development goals
- **UD:** Urban design

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01 INTRODUCTION

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1.1 | INTRODUCTION

1.1.1 GENERAL INTRODUCTION

Based on studies performed by the United Nations, it is expected that the level of world urbanization and world population will be much more increased (Hui, 2011), resulting in greater pressure on the metabolism of cities. The demand of flows such as water, energy, materials, fertile soil, food and clean air are destined to be much more demanded in order to fulfil the requirements of the new growing society. However, considering the depletion of natural resources, increase of waste and climate change issues, among others, there is an urgent need to adopt other operating systems that are more respectful with the natural environment.
The sustainable development goals (SDGs) set in 2015 by the United Nations serve as a good start for achieving a better and sustainable future for everyone. There are 17 goals and they are all interconnected, trying to address the current global challenges (UN, 2019).

Since the Industrial Revolution period, great advances in the technology area and urbanization has been performed but this also resulted in a sharper depletion of fossil fuels than the previous humanity stages. The mobility, economy, society and political power have been organized around the unlimited consumption of natural resources without thinking that in the next future, these valuable resources might be gone. There is no an exact date of when this will happen, but experts state that sooner or later will occur, so if society still keeps doing their activities and lifestyle in this way, the following questions arise: what will happen next if there are no more resources? How will humanity be able to fulfil their necessities?

In natural cycles, like the water cycle, every element that is extracted from its natural sources is sustainably transformed and then release back to its origin, being again profitable and reusable for the next cycle process. However, the way humans have developed products is much more different, because when the lifespan of a product or material has passed, they have lost their economical and functional value, becming useless and thrown away or burned. Products are currently designed to be expired, broken or lose their efficiency and value at a certain point, even though they could be designed to last longer, due to consumer behaviour of developed countries, tempted to buy new products or being constantly updated.

Sustainable solutions and ideologies have been searched and developed since the past decade in order to take responsibility for the nature and sources from the planet. Circular economy in the built environment is mainly focused on the irresponsible extraction and utilization of natural raw sources and the intention to reuse them as much as possible before going to waste through smart designs and processes. However, one step further that needs to be considered for achieving in reality a circular building is to consider the social aspect and the local context where it is placed, in which the exchange with other systems is the key for having a balanced system between economy, environmental and social aspect.
A social circular economy is a further approach of the current state that could determine the effectiveness of the circular economy principles and its real establishment.

In general, the role of supermarkets and grocery stores is important because they act as a connector between the supply and demand. They have enough power to influence people on their consumption behaviour and buying practice, but it is observed that there is lack of social cohesion, communication, participation and interaction between people in big supermarkets (Erwin & Brownson, 2017). Supermarkets are an important facility that brings life inside a neighbourhood, thus it could play a key role for improving the social aspect and enhancing people's satisfaction in a community.

When talking about social aspects, degraded areas present themselves important challenges and great potentials that could be studied. Moreover, as a consequence, environmental and economical issues are linked to these poor areas, resulting in greater impacts and possibilities.

Therefore, the role of Lidl supermarket could be relevant for the improvement of poor socio-economic context not only from social perspective but also from environmental one. The inclusive supermarket of the future would need to be in synergy with the surrounding environment in order to get greater benefits and reduce resource demands.

1.1.2 LIDL AND TU DELFT

Lidl Netherlands is doing efforts for improving its climate impact through all disciplines and thus trying to become the supermarket chain of the future.

Current issues such as climate change or scarcity of resources, among others, make general business market and in this case, Lidl supermarket Netherlands continue searching and improving its commercial operations and services to its customers. Moreover, the concepts of sustainability and circularity are not considered any more distant goals but are quickly gaining more relevance so companies see great potentials in them for the next coming years. The company is aimed to achieve gradually sustainability and circularity along with the whole commercial operations by sustainable strategies and smart designs in order to minimize the climate impact.

For this reason, the company has reached TU Delft in order to improve its sustainability goals and explore several opportunities of the circular economy through all its categories by the help of master thesis students. In the previous years, Lidl thesis were focused mainly on energy, materials and the circular design, therefore this year I felt that organic waste flows within a grocery store like this needed to be finally assessed in order to make a further step into the circular economy and the reduction of the footprint. By focusing on some flows and assessing Lidl and urban context through Sustainable Development Goals (SDGs), further benefits for the company and degraded areas such as Spagen would achieve further benefits for the future.
Moreover, due to the high position of groceries stores and its great influence on the behaviour of consumers, the main food wasters, the new proposal aimed to have a great social component, thus achieving sustainability but also social benefits inside and outside the Lidl supermarket.

02 PROBLEM FIELD

2.1 | BACKGROUND STUDY

2.1.1 CURRENT CHALLENGES

Briefly, some of the main current challenges that the world is facing are related to population growth and urbanization, an increase of waste generation and the depletion of natural resources.

· Population growth and urbanization:

Studies performed by the United Nations (UN) indicated that population is expected to increase considerably by 2050 (Figure 2.1.1.1), meaning that twice as many people in the world will be living in urban settings (6.7 billion) rather than rural ones (3.1 billion).

In The Netherlands (NL), urbanization has been always leading the way Dutch people live, but since 1900 there has been a rapid growth. Around 1977, there has been a dramatical decrease in rural areas, expected to continue by 2050 (Figure 2.1.1.2).

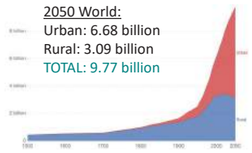


Figure 2.1.1.1: Global urban (red) and rural population (blue) projected to 2050 (Source: Our world in data, 2018).

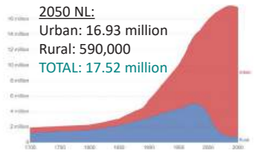


Figure 2.1.1.2: Dutch urban (red) and rural population (blue) projected to 2050 (Source: Our world in data, 2018).

However, it has never been like this before because, for most of human history, people used to live in small communities. Figure 2.1.1.3 shows that global urbanization has largely been focused mainly in the last 200 years (from 1800), and particularly in recent decades, in which this trend has shifted dramatically, resulting in a massive migration of the population towards urban areas (Our World in Data, 2018).

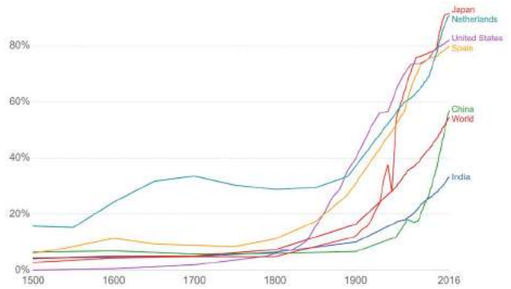


Figure 2.1.1.3: Urbanization over the past 500 years. Share of the total population living in urban area (Source: Our world in data, 2018).

The consequences of these two phenomenons will affect the ecological equilibrium and harmony between nature and human being. They will put great pressure on the metabolism of future cities because even though cities occupy only 2% of the world's surface, they currently consume 75% of its resources (Girardet, 2008). The demand of main flows such as water, energy or materials are destined to increase tremendously for fulfilling all the requirements of the new growing society.

· Increase of waste generation:

The expected increase of population and the level of urbanization, together with economic development, will have direct consequences on waste management, which waste will be also increased. As cities or countries are being urbanized, their economic wealth increase too, resulting in the following chain: higher economic level allows higher standards of living, resulting in a higher amount of consumption of goods and services and causing an increase in the amount of waste generated. Moreover, rapid urbanization and population growth result in larger population centres, making more difficult the collection, storage and treatment of waste.

Solid waste management is a global concern that affects to everyone and at different scales, but the negative impact of poor waste management rely mostly on the natural environment and vulnerable societies (World Bank Data, 2012).
In general terms, waste generation (municipal solid waste) is around 2.01 billion tonnes/year or 0.74 kg/person/day (0.11-4.54 kg/person/day), but it is expected to increase by around 3.40 billion in 2050 (World Bank Data, 2018). So citizens and corporations will need to take more responsibility for the waste generation and disposal methods, in which product design, reduction, treatment measures and waste separation will play a key role in the future.

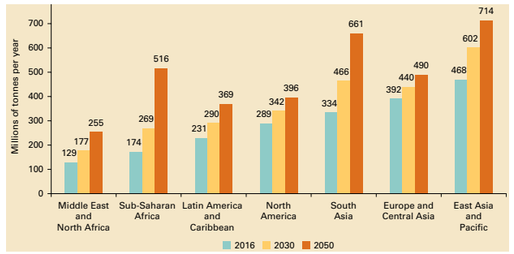


Figure 2.1.1.4: Total projected waste generation by region (Source: World Bank Data, 2012).

Solid waste is generally considered an "urban" issue (World Bank Data, 2012, p.18). In rural areas, the level of waste generation tends to be low due to for example lower income, less consumption of products or services, and higher levels of recyclability and reusability.

Moreover, lower-income countries usually tend to produce less waste but also have fewer budgets for recyclability and waste treatment, being waste 90% of the cases disposed of in open dumps.

2.1 | BACKGROUND STUDY

2.1.1 CURRENT CHALLENGES

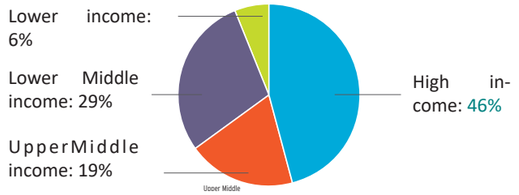


Figure 2.1.1.5: Waste generation by income level, being higher as the income level increases too (Source: World Bank Data, 2012).

Nevertheless, the trend shows (Figure 2.1.1.6) that lower middle income level will have the greatest population growth at the same time as they will be the greatest waste generators. Therefore, the highest amount of waste will not only come from high income but also from lower-middle-income class, generating mostly paper (30%) and organic waste (55%) (World Bank Data, 2012).

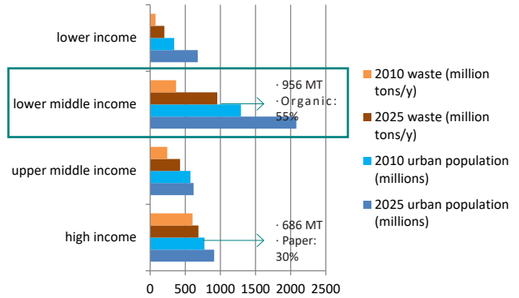


Figure 2.1.1.6: Urban waste generation by income level and year (Source: World Bank Data, 2012).

· Depletion of natural resources:

It is not new that human actions and activities are harming the global environment. In fact, since the Industrial Revolution, this issue has dramatically gotten worse because although in this period, technology, economy, urbanization, progress and prosperity have increased, it has also led to unlimited consumption of natural resources, without taking care of the natural cycles and regenerative process of the Earth. Moreover, urbanization and population growth have exacerbated this issue due to the high necessities of the new society and subsequent transformation of the land and high amount of contaminants to nature.

Fossil fuels, such as coal, oil and gas have been playing a dominant role in global energy systems since the Industrial Revolution, but specifically from this period, their consumption has increased more than 1300 times (Figure 2.1.1.7) (Our World in data, 2020).
Fossil fuels carry negative impacts, being considered the most contaminant source of global energy production and producing a high amount of C02 emissions. The impact in the short term is in the form of local air pollution, whereas in the long term it appears in the form of climate change (Our World in data, 2020).

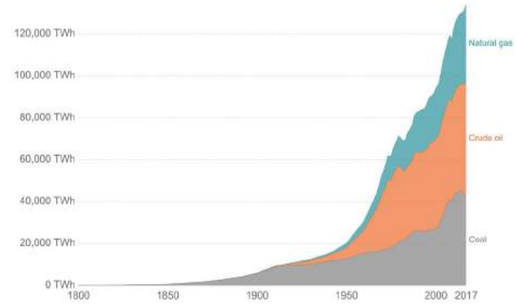


Figure 2.1.1.7: Global fossil fuel consumption: Global primary energy consumption by fossil fuel resource, measured in Terawatt-hours (TWh). (Source: Our world in data, 2020).

In fact, human beings are using the natural environment 1.75 times faster than the planet's ecosystems can regenerate, being an equivalent to 1.75 Earths (PR Newswire, 2019). The environmental consequences of this excess are being more evident every year, so if humanity still continues with the harmful extraction and consumption methods that have been used since the last centuries, most of the fossil fuels will have disappeared by around 2050. However, not only fossil fuels will be affected but also the rest of natural ecosystems will be dramatically degraded, and additionally, valuable minerals will be gone only in a couple of years (Figure 2.1.1.8) (Swain & McCandless (2012).

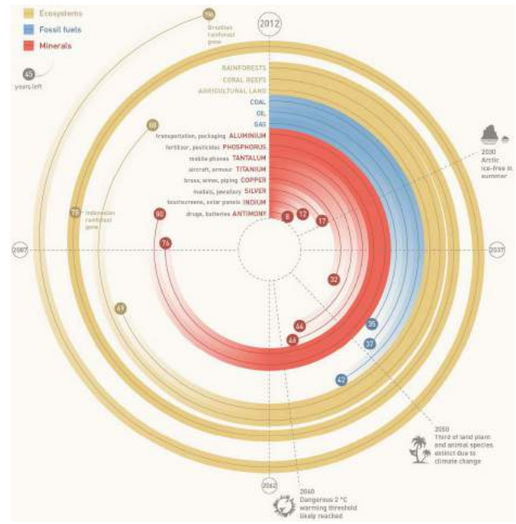


Figure 2.1.1.8: Estimated remaining world supplies of non-renewable resources (years starting from 2012): Ecosystems, fossil fuels and minerals (Source: Swain & McCandless, 2012).

2.1.2 SUSTAINABLE DEVELOPMENT GOALS (SDGs)

The Sustainable Development Goals were set in 2015 in order to achieve a better and sustainable future for everyone. They are all interconnected and they address the global challenges that are currently happening, including the ones related to inequalities, poverty, environmental degradation, climate change, justice and peace (UN, 2019).

SDGs define global sustainable development priorities and aspirations for 2030 and by all United Nations Member States. They are considered an urgent call for action by all countries, including governments, business and civil society to end poverty and create a life of dignity and opportunity for all (GRI, UN & WBCSD, 2015), therefore efforts need to be globally in partnership (SDG, 2018).

The following 17 goals, together with their critical current situation, are (UN, 2019; GRI, UN & WBCSD, 2015):

· 1: No poverty: End poverty in all its forms everywhere. (Over 700 million people still live in extreme poverty).
· 2: Zero hunger: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. (1/3 of the world's food is wasted and 821 million are undernourished).
· 3: Good health and well-being: Ensure healthy lives and promote well-being for all at all ages. (Vaccinations resulted in an 80% drop in measles deaths between 2000-2017).
· 4: Quality education: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. (617 million children and adolescents lack minimum level in reading and mathematics).
· 5: Gender quality: Achieve gender equality and empower all women and girls. (1/3 women has experienced physical or sexual violence).
· 6: Clean water and sanitation: Ensure availability and sustainable management of water and sanitation for all. (Water scarcity affects nowadays more than 40% of the world's population).
· 7: Affordable and clean energy: Ensure access to affordable, reliable, sustainable and modern energy for all. (3 billion people still lack clean cooking fuels and technologies).
· 8: Decent work and economic growth: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. (1/5 of young people are not in employment, training or education).
· 9: Industry, innovation and infrastructure: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. (Roads, sanitation, water and electricity are still scarce in many developing countries).
· 10: Reduced inequalities: Reduce inequality within and among countries. (The poorest 40% of the population earn less than 25% of the global income).
· 11: Sustainable cities and communities: Make cities and human settlement inclusive, safe, resilient and sustainable. (9/10 urban residents are in contact with polluted air).
· 12: Responsible consumption and production: Ensure sustainable consumption and production patterns. (By 2050, it is estimated that almost 3 planets could be required in order to maintain the current lifestyles).
· 13: Climate action: Take urgent action to combat climate change and its impacts. (Global C02 emissions have increased by almost 50% since 1990).
· 14: Life below water: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. (Over 3 billion people depend on coastal and marine biodiversity for their livelihoods).
· 15: Life on land: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. (Forest are the habitat for more than 80% of all terrestrial species of animals, insects and plants).
· 16: Peace, justice and strong institutions: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels. (In 2018, the number of people fleeing from war, conflict and persecution exceeded 70 million).
· 17: Partnerships: Strengthen the means of implementation and revitalize the global partnership for sustainable development. (Achieving SDGs could create around 380 million new jobs and open up 12 trillion (US dollars) of market opportunities by 2030).

Due to broad sense and complexity of addressing each SDG, there are several indicators that help to stablish little targets and doable accomplishments. Indicators express the relationship between entities and their impact on sustainable development, so that performance can be tracked over time. Some of the achievable indicators within the project boundary is displayed in chapter 9.2.2 *Achievement of SDGs (indicators).*

Sustainable Development Goals are deeply connected with the term sustainability, in which as described before, they deal with topics related to economic, environmental and social aspect. However, in the following paragraphs, a lack of social aspect is observed in the SDGs in the Dutch context.
Figure 2.1.2.1 shows the situation in The Netherlands, in which green colour refers to the trend moving towards an increase in well-being, whereas the red colour refers to its decrease. As it can be observed, the better steps and positive trends in the country are related to the goals 2, 5,

2.1.2 SUSTAINABLE DEVELOPMENT GOALS (SDGs)

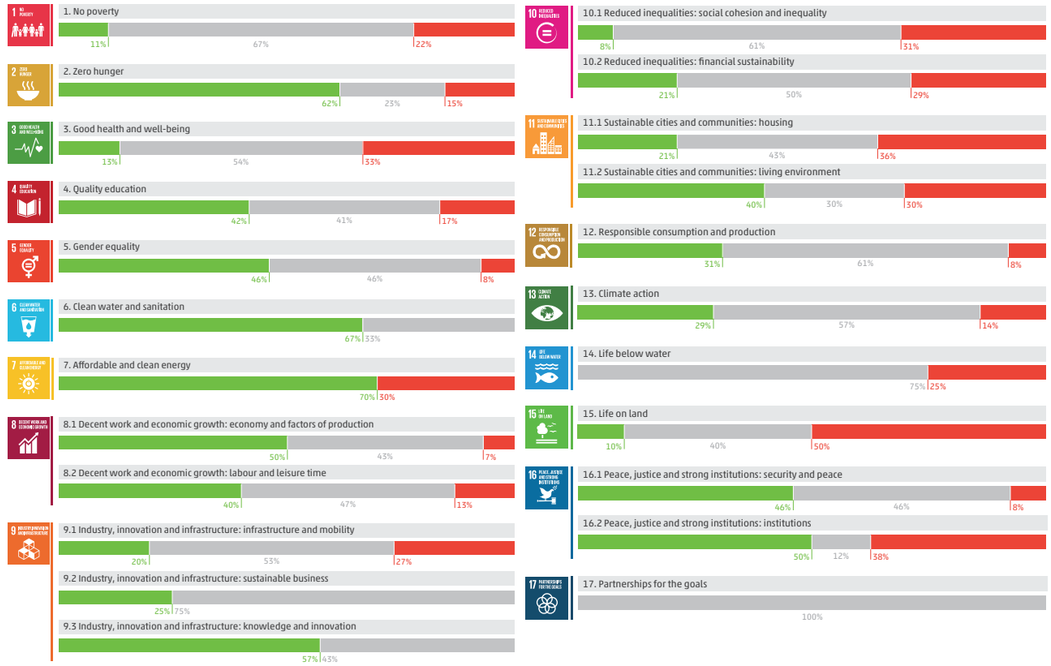


Figure 2.1.2.1: Trends in the Netherlands for each SDGplus (share of total number of indicators measured per SDGplus, which is a combination of CES and several other indicators) (Source: Statistics Netherlands, 2019).

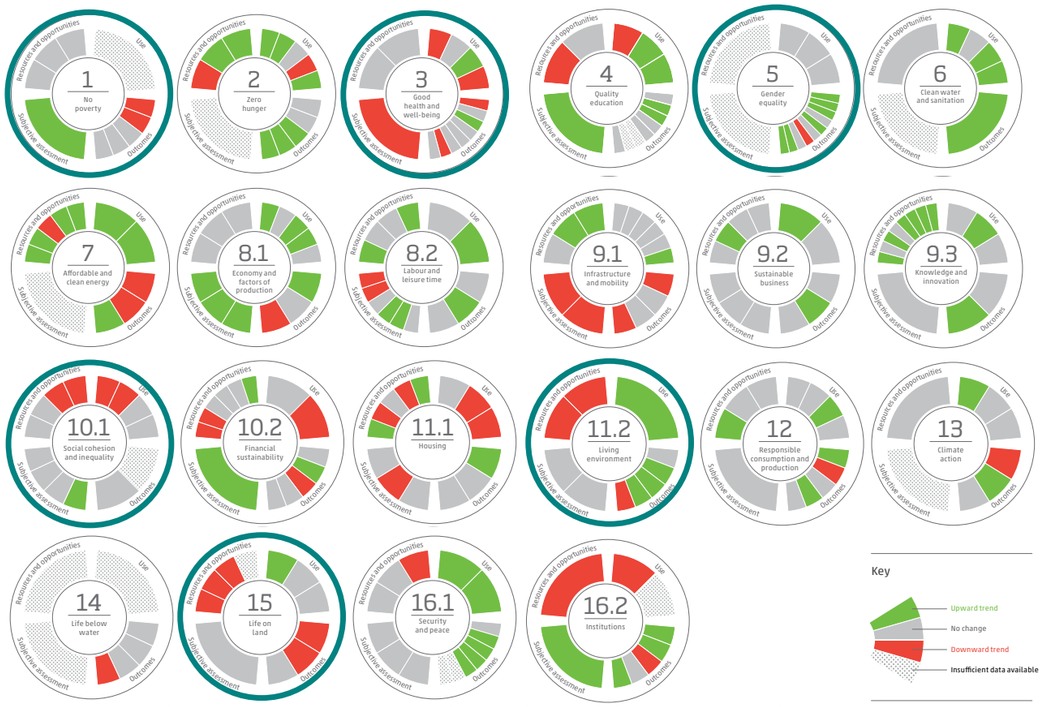


Figure 2.1.2.2:Trends of measured SDGplus indicators by type of indicator (Source: Statistics Netherlands, 2019).

6, 8 and 9.3. On the contrary, the current declining trends occur in the goals 3, 9.1, 10.1, 11.1, 14 and 15, in which efforts were being reduced.
The majority of these last percentages regarding SDGs, are related to social aspects, in which The Netherlands seems to need to improve social cohesion, enhance community feeling and improve people well-being in general.

Figure 2.1.2.2 gives an overview of the trends of all indicators measured, which are divided into 4 categories. The highlighted goals are the areas of opportunities regarding social aspects that could be introduced in this thesis, based on the low results from Figure 2.1.2.1.

However, even though the previous graphs give an overview of the situation in the Dutch country, it does not show its position within the broader 2030 goal frame context.

Figure 2.1.2.3 is used as an analytical tool to assist countries for identifying strengths and weaknesses across the SDGs goals. It represents that around 26 of the 2030 targets have been achieved in The Netherlands, and many of the remaining goals have small distances for being achieved. Nevertheless, some challenges still persisting and obstructing for meeting the targets, such as high environmental pressure on soils (target 2.4) and high rates of tobacco consumption (target 3.a) (OECD, 2019).

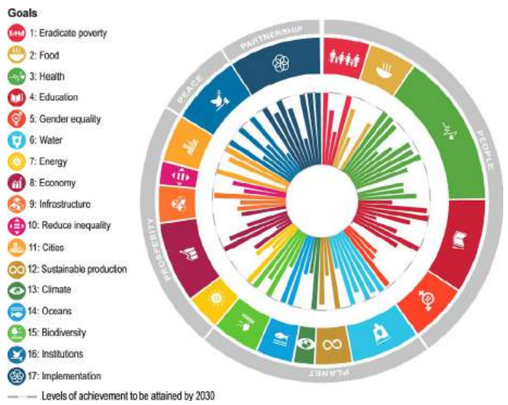


Figure 2.1.2.3: The Netherlands' distance from achieving each SDG target. (The longer the bar, the shorter the distance still to be travelled to reach 2030 target) (Source: OECD, 2019).

Being more specific, the following figure 2.1.2.4 shows the position of the Dutch country in relation to the OECD average. For instance, it represents that The Netherlands is in general very close to reaching goals regarding Planet (water, sustainable production, climate, oceans, biodiversity), People (poverty eradication) and Partnership (implementation). Moreover, it shows that the country significantly surpasses the OECD average in People (poverty eradication, education, gender equality; goal 1, 4, 5), Planet (water; goal 6), Prosperity (reduce inequalities; goal 10), Peace (institutions; goal 16) and Partnership (implementation; goal 17). (OECD, 2019).

Nevertheless, the Figure 2.1.2.4 shows that great efforts in People (food, gender equality: goal 2, 5) and Prosperity (economy; goal 8) need to be increased. Moreover, Dutch targets are similar or below the OECD average in for example People (food), Planet (Climate) and Prosperity (energy, cities), meaning that the country should neither loose track of these targets.

Therefore as a conclusion, the combination of both factors; Dutch distance to achieve 2030 target and the position in relation to OECD average, should highlight the necessity of joining efforts for keeping the rhythm of right measures at maximum level and finding new efficient measures for minimising big distances from 2030 targets.

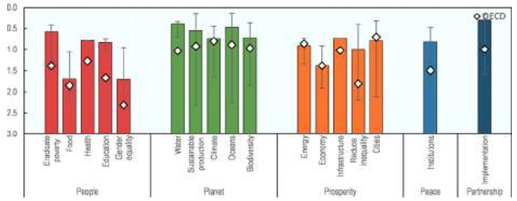


Figure 2.1.2.4: The Netherlands' average distance to targets at goal level and OECD average. (The longer the bar, the shorter the distance to reach each SDG. Distances measures in standardised units, being 0 the level for 2030 has already been reached and 3 is the distance which most of OECD countries have already travelled) (Source: OECD, 2019).

2.1.3 CENTRALIZATION VS DECENTRALIZATION

· Centralization:

The way centralization is referred in this thesis is mainly about the concentration of resources, in which for example the generation of energy or waste treatment is centralized in one unique system rather than spread through several ones. That is to say, in a city, one unique and common source provides service for the rest of consumers (areas or neighbourhoods).

However, this centralization system carries several problems, for example the main ones:

· Pollution: Areas or neighbourhoods closer to the common source are more polluted than the areas located further.
· Differences between areas or neighbourhoods: There is no equal distribution between the areas, in which demand and services vary. Moreover, neighbourhoods closer to the source would have greater benefits than areas located further from the source.
· More complexity and bigger: Due to one unique source, larger and more complex equipment is needed for fulfilling the requirements of the entire city.
· Collapse: If one of the distribution lines is broken or obstructed, the affected area is completed isolated and without any supply and help.

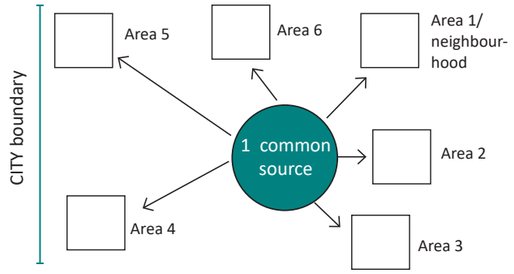


Figure 2.1.3.1: Centralization concept (city scale).

· Decetralization:

One of the main factors that have led towards an urban decentralization was the steam power, railroad constructions and consequently the introduction of car subways, which allowed moving goods and people between cities and suburban areas. This decentralization tendency has been occurring since 60 or 70 years, in which cities had a greater emphasis on the expansion towards peripheries areas rather than the rebuild of city centres. (Hoyt, 1940).

The disadvantages of centralization disappear in decentralized systems because every small area or neighbourhood would have its own source or supply, and would operate independently from each other. So several advantages of decentralization system are:

· Pollution: Less distance between production-consumption will be needed, resulting in less transportation loss and C02 emissions.
· Equality: There is an equal distribution among different areas, having similar local facilities and services.
· Simpler and smaller: More simple and smaller equipment of the source is needed.
· Independence: If the main line is broken, the local energy production, for example, will still providing its service to the area.
· Local well-being and general problems will be much easier to address from a local perspective point of view.
· Reduction of resources consumption due to the smaller area, resulting in a more realistic way to achieve a balanced system between offer and demand, for example neutral energy: local demand balanced with local energy production.

The way civilization generates, distributes and consumes sources is changing. The scale and rate of this change is one of the major challenges of the current cities situation, but also brings opportunities in social, environmental and economic aspects. Therefore decentralization seems to be a good option for assuming the current challenges world is facing, in which solutions are addressed from a local perspective point of view, allowing each area to develop its own community belonging and culture feelings, at the same time as improving environmental, economic and administrative aspects.
Moreover, decentralization can solve not only local scale (neighbourhoods or small areas) but also bigger scale such as cities by a repetitive pattern, similar to a modular approach.

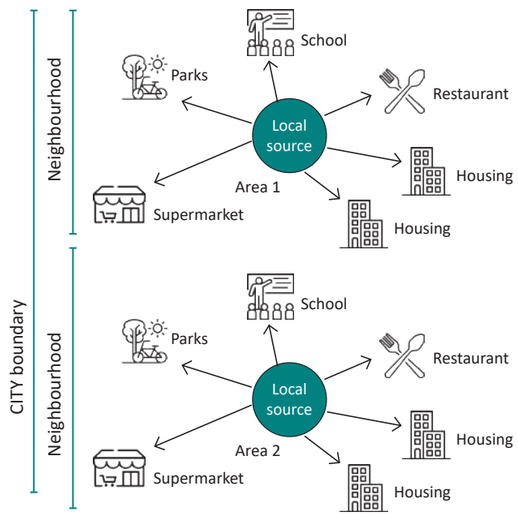


Figure 2.1.3.2: Decentralization concept (local scale) as a solution for city scale through repetitive pattern (solving local issues).

2.2 | PROBLEM ANALYSIS

2.2.1 LIMITATIONS OF THE CIRCULAR ECONOMY (CE)

Very briefly and as already known, humans have been always developed and based its evolution on the linear model (LM), which is established around "take, make, consume and dispose" pattern. Within this model, all materials and products have an end of life, resulting in a high amount of waste, consumption and faster depletion of resources. However, since the past decade, other ideologies have been searched but they were still producing a considerable amount of waste. The last movement to appear is the circular economy (CE), which differs from the LM in the preservation of the value. The circular economy uses renewable energy and follows the 3R (reduce, reuse and recycle), so the use of natural resources and waste is minimized, the products are put back to the cycle chain giving them a second opportunity, and raw materials are recycled to the high standard (Hetgroenebrein, 2019).
So, the circular economy has gained recently more attraction, believing that it is the solution for the current linear system and global challenges.

Nowadays it is a very popular concept supported by the EU and promoted by several national business and companies around the world. In comparison to the LM, in which the main objective is focused on profitability (Figure 2.2.1.1), the CE is an operating model that ensures the economy does not harm the natural environment, giving to the planet much more than it takes from it. But the implementation of the CE requires resources, money and informational flows, among others, which result in a slow and difficult economy model transition.

Although CE has plenty of benefits, it presents certain limitations when talking about *sustainability*, which consists on the balance of 3 aspects: economy, environment and social. Within CE model, there has been a greater emphasis on maximising resources and labour productivity in order to get more efficient answers rather than effective ones, so focusing mostly on economical and environmental aspects, and leaving some important social points such as specific benefits for end-users (Robinson, 2017).

On the other hand, the objectives of social enterprises (SE) or actions are generally focused on creating a social impact while earning some money with their actions, so mainly social and economic aspects, forgetting most of the time the potential damages for the environment (Figure 2.2.1.1). They tackle societal problems by improving the situation and providing opportunities for any kind of disadvantaged people (children and old people, disabled, homeless, refugees, crime victims...), at the same time as strengthening the communities.

So, social circular economy (SCE) is a new term that combines the last two concepts (CE and SE), where organizations follow CE principles and also have social missions for providing benefits for people, planet and profit, thus meeting the total sustainability concept and objectives (Figure 2.2.1.1). Its aim is to inspire people to rethink, redesign and achieve a positive future through SCE principles, which provide the great conditions for enhancing innovation and creativity for solving the societal, economic and environmental needs (Robinson, 2017).

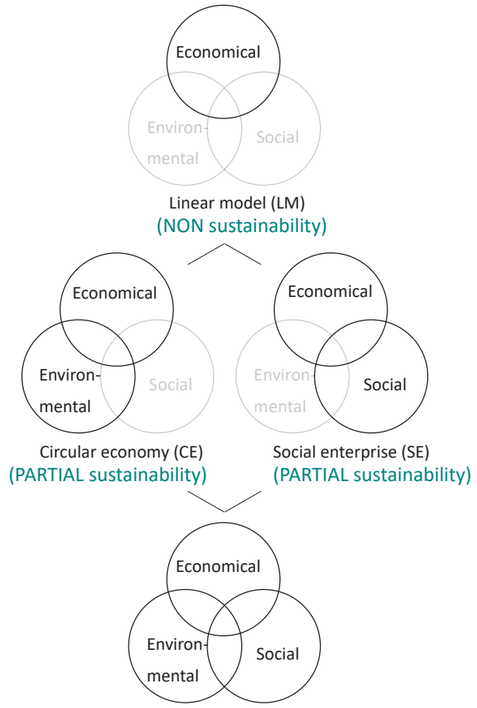


Figure 2.2.1.1: Sustainability achieved in LM, CE, SE and SCE.

A circular ecosystem will have a combination of the natural and social cycles (as occurs with SCE), which will enable to achieve the final and balanced prosperity.

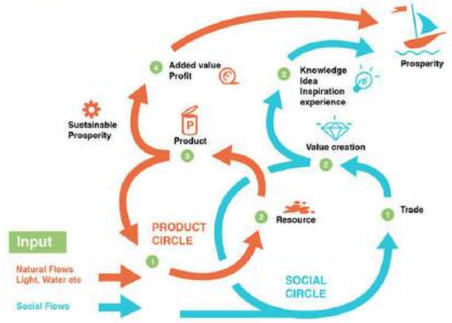


Figure 2.2.1.2: Final prosperity when applying SCE, with natural (CE) and social flows (SE) (source: Robinson, 2017).

2.2.2 CIRCULAR ECONOMY VS SOCIAL CIRCULAR ECONOMY

The main difference between the Circular Economy (CE) and Social Circular Economy (SCE) rely on the introduction and consideration of the social aspect.

One useful example in order to understand better the main difference is when substituting robots operations by refugee women. In the CE, robots can repair mobile phones cheaper and faster than the current LM, allowing to achieve only one sustainable development goal (SDG). However, if more focus on the right people is given and machines are replaced for example by 5 refugee women doing also those repairs, 3 SDGs could be now achieved. This change would result of course in slightly lower efficiency of the process, but would allow the following advantages and their respective benefits for society (Robinson, 2017):

· Inclusivity of women and disadvantaged people (improving inequalities and integrating disadvantaged people on society, fight for women rights, ...)
· This refugee women would have now income for living and being independent (reducing government's expenses, ..)
· If they earn money, they would spend it locally rather than sending the money to a foreign bank in the case of robots (thriving local economy, ...).

SCE would not only consider the social and economic aspects, but also the importance of preserving nature through its actions. Every aspect of sustainability receive benefits, for example:

·Society: Reduction of inequalities and support for disadvantaged population, while lowering government costs.
·Environment: Fewer emissions and extracted raw materials.
·Economy: Higher net material savings, mitigation of price risk and employment.

Moreover, SCE also recognises that more creation of value and more local and distributed solutions are keys for achieving sustainability.
In traditional economies, the massive production has been always concentrated in one location, allowing economical growth and benefits, but also risks regarding social and environmental consequences. The concentration of values can generate inequalities in the economic, environmental and social aspects, because fewer people would have access to those values. Additionally, exploitation and movement of resources in larger scales involve an increase in costs (Robinson, 2017).
Therefore, SCE defends the necessity of the focus on the local scale, having some similarities with the previous concept of decentralization.

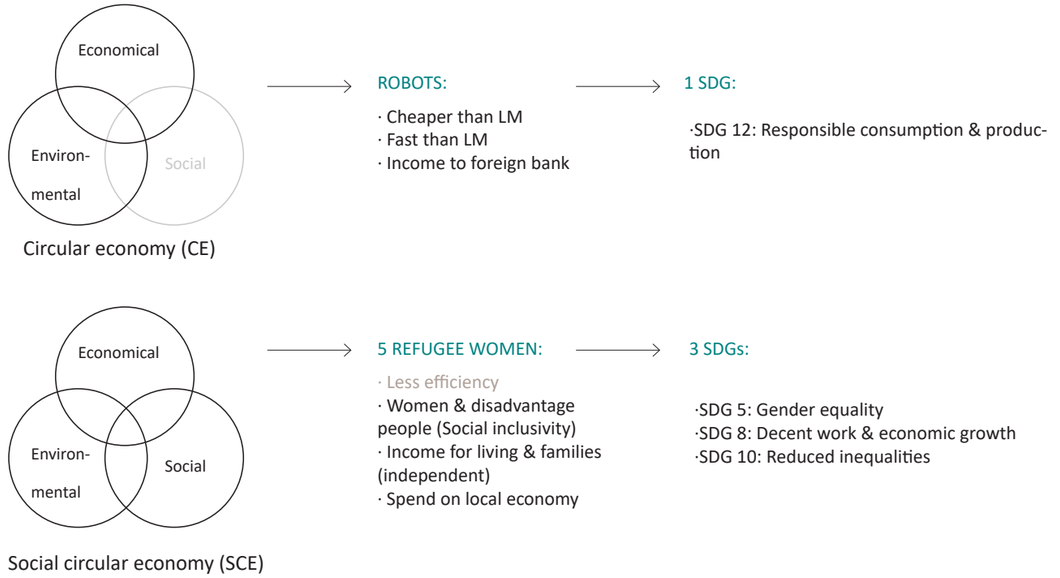


Figure 2.2.2.1: Comparison between CE and SCE.

2.2.3 WELL-BEING IN THE NETHERLANDS

As described before, the level of well-being not only affects individually to people or community but also the rest of the pillars of sustainability. In the end, declines in social aspects result in a general life's disequilibrium, altering reduction of efficiency and growth.
In order to understand this important dimension of sustainability within the thesis scope, well-being in the Dutch context is being analysed.

The Organisation for Economic Co-operation and Development (OECD) is a group of 34 democratic countries that explores and develop economic and social policies.
It has developed a tool called Better Life Index (BLI), in which different topics related to well-being are able to be measured in many worldwide countries. How's life is the statistic report that is released every two years and describes the essential aspects of life that influence people's well-being. It presents 11 dimensions and around 80 indicators, covering current well-being results, inequalities and resources for future well-being progress.

In general since 2010, people's well-being has improved in many ways but progress has been slowed down or decreased in other aspects, such as people connectivity with each other and their government. One of the problems of well-being outcomes relies on the big gaps that exist by gender, education and age. In fact, OECD countries that achieve good results on average, they have also great equality standards between population groups and fewer people living in deprivation (OECD, 2020).

Figure 2.2.3.1 shows the Dutch relative strengths and weaknesses in well-being, being the longer bars the better outcomes and vice-versa.

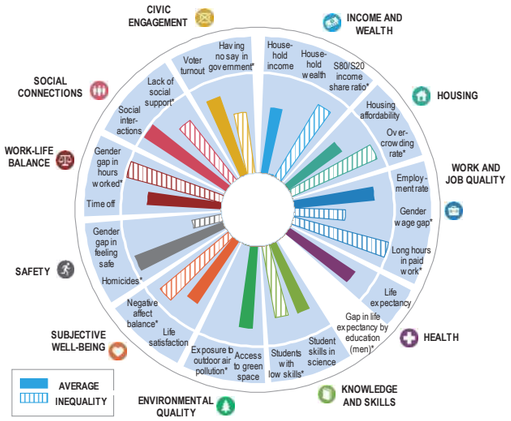


Figure 2.2.3.1: Overall Netherlands's current well-being, 2018 (Source: OECD, 2020).

In comparison to other countries, The Netherlands achieves a good performance in many measures regarding the Better Life Index, represented by Figure 2.2.3.2.

Figure 2.2.3.2: Comparison of Netherlands's performance in several topics of Better Life Index (Source: OECD, 2020).

Not all the aspects represented in Figure 2.2.3.2 are of interest of this research, therefore a focus and more detail information about the following points is aimed:

· Income:
Money cannot buy happiness but it plays an important role in achieving higher living standards. Dutch people have a lower income per capita than the OECD average, but in terms of employment, the country (76%) is above the OECD employment average (68%) (OECD, 2020).

· Community performance:
Regarding social well-being, there is a strong community feeling and high rate of civic participation among Dutch people, in which 91% of citizens believe to have someone who trusts in case of necessity, being above OECD average of 89%. A strong social network or community can not only provide emotional support during bad and good times, but also job opportunities, services and others.

2.2.3 WELL-BEING IN THE NETHERLANDS

In general, Dutch people feel more satisfied (rate of 7.4) with their lives than the OECD average (6.5) (Figure 2.2.3.3).

· Life satisfaction:
Measuring feelings can be hard and subjective, but it can help for obtaining valuable information regarding the quality of life. It can provide a personal evaluation on an individual's education, income, personal fulfilment, health and social conditions, to name a few. Surveys or interviews, for example, can be very useful for measuring life satisfaction and happiness.
Dutch people have qualified their general satisfaction in life about 7.4, being above the OECD average of 6.5 (Figure 2.2.3.4) (OECD, 2020).

Figure 2.2.3.3: Dutch community performance according to Better Life Index (Source: OECD, 2020).

Figure 2.2.3.4: Dutch life satisfaction performance according to Better Life Index (S: OECD, 2020).

· Health:
In relation to health, the quality of the local living environment is crucial, having a direct impact on personal health and well-being. An unspoiled environment is a source of satisfaction, enhancing mental well-being, allowing to perform physical activities and distressing from dairy life. Having the chance and access for enjoying greenery spaces, for example, is an important aspect of quality of life. Moreover, the economy not only relies on productive and healthy workers, but also on natural resources such as timber, plants, crops, water, fish, etc. Therefore is the duty of each country to preserve the natural environment for present and future generations (OECD, 2020).

· Environment:
The level of atmospheric PM2.5 (tiny air pollutant particles that cause damage to the lungs) has been monitored by OECD countries due to its influence on the reduction of life expectancy and harm to humans. In some countries, the proportion of the population exposed to PM2.5 has been reduced. However, in half of the countries, around 90% of the population is still under the exposure of these concentrations, being above the World Health Organization guideline limit of 10 micrograms/m3.
In The Netherlands, people have a life expectancy of 82 years, being 2 years above the OECD average. The level of atmospheric PM2.5 is 14.0 micrograms/m3, slightly higher than the OECD average of 13.9 micrograms/m3.
Similarly, access to clean water is important for human well-being. The challenge is set on how to manage it efficiently in order to satisfy and meet the demands of each country.
Water quality in the country is great and Dutch people feel satisfied (93%), being above OECD average of 81%.

Figure 2.2.3.5: Dutch environment performance according to Better Life Index (Source: OECD, 2020).

In general, although the majority of Dutch population perceives their well-being as good or enough, there is a minority of the population that still suffers from deprivation, as represented in Figure 2.2.3.6 (OECD, 2020).

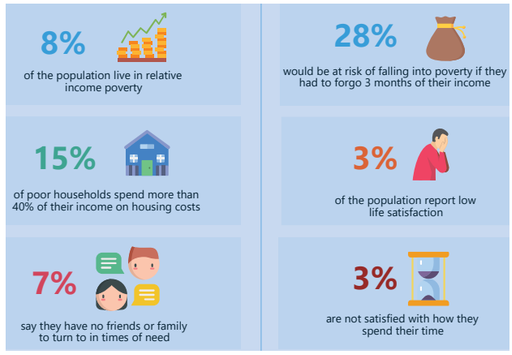


Figure 2.2.3.6: Deprivations in selected indicators of current well-being, The Netherlands 2018 (Source: OECD, 2020).

Even though the average of the Dutch population achieve good performance in well-being, the fact is that not all areas and territories have the same circumstances.
As analysed in previous chapters, Spangen is one of the most degraded, experiencing mainly social issues and resulting in (Gemeente Rotterdam, n.d.b):

- Deprivation and poverty
- Crime and vandalism issues
- Inequality and segregation of communities
- Low quality of life
- Social exclusion
- Feeling of isolation and loneliness
- Low satisfaction

Therefore, great efforts should be focused on people well-being in order to improve their life's satisfaction, interconnection and relationships, integration, etc. By focusing on this aspect, the other two would be much easier to address within this socio-economical circumstances.

2.2.4 DEFINITION OF FLOWS

The ambition of the government of The Netherlands is to adopt a completely circular system by 2050, reducing the use of primary resources at 50% (Government NL, 2018). Circular economy not only deals with technical and raw materials, but also the rest of the relevant flows inside the built environment, such as energy, air quality, water and topsoil (and recently: space). All these main five sources are consumed and exploited (fossil fuels), others are contaminated (water and air), and others are degraded or even lost (soil and organic materials) (Luscuere, 2018).

In this thesis, these five flows are being referred to within the built environment context, discarding other fields and disciplines. They are generally described for getting a better understanding of the current situation and find possible spaces for improvement according to sustainable measures. Later on (chapter 05 *Analytical framework*) and after further analysis, the essential flows of interest will be selected for narrowing down this report.

- Material flows:

In general, the largest part of the construction waste is derived from demolition projects, being 53% of its waste recovered and recycled in the EU (2016) but representing a circularity rate of only around 12% (Eurostat, 2019).

It seems that The Netherlands has been leading in terms of recyclability (Schut, Crielaard & Mesman, 2015) because 95% of their building materials waste are being recycled and reused as foundations or as a filling material in the civil engineering sector. But this process still not totally circular because it does not recover the value of the materials, thus should be called *downcycling.*
So, the building construction sector reuses only 3-4% of its waste, thus the rest of materials still come from primary resources. For the past 20 years, the civil engineering sector and the recycling industry, has covered the real problem of the building industry waste but it has reached a considerable saturation of reused materials due to the reduction of the demand of this type of constructions. Moreover, nowadays waste problem has been recognized due to the high environmental impact caused by the production of building materials, so awareness for developing a strategic waste management plan has been raised (Schut et al.,2015)

For example, building materials account for 40-50% of an standard office building's carbon footprint and producing cement and steel can consume around 80% of energy during construction (World Economic Forum, 2018). Around 40% of all global mineral's extraction is used only in the built environment, and their extraction and production process are responsible for 15-20% of human global C02 emissions, accounting for a 25-40% in the total building sector (Schut et al., 2015; Pomponi & Moncaster, 2017).

Therefore it is clear that building sector should not continue using the classical methods, where materials are consumed faster than they are grown, but change into a more holistic system approach and circular optimization for the design, construction, maintenance, operation and end of life buildings.

- Water flows:

Freshwater is a finite vital source for organizations and communities for their survival, and is currently one of the main problems that many regions are facing around the world, decreasing progressively its access and affecting to around 2 billion people. This issue is estimated to get worse by 2050, where at least one out of four people will live in a country affected by shortage of freshwater (Kiselev, Magaril & Rada, 2019).

Water is being mainly used in these traditional areas: agriculture, municipality, environment and industry, needing to put efforts on the last one due to downcycling process (Arup & Antea Group, 2018). Despite all the progress of OECD countries in reducing water pollution, agriculture and urban run-offs remain a challenge (OECD, 2020).
The linear model (LM) and its consequent climate change have put limited water resources under pressure. The lack of sanitation services in some areas and the improper or limited treatment of the wastewater treatment plants (WWTP) generates organic elements and harmful nutrients for human health (nitrates and phosphates). According to UNESCO, only 20% of global wastewater is treated properly in WWTP, generating around 140 million tons of dry matter sewage sludge (Kiselev et al., 2019). New WWTP could reduce pollutants and harmful elements but at the same time it would increase energy consumption, expected to rise up to 44% by 2030, thus putting again pressure on the environment.

In The Netherlands, around 99% of the household wastewater is treated but the problem relies on sectors such as cooling in electricity production (56% of freshwater), followed by manufacturing (28%) or public water supply (11%). The Dutch government seems relaxed about water awareness, needing to provide rainwater collection measures and fight against the climate change in all the aspects of the circular economy (Climate change post, 2019).

Different wastewater management solutions and water flows studies are being developed around the world, demonstrating the necessity for a sustainable and friendly solution from an environmental, economic and energy point of view, but actions still not enough (Kiselev et al., 2019, p. 109). So, sustainable water treatment management is a global challenging task, being likely to be the key to preserve freshwater sources for global and local demand long term and decrease energy consumption.

2.2 | PROBLEM ANALYSIS

2.2.4 DEFINITION OF FLOWS

- Topsoil flows:

Soil is the fragile skin of the Earth where life occurs, and is one of the most valuable resources for the human being. It is becoming severely degraded due to a combination of unusual natural processes induced by climate change (unusual rain, snow, flood...) and intensive farming, resulting in these harm and degradation processes (Usman, 2011):

- Physical: Crusting, compaction, erosion, desertification, environmental pollution, degradation etc.
- Chemical: Acidification, salinization, infertility, etc
- Biological: Reduction of biomass carbon and biodiversity of land.

The consequences of these are a severe decline of soil quality, fertility and release of organic carbon, leading to a reduction of agricultural activity and contribution to climate change through the increase of greenhouse emissions. The physical process is the most serious one, not only affecting fertile land issues but also streams, rivers and species due to sedimentation, obstruction of natural water flows, permeability (flooding), etc. Moreover, according to experts, 3% of the Earth's surface is suitable for farming and around 75 billion tonnes of fertile soil is being degraded and lost every year (Harrabin, 2019). So considering population growth and other current climate trends, the next question arisen is the possibility to still feed the new 9 billion population by 2050 through natural sources.

The topsoil in The Netherlands is artificial, but fertile and wet due to its characteristic geographic location in a delta. The land use is intensive, being one of the highest agricultural production levels per unit surface in the world.
Water and soil are vital elements that are very connected because around two-thirds of the freshwater is held in the land in the form of soil moisture (ISRIC, 2019). Moreover, soil not only allows biodiversity, habitat and farming, but also storage, filtration and transformation of substances, development of human activities and supply of raw materials. So in general terms, soil provides the basic platform for the living species and the human development, therefore restoration measures and soil management should be found and changed in order to preserve it.

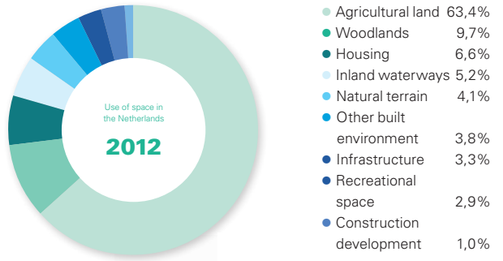


Figure 2.2.4.1: Land use in Netherlands in 2012 (Source: Vewin, 2017).

In the next chapters, the importance of topsoil will be replaced by food flows, which is in line with the thesis topic. The European Commission is taking seriously the issue of tackling the food waste, because is not only a loss of food but also the resources for producing it, which is becoming even more scarce (European Commission, 2019b). According to the United Nations Food and Agriculture Organization (FAO), around 33% of perfectly good food is never eaten and goes to the bins, accounting for 270,000 tons/year and a value cost of 2.9 trillion euros/year. Meanwhile, 9% of Europeans cannot afford a quality meal every two days, which causes a big contrast with the ambition of SDG (Zero Hunger by 2030) (Krammer, 2019). Particularly in 2015, the total amount of food waste in the Netherlands was around 2 billion kilos, being 40 kg of waste food per person/year, and causing a loss costs of 145 euros/person/year (Van Dooren, 2018).
Therefore, the EU countries are committed to meet the Sustainable Development Goals (SDG), which one of the objectives consist on the reduction by 50% per capita food waste at the retail and consumer level by 2030 and reduce food losses through the food production and supply chains (European Commission, 2019b). Having this in mind, along with the objective of The Netherlands for becoming the first European country to achieve 50% food waste reduction by 2050 (Government NL, 2018), Lidl supermarket has the opportunity become the first zero-waste supermarket and improve its commercial operations from a sustainable and circular perspective.

- Energy flows:

It is estimated that more than a million TJ of energy is consumed every day, reaching its limits and exacerbated mainly by global population growth and development of industrialization. However, there are inequalities around the world, being 1.2 billion people who still do not have access to proper and modern energy services and 3 billion people who still relying on archaic methods (Gray, 2017).

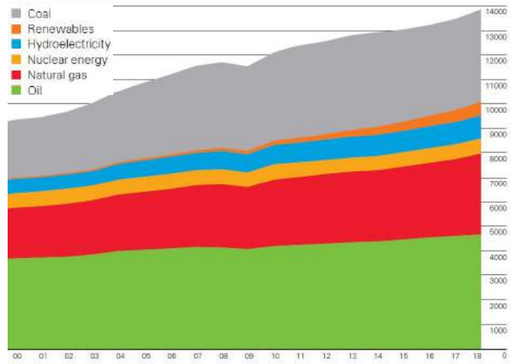


Figure 2.2.4.2: Global increase of primary energy consumption. Renewable energy production grew significantly but not as much as the total increase of the rest (Source: BP, 2019).

2.2.4 DEFINITION OF FLOWS

There is a prediction for 2040 in which global energy demand will have increased by almost 50%, focusing the challenge on cooling system coming from India or China, which consumption will surpass the heating (Gray, 2017).

The major problem that humanity faces is not only climate change, but also the depletion of natural resources reserves and raw materials, due to the completely dependency on finite fossil resources for human development. Scientists around the world state that the unique solution would be to stop relying on fossil fuels, so other ways of energy savings methods and green energy production were searched and developed in order to build a completely self-sufficient energy system and for a long term (Gray, 2017). However, despite the rapid growth of renewable energy in recent years, it only provides around a third of the total increase in power generation. Over a half of the energy still comes from fossil fuels, achieving since it has started in 1850, a total extraction of crude oil over 135 billion tonnes (Gray, 2017; BP, 2019).

In the built environment, the building code dictated some solutions and additionally, awareness among citizens has been increased, resulting in new energy-saving devices, sustainable construction materials or smart designs for achieving greater efficiency and lower consumption.
The Netherlands has dictated though the Dutch building code, minimum rules for the energy performance of buildings (energy performance coefficient, EPC) since 1995, improving the value from 1.4 in 1996 to 0.4 in 2015 and 0.0 in 2020 (Jansen, Luscuere, Tenpierik, Geldermans, 2016). "Energy neutrality" in a building occurs when the annual building-related energy (BRE) consumption is balanced and compensated with the production of green energy of the building itself (EPC= 0), without considering the user-related energy consumption (URE) (Jansen et al, 2016). However, URE is not generally considered in EPC calculations, so in order to go one step further and beyond "standard energy neutrality", other types of calculations that include the URE and operational energy have arisen, such as the Dutch Nul-op-de-meter (NoM), achieving now "energy positive" values and therefore, a below zero EPC results (Rijksdienst voor Ondernemend Nederland, 2014).

- Air flows:

Indoor but mostly outdoor air pollution is not only a big worldwide problem that affects the environment and health (diseases, extra expenses for treatments, unwanted deaths and reduction of life expectancy) but also business market productivity and people quality of life. Urban pollution is linked to health problems such as eye irritation, dementia, diabetes or chronic respiratory disease (asthma, lung cancer,...) (OECD, 2020).

Despite all the measures for decreasing pollutant emissions, in general, the impact of urban air pollution continues to get worse, becoming probably the main environmental cause of premature deaths by 2050 (OECD, 2020). It is considered that the global health costs associated with air pollution are over 5 trillion dollars/year and additional it is has increased in 3.5% in 2013. Moreover, there was around 3 million premature deaths in 2012 due to outdoor polluted air, being mostly concentrated in low and middle-income countries (87%).

In The Netherlands, this air issue caused in 2015 around 1,900 premature deaths due to nitrogen dioxide, 9,800 due to fine particulate matter concentrations and 290 due to ozone concentration, ending with a general number of 12,000 in 2017 (Stone, 2017; World Health Organization (WHO), 2018; European Commission, 2019a). Only the exposure to particular matter has been responsible for 4% of the diseases in the country and 80% if considering the exposure to all types of polluted air (TNO, 2019).

In the Netherlands, industrial processes, traffic and agriculture are the largest air contaminants, being the industrial combustions the largest contributors of S0x (over 60%) and agriculture causing a total damage cost of 6.5 billion euros/year through harmful substances emissions (Zoppi, 2019; WHO, 2018). Although new vehicles are becoming less polluting due to high level of electric car implementation, traffic levels and heavy vehicles have increased in the country.
The Dutch government has been invested and made positive improvements since 2000, being able to reduce heavy metals emissions and achieving a reduction of -50% of lead, -49% mercury, -34% of cadmium, etc. However, the most harmful particle, the finer particulate matter has not been addressed due to inefficient standard measures (OECD, 2015). Due to EU air quality guidelines and regulations, with strict limit values for air pollutant concentrations, the country has achieved reducing harmful and suspended particles since 2000 by around 48% for PM2.5 and by 32% for PM10 (WHO, 2018). However, these quantities, together with C02, NH3 (ammonia), N0x (nitrogen oxides) and VOC (volatile organic compounds), are still over the EU limitations in some regions of the country, thus still considered the most contaminated of Europe in terms of PM2.5 and PM10 (Luscuere, 2018).

Air pollution is another challenging factor that should not be underestimated but considered, and additionally, it could be simply and indirectly improved by the implementation of the CE concepts.

2.3 | THE LIDL SUPERMARKET

2.3.1 COMPANY PROFILE

· Why a supermarket?:

The role of supermarkets and grocery stores is important because they act as a connector between the supply and demand, so production and consumption sector.

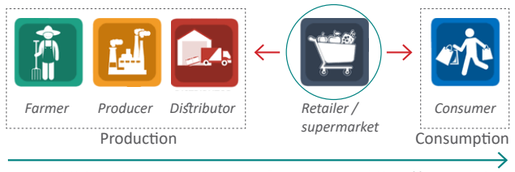


Figure 2.3.1.1: General food supply chain (Source: https://www.sketchbubble.com/en/presentation-food-supply-chain.html).

Supermarkets play an important role inside the society and neighbourhood, accounting for around 85% of the grocery market and having enough power to influence people on their behaviour and buying practice (Bourlakis, Weightman, 2004).
One important point is the lack of social aspects, because the bigger the supermarket, the less communication and interaction between people (Erwin & Brownson, 2017). Therefore, Lidl supermarket could play a key role inside the neighbourhood for improving the social atmosphere, Lidl's profits, enhancing people's satisfaction and well-being within the community. For this reason, this thesis will try to implement the circular economy principles from Lidl supermarket's perspective, functioning as a social and sustainable hub for the surrounding environment.

· Company profile:

Lidl is a German global discount supermarket chain that operates around 10,800 stores across The USA and EU.
It was founded in 1930 as a wholesaler of fruits and vegetables and since then, it became into a general food wholesaler, opening its first store in the 1973 (Lidl, 2019). In 2015, it became the largest supermarket of EU and in 2016, Lidl opened its online website (Lidl, 2015).
Nowadays, Lidl supermarkets are part of the Schwarz Group, which is considered one of the largest food retail companies in Europe abroad. The active presence of Lidl is mainly in Western and Central countries of Europe (32 countries) but it is aimed to expand towards the Eastern part of EU and North America, which openings already started in 2017 (Wikipedia, 2019a).

The first two branch offices of Lidl in The Netherlands were opened in October 1997 and nowadays it is considered the third most important supermarket in the panorama of Dutch supermarkets (Albert Heijn (35% in 2019), Jumbo (21%, Lidl (10.7%), Aldi (5.9%)...), having over 420 stores, 6 distribution centres and 19,000 employees distributed through the whole country. Branches in The Netherlands are owned or completely rented by Lidl and are centrally managed from the head office in Utrecht (Statista, 2020).

Figure 2.3.1.2: Lidl supermarkets (yellow circles) and 6 distribution centres (white DC circles) located around The Netherlands. The main office is located in Huizen, Utrecht (Lidl icon) (Source: https://www.werkenbijlidl.nl/lidl-als-werkgever/onze-locaties).

Lidl supermarkets function as a grocery discount segment within the retail industry, offering very low-cost products compared to the other conventional supermarkets. Pushing prices down is achieved due to one of its measures based on the "pass-the-savings-to-the-consumer", where products are displayed and sold in the original box and pallets. Moreover, Lidl distributes many low priced gourmet foods by producing them either in one EU country or where the store is located, making also customized purchasing contracts with their suppliers. Lidl counts on around 1,800 products, including food products nationally regulated, such as fresh vegetables, bread and milk products, but also non-food products that are regulated from EU, such as kitchen equipment and clothes. Therefore, smaller product range, the restricted offer of branded goods and cost-efficient management, among others, are the key to its success.

The company has a strong commitment for mainly improving its model business, fighting for the reduction of food waste, creating a new health plan for the employees, making the diet easy and affordable for everyone, creating closer bonds between suppliers-government and achieving high sustainability goals. Therefore, the Lidl sustainable strategy is planned around 5 main topics (Lidl, 2015):

- · Assortment
- · Climate (explained further in the next page)
- · Employees
- · Society
- · Relationship

Lidl company distributes its products through several types of stores, which are (Lidl Real Estate, 2020):

Figure 2.3.1.3: Different types of Lidl stores (Source: Lidl, n.d.).

2.3.2 LIDL NL SUSTAINABILITY PROGRAM

Sustainable climate goals have been established by the Dutch government, including objectives and measures such as the increase of energy prices or sustainable awareness among citizens in order to facilitate the transition towards the circular economy.

Lidl has taken seriously this necessity so they have been investing and developing new innovations for reducing its ecological footprint of their buildings and operational processes. They are committed to increase their positive impact on society and the environment through their current principles, which consist mainly on the moderation use of energy and raw materials, limited waste, an increase of sustainable products, sustainable construction and working processes (Lidl, 2015).

Moreover, as required by the Global Reporting Initiative (GRI) guidelines, the company performed an analysis in order to determine which issues were relevant for Lidl and their stakeholders. For example, the following topics arose:

· Sustainable purchase
· Healthy products
· Food waste
· Working conditions in Lidl
· Energy
· Animal welfare

In the annual year report (2015-2016), Lidl discussed the improvements and sustainability progress they have made, showed the figures and percentages of the achievements and set the new objectives for the coming years.

Among the main current achievements, Lidl state they have progressed further in sustainability aspects, which figures are compared to the previous year (Lidl, 2015):

· Logistics improvements: New DC was opened so there was a reduction in -0.02 Km of transportation/pallet (4.56 km) which result in -0.001 Kg of C02/package (0.065 Kg of C02). The charge factor from DC to a branch decreased in -0.57% (88.63%).
· Recycling: There was a recyclability increase of +1.3% (91.91%) of plastic materials (PET), organic materials (paper, waste, wood) or scraps. Recycling value through packaging disposal guide.
· Social: Annual activities for the neighbourhoods.
· Energy: Energy consumption has decreased -5.07 kWh/m2 (218.44 kWh/m2) and free charging points for electric vehicles through solar panels were implemented. The most sustainable DC in the country was constructed. There was an increase of +12 branches with energy label A++++, installation of over 20,000 solar panels in 20 branches, 3 DC and head office.
· Sustainable fruits and vegetables: There was primary importance the way they are produced, taking into account factors such as minerals, biodiversity, water and energy and additionally, the aeroponic production system was implemented. Moreover, Lidl provides free fruits for all kids in every branch and to schools, as well as a donation of around 600,000 Kg to charities and Food Bank NL.
· Gas disconnection: The majority of branches have abandoned the gas as a primary resource.

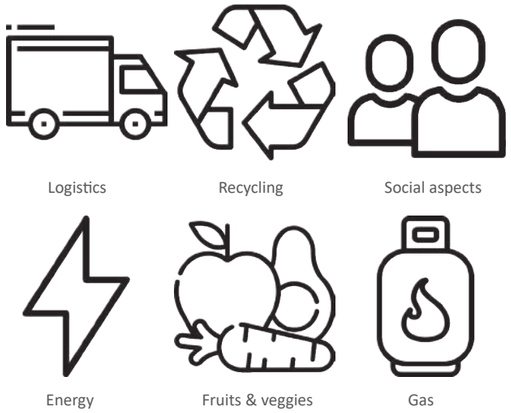


Figure 2.3.2.1: Summary of the Lidl achivements in 2015-2016 (Source: https://www.flaticon.com/search?word=soil%20ICON).

However, the main sustainability progress the company made was focused on the energy aspect. Due to its high commitment to sustainability, Lidl has performed a great development and innovation towards energy efficiency through their buildings and distribution centres, achieving and improving their DC BREEAM certification from "Excellent" in Heerenveen (2013) to "Exceptional" in Waddinxveen (2016) and even further in Oosterhout (2018). Moreover, Lidl supermarkets will also meet the requirements in order to achieve A++++ energy label, for example as was the case of the renovated Lidl Stein, which has been the first one to obtain that label and thus converted as a reference for the rest future Lidl supermarkets.

As regards to social aspects, it is relevant to mention that the company has improved the benefits for the employees, who were able to enjoy promotion opportunities, learning activities, etc. However, a few annual activities have been organized for the consumers and neighbourhoods but mainly focused on some specific districts rather than improving general customer satisfaction at national level (Lidl, 2015). Therefore if truly social improvements are aimed to be achieved within the community, much more effort and measures would need to be improved, such as for example the implementation of a new social space inside the branches.

2.3.2 LIDL NL SUSTAINABILITY PROGRAM

The main general sustainability targets that Lidl Netherland had set for the following year, 2017-2018 were (Figure 2.3.2.2) (Lidl, 2015; Lidl, 2018):

· Finger footprint: Calculation of own commercial operations and C02 emissions in order to reduce finger footprint.
· Sustainability focused on circularity: Sustainable plan development of commercial operations focused on circularity with the help of TU Delft. Focus also on packaging, with a reduction aim of 20% of own brand plastic packaging, 100% recyclable or reusable packaging by 2025, and 50% recycled content across all packaging.
· Social: Create social value to the lifestyle of the neighbourhood and a more healthy and sustainable environment and communities. Moreover, participation in sustainable campaigns, a social improvement from local branches and support annual programs for kids development in areas of nutrition, nature and culture. Moreover, there have been developing greater goals but only for the employees, for instance; gender equality, better lifestyle or participation. More involvement is needed for enhancing and improving citizen's well-being.
· Energy: Energy efficiency improvement by 2%/year, achieving an improvement of 20% in 2020 compared to 2010. By 2020, self-energy production would be more than 10% and 10 branches/year with solar panels will be upgraded. Implementation of the new wind turbine would be before 2018 (delayed), 100% LED in all branches before 2020 and all-new branches will have an energy label of A++++.
· Food waste: More donations, provide transparency data, active participation in campaigns for emphasizing sustainability topics, local participation from stores to contribute to a sustainable and healthy neighbourhood.
· Gas: Total disconnection from 2018 onwards.

In comparison with achievements and goals, there has been a considerable increase in the importance of the social aspects and influence on the surrounded community of Lidl branches, but with little real achievements and commitments. Business cannot succeed in societies that fail, so social improvements need to be focused and further developed not only for employees and own company operations, but also putting effort in the surrounded community and the rest of the neighbourhood.
Moreover recently in 2019, Lidl has uploaded its report about "Corporate due diligence when purchasing the range", in which the main focus relies on human rights and ecology. According to it, one solution in order to address this is the implementation and effort in producing its own brands (Lidl Nederland, 2019). So more social well-being in the neighbourhood and local perspective will be relevant and considered for the future design process of this thesis. A critical point is about food waste, in which measures would need to be addressed from prevention techniques rather than solving it by performing more donations. This issue will be also considered in the following chapters.

On the other hand, although Lidl has obtained the greatest certification of BREEAM and very good energy labels in some of their buildings, the next sustainable ambition is to achieve a Zero Lidl supermarket with an Energy performance coefficient (EPC) of around 0, including building-related energy and operational energy consumption (BRE and URE). However, Lidl should not only be longer focused on energy aspect, but also in the rest of important elements in the environment and thus relevant for the implementation of the social circular economy and sustainability targets, such as water, waste, soil, etc, which will be further developed in the next chapters.

Figure 2.3.2.2: Summary of the Lidl goals for 2017-2018 (Source: https://www.flaticon.com/search?word=soil%20ICON).

2.3.3 LIDL GB SUSTAINABILITY PROGRAM

As a summary, Lidl Netherland has set sustainability targets for 2017-2018, which was represented in Figure 1.2.3.2 (Lidl, 2015):

- · Finger footprint
- · Sustainability focused on circularity
- · Social
- · Energy
- · Food waste
- · Gas

However, Lidl GB has published a more structured and detailed report about its ambitions for 2017-2018, being for the same goal period for Lidl Netherland. The future achievements and targets of Lidl company should be similar in every country, and due to broader information and perhaps some similarities with Dutch population, it was worth to describe and consider GB ambitions too.

GB ambitions for 2017-2018, as represented in Figure 2.3.3.1, were established around 3 themes, similarly to sustainability dimensions: Producers, people and planet (LIdl GB, 2018).

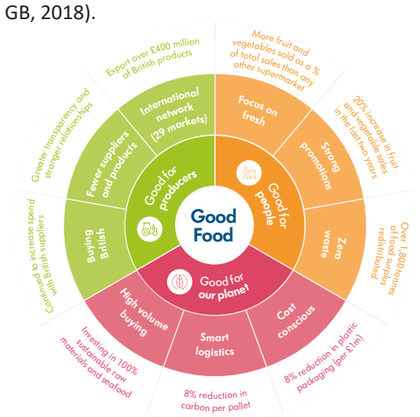


Figure 2.3.3.1: Lidl UK ambitions for 2017-2018 (Source: LIdl GB, 2018).

For each theme, Lidl GB has mapped priority issues and set clear ambitions (LIdl GB, 2018), but the detailed description will be mainly focused on people and planet, as well as specific topics of interest for the thesis:

-Good for producers: Fair and sustainable way, improving people and animal lives, long-term food production and strengthen relationships:

·A- British food and farming
  ·Goal 1: Investment of British food and farming industry, local business growth.

·B- Supplier relationships: Enable producers to grow and local sourcing:
  ·Goal 2: Opportunities for small business to grow.

·C- Human rights and ethical trade.
·D- Animal welfare

-Good for people: Making safe, affordable and nutritious food accessible and caring for colleagues and communities:

·A- Healthy eating: Make healthy food and accessible for families:
  ·Goal 1: Increase consumption of fruit and veggies, especially in children (by messaging and promotion)
  ·Goal 2: Healthier food by reducing sugar and salts.

·B- Charity and community partnerships: Support organizations that fight against the issues most important that communities face to:
  ·Goal 3: Donate more quantity to the national charity partner.
  ·Goal 4: Donate 5 million meals by 2020 to good causes though "Feed t back" programme.

·C- Supporting our colleagues: Create environment that allow colleagues to maximise their potential:
  ·Goal 5: Improve general gender balance ratio
  ·Goal 6: Increase woman representation in senior management positions.
  ·Goal 7: Conduct employee surveys for measuring and track employee engagement.
  ·Goal 8: Develop long-term diversity and inclusion strategy

-Good for our planet: Promoting sustainable and efficient use of resources, minimising losses though the food chain:

·A- Climate change and energy: Promote low economy based on science-based trajectory for business and work with suppliers:
  ·Goal 1: Reduce GHG emissions.
  ·Goal 2: Produce 100% electricity from renewable sources from 2919.

·B- Food waste: Minimize food loss through value chain from farm to fork.
  ·Goal 3: Reduce FW per store by 25% by 2020 and 50% by 2050, in line with SDG.
  ·Goal 4: Launch a campaign to influence customers to reduce FW at home.

·C- Plastic and packaging: Eliminate unnecessary plastic on products and packaging and support and ensure all plastic can be recovered and recycled.
·D- Deforestation: Support timber-based products and packaging from sustainable sources.
· E- Raw materials and seafood: Sources that respects the environment and improves lives:
  ·Goal 5: Certified sources by the end of 2020.

2.3.4 LIDL GOALS VS SDGs

By combining the Lidl Netherland and GB targets, the main following Lidl company ambitions can be summarized.
There has been put a filter according to the boundaries and possible objectives of this thesis, in which the main focus was on environmental and social aspects:

- Economical aspects:

· Support and improvement of local business growth.

- Social aspects:

· Consumption of healthier products
· FW reduction at home and food chain, through more donations.
· Gender equality, inclusion and diversity among employees.

- Environmental aspects:

· Reduction of GHG emissions.
· Electricity from renewable sources.
· Gas disconnection.
· Circularity solutions and certified sources.

Therefore, these goals together with achievable SDGs will be considered in the future proposal. In order to know the specific indicators from each goal, chapter 9.2.2 *Achievement of SDGs (indicators)* should be read.

The role of SDG in business can be important because they allow leading companies to demonstrate how their business can help to advance to sustainable development. For example, by covering and achieving some SDGs relevant to Lidl, such as health, environmental degradation or equality, the SDGs could help to communicate business strategies with global sustainable priorities. Moreover, by integrating sustainability considerations in their business operations, companies can have greater benefits for themselves, such as increasing sales, developing new market segments, improving operational efficiency, strengthening the brand, stimulating product innovation or reducing employee turnover, among others (GRI, UN, WBCSD, 2015).

SUSTAINABILITY

ECONOMY	SOCIAL	ENVIRONMENT
Local economy growth	Food waste	Social aspects
-SDG 8: Decent work and economic growth -SDG 10: Reduced inequalities -SDG 17: Partnerships for the goals	-SDG 2: Zero hunger -SDG 12: Responsible consumption & production	-SDG 3: Good heath and well-being -SDEG 5: Gender equality -SDG 10: Reduced inequality -SDG 11: Sustainable cities & communities

Finger footprint	Energy	Gas	Sustainability focused on circularity
-SDG 13: Climate action -SDG 15: Life on land	-SDG 7: Affordable & clean energy -SDG 12: Responsible consumption & production	-SDG 7: Affordable & clean energy -SDG 13: Climate action	-SDG 6: Clean water and sanitation -SDG 11: Sustainable cities and communities -SDG 12: Responsible consumption & production -SDG 13: Climate action

Table 2.3.4.1: Summary of the Lidl company sustainability goals for 2017-2018 and the respective SDGs that could be achieved for each hypotetical improvement and measure (Source: https://www.flaticon.com/search?word=soil%20ICON).

2.4 | CASE STUDY

2.4.1 ROTTERDAM, DELFTSHAVEN & SPANGEN

Due to the free selection of the study case, several criteria were performed in order to discard different possibilities and narrow down the final area.

Even though the research criteria were based in simple but ordered points, this was a rapid and efficient method for finding the optimum urban area for the thesis:

· 1- Selection of the region and city:
- -Circular economy
- -Amount of waste
- -Quality and quantity of data.

· 2- Selection of district or municipality:
- -International people
- -Lower middle income
- -Low rate of well-being
- -People satisfaction

· 3- Selection of neighbourhood & Lidl store:
- -Type of Lidl store
- -Type of facilities in neighbourhood

1- Selection of the region and city:

Through conducting superficial research, it was known that several interesting projects about the circular economy have been performed in Amsterdam and Rotterdam. Additionally, it was important to find a location in which a high amount of waste was produced, mainly focused on big cities such as the mentioned above. Moreover, it was found that Zuid-Holland was a region with a low recyclability rate, thus being an important factor to be considered in the thesis (European Environment Agency, 2013). Although the Figure 2.4.1.1 does not represent the total municipalities of The Netherlands, it provides an overview of the recyclability rate of some areas of the country, discarding the possibility to choose Amsterdam area as a case study.

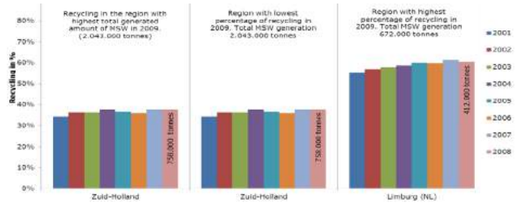


Figure 2.4.1.1: Regional differences in total recycling of Municipal Solid Waste (MSW) in The Netherlands (Source: European Environment Agency, 2013).

In order to make sure the correct selection of the urban areas, between Amsterdam or Rotterdam, rough research of municipality and other websites was performed in order to measure the available data for the development of the thesis. In the end, Rotterdam was selected due to its qualitative, broader information and graphical maps for the definition of the future area of research.

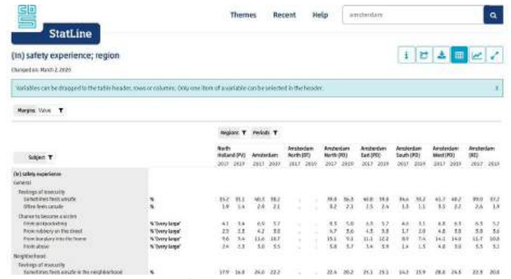


Figure 2.4.1.2: Website of CBS about Amsterdam data (Source: Cbs NL (2020).

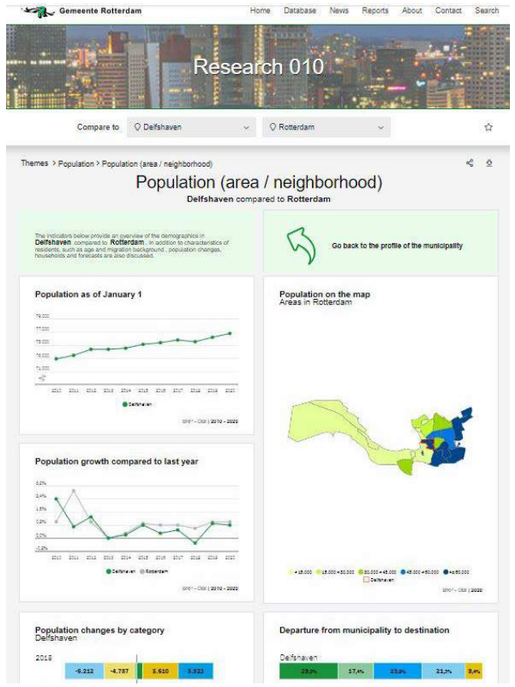


Figure 2.4.1.3: Website of Municipality of Rotterdam; first page (Source: Gemeente Rotterdam. (n.d.a).

Figure 2.4.1.4: Website of Municipality of Rotterdam; map page (Source: Gemeente Rotterdam. (n.d.a).

2- Selection of district:

Due to the focus on the social aspect of sustainability,

issues related to the well-being of citizens needed to be searched. One of the goals of the thesis was to improve the well-being of people, increasing their satisfaction and social cohesion within the neighbourhood.
Therefore several social factors such as criminality, low-income areas, immigrants, satisfaction rate, poverty and employment rate, among others, were searched simultaneously and layer by layer in order to find the final potential area that meets in the majority all those factors. In order to achieve this data, the website of the Municipality of Rotterdam was used, providing specific information and maps (Gemeente Rotterdam, n.d.a).

Figure 2.4.1.5 represents the areas (dark green colour) in which more residents with migrant backgrounds live, being mostly the South and Middle of Rotterdam.

Figure 2.4.1.5: Distribution of residents with migrant and international backgrounds (2018) (Source: Gemeente Rotterdam. (n.d.a).

As described in chapter 1.1.2 *Increase of waste generation,* lower-middle-income class (highlighted in blue-green colour) represents the group expected to generate more waste in the near future, thus being an important group to be considered in the thesis. This group is distributed in the South and Middle of the city, according to Figure 2.4.1.6.

Figure 2.4.1.6: Percentage of people with low income in long term (2017) (Source: Gemeente Rotterdam. (n.d.a).

Well-being is one of the valuable keys for the thesis and aimed to be improved at the end of the design proposal. In order to do so, it was necessary to find which areas had low or the least citizen's well-being (in purple and blue colour), which were concentrated in IJsselmonde, Charlois, Hoogvliet and Delfshaven.

Figure 2.4.1.7: Well-being distribution (19-64 years old; in 2016) (Source: Gemeente Rotterdam. (n.d.a).

Satisfaction in the neighbourhood is related to the previous factor of well-being, so similarly, low scores of satisfaction areas were searched (in purple and blue colour). In the end, the following municipalities appeared: Feijenoord, Delfshaven and IJsselmonde.

Figure 2.4.1.8: Satisfaction in the neighbourhood (2018). (Source: Gemeente Rotterdam. (n.d.a).

3- Selection of neighbourhood & Lidl store:

In the end, the two municipalities that remained after applying all these criteria were IJsselmonde and Delfshaven. However, looking each municipality more into detail at the surrounding facilities, Lidl location and typology, and in general more opportunities for improvement such as lack of parks, low activity, lack of greenery or social clubs, Delthaven was finally chosen.
Deltshaven is a municipality that consists of 9 different neighbourhoods inside, being Delfshaven, Bospolder, Tussendijken, Spangen, Nieuwe Westen, Middelland, Oud Mathenesse, Witte Dorp and Schiemond (Figure 2.4.1.9).

Lidl store is located in the neighbourhood of Spangen, an area where lots of migrant's background live and their quality of life is not properly fulfilled according to their satisfaction surveys.
On the other hand, sustainable measures are usually installed in selected areas, being mainly in wealthier, more active, attractive or safety ones. For example, this neighbourhood lacks saving energy systems, rainwater collection tanks, automated mechanism, etc, thus having gaps for improvement related to the urban flows.
Making changes within this type of neighbourhood would have a tremendous impact not only on urban metabolism but also on the well-being of Spangen citizens.

More characteristics of Spangen neighbourhood, as well as the analytical and contextual data, can be found in chapter 5.1 *Spangen.*

1- Delfshaven
2- Bospolder
3- Tussendijken
4- Spangen
5- Nieuwe Westen
6- Middelland
7- Oud Mathenesse
8- Witte Dorp
9- Schiemond

Figure 2.4.1.9: Delfhaven district with the number of habitants per neighbourhood (Source: Allecijfers.nl, n.d.).

2.5 | PROBLEM STATEMENT & R.QUESTION

2.5.1 PROBLEM STATEMENT & VISION

As climate change and current global challenges are getting worse, the United Nations have established the Sustainable Development Goals (SDGs) in 2015 in order to achieve a better and sustainable future for everyone. This plan is considered an urgent call for action and is intended to be achieved by 2030 by all United Nations Member States (SDG, 2018).
Sustainable Development Goals are deeply connected with the term "sustainability", which consists of the equal balance of three dimensions: economy, social and environment (United Nations ESCAP, 2015). However, within the Dutch context, statistics show that the current **declining trends occur in the goals related mainly to social aspects, being necessary to put efforts in the improvement of social cohesion and inequalities, enhance community feeling and improve people well-being** in general (Statistics Netherlands, 2019).

On the other hand, it seems that the "circular economy" (CE) has been seen as the solution to address climate change and other current issues such as the population and waste growth or depletion of natural resources (Robinson, 2017). Nevertheless, **circularity in the built environment has to do with the logistics in place, meaning very little if circulation is not ensured with the rest of the urban context where is located.** The fact that synergy between the building and the surrounding local environment can be established, will allow exchanging, reusing and sharing flows and sources more efficiently, thus reducing general waste and the need of new sources, as well as creating a greater impact on the society.
Additionally, circular economy principles are mainly focused on the two dimensions of sustainability (environment and economy), leaving some important social points. **Therefore a new approach has emerged taking into account the total three dimensions: "Social Circular Economy" (SCE)**, in which follows CE principles but also have social missions in order to provide benefits for people, planet and profit (Robinson, 2017).

It is already known that supermarkets, in this case Lidl, are great "linear" consumers of energy, sources of food waste and others. Moreover, supermarkets play an important role within the neighbourhood, accounting for around 85% of the grocery market, thus having considerable power and influence on society in order to start making the change towards sustainable operations (Bourlakis, Weightman, 2004). **However, according to the company annual report, the sustainable objectives of Lidl NL are mainly focused on the two dimensions (environment and economy)** (Lidl, 2015)**, needing to go and invest further regarding social aspect** if truly sustainability and SDGs are aimed to be achieved.

Spangen is selected as the neighbourhood study case, being one of the **most degraded areas in the country and having several difficulties in terms of income, satisfaction, well-being, waste or criminality, among others** (Gemeente Rotterdam, n.d.a), **but with great social circular economy potentials.**

<u>All this results in this problem statement summary:</u>

Lidl NL sustainability goals are mainly focused on the implementation of Circular Economy principles, but this has limitations due to the need to integrate the local context and put efforts on the social aspects in order to obtain a balanced sustainable system, thus SCE approach emerges. Moreover, Spangen is one of the most degraded neighbourhoods of The Netherlands that experiences some difficulties related to urban metabolism (waste) and especially social aspects, being very far from the Sustainable Development Goals established by the UN.

<u>This thesis will tackle these challenges, resulting in the following vision:</u>

To integrate also the social dimension within a Lidl supermarket redesign and according to synergy and Social Circular Economy principles, in order to help to achieve Sustainable Development Goals (SDGs) and a more efficient urban metabolism in Spangen.

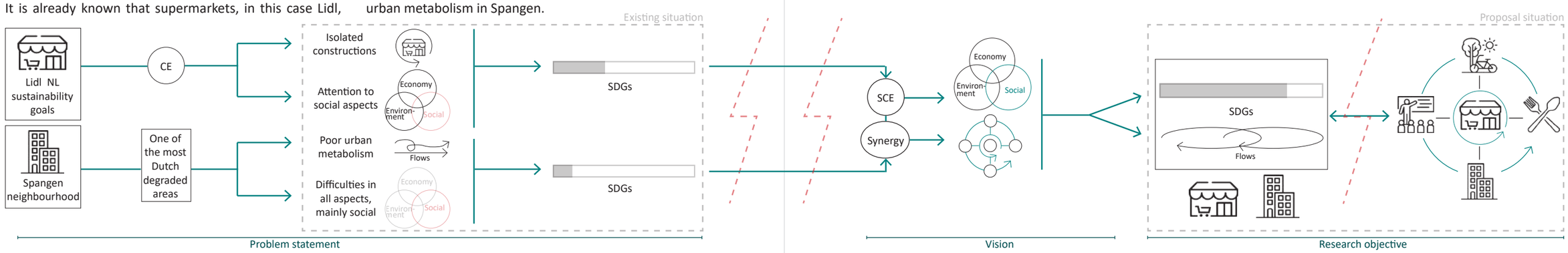


Figure 2.5.1.1: Representation of problem statement, vision and research objective (continued on next page).

2.5.2 R.OBJECTIVE(S) & R.QUESTION(S)

The research focuses on contributing to the Lidl NL sustainability program, mainly in terms of social aspects, at the same time as improving the urban flows of the neighbourhood through sustainable principles.
In the end, the goal of this research is to achieve further SDGs in both Lidl and neighbourhood, through the optimal redesign of a specific Lidl supermarket.

· Research objective:

The purpose of this thesis is to redesign a Lidl supermarket according to SCE principles, functioning as a social and circular facility in synergy with its local urban context, in order to help to achieve Sustainable Development Goals (SDGs) and improve the urban metabolism related to essential flows in Spangen.

· Research sub-objectives:

- Identify and quantify the essential flows of interest for Spangen neighbourhood and Lidl supermarket regarding SDGs.

-Identify the existing social initiatives for the local community, highlighting the ones that could be improved or introduced through Lidl redesign.

-Find a sustainable proposal (or different design possibilities if applicable) according to SCE principles and through Lidl redesign for the achievement of SDGs and improvement of essential flows in Spangen.

· Research question:

To what extent the sustainable redesign of Lidl supermarket can improve the social context, urban metabolism related to essential flows and help to achieve Sustainable Development Goals (SDGs) in Spangen?

· Research sub-questions:

The research would answer the main research questions through the following research sub-questions. Moreover, for a better understanding, research sub-questions can be divided into two categories:

-Existing situation:

1- What are the essential flows of interest for Spangen neighbourhood and Lidl supermarket regarding SDGs?

2- What is the current urban metabolism, related to essential flows, between Lidl supermarket and the local neighbourhood?

3- What are the existing social initiatives for the local community and which ones could be improved or introduced through Lidl redesign?

-Proposal situation:

4- What are the main circular opportunities that can be achieved through Lidl redesign for the improvement of the urban metabolism and according to the socio-economic context of Spangen?

5- Which Sustainable Development Goals result from the synergy between Lidl redesign and the neighbourhood?

Figure 2.5.2.1: Representation of problem statement, vision and research objective (continued from previous page).

03 RESEARCH METHODOLOGY

3.1- Research methodology:

3.1.1 Conceptual framework

3.1.2 Research limitations

3.1 | RESEARCH METHODOLOGY

3.1.1 CONCEPTUAL FRAMEWORK

· Conceptual framework:
Based on the main issues occurring in Lidl and the case study context, a clear vision of this thesis can be set. Afterwards, by developing different designs possibilities and evaluate them, the final design proposal can be achieved.

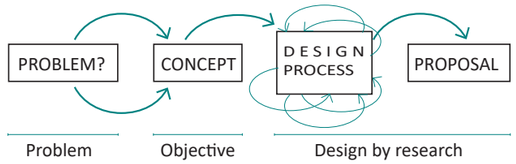


Figure 3.1.1.1: Simple summary of the approach.

The project concept is focused on the ***achievement of Sustainable Development Goals (SDGs), improvement of the social context and urban metabolism in Spangen through the sustainable redesign of a Lidl supermarket*** (theoretical approach). There are several contextual factors in between (baseline) that need to be analysed before in order to achieve the final goal. Therefore the approach framework is aimed to follow these steps: Baseline (analysis), development and improvement.

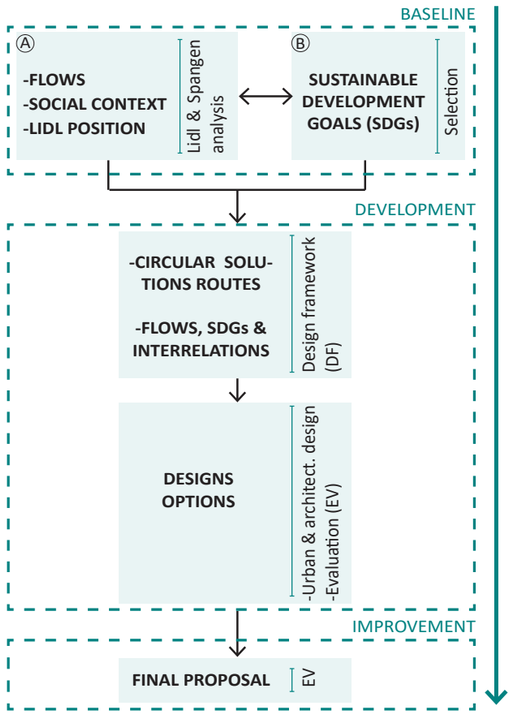
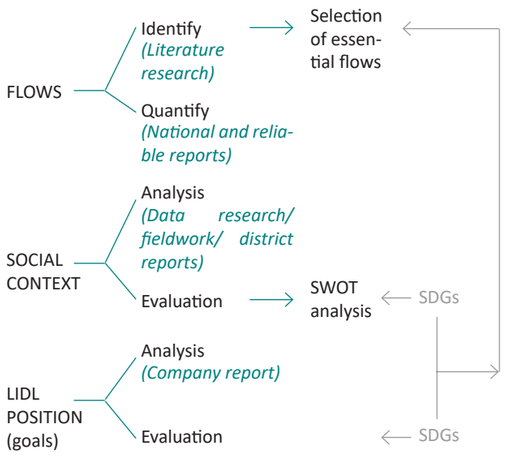


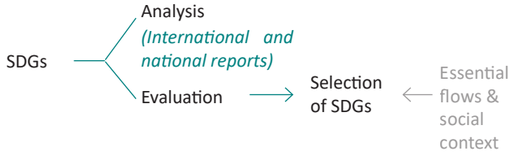
Figure 3.1.1.2: Approach framework and how to achieve it.

·1 BASELINE:
First of all, it is crucial to understand the current situation within this thesis boundaries and find room for improvements. On one hand, an analysis of the main factors (flows and social context) in both Lidl and Spangen neighbourhood will be performed and on the other hand, parallel and in relation to this, it is necessary to get an overview of the current SDGs and think about future potentials that could be achieved through the proposal. The analytical methods (green colour) and selection methods (grey colour) for block A and B are:

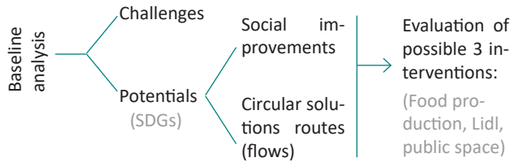
A- Lidl and Spangen analysis:



B- Selection of SDGs:



The analysis of the context situation (baseline) will result in the selection of essential flows and different interventions in order to achieve efficiently the goal.



·2 DEVELOPMENT:
This stage consists of the design process through design by research, and the development of a design framework (method; DF) for providing a simple and structured order, as well as including several factors in an optimal way.
Due to the complexity in the achievement of SDGs and the need to integrate the social dimension in the final proposal, the design framework is inspired and adapted from the ELSI diagram of the Symbiosis in Design (SiD) framework, developed by Tom Bosschaert.

3.1 | RESEARCH METHODOLOGY

3.1.1 CONCEPTUAL FRAMEWORK

Briefly, the DF is divided in two parts, being the first one focused on the development of general strategies for improving the local urban metabolism and SDGs (through indicators) and the second one, based on the selection of strategies adapted to local conditions and spatial locations. Moreover, some strategies are linked to each other so by making groups and evaluating iterations, a final optimal proposal can be achieved. Further detail of the design framework can be found in chapter 4.6 *Design framework.*

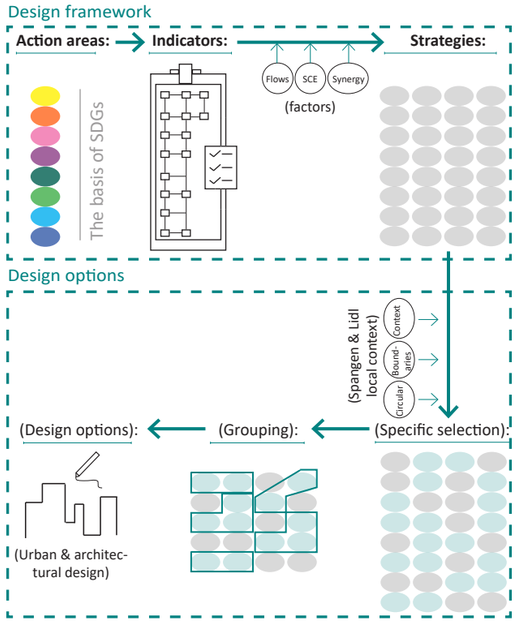
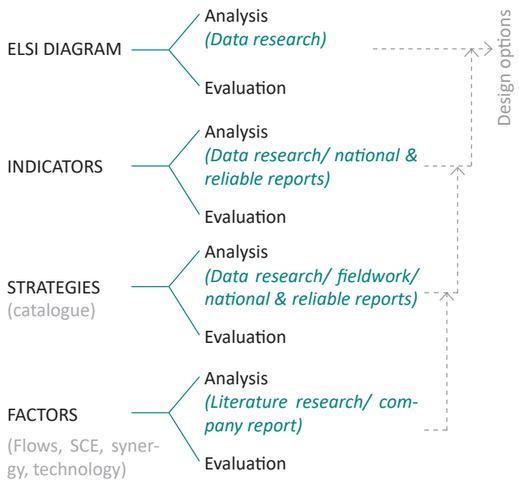


Figure 3.1.1.3: Summary of the development phase.

The references for the development of the DF are:



·3 IMPROVEMENT:
The last stage will be the selection of the final proposal, based on further evaluation of the different spatial options from the previous step, and able to meet and achieve further SDGs and improve the urban flows in Spangen and Lidl. The solution will be supported by calculations in order to make a comparison, know the benefits and understand more about the feasibility of the project.
The analytical methods for the flow calculations are:

FLOWS (ew proposal) —— Calculations *(National & reliable reports) / data research)*

· Research boundaries:
In order to narrow down the research and focus on the main aspects, the following boundaries are described:

-City scale is not studied because it goes out of the scope of this report, but it could be achieved by a modular approach and repetitive pattern.
-The design proposal will be aware of technical and spatial planning, leaving apart most of the financial aspects. But even though the economical dimension is not the main focus, the future actions should meet and be adapted to the socio-economical local context.
-An efficient study of urban metabolism and its social context could result complex if a very big area is analysed. Therefore, there is a preference for the detailed study of a small area located next to the supermarket, around 2,000 habitants. Only once this small area is totally solved, the rest of the neighbourhood or bigger area could be added to the proposal.
-The benefits of flows will be destined to improve Lidl commercial operations. Moreover, benefits for the neighbourhood will be also desired, looking for the general public and common spaces (facilities, public space, etc) rather than private households.

· Data collection techniques (qualitative research):
There has been designed a plan for collecting analytical data, but due to Covid-19 circumstances, other data collection alternatives needed to be found. Howoever, some personal conversations with the associations and neighbours were able to be performed before Covid-19, allowing to obtain some important information. But due to further progress of the virus, more theoretical data based on national reports were searched.

Although the research was mainly qualitative, there have been two types of data collected, being quantitative (a) and qualitative (b):
· Existing data (*Company report*) (a): Collected by private entities and made available for public use (e.g: *Lidl sustainability report, Except, Metabolic*). Criteria: Company website and latest available report (2010-2018).

3.1.1 CONCEPTUAL FRAMEWORK

· Existing data (*International & national reports*) (a & b): Collected by public entities and made available for public use (e.g: *SDGs by UN, European Commission*). Criteria: Organization website and latest available report (2018).
· Existing data (*National & reliable reports*) (a & b): Data collected by public agencies or private entities and made available for public use (e.g: *Netherlands Nutrition Centre, CBS, WRAP UK, United States Environmental Protection Agency: EPA, Association of Dutch Water Companies: Vewin*). Criteria: Latest available report (2015-19).
· Existing data (*District reports*) (a & b): Data collected by public entities and made available for public use (e.g: *Gemeente Rotterdam*). Criteria: Council website and latest available data (2019-20).
· Existing data (*Data research*) (a & b): Data collected by public agencies or private entities and made available for public use (e.g: *World Weather Online, Stichting Openhaard*). Criteria: Website and latest available data (2017-20).
· Existing data (*Literature research*) (a & b): In general, the rest of the data was partly performed by searching for several literature reviews. The most common used literature was obtained via online, using Google Scholar and Google search, thus there was a variety of data collection coming from different scientific platforms like Science direct, scientific magazines, journal articles, the website of public and recognized organizations, well-known companies database, academic thesis, books on library platforms, to name a few, but checking always the reliable original resource. For example, blogs, personal websites and small companies database, among others, were avoided or carefully analysed by comparing the data in 3 other different sources.
The criteria for filtering and selecting the material was through: latest date (from 2017 onwards), newest trends and most well-known organizations (local, national or international identities).
· Interviews (*fieldwork*) (b): In order to gain a better insight into the possibilities for improvement of the neighbourhood, semi-structured interviews were conducted during the 5 site visits in December-February 2019. It is common that non-prepared interviews might produce results that cannot be generalized beyond the sample group, but they provide a more in-depth understanding of citizen's perceptions, motivations and emotions.

The following people were interviewed at different facilities:

-Social club *Westervolkshuis:* The person in charge of food activity and two volunteers.
-2 citizens of Spangen.
-Supermarket: Owner of *Ooms* and employee at *Toros Bakkerij.*
-Restaurant: Employee at Kebap Dürüm *Evi* and *Onur Firini.*
-Others: Employee at *Lidl* and tattoo store.

The questions were short and recorded by personal notes. Moreover, the type of questions was related to: Timetable of the facility, level of satisfaction in the neighbourhood, availability of leisure spaces (result: young people go to city centre due to lack os recreational spaces), type of activities performed in leisure time, challenges perceived in the neighbourhood (results: lack of greenery, vandalism, hard pavement, employment issues..), level of circularity in their processes (result: through away surplus and FW every two days without recovering), desires for improvement, etc.
· Own observation (*fieldwork*) (b): The site visits done in December-February 2019 allowed obtaining the following information:

-Indoor distribution of Lidl (pictures, measuring and drawing floor plan).
-Lack of greenery and hard pavement.
-Flooding and too much water on surfaces (there was a rainfall).
-Lack of outdoor activity (at 13.00, at 19.00 and at 21.00 h), inactive streets.
-Movement of Lidl customers (drawing)
-Car flows (drawing).
-Sunny and shadow areas.
-Lack of benches and sustainable measures (except water purification next to the stadium).
-Multicultural atmosphere.
-Young people.
-High activity atmosphere in social clubs.

· Method of analysis:
There were two different methods for the analysis according to quantitative or qualitative data.

-Quantitative: Before performing the analysis, the gathered data was prepared using Excel and tables. The dataset was checked for missing data or outlines. In case of missing data, extrapolation from other similar countries or reliable reports was made. The data was then analysed using comparatives between original and improved situation.
-Qualitative: The interviews and own observation were transcribed and thematic analysis was conducted, consisting of coding and closely examining the data in order to identify broad themes and patterns (Scribbr, 2019). The themes were related to strengths, weakness, opportunities and threats. Each theme was examined for obtaining a better understanding of people perceptions, motivations and issues.

3.1.2 RESEARCH LIMITATIONS

The final design of this study had some weaknesses and limitations:

1· Food waste recovery rules and regulations:
This study, among other things, tried to address the viability of recirculating food flows between different facilities of the neighbourhood by on-site processing in the GH and Lidl cafeteria. However, the viability of food flows always carries principally social, economical, environmental, ethical and jurisdictional determinants. The last one seemed to be the most influential factor. In this sense, this research was mainly theoretical so a translation to reality would require further studies in many fields: local political, management enthusiasm, permission/exemption process, catering industry permissions, health regulations, etc.
2· Livestock and crop production:
This study would require expertise in greenhouse agriculture, livestock care and exploitation in order to make the proposal worked as much efficient as possible. The moment plants were added and selected to the greenhouse, expertise on plant behaviour to indoor and outdoor climatological aspects would be vital. Moreover, the level of stress and behaviour of livestock would need to be studied. The influence of plants in the indoor climate and its synergy relation between livestock species within this research was based on precedent projects and educated assumptions. So this would add a level of uncertainty to the feasibility of producing both livestock and crop production in the top roof of a building. Nevertheless, there were many precedents that indicated the success of greenhouses on top roofs.
3· Calculations of flows:
All the calculations concerning the essential flows such as plant and livestock yield, food supply and demand, water consumption and collection, C02 sequestration or O2 production has been performed in Microsoft Excel. At the end of this research, the worksheets contained large amounts of numbers and data. Even though this research has been performed with great care and caution, minor calculation or typing mistakes could not be ruled out.
Moreover, on one hand, some of the important data required from Lidl and the rest of neighbourhood facilities could not be obtained, therefore Lidl reports from other countries, standard supermarkets, schools and restaurant's data were used. On the other hand, several detailed data was extracted from reports, company websites, newspapers, etc but would have been preferred to obtain it from expertise people of each field. Therefore even though calculations could help to support and imagine the feasibility of the proposal, these would have a level of uncertainty and inaccuracy regarding the specific places of study (Mariaschool, Toros supermarket, Maak Rotterdam cafeteria, etc).
4· Study of pollutant air particles and substances:
In relation to the previous point, calculations were performed as much in detailed as this research could. However, due to the extension, the complexity and the amount of work required for each selected flows, certain aspects were left out from investigation due to out of the scope of master thesis. Pollutant air consisted of several particles and harmful substances that might have influenced the result of the final proposal, concluding for example, in a more necessity of specific plants, material construction type or other solutions to combat and improve air flows.
5· Achievement of total SDGs:
As concluded before, SDGs consisted of several indicators so, in order to achieve completely each SDGs, a thorough assessment of each indicator would need to be performed prior to the design process. However, this was not the case, as a general understanding of each SDG was performed, enabling to derive strategies for its achievement through spatial interventions but in a broad sense.
It should be noted that anyway, although further indicators were able to be obtained through an early study of them, the total achievement of SDGs would still not be achieved due to political and economical matters, as well as their objective to try to solve everything, resulting in a bit unreachable at small scale designs like this study.
6· Covid-19 virus effects:
Covid-19 is a pandemic health issue that affects everyone in all places and circumstances within social life. As expected, Covid-19 appears that will stay for a long-term period within the society, changing the way people socialize, interact, behave and communicate. This rare situation would have effects on the design proposal because social distances and spaces would need to be extended, resulting in less production, less sociability, less participation and in general fewer benefits. For example in Lidl cafeteria, a separated entrance from the commercial area would be probably needed, sharing spaces would be limited so individual and separated spaces would be needed, the children area would result in a dangerous place for spreading the virus, etc. In the square, wider spaces would be needed, limiting the social efficiency of fountain area, sand playground or needing small individual constructions for each table of the terrace. In the greenhouse, the production area would not be necessarily affected but dining area and workshop rooms would require wider spaces and other interior distribution of furniture.
7· Top roof structure:
The greenhouse has been designed considering that the existing structure could bear the new intervention. But although lightweight solutions were taken into account, this was an important factor that would need to be solved.

Despite all concerns, this study could offer insight and inspiration in the potential and positive impact of social economy principles in degraded areas.

04 THEORITICAL FRAMEWORK

4.1 | THE CONCEPT OF CIRCULARITY

4.1.1 THE LINEAR MODEL (LM)

· Environmental concerns:

The cumulative pressure of the human activity on the planet (exacerbated since industrialization), as well as the reduction of healthy forest, rivers and oceans, shows that resilience and resources of Earth are being sapped, indicating that by the new millennium, 1.5 Planet Earths would be needed in order to maintain the current social, economic and demographic existence (WWF, 2012).

The Earth has been experienced many environmental changes, but remaining stable for the past 10,000 years. In this Holocene period, civilizations were able to arise, develop and thrive within a relatively narrow and environmental range. Nevertheless, this stability has been under threat since the Industrial Revolution, the Anthropocene era, where fossil fuel's dependency, agriculture industrialization and human activities have become the major cause of the global environmental change (Sariatly, 2017).

In an attempt to classify the human impact in the environment and try to maintain the Holocene state, researchers have proposed the concept of Planetary Boundaries, which boundaries define the optimal space for the human actions. However, three out of nine Earth system processes have already transgressed their boundaries: climate change, biodiversity loss and interference with the nitrogen cycle, meaning that would result in an unacceptable environmental change for planet ecosystem (Steffen W. et al., 2015; Rockström, J. et al., 2009).

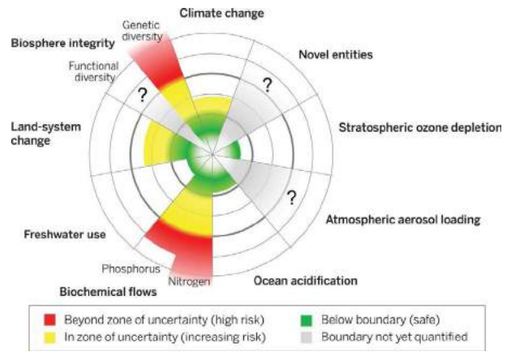


Figure 4.1.1.1: Current status of the control variables for seven of the planetary boundaries for the climate changE (Source: Steffen, W. et al., 2015).

· Linear model:

In general terms, since the Industrial Revolution, the business economical model in developed countries has been based on the linear model (LM), which led to an important growth of production but also to unlimited resource consumption.
On one hand, development means economic and population growth, which goes hand in hand with changes in consumption behaviour (mainly luxury products and fresh food), necessities of infrastructures, urbanization and industrialization, transportation, etc, resulting in large amount of raw materials and natural resource and involving pollution and waste issues.
On the other hand, according to Ellen MacArthur Foundation (2013), the current prevailing design relies on the historic wealth's distribution in the geographical regions around the world. Consumers of resources have been concentrated in the most developed regions (Western society), where abundant resources of material and energy were widely available and reachable. As a result, materials have been very cheap compared to the human labour cost, so business models relied on extensive use of materials and economized human work has been established. However, this has led to the negligence and unnecessary of recycling, reusing and promoting waste measures.

This linear model follows the take (extract)-make (manufacture)-consume-dispose pattern, represented in Figure 4.1.2.1. Raw materials are extracted from nature, transformed into products, sold and used, and then disposed after having lost their physical, economic or functional value, becoming waste. Usually, some of this waste is treated and sent to the recycling streams, but a great amount of it is incinerated or even disposed at landfills (GCR group, 2017). Around 65 billion tons of raw materials (expected to grow to around 82 billion tonnes in 2020) were used in 2010, of which 2.7 billion tons were dumped as waste, and additionally, 21 billion tons of materials are currently being discarded during the production process before becoming part of the final product. This waste not only cost the loss of function but also all the source of energy involved. (Ellen MacArthur Foundation, 2013).

The growing world population trend and the increase of purchasing power (demand for raw materials) are difficult to slow down. So in order to ensure the availability of natural resources, urgent change in the way of harvesting, producing and recycling them needs to be done. Nowadays, the government and companies have begun to realize the serious economic risks, environmental and social consequences of this model, so they started adopting more sustainable measures.

But the best solution that can be achievable and could slow down the degradation of the environment is the complete disconnection from natural resources and the new design system where renewable energy and recirculation of flows would be maximized before going to waste. This could be achieved through Circular economy CE), a concept that has emerged in 1970 and recently become more popular, being able to contribute to the disconnection of natural resources and achieve planet prosperity.

4.1.2 THE CIRCULAR ECONOMY (CE)

The circular economy is an industrial and economical system designed to deal with the current and destructive linear economy model. The pioneers of CE were Braungart & McDonough and The Ellen MacArthur Foundation, whose emphasis for going beyond sustainability formed the base for developing further the circular economy concept (Mcdonough, 2019).

In principle, the CE can contribute to an affordable and sustainable supply chain of raw materials because all the waste flows can be reused to create new values and help to reduce the dependence of natural resources, therefore allow progressively regenerating them (SB Insight, 2019).
It is a dynamic, positive and interconnected solution system that is based on creativity, collaboration and entrepreneurship that works for everybody at different sectors in order to achieve SDGs and fight against climate change (De Wit et al., 2019). Its main goal is to separate economic growth from natural resource depletion through designing disruptive services, business models, products and public policies (Living Circular, 2018).
However, according to the Circularity Gap report 2019, only 9% of the world economy is circular. This is due mainly because humanity still keeps on optimizing the LM, but the real swift towards CE will require efforts from industries, users, government, etc in order to change completely the way people think, act and consume products.

Unlike LM, in a CE, natural resources and raw materials are restored after the end of life (3R), becoming a new source and thus avoiding waste and destruction of value at the end of the chain process (Figure 4.1.2.1). It shifts towards renewable energy, eliminates toxic chemicals that affect recyclability (recycle), optimize and reduce waste flows (reduce) through an early designing phase of products and systems, mitigating greenhouse gasses emissions and stopping the depletion of natural resources (allowing progressively regenerating them).

The principles of the circular economy are organized in 3 domains (raw materials, producers and consumers), which are based on 7 pillars (Living Circular, 2018):

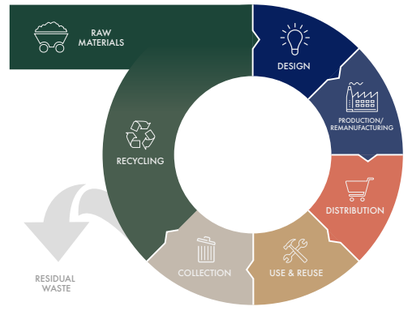


Figure 4.1.2.2: Model based on 7 steps that are vital in the circular value chain of a product (Source: SB Insight, 2019).

· Raw materials: Turning waste into new resources:
1- Recycling: Considering waste as a valuable resource by reintroducing it back to production cycle, thus avoiding waste, protecting natural resources and offering economic opportunities.
· Producers: Search for effectiveness at every stage of the production process.
2- Sustainability supply: Sustainable extraction, exploitation and purchase are the basis of efficient use of natural

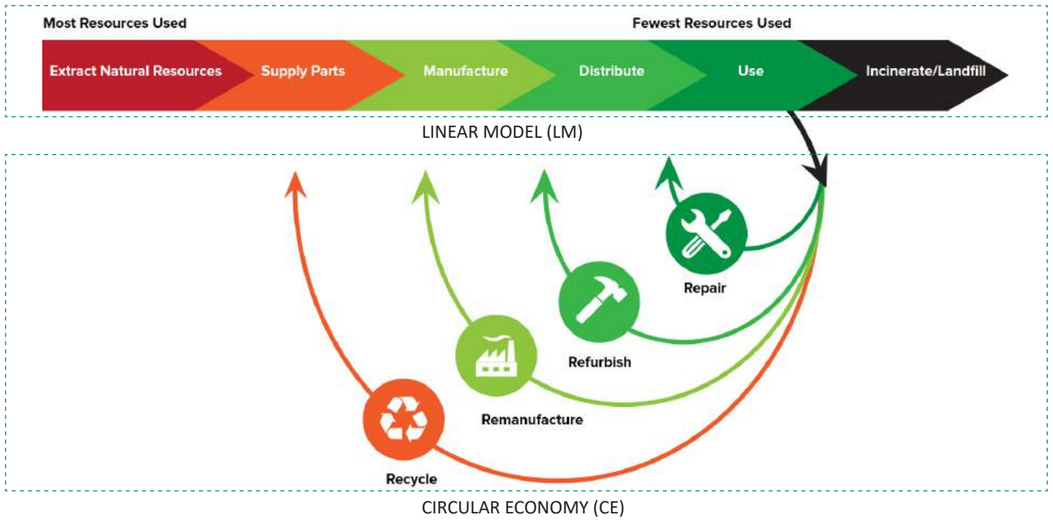


Figure 4.1.2.1: Linear model and future solution (Source: https://www.wastequip.com/about/wastequipcares/bekinder-to-our-environment-with-kristin-kinder).

resources, reducing waste and the negative social and environmental impact.
3- Eco design: Considering the environmental impact through early designing steps.
4- The economics of functionality: Selling the functionality of a product or service rather than the product itself.
5- Industrial and territorial ecology: Synergy with its local environment for stimulating the exchange of resources, sharing and pooling, creation of new activities, etc.

· Consumers: More responsible consumer demand and behaviour.

6- Responsible consumption: Consumer buys products that are respectful with the human beings and the environment.
7- Extending the duration of use: Second life use through repair, resell, exchange or give away.

5 main benefits can be achieved within CE framework, such as: Resource benefits (increasing efficiency and decreasing inputs), environmental, ecosystem, economic (innovation, opportunities and cost reductions), and social benefits (new values, consumer's behaviour or job opportunities) (Ingallina, 2017).

The Dutch Government has developed the "Government-wide programme for Circular Economy" (GWCE), which aims consist on reducing the impact on the environment and developing healthy, safe and living conditions, therefore establishing an economical objective for becoming 50% circular by 2030 and completely circular by 2050. Programmes such as "From waste to resource" (VANG), "National raw materials agreement" or "Green growth and bio-based economy", allowed developing several initiatives and proving their benefits, for example with energy cascading, extraction of heat from water waste flows or taking new advantage of other residue materials. The Netherlands has been considered the leader in Europe in terms of recyclability, recycling over 80% of the materials and having a high material productivity ratio (Government NL, 2019; Cbs NL, 2018).

In general, the focus of the CE concept has changed over the years, being influenced by different theories, so in order to explain the current focus of the circular economy within this thesis, some influences are briefly discussed:

· Regenerative design: Products or services are renewed through reintroducing back to the same processes system, requiring little inputs. For this, system thinking, interdisciplinary collaboration and knowing natural resources limitations are required (World Business Council for sustainable development (WBCSD), 2018).
· Industrial ecology: This approach seeks to transform industrial processes into cyclical processes, considering natural ecosystems as a base model. It is mainly focused on energy efficiency, resources and waste exchange (Bruel et al., 2018).
· Bio-based economy: The idea is to start re-integrating human activities according to the biological metabolism existing in the Earth in order to achieve the same quality of services but seamlessly integrated into the biosphere (Metabolic, Studioninedots & DELVA L.A, 2014).
· Blue economy: It tries to deal with environmental problems working with what is locally available and generating various income streams. It tries to follow innovations and new ways of making a profit in order to reduce the environmental negative effects and waste, addressing mainly the economic side of the CE concept. Similarly to Green Economy, this blue economy model also tries to improve human well-being, social equity and inclusion (Common Wealth Secretariat, n.d).

However, despite all these approaches, there is still missing important points of social aspects in the CE, being discussed in chapter 4.1.4 *The social circular economy.*

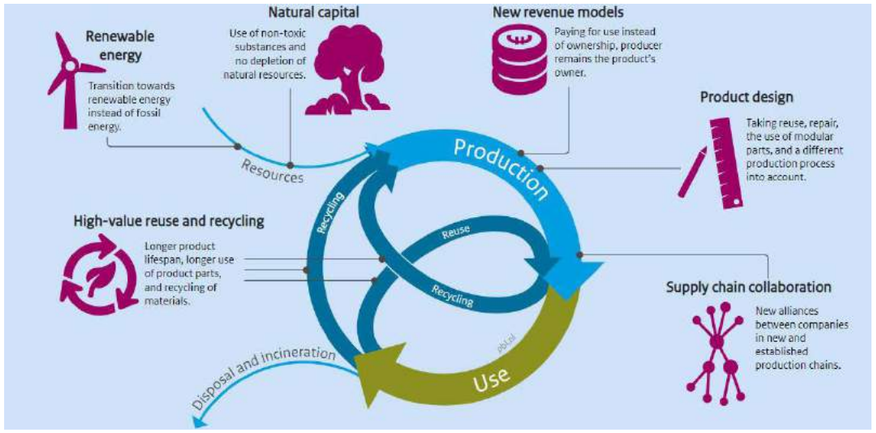


Figure 4.1.2.3: Elements of a circular economy: Renewable energy, natural capital, new nevenue models, product design, supply chain colllaboration and high-value reuse and recycling (Source: PBL, 2019).

4.1.3 THE SOCIAL CIRCULAR ECONOMY (SCE)

The term of social circular economy (SCE) appeared due to the limitations of the circular economy (CE; focused on environmental and economic aspects) and social enterprise concept (SE; focused on social and economy), in which one aspect of sustainability definition is missing in each concept.

On one hand, the circular economy is, by definition, an industrial economy that is regenerative and restorative by design, keeping sources in use at their highest value for as long as possible (Robinson, p.4, 2017).
On the other hand, social enterprises use business principles in order to achieve social benefits and make a positive change in the world. It ensures that economy does not harm the society and tries to achieve the highest social benefits as possible, by tackling societal problems of disadvantaged people and strengthening its communities. SE usually operate in a wide spectrum of organisational forms (Robinson, 2017):

Figure 4.1.4.1: An spectrum of social enterprise forms.

The main difference between SE and charities or non-profit organizations are the introduction of economic aspect, in which the latest perceive the money from continuing funding, grants and donations. Social enterprise has the following characteristics (Robinson, 2017):

· Clear social mission.
· Income generated by trading goods or services.
· Reinvestment of profits back to their organization or mission.
· Independent and autonomous from state.
· Transparent and accountable.

The social circular economy has not to do with reducing environmental impact while following a social mission, nor providing decent and equitable working conditions while performing in a circular way. It is the result of the combination of the CE and SE concept, in which it defends that the global system needs to have economic prosperity within a rich society and also a regenerative environment, for achieving benefits at the three dimensions: people, planet, and economy. Thus, it aligns well with the improvement of social well-being and the planet, as well as the UN's Sustainable Development Goals.

SCE is the result and latest improvement of the different economical models occurring since the last decades.

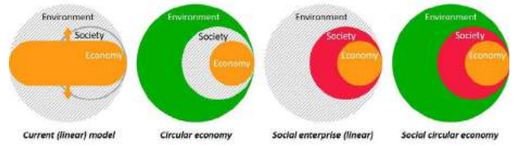


Figure 4.1.4.2: Schematics of systems designed by the different archetypes, in which fully coloured highlighted regions areas are considered for the system design (Source: Robinson, 2017).

Unlike environmental or economical aspects, social issues are commonly connected with people, needing to be localised and solved though distributed models that can support them. For example, the proper help for an isolated elderly woman would need to be solved by local presence and intervention rather than by distance help. Therefore SCE brings back the effort and necessity of social aspect and local approach within the circular economy principles. Similarly, by performing circular operations though smaller loops and closer to the consumers (circular economy at local human scale), less cost and complexity would be avoided (Robinson, 2017).

One practical example of this SCE term would be the transformation of hypothetical organizations "B" and "C" (typically seen in the linear model and which perform harmful activities for the planet and the society) into "A" (SCE) (Robinson, 2017):

· Organization B: Production of bags from cheap virgin cotton, resulting in high consumption of water, fossil fuel, fertilizer, and high use of pesticides.
· Organization C: Workers with few rights, often being underpaid and also under-age.
· Organization A: Transformation of the corporate uniform "waste" into bags, and made by disadvantage people, with a decent salary and working conditions.

The consequences of these traditional models are often solved independently by the circular economy and social enterprise principles. Even though these approaches are very valuable for giving benefits to the world, none of the frameworks has a full systemic view, thus producing non-optimal outcomes from a global perspective. However, the shortfalls of each concept are solved by the SCE model, in which every fundamental aspect is taken into account, solving and having a balanced between economical, environmental and social aspects.

4.2 | URBANISM

4.2.1 URBAN METABOLISM, DESIGN & SYNERGY

· Urban metabolism (UM) & urban design (UD):

Interventions within the built environment require a better understanding of the internal processes and management of an urban area, so the theory of urban metabolism is discussed.

Urban metabolism (UM) has become a framework for professional from different disciplines in order to examine the environmental impact and understand urban fabrics operations in a systemic way. UM refers to the exchange of energy, movement of flows, matter and information that occurs between the urban settlement and its surrounding natural environment or graphical context.
In fact, the urban ecosystem is an open system in which resources and flows can both enter the environment and leave after being transformed for example, by simple or complex technical or socio-economic processes. By understanding the city as an ecosystem and the way it works, it will allow to increase urban efficiency, understand the hidden processes and quantify the challenges and measures to be taken, at the same time as achieving a more circular and sustainable urban metabolism.

Sustainability is deeply related to the pressure that humans exert on the natural environment nearby, so new urbanism is needed, in which is capable of efficiently manage the metabolic flows and transform its current linear process into another system that imitates the way nature works; circular and recyclable system (Wikipedia 2019). In order to improve the sustainability aspect of a UM, two steps are necessary. Firstly, the use of ecosystem thinking for exploring an optimal resource consumption in different processes and secondly, the use of synergies between flows and sectors, including equally the three dimensions of sustainability. Therefore a sustainable UM would be not only optimal but also synergetic within the surroundings and sustainable aspects (Van Bueren et al., 2012).

However, UM serves mostly as an analysis method for understanding neighbourhood operations and performance of an area, but it does not provide any method for improving the system or implementing new solutions. Thus, urban design (UD) discipline is needed, being this combination of different professions the basis for sustainable urban development. The final proposal of this thesis could follow this combination, in which an assessment of different flows and impact would be performed in the neighbourhood (UM), in order to the propose spatial interventions for its improvement (UD).
On the other hand, the social circular economy concept should be integrated into the future proposal, but the key is how to implement it within the neighbourhood environment. Therefore the challenge relies on the establishment of a link between the social circular economy thinking and the contextual urban design discipline, through the help of urban metabolism analysis. When solved, spatial effects of circular concepts can be implemented and additionally, various integration and improvement of processes within the urban environment could be achieved.

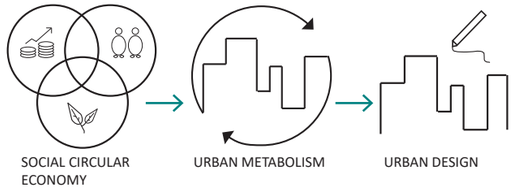


Figure 4.2.1.1: Creation of new link between concepts and disciplines: circular economy concept, urban metabolism and urban deign.

· Urban synergy:

Synergy could be defined as a collaboration of two or more agents that works together for producing an achievable and better result, which would not be possible to obtain by the sum of those agents independently. The characteristics of synergy include (Hardin & Armstrong, 2012):

· Dynamic state in which combined actions is favoured over the individual component actions.
· Behaviour of the whole systems is not predicted by the behaviour of independent parts.
· Cooperative action of two or more stimuli leads to greater response than individual stimuli.

Synergy can create urban metabolism by combining different resources that can work together in order to create a new system.
Additionally, urban synergy is closely related to "urban ecology" concept, in which deals with the sustainable interaction of species in an urban area and their interaction with the community. Urban ecologists try to study all the nature and greenery located in urban areas in order to understand the factors and availability of those resources, at the same time as analysing their level of pollution, exploitation and other pressures. By considering this ecological perspective and understanding environmental threats and challenges, healthier design, preservation of ecosystems and better management of communities can be achieved (Hardin & Armstrong, 2012).
Therefore this means that urban synergy follows and is capable to create a sustainable system within the neighbourhood or urban environment, contributing to achieving a sustainable urban development, including measures such as the preservation, exchange and reuse of resources, among others.

In this thesis, urban synergy will be aimed to be achieved between different facilities of the neighbourhood in order to obtain the maximum benefits from them through interdependency or mutual symbiosis.

4.3 | SOCIAL SUSTAINABILITY

4.3.1 THE IMPORTANCE OF SOCIAL ASPECT

Social sustainability is a commonly overlooked aspect of sustainability definition due to the main focus on the environmental and economic aspect in every sustainable development discussions. However, the three dimensions of sustainability should be equally addressed in order to achieve the most and balanced sustainable result.

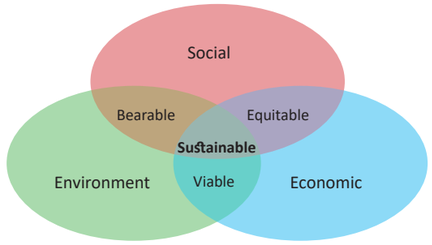


Figure 4.3.1.1: The 3 pillars of sustainability.

Since 2002, WACOSS has been addressing the lack of attention to the social aspect of sustainability. The main objective of social sustainability is to achieve that current and future generation can support and create healthy, liveable communities and provide a high standard quality of life, by promoting equitable, connected, diverse and democratic values (Adec innovations, 2019). It supports social and cultural life, social amenities, systems for citizens participation, places and people in order to foster their own development.
Social sustainability embraces topics such as: social and health equity, community development, liveability, social capital, social support, labour and human rights, place-making, social responsibility and justice, cultural competence, community resilience and human adaptation. But according to Nobel Laureate Amartya Sen, social sustainability has 5 main dimensions, in which these principles determine the level of social sustainability of a project or business (Hodgson, 2016; Wikipedia, 2020):

· Equity: Offer of equitable opportunities and outcomes for all its members, focusing on poorest and most vulnerable people. Identification of the needs of disadvantaged people and promote fairness.
· Diversity: The community promotes and encourages diversity, meeting their needs.
· Social cohesion: Offer of processes, systems and structures that promote connectivity between inside and outside the community and at formal, informal and institutional levels. Develop a sense of belonging, access to public and civic institutions and support to the disadvantaged group.
· Quality of life: Community ensures that basic needs (education, housing, safety..) are fulfilled, enhancing the life quality at individual, group and community level:
· Democracy and governance: The community provides democratic processes, accessibility, open and accountable governance structures.

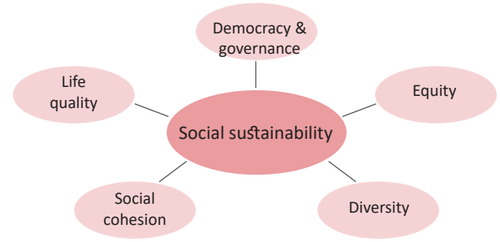


Figure 4.3.1.2: The 5 dimensions of social sustainability.

United Nations recognized the need for strengthening the social dimension of sustainability, so around six points of the Sustainable Development Goals are focused on this (United Nations, 2016). In fact, human beings are social creatures by nature, in which studies show that the frequency of contacts with others and the quality interconnections is related to higher positive feelings and determine the level of well-being of each person, aimed to last for a long term period (OECD, 2020).

The importance of social sustainability goes beyond people usually think. In the paradigm of human development, social well-being is obviously affected by the level of balance between economic circumstances and environmental characteristics of a place, but these dimensions should represent only a way for increasing social expenditure and achieving better comfort of life.
The lack of the two previous dimensions of sustainability would result in a non-optimal outcome, but when there is a lack of social development, including poverty, inequality and weak rule of law, the other two dimensions would be much more affected, such as in commercial operations and growth. Additionally, the consequences of forgetting this important social aspect can result in the following main social problems (Morgan, 2017; OECD, 2020):

· Deprivation and poverty
· Crime and safety issues
· Inequality and segregation of communities
· Low quality of life
· Social exclusion
· Feeling of isolation and loneliness

For example, social isolation may result in family breakdown, loss of a job, illness, financial issues, difficulty in social reintegration, etc.
Nevertheless, on the contrary, actions in order to achieve social sustainability, could result in the unlock of new markets, help to attract more business partners, or be an inspiring source of innovation for new products or services lines. So for instance, when there is a better social responsibility in a company and employees are satisfied, there is more employee's commitment and productivity, improvement of risk management and reduction of company-community conflict, among others (Karbassi, 2018).

4.4 | PRECEDENT STUDIES

4.4.1 OVERVIEW

Several precedent studies are described due to their sustainable relevance and inspirational help for the future design proposal. They are presented following a concept order: greenhouses and circular buildings, community integration and urban planning (smaller to bigger scale).

Each study describes in general terms the design concept or goals of the project, as well as its main sustainable strategies used and within the boundaries of this thesis. For example, aspects within the circular economy are mentioned, at the same time as general flows directions, social aspects, urban environment contribution, etc.

At the end of this chapter, a brief comparison between all the projects is presented regarding the general flows.

Project:	Year:	Location:	Main designers:	Materialization:	Concept:
The Green House	2018	Utretch, NL	Architectenbureau cepezed	Real	Greenhouse within water, food & energy Nexus.
Polydome	2014	De Lier, NL	Except	Project	Polyculture and net zero impact food production
The Circl	2017	Amsterdam, NL	De Architekten Cie	Real	Circular building
The Urban Village Project	2018	Worldwide	Space10 & Effekt Architects	Real	Circular community vision; Affordable, sustainable and liveable
De Ceuvel	2012-2014	Amsterdam, NL	Metabolic and 7 more experts	Real	Sustainable circular urban complex (eco-hub)
The Park 20/20	2010	Hoofddorp, NL	Delta Development GRoup, VolkerWessels and Reggeborgh Group (W. McDonough + Partners)	Construction in process	Business park Master plan; Cradle to cradle concept

Table 4.4.1.1: Precedent project list.

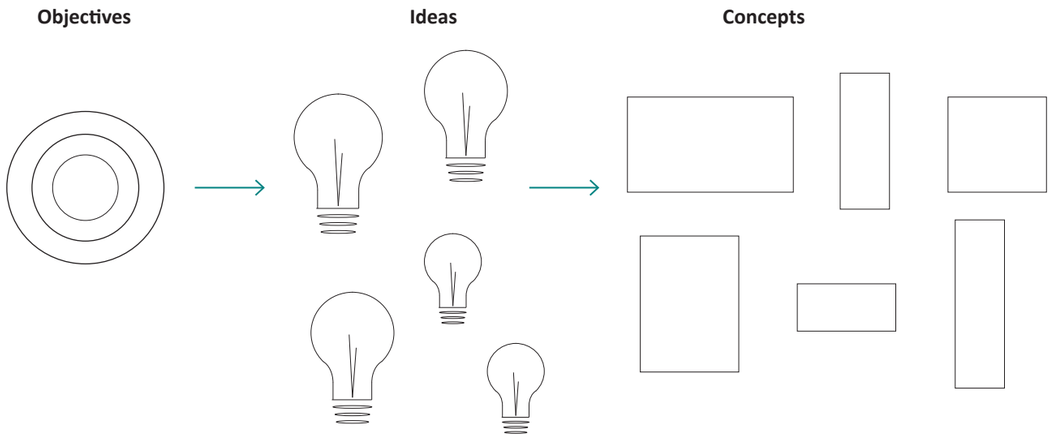


Figure 4.4.1.1: Representation of the importance of precedent studies for getting inspiring ideas for developing future concepts.

4.4.2 THE GREENHOUSE (Utretch, NL, 2018)

· The Greenhouse (Utretch, NL, 2018):

Big apartment block or offices were aimed to be constructed in a specific site in Utrecht, next to the station area, but while the political agreements were not achieved, the spot would remain vacant during 15 years. Meanwhile and in order to avoid this useless space, the main goal was to design and provide to the land a temporary, safety and lively function as fast as possible through a temporary, functional and circular construction (Castro F., 2018).

The Green House building is mainly a representation and result of the complex relation or nexus of water, food and energy. In general, it consists of a restaurant based on circular principles; no waste, temporary and removable building concept, local food supply, etc. Its aim is to serve as a representative circular building and inspire people, offering a special experience through innovative and advanced workplaces, accordingly to “smart sustainable city” concepts. The pavilion was constructed in an impressive speed, within three months, and additionally, it could be demounted and constructed again perfectly in another place due to its prefabricated and recyclable elements.

The two-storey circular pavilion contains a vertical urban farming (80 m2), restaurant and flexible meeting rooms. The vertical farming can be seen from most of the locations, either from outside or inside due to its second transparent skin, enabling increase food production awareness within the urban environment.

The implementation of circular concepts started through the early design processes, so most of the materials and rest of waste were designed to be recycled and reused since the beginning. Moreover, other objectives were focused on a circular operation based on reducing waste, energy and water consumption.

The circular concepts that were followed by the Green House for its design were (Strukton, 2019):

· Use of sustainable energy (bio-based or fully recyclable materials).
· Usable materials and energy from waste or by-products.
· Extend the lifecycle of products through repair, upgrading and resale.
· Using sharing platforms to ensure an increase in the use of products.
· Pay for the use or result of a product (pay for use).
· Limit material use and energy consumption.
· Suppliers contract in order to make them take back the product at the end of useful life.

The main sustainable measures considered in this temporary construction were (Rethink the future, 2018):

· Demountability, disassembly details and optimization.
· Reusable materials from other buildings nearby.
· Standard construction (joints are not altered, punctuated or weld for allowing recyclability).
· Energy neutral building.
· Local energy production (PV panels).
· Underground energy storage.
· Reused furniture or made with recycled materials.
· Rainwater collection and reuse of condense water.
· Automated sensor systems.
· Green natural shading (trees).
· Double curtain wall (increase insulation from recycled glass).
· 1st AC plug free restaurant (without electricity but with energy-efficient ovens from renewable energy).
· Biodiversity in farming (60 varieties and 3400 plants).
· An aquaponic system with LED red lighting.
· Collaboration to “Colour Kitchen”, an organization to prevent waste.
· Job generation for the neighbourhood (30-40 new jobs)
· Mainly vegetarian menu, seasonal dishes and local products.
· Reusing organic waste as fertilizer for the greenhouse.
· Perforated acoustic panels.
· Internal green wall to increase indoor air quality.
· Heat exchangers & climate recovery systems.

Figure 4.4.2.1: Project design of the Green House (render) (Source: https://www.gbn.nl/uncategorized/gbn-groep-levert-herbruikbare-materialen-aan-the-green-house-circulaire-paviljoen-aanbouw-utrecht/

· Polydome (De Lier, NL, 2014):

Since 1960, agriculture around the world has experienced a massive conversion towards monoculture, in which scale and specialization of products increased. However over the time, disadvantages of this system began to appear, starting from deforestations, manure surplus, use of chemical pesticides and great consumption of resources, among others (Except, 2011).

The Netherlands is the leader in greenhouse technology and efficient production, but there have been few innovations in the sector’s development. The project of Polydome represents an interesting direction to find new ways for Dutch greenhouse innovations and more sustainable

4.4.3 POLYDOME (En Lier, NL, 2014)

practices, offering commercial scale, net-zero impact food production, energy savings, production stability and flexibility (wide possibilities and opportunities).

The project is a different and revolutionary approach that enhances the development of biodiverse farming systems under one unique roof, creating an inherently sustainable cycle due to the mutual support among the elements. According to the authors, "the goal of Polydome greenhouse is to combine the best of low-tech and high-tech approaches in order to achieve a holistically sustainable agriculture production system" (Except, 2011, p.19). Therefore, the aim is not trying to maintain strict control over the cultivation process, as in greenhouse agriculture, but designed to function like a natural ecosystem with self-supporting animal and plant interactions (Except, 2011).

It is expected to produce a large variety of crops and livestock species, such as fruits, vegetables, herbs, mushrooms, honey, chickens, fish, etc. In this way, polyculture and particularly Polydome, presents several advantages, for example (Except, 2011):

· The combination of plants and vegetables results in healthier growing plants and less artificial pesticides use.
· Mushrooms, composting and animals produce high levels of C02, which is beneficial for plant's growth.
·The manure of animals can serve as fertilizer for plants.
· Close of energy and nutrients loops, reducing energy and recycling waste.
· Wide variety of products, fulfilling local food needs of an entire community and reducing transportation.
· In summary, the waste of one product can be useful for the input of the next one, reducing other costly technological interventions.

Simulations, calculations and economic and market analysis, to name a few, have been performed in order to know the feasibility of the project. Several principles are relevant for the success of the project, such as (Except, 2011):

· Self-supporting system.
· Low-tech whenever possible.
· Valuable crops over large-scale production (economic advantages).
· Flexible performance.
· Diverse, social labour.
· Greenhouse production.
· Active polycultures.
·High yields, productive ecosystems, economically resilient.
· Long-lasting (30-100 years)

Among the sustainable goals considered in the project are (Except, 2011):

1- Energy & materials:
· Energetically self-sufficient.
· Low or zero material inputs (renewable sources).
· Rainwater collection.
· Recovering of local materials of value (zero waste).

2- Ecosystem & species:
· Diversity and mutual support.
· Natural ecosystem interaction, natural pollination and protection against diseases and pest.
· Maximization of productivity/m2 through species in both space and time.
· Maximum benefit from natural variations in lighting, thermal and moisture through crop placement (rather than mechanical ventilation or curtains for shadows).
· Prioritization of animal welfare.

3- Culture & economy:
· Economically viable within a short to mid-range time horizon.
· Great quantities of high-quality products.
· Minimization of difficulties and undesirable labour.
· Flexible production, being resilient to economic fluctuations and improving food security and access.
· Local food culture benefits.
· Additional opportunities to food production; education, social uses, processing, retail...
· Reduction of food transportation.
· Longer use possibility than a conventional greenhouse, landscape's integration, inspiring environment space.

4- Health & happiness:
· Healthy, enjoyable environment, safe space.
· No toxic chemicals for humans or ecosystems.
· Healthy and nutritious food.
· Long term food security and improving food access.
· Source of enjoyment to both owners and local residents through its role and relevance in the neighbourhood.
· Aesthetically pleasant appearance.

Figure 4.4.3.1: Interior vision of Polydome (render) (Source: Except, 2011).

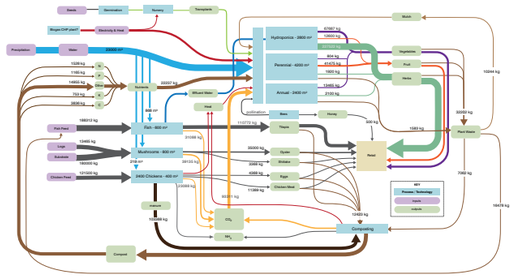


Figure 4.4.3.2: Polydome concept overview (Source: Except, 2011).

4.4.4 THE CIRCL (Amsterdam, NL, 2017)

· The Circl (Amsterdam, NL, 2017):

Circl is a pavilion located at the Gustav Mahlerplein at the Zuidas, near station Zuid and in front of the ABN AMRO's main building. It was created in 2017 by ABN AMRO bank in order to share the knowledge and involve its clients with the circularity concept.

In the beginning, the necessity of a new construction arose with the objective to create more conferences rooms for the use of the bank. However, it changed into a circular and challenging design for that period. Nowadays, the building has energy label A and it represents the sustainability objectives of the bank in order to facilitate circular models and contribute further to a future proof society (ABN AMRO, 2019).

It has been constructed and designed according to sustainable and circular principles, such as energy efficiency, disassembly, reused materials (minimal use of raw materials), future utility of its components, etc in order to make the least impact as possible on the environment. All the circular measures were taken into account during the design phase, where good prevailed over beautiful or aesthetics aspect.

Circl is considered as a living lab, where anyone with good ideas about sustainability or circularity can join the activities organized inside the building. According to the designers, the pavilion is a place to learn, get inspired but also to bring people together coming from the offices or neighbourhood nearby.

The building consists of 3 floors with a rooftop bar, restaurant, conference rooms and a rooftop garden. Every kind of people who has interest in sustainability and circular economy are very welcome, in which they can enjoy sustainability theme programmes while meeting and discussing with other interested people.

The main sustainable measures considered in this pavilion are (Circl, 2017; Wopereis, 2017):

· PV panels. 260 panels on the roof and 260 on the outer edge of the exterior walls of the building. (Supplier from The Hague, thus decreasing environmental impact).
· Horizontal and vertical geothermal heat exchangers, with 9 boreholes of 80 m deep.
· PCM on floor and ceilings in the ground floor acting as a thermal battery, minimising energy consumption.
· Minimum waste during the construction phase and future use of the building.
· Disassembly; screwed, bolted, clicked or clamped connections wherever is possible (assembly and future deconstruction considered in the design phase).
· Avoid energy loss from the use of inverters of PV panels. LED lighting and devices run on DC instead of AC.
· Limited energy consumption of 12 V.
· Lighting sensors adjustable according to the daylight and activities of the spaces: "Sense organic"
· Lights (bulb) are individually adjusted and exchanged.
·Reuse of materials and components (wood, partition walls, aluminium, wood from windows, reused concrete for tiles, 16,000 old jeans as ceiling insulation…).
· Only one elevator instead of 2 and it is paid depending on its use (rent instead of pay and return policy after 10 years). Lift, lighting and rest of wood material as a lease construction.
· Wood instead of concrete (structure), demountable.
· Future reuse of the park due to its Meccano parts, linked the pieces together by recycled plastic pins.
· All materials, components and products are recorded in "digital twin" (building passport: "LLMNT")
· Restaurant: Catering services employ people with disability and uniforms are from recycled plastic bottles.
· Low energy consumption kitchen; 100 kW instead of 200 kW and offer of low energy recipes.
· Biodiversity on the roof garden; birds, bees, butterflies.
· Urban farming for local food production.

Figure 4.4.4.1: Lateral side of the pavillion, where local food production can be freshly harvested (Source: https://www.bambouwentechniek.nl/projecten/circl-circulair-paviljoen-abn-amro-amsterdam?position=2&list=Bi95qLZ6fxmNr7jxHefdGXD8_vz54rXSUULlgEXDgOU).

Figure 4.4.4.2: Interior vision, where most of used materials were recycle (Source: Wopereis, 2017).

· The urban village project (Worldwide, 2018):

This project follows a concept that has been spread and materialized or constructed around the world, ensuring more satisfactory ways of living together. It rethinks the way home, cities and neighbourhoods are designed, fi-

4.4.5 THE URBAN VILLAGE PROJECT (Worldwide, 2018)

nanced and shared in the future in order to improve life quality (Archello, 2019).
Their mission is to tackle some of the current problems humanity face in the urban environment, such as loneliness, climate change, lack of affordable housing, fast urbanization, or ageing population, and trying to inspire and engage others towards a more sustainable, circular and beneficial way for everyone.

The project follows 3 main core ideas: Liveability, sustainability and affordability (Urban Village Project, 2019):

· Liveability: Related to the fulfilment of unique people's need, adaptability to the rhythm of daily life and offer support and social life. Community life is the key to achieve this, offering flexibility and boosting a sense of belonging.

- The community at the heart: Enhance of cross-generational shared living communities, combine private and public spaces where people interact with the rest of lively community, share and enjoy the social lifestyle and create real relationships.
- Flexible homes for life: Adaptable apartment types according to single, family or couple situation.
- A fulfilling daily life: Shared facilities and services installed in another block for fulfilling daily requirements and for every type of people, ages and living situations.

· Sustainability: Seen not like a burden but like a natural part of daily life, embedded through the management, design and life cycle of the built environment.

- Sustainable living made simple: Introduction of sustainability in a seamless way, where water collection, renewable energy, local food production and composting are integrated into daily life.
- Built entirely from sustainable wood: Much more benefits when using timber cross-laminated than concrete or steel, such as mental health improvement and environmental advantages.
- Designed for disassembly: Most of the components and construction materials can be disassembled and replaced, reused and recycled, reducing environmental impact and increasing flexibility among users.

· Affordability: In order to make affordable homes real, there is a focus on investors in short term and challenges of existing development models.

- High-quality housing for less: This standardised modular building would be prefabricated, mass-produced and flat packaged, decreasing construction costs and increasing speed.
- Subscribe to your home: There will be an offer of different prices and subscriptions according to every user, such as monthly rate with essentials (electricity, water, heating, maintenance and shared facilities), additional offers (food, media, insurance, transport and recreation) and the possibility to access ownership progressively through buying trimestral "shares" of real state.
- New ways to own your home: There would be a possibility for people to become homeowners by creating housing cooperative, in which "shares" of the property could be bought. After a long time, the property would be owned by the community, in which residents could also sell their shares to the cooperative again.

A digital tool has been created in order to provide more control, enhance community life and connect people to their subscriptions, services and facilities.

Figure 4.4.5.1: Exterior and interior vision of the Urban Village Project (render) (Source: https://www.archdaily.com/918417/ikea-explores-future-urban-living-for-the-many).

Figure 4.4.5.2: Sustainable measures to manage resources within the community (Source: https://www.archdaily.com/918417/ikea-explores-future-urban-living-for-the-many).

4.4.6 DE CEUVEL (Amsterdam, NL, 2012-2014)

· De Ceuvel (Amsterdam, NL, 2012-2014):

De Ceuvel is situated in the old industrial area Buiksloterham and is one of the pioneers of the transformation of that polluted site towards a sustainable residential area. It is a cultural urban hub where innovation, sustainability and art are joined.
It is considered one of the most unique and sustainable urban development complex in Europe. The concept was developed in order to stimulate and find new ways for managing resources in the urban environment, trying to be energy self-sufficient as possible and processing its own waste through innovative ways. Moreover, it tries to be a symbol of vanguard and social transition towards contemporary circular lifestyle, as well as evolve and adapt to different needs over time.

At de Ceuvel, Metabolic it has been installed technologies that capture nutrients from waste streams, filter and collect water, generate energy and monitor resource flows. According to the designers, the clean technology used on-site showcase possibilities in a future circular economy (Projects mcrit, 2015). Its sustainability targets are mainly to achieve 100% water self-sufficiency, 100% wastewater management, 50-70% nutrient recovery and 10-30% on-site food production (Delva Landscape Architects, 2016).
The former contaminated industrial plot has been transformed into this circular economy complex, which consists of these elements: workshop and rented spaces called Metabolic lab (where people can learn and share the knowledge about innovation and circular economy), cafeteria (for enjoying the harvested food), greenhouse, accommodation on floating boats and the rest of biorefinery components (in order to create a sustainable close loop). The designers state that the transition towards a circular economy and society has not to do only with the technical transition but also cultural, where people need to learn new ways of thinking and how to apply techniques and technologies. Influencing people through the cultural programme in the enjoyable and learning rooms (workshops, lectures, music events, films, art exhibitions) will result to an increase of more involvement in sustainability, innovation and art.

The goal was to provide an example of a small scale closed-loop and regenerative urban development using clean technologies for recovering and managing the soil, water, waste, energy and sanitation, at the same time as providing local food production. Moreover, the creative reuse of the waste materials coming from the site represents a key resource where still valuable elements can be extracted. This "clean tech playground" is a space for learning and sharing innovation and creativity, where the goal is to make sustainability concept as tangible, accessible and fun as possible (Deceuvel. 2018).

What makes this unique ecosystem possible is the fact that it has a private smart grid (renewable energy-based), allowing exchanging produced energy to the grid without any market barriers. The main sustainable measures that were applied in this project are (Deceuvel. 2018):

· Retrofitting of old houseboats into new bed and breakfast facility (Recyclability of second-hand materials coming from all The Netherlands).
· Waste classification: Glass, paper, plastic, organic, rest..
· Phytoremediation for cleaning the contaminated soil.
· Windy jetty design (over the purifying park).
· Recycled materials for furniture (Benefit: Upcycling).
· Dry compost toilets (waste is pre-composts in the toilets before being for further treated in the tumbling composter. Benefit: No water is needed and the solid waste can be used by specific treatments they developed).
· Heat exchangers to reuse over 60% of the indoor warm air (heat pumps and an air-to-air heat exchange ventilation systems. Benefit: No gas is needed, only renewable electricity).
· Halophyte filters to process wastewater, biofiltration system for kitchen wastewater (Benefit: Simple constructions where clean water is discharged into the ground through passing different layers: Sand, gravel, shells, plants that consumes organic matter such as nitrogen and phosphorous).
· PV panels (150 panels= 36,000 KWh/year, covering part of the demand).
· Peer to peer blockchain-based energy trading system, the Jouliette. (Benefit: Energy exchange over selling surplus power, thus creating a smart local energy grid).
· Struvita reactors for capturing nutrients from urine waste (Phosphate is recovered and mixed with other local inputs to be used as fertilizer).
· Closed-loop aquaponic farming in the greenhouse (vegetables and herbs).
· Cancellation of the project biogas boot in 2019, becoming the first biogas boat of the world. (Benefit: It would convert organic waste into biogas used for cooking through a biodigester, using the remain digestate as nutrients for plants and insects).

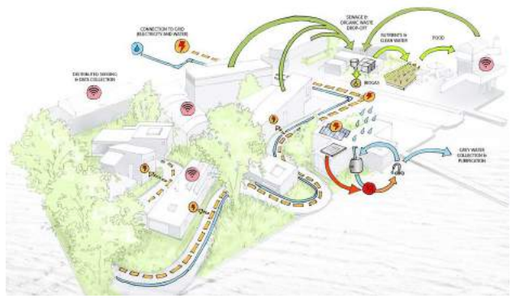


Figure 4.4.6.1: General recirculation of flows in the urban complex (Source: Projects mcrit, 2015).

4.4.7 PARK 20/20 (Hoofddorp, NL, 2010)

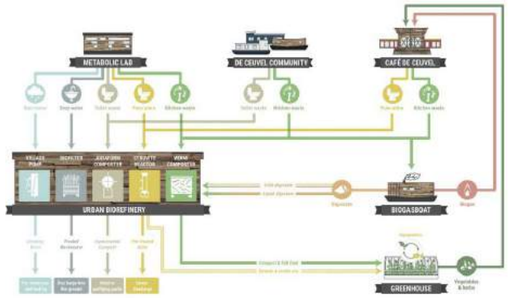


Figure 4.4.6.2: Recovering diagram of energy and other flows in the urban complex (Source: Metabolic, 2018).

· Park 20/20 (Hoofddorp, NL, 2010):

The "Park 20/20" is a master plan project that will be located in the South of Amsterdam, Hoofddorp, close to Schiphol airport. It is the world's first Cradle to Cradle working environment which combines innovation and sustainable designs. The program consists of high-density offices, hotel and office tower, athletic facilities, retail and public open spaces. In the beginning, it was a challenging project due to the inexperience of the Cradle to Cradle concept on an urban scale, but soon became possible and highly effective. The park is a mixed-use, business and retail centre, considered an inspiration model for sustainable design in Europe (Park 2020, 2019).

The result of the landscape design is an inspiring, healthy and productive working atmosphere, able to stimulate and satisfy employees. Values such as sustainability, job satisfaction, recreation and economic growth come together in this open atmosphere. Everything is designed according to the optimal use of natural energy production and resources and additionally, Cradle to Cradle principles. Its aim is to be energy efficient, carbon neutral and if possible, an energy exporter.

This business park uses an optimal ecological approach and performs with closed systems of water and energy in order to achieve completely human wellbeing for the present and future generations. The water and landscape structure function as a part of the water filtration system and a system for green renewable energy that regulates the cold and heat of the buildings.

Inside this complex, a Living Garden (VGH Park) has been designed not only as a green decoration but also as a positive contribution for quality of life, biodiversity and health of people. Landscaping and plant's choice are important for the enhancement of biodiversity, especially for breeding critically endangered animals.

4 core concepts that were followed in the design of the project are (Delta Development Group, 2019):

· Disassembly design (Re-mountability and flexibility).
· Service products (Leasing contracts, increasing recyclability and development of products)
· Productivity and health (green and landscaping design).
· Material banking (Classification in biological or technical nutrients for promoting future recycling).

Moreover, other sustainable measures applied in the project are (Kennon Williams landscape studio, 2019; Delta Development Group, 2019; Park 2020, 2019):

· Passive design (optimum solar and wind orientation).
· Heat and power generation from biogas storage of hot and cold in aquifers.
· Integrated and centralized energy system (quality air and reduction of C02)
· Heat exchange with the shallow underground.
· Storage of heat in insulated containers. Hot and cold storage system.
· Greenhouses and composting program.
· Central water, heating and waste management.
· Water: design of central greywater treatment on-site based on Halophyte filter (irrigation), rainwater collection for toilets and green wastewater treatment from the buildings and park; biogas production.
· Insulated buildings.
· Heating and cooling system for the entire complex, allowing having thermal balanced between buildings, thus, reducing its cost in each building.
· Waste-free, closed-loop design
· Certified materials and reusability (disassembly design).
· Integration of regenerative landscape strategies; ecology and biodiversity.
· Effective district scaled sustainable infrastructure by connecting different uses of buildings.
· Glasses of the buildings are from AGC, the only C2C glass manufacturer in the EU, reducing average costs as more units are needed in the complex.
· PV massive installation, reducing costs per unit and inverter devices need (45 watts/m2 of output).

One fundamental aspect of this project is the connection and sharing system with other buildings, which allows for obtaining greater benefits than a singular building, such as social development, collective and technical opportunities, exchange of neighbourhood flows, etc:

· Treating wastewater: The average costs of treatment (cost per treated unit) is reduced when several buildings are connected (costs is divided by more buildings).
· Material banks: Only worth it when a big amount of materials are available.
· Heating and cooling system for the whole complex.
· PV wide capacity (energy generation), reducing costs per unit and inverter devices need.
· Common recycling management.

4.4.8 CONCLUSIONS & COMPARISONS

Figure 4.4.7.1: Exterior vision of the Park 20/20 Masterplan (render) (Source: Kennon Williams landscape studio, 2019).

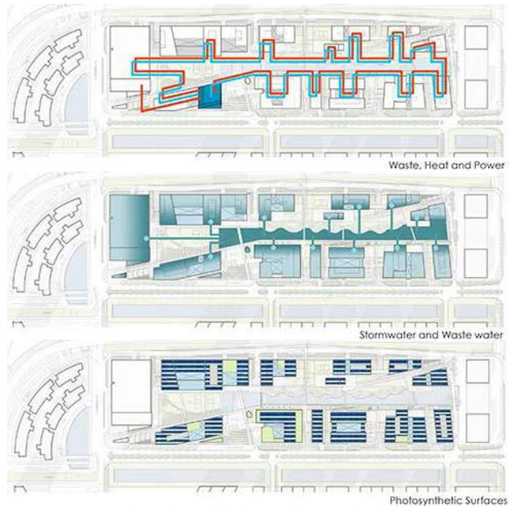


Figure 4.4.7.2: Floor plans of different flows and PV surfaces (Source: William McDonough + Partners, 2019).

· Conclusions and comparisons between projects:

All the cases deal with the flows mentioned in the previous pages, trying to minimise their environmetal impact by selecting the right steps towards circularity.

-Material flows:
The six former cases strive to use as many recyclable materials as possible (material passports), use of leasing contracts and disassembly systems for reusing the materials at the end of the lifespan of the buildings. Specifically, The Urban village and Park 20/20 go for modular design, mass production and prefabrication process in order to decrease average costs per unit and increase speed.
-Water flows:
The majority of the projects have sustainable measures such as water collection, aquaponics, biofiltration systems and reuse of condense water. Specifically, De Ceuvel and Park 20/20 have halophyte filters to process greywater and dry compost toilets were implemented in De Ceuvel due to its unnecessary use of water.
-Food flows:
All the projects have local food production inside or nearby the building, consisting of greenhouses (Park 20/20) or aquaponics (the rest), which allows having greater benefits than traditional agriculture, such as the minimum or non use of soil, less water and energy requirement (LED lighting) and natural filtration. Urban food production is related closely to the other flows, allowing to close the loop and obtain higher benefits for example in the case of organic food-fertilizer-food production pattern. Moreover, measures for preventing food waste is considered in The Greenhouse, where vegetarian menu, seasonal dishes and local products are offered.
-Soil flows:
Innovative techniques allow converting waste into fertilizer, thus increasing and improving the quality of soil. For example in De Ceuvel, struvite reactors are implemented for capturing nutrients from urine waste and use later as fertilizer. Moreover, phytoremediation plants clean naturally the formerly contaminated soil. Composting programs in Park 20/20 and Polydome allow closing the loop regarding waste and improving soil.
-Air quality flows:
Even though that most of the precedent cases have not specific measures focused on the quality of air, there is indirect benefits through the introduction of green areas, reduction of vehicles and reduction of harmful particles coming from toxic materials. Polydome explores a new approach by combining the optimal natural processes from livestock and crop production (CO2-O2).
-Energy flows:
Almost none of the projects achieve zero energy, meaning that they still rely on fossil fuels in some periods of the year, except the case of The Greenhouse.
-Sharing system:
It is important to mention that although most of the projects do not take into account the community where is located, there are much more benefits when sharing and exchanging flows rather than an isolated building. For example, in the Urban Village, exchange of apartments allows flexibility among users, central space for common services allows optimization and recreation, sharing enhance community and cohesion among different types of living situations. Park 20/20 follows also an urbanistic approach, in which it takes into account the connection and sharing feature for boosting social development, collective and technical opportunities and exchange of flows.

Another characteristic to be considered is the social aspect, where people can profit from the design project, such as job generation for the neighbourhood in The Greenhouse or community cohesion and participation in Urban Village.

4.5 | TECHNOLOGY RESEARCH

4.5.1 AQUAPONICS

The objective of this literature study is to briefly describe and find possible low tech but innovative technologies that could be applied in the final design proposal. Therefore, the following systems are the main important ones:

· Aquaponics:

As already known, aquaponics is a sustainable and integrated production system of fish and plants that combines traditional fish farming (aquaculture) with vegetable and fruit farming without soil but with water in a symbiotic environment (hydroponic) (FAO, 2014).

The main benefits of this system are the absence of soil, faster growth due to the continuous nutrient supply, more efficient and less water (70% less) and energy usage compared to a conventional fish and vegetable farming, no use of pesticides or chemicals, close loop, high quality of products, no waste, adaptable to different places, no environmental pollution and biological cultivation. However, this sustainable circulation is not enough for the growing of fish and plants due to the necessity of external food supply for the fish and nutrients for the plants, such as additional iron, calcium, potassium and magnesium. Moreover, other downsides are the little adaptability to different types of crops and fishes, fragility, sufficient knowledge of the system, costs and continuous control on the production (Desima, 2016).

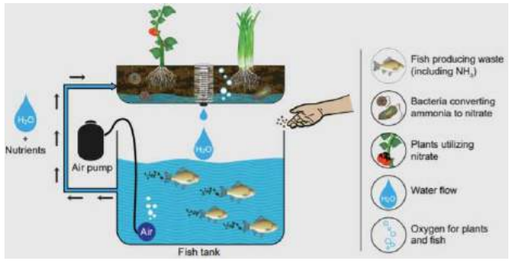


Figure 4.5.1.1: Biological components in the aquaponic process: fish, plants and bacteria (Source: Desima, 2016).

The types of aquaponics system differ in space, type of crop cultivation, environment and technical capabilities. The three main techniques are: Nutrient film technique (NFT), media beds and deep water culture (DWC) (Goering, 2019):

In "Nutrient film technique (NFT)", the waste from the fish becomes the nutrients for the plant, after the mixture is being pumped through specific filters that enable to break the waste down into nitrites and later into nitrates. The plants absorb those nitrates that are in the water pipe in order to grow, and additionally, they are able to filter that water before it gets pumped back into the fish tank.
The advantages and disadvantages of this system are:

· Advantages:

-Continuous supply of water, oxygen, and nutrients
-Space efficiency (vertical disposition)
-Easy to access and harvest
-Lower labor costs
-Less water needed, lightweight

· Disadvantages:

-Susceptible to obstruction
-Filtration needed
-Higher possibility of water temperature fluctuation
-Not suitable for larger or flowering plants

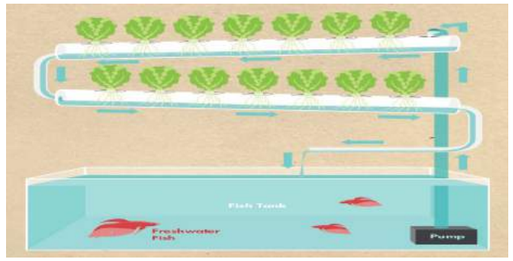


Figure 4.5.1.2:NFT aquaponics system (Source: Desima, 2016).

"Media beds" use containers filled with gravel or expanded clay in order to support the roots of plants. The bed is flooded and drained with nutrient-rich water to give the plants the nutrients and oxygen that they need. Unlike NFT, the media used to support the plants, act as a mechanical and biofilter in order to breakdown the fish waste coming from the fish tank. The advantages and disadvantages of this system are:

· Advantages:

-Grows larger crops well (larger roots)
-Good biofiltration
-Media (soil) acts as filtration
-Simple system, no engineering
-Low implementation costs
-Great for smaller scale system

· Disadvantages:

-Hard to scale for large production
-Higher maintenance and labor (more cleaning)
-Not efficient space
-Weight of the soil

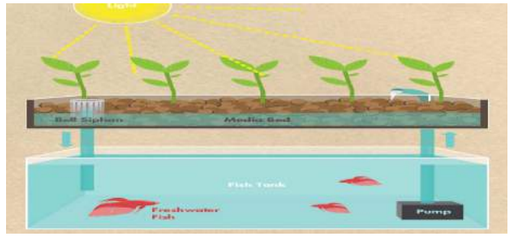


Figure 4.5.1.3: Media bed aquaponics system (Source: Desima, 2016).

4.5.2 RED LSC PHOTOVOLTAIC PANELS

"Deep water culture (DWC)", also known as raft or float systems, it uses floating rafts in order to suspend the roots from the plant into an aerated and nutrient-rich water. The roots of plants float directly into a water tank about 30 cm in depth. In comparison to the previous method, there are no media to process the solid wastes, therefore an additional filtration system needs to be implemented, such as in NFT. The advantages and disadvantages of this system are:

· Advantages:

-Commercial production purposes
-Productive
-Good for warmer tropical climates
-Easy to harvest
-Low temperature and nutrient fluctuations

· Disadvantages:

-Filtration needed
-Higher upfront cost
-Advanced technique's knowledge
-Space efficiency
-Weight of the water tank

Figure 4.5.1.4: DWC aquaponics system (DWC) (Source: Desima, 2016).

A derivation of these systems is the "Vertical grow tower". It consists of a vertical structure but it performs similar to the other systems, especially NFT. The towers are supplied with the nutrient-rich water from a pond type water pump, which is entered from the top, allowing using the gravity in order to flow downwards and providing the plants with the required solution. The remaining water is collected again at the bottom and returned into the fish tank.

In the hypothethical future GH, due to the lightweight and low-tech method requirements, NFT and vertical grow tower seem to be the most beneficial system for the design proposal.

· Red LSC photovoltaic panels:

Luminescent solar concentrator (LSC) is a device made of a type of translucent plastic that has commonly organic dyes inside, so with the internal reflection properties, it enables to concentrate the sunlight usually to the edges. On these edges, photovoltaic cells are attached in order to generate electricity (Debije, 2015) (Figure 4.5.2.1).

The main benefits of LSC are that it works either with direct or diffuse light, working also independent from the direction or angle of the sun rays. Due to its duration and flexibility, it can be shaped in vertical, horizontal or even curve orientation. Its range of colours and transparency is very broad, allowing to be integrated into big or small scale projects.
The downsides are that its energy production is not as high as conventional PVs and that it has not been widely commercialized (Stijn, 2016), although there has been doing several types of research about new materials such Lumogen F Red 305 and Polydimethylsiloxane (LR305-PDMS). Moreover, it has re-absorption losses due to the overlap of the dye's absorption and emission spectra, and dye stability under solar irradiation needs to be considered. However, due to the advantage of its simplicity and lightweight material, transparency, low cost and the possibility to select the specific light that plants need to grow (red colour wavelength), it might be a convenient solution for the design of the chosen greenhouse.

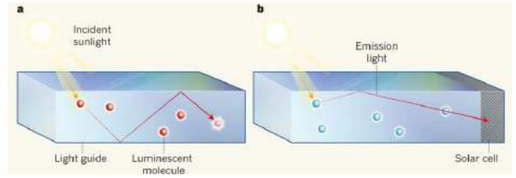


Figure 4.5.2.1: The working principle of the luminescent solar concentrator. a) There is light losses from reabsortion. b) No reabsortion due to luminiscent nanocrystals (Source: Debije, 2015).

LSC panels can vary depending mainly on its configuration, materials and dyes, affecting its final efficiency (Reinders, 2016):

·Type of configuration:
- Solar cells attached to edges of lightguide
- Solar cells at backside of LSC

·Lightguide materials:
- PMMA
- Polycarbonate
- Other polymers
(often reflectors are attached to the lightguide where necessary)

·Dyes:
- Organic dyes (perylenes, coumarines etc)
- Non-organic dyes (Cr3+ Eu3+)
- Quantum dots (PbS)

·Efficiency (example):
In laboratory set-up: 7,1% for a small 5 × 5 × 0.5 cm PMMA LSC with Lumogen F Red305 and Fluorescence Yellow CRS040, reflector sheet and 4 GaAs cells attached to all 4 edges

Figure 4.5.2.2: A potential application of the luminescent solar concentrator in Palais des Congrès in Montreal, Canada (Source: Debije, 2015).

4.5.3 PHASE CHANGE MATERIALS (PCMs)

“LUMO” solar panel (Created in 2011):

These standard densities (SD) panels are based on LSC (88%), but they contain a low density of PV strips (in particular silicon photovoltaic, 12%) that are placed periodically on a panel of glass, allowing sunlight to be transmitted between the strips. A thin layer of the luminescent material (luminescent perylene red dye) is placed at the back of the glass, letting to convert the green light into red light (Soliculture, 2017).

The red light is known to be more efficient for the growth of plants, and in this case, this optimized light spectrum enhances power production in this panel. The company has patented this panel (frameless and customizable size) and believe that placed on roofs, they can save energy consumption until 30% compared to conventional greenhouses. They have proved these panels around the USA, achieving reducing until 1 week of production in some cases (Chalmers, 2018).

The mechanical specifications of this panel (Model 114) are (Soliculture, 2017):

-Length: 200 cm
-Width: 105 cm
-Thickness: 4.2 mm
-Module area: 2.1 m2
-Weight: 20.5 Kg
-Maximum load: 222.7 Kg/m2

The electrical specifications are:

-Maximum power (Pmax): 115 W
-Maximum power voltage (Vmp): 13.6 V
-Maximum power current: 8.4 A
-Open circuit voltage (Voc): 17.3 V
-Short circuit current (Isc): 9.2 A
-Connector type: Amphenol H4
-Module efficiency: 7%

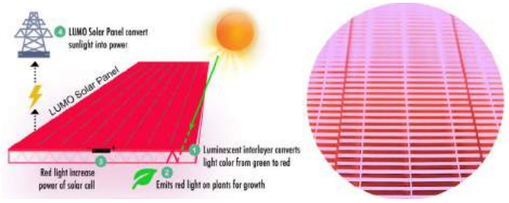


Figure 4.5.2.3: A schematic shows LUMO’s enhanced red light both increases electricity production and optimizes the light spectrum for plant growth (Source: Soliculture, 2017).

Apart from the design module with straight stripes (Figure 4.5.2.3), several studies have stated that “Criss Cross” design panel is the most efficient one, achieving an energy performance of around 1,342 kWh/year in a greenhouse of 22.3 m2 (Corrado et al., 2016).

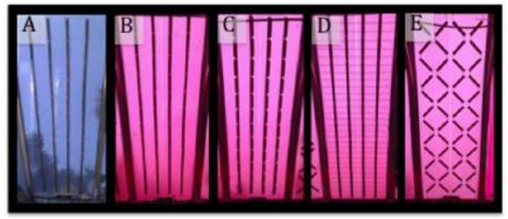


Figure 4.5.2.4: Different panel designs: A) Clear; B) Straight; C) Edge Cells; D) Polycrystalline; E) Criss Cross (Source: Corrado, C. et al., 2016).

· Phase change materials (PCMs):

Thermal energy storage systems using phase change materials (PCMs) can be very useful in order to improve the indoor thermal performance of one space, when placed on the inner side of the facade envelope for example.

As already known, they can store and release thermal energy during the process of melting and freezing, changing from one phase to another one. When this material freezes, it releases a large amount of energy in the form of latent fusion heat or crystallization energy. Conversely, when the material melts, the same amount of energy is absorbed from the environment nearby in order to transform from solid to liquid (PCM products, 2018). PCMs are able to manage internal temperatures effectively and efficiently, reducing the consumption of HVAC systems and providing a comfortable and consistent working environment. PCMs also provide an efficient means of bulk thermal storage, reducing energy use during peak demand periods, reducing or shaving peak demand charges (Greencastle innovation, 2018).

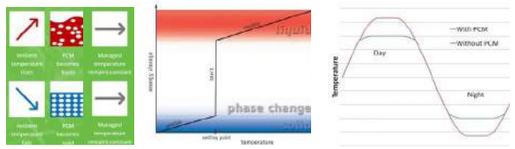


Figure 4.5.3.1: PCM principle and function (Source: Greencastle innovation, 2018).

The composition of this material can be broad, for example (Climate Tech Wiki, 2018):

·Eutectics: It consists usually on solutions of salts in water with a phase change temperature below 0°C.

·Inorganic materials (salt hydrates): These specific salts are able to incorporate crystallization water during the freezing phase, and their phase change temperature is above 0°C (greater phase change enthalpy). The benefits of these materials are: high latent heat values, non-flammable, low-cost and readily available. However, the disadvantages of inorganic PCMs have led to the investigation of organic PCMs. Some of these disadvantages are corrosiveness, instability, improper re-solidification and a tendency to supercool.

·Organic materials (parafins): Briefly, they tend to be polymers with long-chain molecules composed mainly of carbon and hydrogen. They experience higher levels of crystallinity when freezing, mostly above 0°C. The advantages of these are that are chemically more stable than the previous group, which means that they melt congruently and supercooling does not carriage as a significant problem. Moreover, they are more compatible with absorption into several building materials and they are not corrosive. However, they are flammable and have lower phase change enthalpy, they may generate harmful fumes on combustion, low thermal conductivity and the reaction with concrete hydration might cause some minor problems. Fortunately, the appropriate selection and modification of the composition of these materials have eliminated most of these undesired problems.

The main benefits of these materials are their lightweight solution for thermal mass and their smooth way to control interior temperature (gradually).
There are several ways to implement PCM in the built environment, such as in metal sheets, ice packs, plastic encapsulation, with modified PCM, pouches, bespoke, etc. Several companies have developed their own product in order to implement on the walls, roofs or flooring, such as: Insolcorp (infinite R panel), EcoCore panels, GlassX’s Crystal product, Dupont Energain (BioPCM), BASF (Micronal PCM), etc.

Micronal PCM product:

This product was introduced by the company BASF around 2004 and it consists of a paraffin wax storage medium inside a microscopically small acrylic plastic sphere, which is able to melt and solidify. PCM is encapsulated in a high strength acrylic polymer shell, which makes it durable after several decades. The main benefits are that there are no heat losses and it can be easily incorporated into a standard construction material such as gypsum, cement or wood fibres. For example, Knauf has developed “Knauf PCM SmartBoard” with this product, where they state that two layers of 1.5 cm Knauf PCM SmartBoard could provide the same thermal capacity as 36.5 cm vertically perforated brick or 14 cm concrete wall (Mclaren, 2015).

Inifite R panel:

Infinite R panel consists of a multilayer panel, where PCM gel is placed in a multitude of pockets in a flexible plastic roll film located behind the latest board. The material of PCM is salt hydrate and when it is installed within a structure wall, it actively stabilizes the interior temperature of the room, absorbing heat when the temperature exceeds the desired target and releasing heat when the temperature drops below that target. According to the company, the panel is 100% natural, using mineral-based raw materials such as salts, clay and water (Greencastle innovation, 2018).

The advantages of this panel are:

-Reduced energy costs, up to 40% (carbon footprint reduction)
-Increased comfort
-Thin, lightweight
-Easy to install
-Store “off-peak” for daytime use
-Fast Payback: Heating & cooling savings
-Fire resistant (A)
-Non toxic and 100% natural

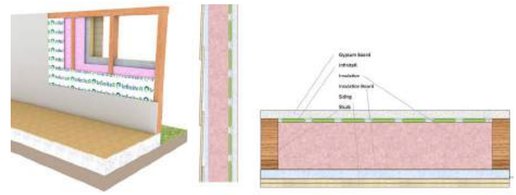


Figure 4.5.3.2: Collocation of Inifite R for cold climates (Source: Greencastle innovation, 2018).

In the hypothetical design proposal of any partition wall (mainly in the GH), a PCM sheet of this similar type could be installed in the inner surface of the walls, due to its lower cost compared to other thermal products, easy maintenance and high benefits compared to the standard partition wall. In this way during winter, the amount of sunlight can be stored during daylight (melting and absorbing heat; reducing the temperature of the room) and release it during the night, allowing reducing the heat consumption and increasing indoor comfort. Conversely, in summer, the low temperature reached at night could be released during the day in order to reduce the cooling. According to simulations studies in greenhouses, PCMs could reduce until 20% of the total heat demand during one winter season (Greencastle innovation, 2018).
The conventional system that was traditionally used in a greenhouse in order to store the heat was based on water storage tanks. However, PCM within a wall is designed due to its higher efficiency. The advantages and disadvantages of using PCM over conventional water storage techniques are described (Liu et al., 2016):

Advantages:

- Higher thermal energy storage capacity compared to the sensible energy storage in water, enabling to introduce smaller storages.
- Constant temperature during charging and discharging.
- Burner cycles for the back-up generation unit and therefore their CO and HC emissions can be reduced.

Disadvantages:

- Higher investment costs
- Peak power during discharge is limited due to limited heat conduction in the solid state of PCM.
- Limited experience with long-term operation of many thousands of charge-discharge cycles.
- Risks of loss of stability of the solution and deterioration of the encapsulation material.

4.6 | DESIGN FRAMEWORK

4.6.1 DESIGN STRATEGY

The previous sub-chapters of the theoretical framework were useful in order to get an idea of the measures that could be used for creating general strategies within the design framework, such as sustainable measures from *Precedent studies*, *Circular economy* principle, *Urban synergy* concept or some low tech ideas from *Technology research.*

·1 Vision:

Before starting to work on the transformation and improvement of the urban context, a refresh of the definition of the vision is needed to guide future work. From chapter 2.4 *Problem statement*, a vision and research objective was defined, being the purpose as following:

To redesign a Lidl supermarket according to SCE principles, functioning as a social and circular facility in synergy with its local urban context, in order to help to achieve Sustainable Development Goals (SDGs) and improve the urban metabolism in Spangen.

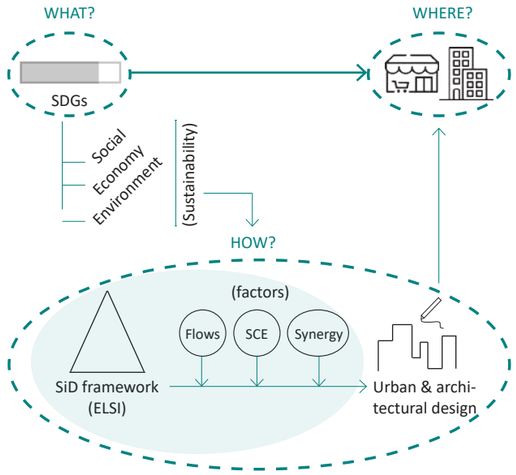


Figure 4.6.1.1: Summary of the vision and process, being design framework highlighted in green shadow.

·2 Design framework:

As described before, SDGs are deeply related to the concept of "sustainability", consisting of the equal balance of three dimensions (United Nations ESCAP, 2015). Due to the complexity of this concept and the need to integrate the social dimension in the final proposal, the Symbiosis in Design (SiD) framework developed by Tom Bosschaert in 2001, is aimed to be used as an inspiration guideline. SiD is an integrated sustainable development model that consists of different levels, in which ELSI (at object level) corresponds to the most used tool of SiD (Bosschaert & Van Zuthem, 2018).

There are five categories in ELSI, being:

· Energy & Materials (Matter)
· Life (Species & Ecosystems)
· Society (Economy & Culture)
· Individual (Health & Happiness)
·(Actions)

These categories are interconnected among them, where each block form the basis for the next top one, and additionally, related to 3 dimensions (space, time and context). For example, all materials are made from energy, all ecosystems are made of materials, the economy is a subset of culture, and individuals are part of a society, and so on (pyramid order). Moreover, ELSI takes into account three dimensions (space, time and context) and can be represented in various ways; more generally or detailed one (Bosschaert & Van Zuthem, 2018).

Figure 4.6.1.2: SiD ELSI diagram (Source: Bosschaert & van Zuthem, 2018).

· 2a Action areas:

SiD ELSI diagram is updated to current context and issues of this century, so the new design framework is inspired by this but with a slight adaptation in order to be aligned with the purpose of this report (Figure 4.6.1.4).

The future design will be adapted to the local citizen's demand and desires, providing rights and opportunities for everyone. Therefore the proposal will try to respond to the issues occurring within the four categories: sources, life, society and individuals.
In order to consider all aspects in a more efficient way and achieve SDGs, there is a need to work simultaneously in the whole eight action areas. Furthermore, these action areas are linked to each other and will need to be addressed all of them preferably from bottom to top, but not necessarily in a specific order.

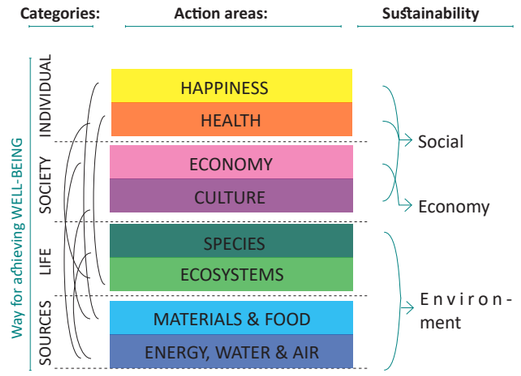


Figure 4.6.1.4: SiD ELSI adapted to the requirements of this report and linked to the three dimensions of sustainability.

The reasons for selecting these action areas are supported by the objectives of this thesis (MIMVU, 2017):

·A Material, food and flows (Sources): There is a need to recognize and defend the natural resources of the local context, increasing efficiency and protection, at the same time as decreasing new inputs resources or waste. The future proposal will need to understand the natural flows and urban metabolism, as well as be integrated with the natural systems of the place, preserving and nurturing its ecological functions.

·B Species and ecosystems (Life): The recognition of natural environment and ecosystems are vital for the equilibrium between human and nature, at the same time as fostering local species and diversity. Several factors of ecosystems should be preserved, understanding the views, buildings, vegetation, urban fabric, species or scale, to name a few.

·C Economy and culture (Society): There is a need to boost local economic activities, cultural or recreation activities, being the basics for living, but always related to the context and local demands. Success spatial systems offer opportunities for the development of all types of activities, such as cultural (art and entertainment), recreational (game and sport), economical (business and participation) and civic life (politics and tradition).
Segregation into public, semipublic or private spaces is needed for being adaptable to each demand and use. Additionally, high opportunities occur in these spaces, being able to generate different stimulations and connections between people.
Social integration, welcoming and quality of spaces, where activities and social life can take place in, will result in higher economic development and greater impact on the surrounding commercial activities.

·D Happiness and health (Individual): Marginalization should be reduced, being necessary to increase social and cultural biodiversity for enhancing integration, cohesion, participation, mental health, etc.
Moreover, universal accessibility should be provided for all individuals, reducing undesired barriers and improving safety in favour of citizens (pedestrians). Therefore open, adaptable and welcoming spaces are essential for boosting integration, overcoming prejudices or stabilising emotional connection between all community members.
Spaces designed for people should be returned, trying to enhance and reinforce the five natural senses (taste, hearing, sight, smell, touch) for acquiring new experiences, perceptions, feelings, etc.

· 2b Indicators:

The previous action areas are quite generic and cannot be evaluated and addressed on their own. An indicator is a quantitative or qualitative measure that simplifies and communicates the reality of a complex situation (Gehl Institute, 2018). So there has been defined several indicators that enable to evaluate and solve the issues happening in each action area, similarly to the SDGs situation. For example, to achieve good *Health*, accessibility, circulation, air quality and safety would need to be tackled.
These indicators were defined according to the thesis objectives and supported by urban reports such as "Recommendations for urban analysis and design" of Ministry of housing and urbanism of Chile (MINVU) and "Inclusive healthy places" (MIMVU, 2017; Gehl Institute, 2018):

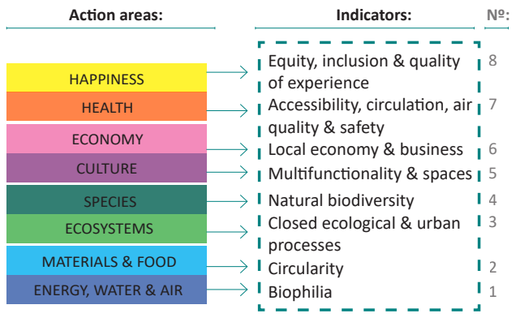


Figure 4.6.1.5: Principal indicators for each action areas for the achievement of SDGs.

· 2c Strategies:

For each indicator, there has been developed a general catalogue of strategies, for outdoor or indoor spaces, in order to address each action area and achieve the final objectives (SDGs and sustainability). General circular solution routes and interrelation between flows and SDGs were considered within the strategies. Due to the broad range of possibilities, only the main important strategies related to the aim of this thesis are described, which are also reasonably supported by the previous reports (MIMVU, 2017; Gehl Institute, 2018).
General strategies were developed due to the lack of specific context analysis. But later on, in the design process for Spangen and Lidl, specific strategies will need to be selected and grouped according to the specific context situation (Figure 4.4.1.6). Table 4.1.1.1 represents the catalogue of general strategies and some examples of translation to spatial designs, which later adaptations will be needed according to the local context. As said before, the order for applying each strategy and solving those action areas is not conditioned from bottom to top order, as long as all of them are evaluated.

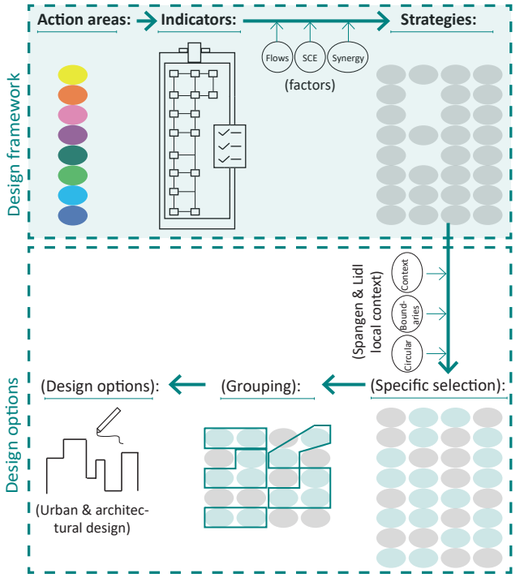


Figure 4.6.1.6: Summary of the design framework and rest of the process for achieving the final proposal.

A- Sources & materials (Sources):

Indicator	Strategy	Code	Description
1-Biophilia	Smart use of local natural resources	A1	Designing with basic natural elements such as water or earth brings great potentials to space, decreasing the necessity of outdoors inputs. For example, water offers tools for improving climate conditions during hot days, increasing humidity, reducing Urban Heat Island (UHI), encouraging game activities, biodiversity and coexistence within the space.
	Profit of climatology	A2	Smart adaptation and profit from climate conditions leads to less efforts and rise of efficiency.
	Shelter against climatology	A3	Passive design play an important role, in which natural shelter should be searched. For example, trees provide natural shadow, shelter from rain and sun flashes.
2- Circularity	Low tech measures and circularity of materials	A4	Smart and sustainable use of natural resources should be considered at the design phase and following a hierarchy of sources: Reduce, reuse, recycle. Moreover, low technology and synergy between facilities should be followed.
	Low tech measures and circularity of water	A5	Smart and sustainable use of natural resources should be considered at the design phase and following a hierarchy of sources: Reduce, reuse, recycle. Moreover, low technology and synergy between facilities should be followed (llocal treatments, rainwater collection, underground storage..)
	Low tech measures and circularity of energy	A6	Smart and sustainable use of natural resources should be considered at the design phase and following a hierarchy of sources: Reduce, reuse, recycle. Moreover, low technology and synergy between facilities should be followed (heat district, local energy production, biogas, waste heat reuse..)
	Low tech measures and circularity of food	A7	Smart and sustainable use of natural resources should be considered at the design phase and following a hierarchy of sources: Reduce, reuse, recycle. Moreover, low technology and synergy between facilities should be followed (composting, reprocess on-site food waste, food production..)

Indicator	Strategy	Code	Description
2- Circularity	Low tech measures and circularity of air	A8	Smart and sustainable use of natural resources should be considered at the design phase (combination of animals and plants, vegetation, hotocatalysts materials...). Combination of air polluters and filters would be beneficial for improving air quality.

Table 4.6.1.1: Strategies and conversion to spatial design for the action area: Sources and materials, and category: Sources

B- Species & ecosystems (Life):

Indicator	Strategy	Code	Description
3- Closed ecological & urban processes	Connection to natural system	B1	Every space get benefits from a direct ecological connection with the surrounding natural systems, so the design should establish this ecological path by presence of water, greenery, animals, eath paths (soft) over concrete surfaces (hard)...
	Visible ecological processes	B2	Visible and understandable ecological process encourage the emotional connection of the community members with the space. Moreover, those ecological process should be not static but healthy, diverse, resilient and complete (visible water natural purification, bee hubs, bird nest..).
	Understanding ecosystem and preserve them	B3	The new design should respect the natural characteristics of the space, understanding the natural process of water, living species, etc. When possible, improvement of process and close of loops will be performed by adding or removing factors.
	Understanding urban factors and preserve them	B4	The new design should respect the characteristics of the space, understanding spatial uses, morphology, movement of people, etc. Moreover, it should preserve architectural elements, enhance the cultural heritage and architecture, emphasize local uses, events, memories and local identity (alignment with the existing geographic features, respect of typologies urban fabric by reinforcing its legibility and its presence, materiality, texture and colours adapted to the site..).
4- Natural biodiversity	Natural biodiversity	B5	Increasing natural biodiversity results in greater possibilities to create interconnections and interactions due to different species. Moreover, variety results in a more reach value and quality of the space. Creation of diverse floral and fauna landscape is appreciated by users, especially singing birds, butterflies, aesthetic and colourful vegetation, etc. Other possibilities are: Different typology of plants, trees, animals, shrubs, different dimensions, colours, smells, ...
	Local species	B6	By enhancing the introduction of local species, not only creates cultural and valuable space for citizens within the context but also encourages the preservation of local identity and more efficient settlement and use of resources due to local species are adapted to the local context.

Table 4.6.1.2: Strategies and conversion to spatial design for the action area: Species and ecosystems, and category: Life

C- Culture & economy (Society):

Indicator	Strategy	Code	Description
5- Multifunctionality	Multifunctionality	C1	Spaces should be designed for encouraging to develop a variety of recreational activities (flexible, open, wide and adaptable spaces). The diversity of the spaces attracts people of different social groups, ages, genders and culture, increasing the diversity of users.
	Active spaces	C2	Diverse type of activities should be included, such as physical (sports, dancing), recreational (games, eating), cultural (teaching, learning, exposition, music...) and social activities (chatting).
	Passive spaces	C3	Actions like resting, reflection, observation, sitting spaces should be also encouraged by **ergonomic** benches, privacy and protection, views and right orientation, peaceful natural sound (birds, water...). Passive activities are also desired and allow people enjoying peace and views. It is another form of interaction between the surrounding environment and people.

Indicator	Strategy	Code	Description
5- Multifunctionality	Coordination of activities	C4	Furniture and facilities for diverse activities are not enough for ensuring the quality development of activities. There is a need to involve administrative organizations or neighbourhood associations in order to keep an active role in the organization and coordination of the activities. Moreover, they are likely to promote ongoing community development, being crucial for improving social resilience.
5- Comfort spaces	Human scale	C5	Spaces should be designed for humans, being necessary to pay attention to proportions and satisfy the demand of users (small dimension of furniture and spaces for enhancing social interaction).
	Subdivision of big spaces	C6	Usually, big spaces are cold and reduce the possibility of social interaction and comfortability.
	Avoid sudden changes in level	C7	Changes in level have not only consequences in accessibility but also in the visual connection of the landscape, therefore gradual and soft changes in level are aimed.
	Climate	C8	Profiting the positive aspects of climatology, allowing the creation of favourable microclimate. Moreover, shelter from climatology is needed in order to protect users and ensure their satisfaction.
	Well maintenance of spaces	C9	Keeping the spaces clean and in good state reduce the risks of having vandalism and starting the degradation process of the area. Moreover, the lifespan of installations can be extended and users can still enjoy them. Well-kept spaces also promote respectful behaviour of their users.
6- Local economy & business	Business ecology	C10	Business and public spaces have symbiotic relation because spaces obtain great benefits from the business area (active space) and business obtain benefits from the proximity of streets, being safety and nice area to walk and pass time (permeable facade, terrace, stores with attractive showcases...).
	Local market	C11	Markets are a great vital focus in urban life, extending its vitality towards other proximity areas.
	Fairs and temporary markets	C12	Fairs and temporary markets activate spaces in an efficient and quick way, at the same time as exchanging economical benefits.
	Gastronomy	C13	Gastronomy plays an important role, not only for the local economy but also for the activation of spaces. Flexible and adaptable gastronomy should be searched in order to encourage streets and satisfy the local demands at any time and to everyone (food production, restaurant, selling point..).
	Local employment	C14	The local economy is favoured when income and expenses stay in the area or neighbourhood. In order to improve the situation, employment rates should be raised, and additionally, recruiting first of all, woman, disadvantaged people and citizens in need.
	Partnership with local business	C15	Small local business should look for cooperation in order to increase visibility and other benefits.

Table 4.6.1.3: Strategies and conversion to spatial design for the action area: Culture and economy, and category: Society.

D- Health & happiness (Individual):

Indicator	Strategy	Code	Description
7- Accessibility	Multimodality	D1	The project should give priority to sustainable and healthy modes of transport, such as pedestrian, bicycle and public transport. Although there should be a differentiation between motor vehicles and pedestrians (+ bicycles) through change texture of surfaces, obstacles or furniture...
	Direct and welcoming access	D2	Spaces should provide direct and easy access for pedestrians and bicycles (wide access and hall in the entrance). Access needs to be easily identifiable, understandable, safe, comfortable and direct (ramps and lifts if needed). Moreover, the connection between border and centre should be smooth and without obstacles, in favour of permeability (remove borders in the perimeter of spaces).
	Universal accessibility	D3	Obstacles and architectural barriers should be removed in order to enhance those people with reduced mobility, such as elderly people or in a chair.

Indicator	Strategy	Code	Description
7- Circulation	Legibility	D4	The spaces of the proposal should be understandable for the users, who should be able to orientate and move freely around the space (easy recognition of paths through eye-catching furniture, sculpture, etc). Moreover, the introduction of clear visual lines in the project will be useful for allowing people to know where to go and locate the objects that are next to them.
	People circulation	D5	In high flow areas, there is a need to make a difference between active and passive spaces through different pavement, furniture organization, etc. Identification of natural tendencies of people should be analysed, in order to respect and enhance their pedestrian trajectory.
	Co-living streets	D6	Co-living streets are spaces where all modes of transport (pedestrians, bikes and motor vehicles) can circulate around the same space without the necessity of segregation. As the case of "Superblock" in Barcelona, the fact of sharing allows citizens to obtain wider spaces, and reduce velocity.
7- Air quality	Air purification	D7	Air contains many pollutants that are harmful to health, being air purifiers, greenery, etc needed.
	Traffic protection	D8	The existence of motor vehicles should be reduced, ensuring safety among vulnerable users and avoiding obstructing pedestrian circulation (remove car presence, change in pavement...).
	Lighting (& well maintenance of spaces)	D9	During the night, lighting is essential in order to provide a sense of protection among users. It is important to use lamps with appropriate tone and value of light, avoiding contrasts between bright and dark areas. LED lighting and transparent walls (glazing) are preferred.
7- Safety	Connection interior-exterior	D10	Indoor activities and outdoor activities should be mixed and interconnected through the permeable facade. By having a closed facade, outdoor spaces could enter in desolation condition or insecurity and vice versa. Moreover, views improve security and perception of the space.
	Active and lively spaces 18h/day	D11	Keeping active spaces during the whole day ensure safety and can reduce criminality and vandalism.
8- Equity & inclusion	Integration over segregation	D12	Spaces should be designed for social integration and co-living of different groups of the community, emphasizing mixing spaces, because no individuals or groups should feel excluded.
	Diversity	D13	Activities and spaces should be designed for all genders, ages and ethnicities, as well as activities for groups, couples or individuals. For example, a space where there is a balance of gender among users, it is perceived as more safe and inclusive area.
	Gradients in privacy & public spaces	D14	In order to make more appealing the spaces and invite everyone to join, there is a need to provide different levels of privacy, including semiprivate or semipublic spaces. The variety and connection between these levels of privacy result in multiple interaction possibilities. People can choose between having passive participation (observation) or else being in the core of the activity.
	Visible identity	D15	An interesting way to create an identity and feel part of a community is the introduction of personal or culture details that brings memories to people and allows to feel close to home.
8- Quality of experience	Stimulation of sight	D16	The majority of the stimulus that is perceived come from sight, being important to consider it. Moreover, important aspects should be placed at the level of the eyes rather than at higher levels.
	Stimulation of hearing	D17	Many outdoor spaces suffer from a high level of noise contamination, so reduction of undesired noise is aimed by placing barriers or other acoustic scenarios. Sounds from natural processes such as water or animals might improve the quality of space and boost interior peace among users.
	Stimulation of smell	D18	Project should enhance smell sense, which could generate some of the most vivid memories of user's experiences. Undesired smells should be reduced as much as possible by introduction or combination of bad and good smells.
	Stimulation of touch	D19	Each material reacts different according to cold or hot temperatures, generating higher comfort and benefits if it is chosen properly according to climate conditions. Textures on surfaces play also an important role, being nice or not to the skin feeling.
	Stimulation of taste	D20	Even though it is not very common, the project could provide new taste experience through fresh organic food, cafeteria..

Table 4.6.1.4: Strategies and conversion to spatial design for the action area: Health and happiness, and category: Individual.

05 ANALYTICAL FRAMEWORK

5.1 | SPANGEN

5.1.1 CLIMATOLOGY ANALYSIS

For the implementation of the future proposal, it is important to understand and analyse, in general, the natural factors such as climate context in order to profit as much as possible the natural resources of Spangen (World weather online, n.d; (Meteoblue, n.d.).

Temperature:
Based on the latest performance, the average temperature in Spangen can be from 7 °C in December until 21 °C in August, whereas the minimum temperature can reach 4 °C in January and a maximum of 23 °C in July. These temperatures will influence the future outdoor activities, crop temperatures requirement, energy production, etc.

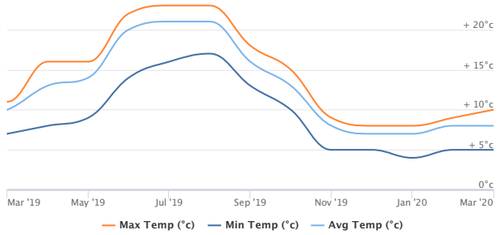


Figure 5.1.1.1: Maximum, minimum and average temperature (°C) (Source: World weather online, n.d).

Rainfall and rainy days:
The annual precipitation in Rotterdam is around 782 mm/year and an average of 60 mm/month. According to Figure 5.1.1.2, April is the month with least rain in Spangen, occurring during 15 days and an amount of 24.7 mm. On the contrary, a maximum of 25 rainy days occurs in February, accounting for 105.6 mm.
It generally, Spangen is a rainy area, having rain every month during the whole year and around an average of 20 days per month. This is a beneficial aspect to consider in the design due to the potential water collection capacity.

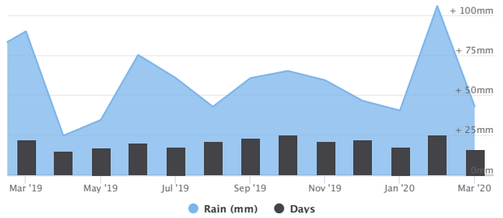


Figure 5.1.1.2: Average rainfall amount (mm) and rainy days in Spangen (Source: World weather online, n.d).

Snowfall and snow days:
There has been little snowfall in the last period, barely being the highest amount occurring in February during 2 days, resulting in around 14.2 cm of snow. In general, as the temperature of the Earth arises, there is a trend in less cold winters and hotter summers.

Wind:
Wind in Spangen is relatively low during spring, summer and autumn, reaching around 14 Km/h, although it can reach an average peak of 27.2 Km/h, maximum wind speed of 34.9 Km/h and gust of 41.1 Km/h in February.
The predominant direction of the wind comes from the South West side, having a wind speed of around 19-25 Km/h during an average of 341 h/year (Meteoblue, n.d.). However, even though in the rest of areas wind blows softer, North-West and North-East direction should be also considered in the future design.

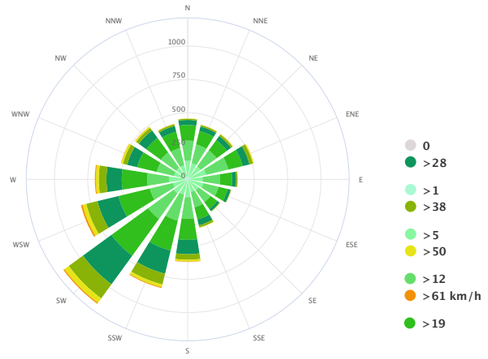


Figure 5.1.1.3: Windrose in Spangen (Source: Meteoblue, n.d.).

Cloud and humidity:
The Netherlands and Spangen is a humidity area, reaching the least humidity in April (63%) and a maximum of 83% humidity in January. Moreover, the least cloudy period occurs in April (38%) whereas in February reaches 73%.

This will have effects on the final proposal regarding energy production, outdoor activities, future crops, material outdoor resistance, etc.

Sun hours and sun days:
October is the month where least sunny days are (3 days) and February where least sun hours are (95 sun hours). However, the peak sun hours occurs in June with 323.5 h and the higher sunny days occur in March and April (15 sunny days/month). The number of hours will affect indirectly the well-being of people in Spagen because, from own experience and observation, citizens are likely to sunbathe and enjoy sun rays whenever they can. Moreover, this will influence the possible crop production, outdoor areas and activities, life on streets, etc.

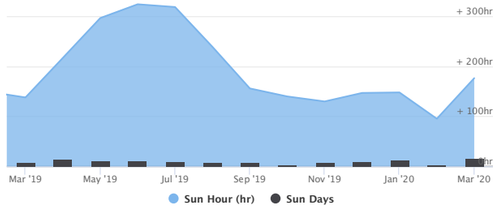


Figure 5.1.1.4: Average sun hours and sun days in Spangen (Source: World weather online, n.d).

5.1.2 URBAN CONTEXT & FACILITIES

Spangen is one of the 9 neighbourhoods of Rotterdam, belonging to Delftshaven district, and consisting of around 65 ha of extension and around 10,400 habitants (Wijnstekers, 2018). It is the neighbourhood that is aimed to be improved, not only from an ecological perspective, but also from a social one, so an brief analysis of its historical, urban context and facilities is developed.

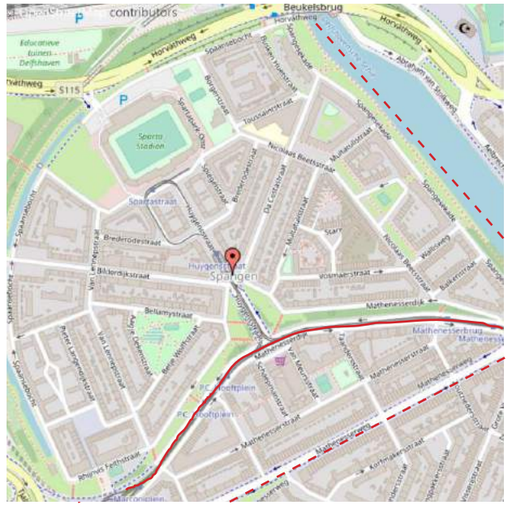


Figure 5.1.2.1: Map of Spangen, with main important street (red line) and boundaries names (dash red line) (Source: https://www.cadcollege.nl/cadtools/Conversie/Kaarten_AutoCAD.htm). N

Figure 5.1.2.2: Aerial view from South of Spangen neighbourhood (Source: https://www.aerophotostock.com/media/b0ac62f2-cc04-4dec-99d5-97399b366851-spangen-rotterdam-nederland-30-juni-2015-spangen-is-eenwijk).

· Historical context:
It is important to understand the factors that marked its socio-economical development until its current decadent situation, because opposite of what is today, Spangen was constructed 80 years ago (around 1920) and it was considered a sign of promise (Burgers & Kloosterman, 1996).

Although there have been efforts for slowing down its degrading pace, Spangen is one of the many Western neighbourhoods that still trying to get out from the misery and effects of economical restructure that began in 1970.
The early industrialization and end of capitalism brought social misery and marked the end of the traditional Spangen. The demand increase of skilled jobs (mostly services) from unskilled type, along with the automation or relocation of factories, has put the traditional working-class out of work (Burgers & Kloosterman, 1996). Moreover, from 1970, there was an increase of migrants looking for affordable and cheap houses, changing its demographic and low-income population and resulting in a declination of population and socioeconomic base. In the end, along with the declination and location change of Sparta Stadium, led to the promotion of Spangen as an extremely dangerous neighbourhood around 1990, increasing more its degradation process (Wikipedia, 2018).

· Urban context:
Spangen has approximately a symmetric and round shape, being the boundaries delimited by the Delfshavense Schie (East), Spaanseebocht (West) and Mathenesserweg (South), as seen in Figure 5.1.2.1 with red dash lines. Although a bridge over Delfshavense Schie was constructed, there is still nowadays noticing a differential level of the ground that splits Spangen into two areas due to the Mathenesserdijk and the railway (Rotterdam Lives Foundation, n.d.) (Figure 5.1.2.1 in red line).

The urban planning of the neighbourhood has been thoroughly designed, following concepts of hierarchy, orientation and monumentality. Moreover, greenery has been an integral part of the urban design too, having 3 main green parks, squares and several trees along the main streets. In general, Spangen has good public access, being the main access routes through Mathenesserweg with Mathenesserbrug, which connects with Middeland / Het Nieuwe Westen areas on East side and Marconiplein and Tjalklaan on West side. On the North side, Horváthweg forms the main access route and in direction to NS Schieveste station and Rotterdam central (Gemeente Rotterdam, n.d.). The residential area is the result of several housing projects, having and sharing communal courtyards, and most of the facilities are located in Mathenesserplein and along the Mathenesserweg street. Residential houses are formed by 15 different sets, which is a combination of several building blocks that have similar a architectural design (Gemeente Rotterdam, n.d.)

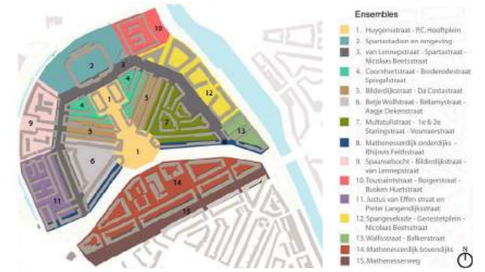


Figure 5.1.2.3: Different 15 sets that exist in Spangen's residential houses (Source: Gemeente Rotterdam, n.d.). N

5.1.2 URBAN CONTEXT & FACILITIES

· Facilities:

Spangen has 4 national monumental buildings, being Het Justus van Effenblok, Het Kasteel of Spartastadion, construction block of Mathenessedijk/Spangesekade and Mathenesserhof (Steenhuis stedenbow, 2009). Regarding amenities, there are 4 primary schools, restaurants, supermarkets, hairdressers, parks, clubs, among others, but with lack of cultural or administrative buildings.

As said before, the differential level of the ground splits Spangen into two areas, in which it can be noticed that the Southern part has a more integrated neighbourhood, it lacks of social and sportive activites characterized from the Northern side. In order to balance the two areas of Spangen, as well as considering the location of Lidl (green colour), the Southern part (orange) is chosen as the first area of study. However, it might occur later that the study area needs to be scaled up and increase the initial boundaries in order to obtain greater synergy within the community and facilities of the neighbourhood.

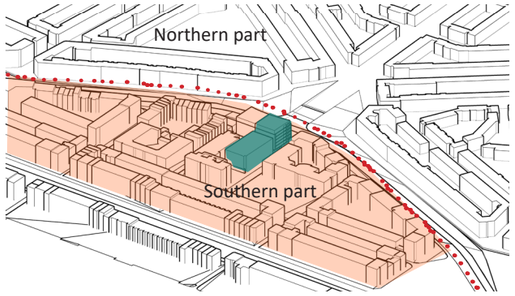


Figure 5.1.2.4: 3D model with delimitation of study area (Southern area, from South-East).

Figure 5.1.2.5: Aerial view of Lidl urban area (from North-East) (Source: Google maps).

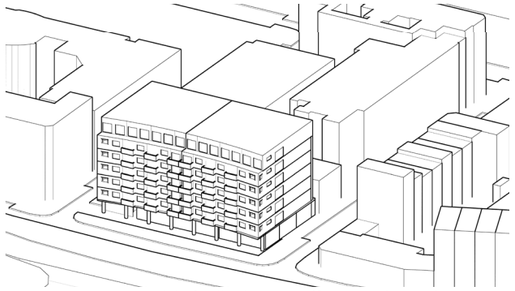


Figure 5.1.2.6: 3D model of Lidl urban area (from North-West)

According to a thorough analysis conducted with the help of Google maps and fieldwork, the number of households in this Southern area is 1,264. Considering an average of 2.19 people in a household (The Netherlands Nutrition Centre Foundation, 2019), the total number of population is 2,768 in this Southern area.

Figure 5.1.2.7: Floor plan of Southern area of Spangen with block's letter.

SPANGEN NEIGHBOURHOOD (Southern part)				
BLOCK	DESCRIPTION BLOCK	Nº HOUSEHOLDS	TOTAL Nº HOUSEHOLDS	POPULATION
Letter	-	Figures	Total figures	(average of 2.19 people per household)
A	Lidl	42+44	155	339.45
		42		
		27		
B	Upper left corner	114	114	249.66
C	Residence	64	126	275.94
		62		
D	School	59	59	129.21
E	Upper right corner	121	121	264.99
F	Bottom left corner	115	115	251.85
G	Left bottom	151	151	330.69
H	Middle bottom	100	172	376.68
		72		
I	Right bottom	67	135	295.65
		68		
J	Bottom right corner	83	116	254.04
		33		
TOTAL			1,264	2,768

Table 5.1.2.1: Nº of households and people living in this Southern area.

These are the main facilities regarding the study flows:

FACILITY			BLOCK
TYPE OF FACILITY	NAME OF FACILITY	DESCRIPTION	letter
Learning / social activities	Kiddoozz	Kinder garden	D
	Mariaschool	Primary school	D
	Stichting Openhaard	Social club	D
Supermarkets	Lidl	Supermarket	A
	Toros Bakkerij	Turkish food, also veggies & fruits	A
	Ooms	Also veggies & fruits	F
	Slagerij Nador	Also veggies & fruits	I
Restaurants / street food	Vishandel Ooms	Fish	F
	Kebap Dürüm Evi	Turkish	F
	Pizza Amore	Italian	H
	Onur Firini	Donner, pizza	J
	Eethuis Kon Moi	Chinese & suriname	J
	Bakkerij Jamama	Desserts and bread	J
	Dürüm Evi	Turkish	J
Cafeterias / restaurants serving coffee	Bar Spangen	Coffee	F
	Satendam	Coffee	G
	Maak Rotterdam	Coffee	H
	Cyprus	Beer	E
	Vishandel Ooms	Restaurant serving coffee	F
	Pizza Amore	Restaurant serving coffee	H
	Dürüm Evi	Restaurant serving coffee	J

Table 5.1.2.2: Name, description and block number of facilities, organised according to the type of services or uses.

5.1.3 EXISTING INITIATIVES

The main and relevant initiatives are explored in order to know and be aware of the future improvements of Spangen neighbourhood and to make, if possible, the future proposals in alignment with them. However, due to few associations in Spangen, general initiatives for Delfshaven that will have effects on Spangen will be briefly described.

· Delfshaven:

-Delftshaven committee:

This committee is formed by 15 chosen residents in order to give advice to the city administration of Rotterdam for the improvement of the neighbourhood. They have published a report in which 5 objectives are set for 2019-2022 period. According to their analysis (divided into 3 domains), the community has still the following issues, resulting in a general dissatisfaction (Gobiedscommissie Delftshaven, n.d.):

-Physical index:

· Housing insulation.
· Outdoor noise.
· Dirt on streets.
· Excess velocity
· Insecurity in bike lines.

-Security index:

· Slight increase of violence threatens.

-Social index:

· Problems with Dutch language.
· Scarcity or bad management of greenery spaces (much hard surfaces).

The following 5 objectives are planned to be improved (Gobiedscommissie Delftshaven, n.d.):

·1 More connectivity through diversity, more reunion places for residents and stimulate own initiatives.
·2 More green and friendly spaces for everyone (improve connectivity, stimulating spaces, and green recreation for all ages; gym, water use and playgrounds)
·3 More clean and car safety (better trash management, attention to cyclists and public transport accesses)
·4 Opportunities for young: Health, education, parent's support and young employment (problem's orientation, nutrition guide, talent's, motivation development...).
·5 Help for elderly, woman, healthy lifestyles investment, language lessons, etc..

-WIJ Delftshaven:

It is political movement formed by a network of residents, collaborative initiatives and self organizations, founded in 2013, in order to build a better society through the increase of citizen's participation and political transparency (Design Scapes, 2018).

These are their objectives (Wij Delftshaven, n.d.):

·1 Inclusivity: Inclusion of 175 cultures and the need for a mixed neighbourhood with meeting rooms, community centres and community gardens.
·2 Social poverty: Reduce dropout of schools and crimes, stress and broken lives from poverty issues. Better access for good debt counselling, talent's development...
·3 Neighbourhood economy: Local economy growth with social base and ecological roof.
·4 Circular sustainability: Think about reuse of waste, energy transition or modern digital production methods, among others, though innovative companies offering local employment opportunities.
·5 Social real state: Increase of a healthy network of spaces in every neighbourhood and fight against the reduction of social initiatives and community centres (social value restoration).
·6 Democracy: Complimentary local democracy and participatory, for managing often different topics such as district budgets, local referendums, theme groups...

-Groene Connectie:

Groene Connectie is a green and ecological initiative for Delfshaven that appropriates the land of old railways in order to create gardens and community parks, and resulting the green backbone for the community of the district (De Vrieze, 2018). The green line of 8 Km extension, not only offers greenery paces and connects to other greenery initiatives of each neighbourhood, but also connects the tourist points of the district (highlighted in red colour) (Groene Connectie, 2016).

Figure 5.1.3.1: Plan of Groene Connectie for Delftshaven. (Source: Groene Connectie, 2016) N

· Spangen:

Based on fieldwork, interviews and municipality's reports, two social clubs were found for providing social activities and basic services to people in need.

-Stichting Openhaard:

Stichting Openhaard is a foundation from 2007 with the objective to contribute for a better and harmonious society without considering ethnicity, age, religion, philosophy, etc. It consists of 2 facilities that are located in Rotterdam city and the South of Spangen neighbourhood, in which it works as a social community building, providing meeting rooms, activities for elderly and children, social meetings and rent of rooms, among others.

5.1.3 EXISTING INITIATIVES

The foundation tries to achieve a better cohesion within the neighbourhood and contribute to better-balanced integration of migrants in the country. Moreover, it has the following objectives (Stichting Openhaard, 2017):

- ·1- Active youth and women population
- ·2- Solutions for dealing with integration issues
- ·3- Stimulation of personal development of young people
- ·4- Skills study progress

The foundation works on projects that are conducted usually in collaboration with third parties and with limited resources for the integration and stimulation of elderly, young and minority group (Stichting Openhaard, 2017).

The facility, located in the Southern part of Spangen, tries to achieve a total of 60 activities per year, organizing several workshops and activities (through volunteers and internships), such as (Stichting Openhaard, 2017):

- · Languages and instrument lessons
- · Cooking
- · Indoor football
- ·Conferences (in collaboration with police, fire brigade and other authorities).
- · Dancing lessons
- · Reading
- · Informatics
- · Excursions
- · Turkish coffee
- · Sewing
- · Kick-boxing
- · Photography

Figure 5.1.3.2: Interior spaces of Stichting Openhaard (Source: Stichting Openhaard, 2017).

-Westervolkshuis:
Opposite to the previous social facility, this is mainly focused on administrative purposes for fighting for the rights of Spangen citizens. However, it also works as a social building in order to boost community feeling, reduce loneliness, provide food to disadvantaged neighbours, and organize some cultural activities, such as:

- · Languages lessons
- · Food service for people in need (once per week)
- · Sewing workshops
- · Annual cultural parties
- ·Kids activities

On the other hand, the rooms of this facility can be rented for around 15 Euros/hour average in order to enjoy the services of the area, for example:

- · Pool room
- · Leisure activities room
- · Flexible space
- · Cooking room
- · Music room
- · Dining room
- · Conference room

A very interesting and productive conversation came from the organizer of the food-service event, called Anne. She was the one who fought the most for reducing criminality in Spangen and started to pay attention to people in need by providing social services and activities. Nowadays, according to her, people who feel lonely and are in bad socio-economic situation can receive a menu for 3 Euros. This event is performed once a week, in which the amount of people who come to profit this opportunity is around 80 persons per day. Mostly old people who feel lonely and without many sources come to this place to gather and chat with other neighbours, spending around 4 hours average. This activity is organized by volunteers and the provision of food comes from economic donations.

One important fact that she mentioned was that there used to be more social clubs before but they were gone, remaining only two in Spangen.

Figure 5.1.3.3: Interior spaces of Westervolkshuis: Pool and kitchen room (Source: https://www.ruimtehurenindebuurt.nl/rotterdam-delfshaven/spangen/westervolkshuis/musicroom).

-Elevate Rotterdam:
Apart from the previous two social clubs, this is the only facility that provides classes in the Southern part of Spangen, consisting of a mix of hip hop and modern dance for all gender and age (Rotterdam Sport, n.d.).

-Urban waterbuffer Spangen:
Although this is not a proper initiative, it is interesting from the sustainable perspective, being the only sustainable installation in the neighbourhood. It is an experimental project located next to the stadium (North) which provides a sustainable water supply for its football installations.
In general, it consists of a solution for the heavy rainfall and floods occurring in the area, at the same time as reusing and purifying rainwater through phytoremediation for irrigation of the football field. Moreover, it solves the ambition of residents of Spangen for improving the greenery in the neighbourhood. From around 40,000 m2 of water collection surface, water is stored underground to avoid flooding (in a water buffer tank). Then it is sent to the phytoremediation tank for its purification. The clean water is stored in the underground aquifer and pumped when is required. Moreover, there is a fountain in order to provide water activities and be used during hot days (KWR, 2019).

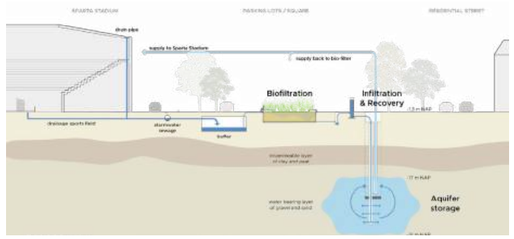


Figure 5.1.3.4: Urban Waterbuffer project (KWR, 2019).

5.1.4 ANALYTICAL DATA

One of the main objectives of the thesis is the focus on social improvements that can be accomplished in Spangen for achieving a better quality of life within the community. Quality of life (QoL) is a broad definition but it is important to investigate it because it has a significant effect on people's behaviour, their life satisfaction, well-being and their overall happiness. Two different approaches can be considered for its study: Objective and subjective indicators. The objective approach is usually based on collected data from Government or municipalities, whereas subjective approach is based on surveys focused on people's behaviour or individual perception (Tabosa, 2018).

Objective indicators:	Subjective indicators:
· Employment rates · Income · Crime statistics · Air quality · Residential density · Amount of parkland · Distance to transit stop · Availability of grocery/food stores	· Housing & neighbourhood satisfaction · Perception of clime · Perception of school quality · Perception of health care services · Feelings about neighbours · Feelings about congestion and crowding · Satisfaction with family, friends, jobs.. · Life satisfaction, overall happiness

Table 5.1.5.1: Example of objective and subjective indicators for studying the QoL of a neighbourhood or city.

The municipality website of Rotterdam (source from BRP-OBI) has a wide availability of data, but only the following topics and specific information that affects the well-being of citizens will be useful for the study of Spangen QoL, discarding topics such as income, traffic, education, or politics (Gemeente Rotterdam, n.d.b):

<u>·1- Population & households:</u>

There has been a population increase since 2017, obtaining nowadays the highest population number over the last decade. Moreover, there is roughly equal percentage of woman and men (Allecijfers.nl, 2020). In fact this year, is one of the first times that Spangen surpassed Rotterdam population rise.

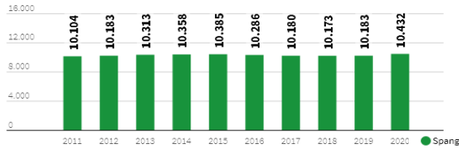


Figure 5.1.4.1: Population as of January 1 (2020) (Source: Gemeente Rotterdam, n.d.a).

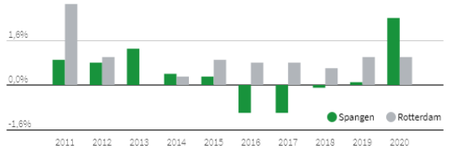


Figure 5.1.4.2: Population growth compared to previous year (2020) (Source: Gemeente Rotterdam, n.d.a).

Spangen is constituted by mostly children, young and adult people, rather than mainly elderly. Compared to Rotterdam, this neighbourhood has a large working-class population and fewer elderly population, although they are increasing every year.

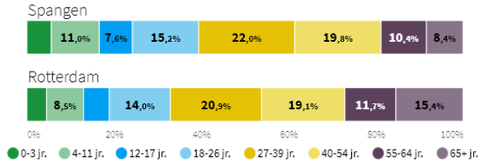


Figure 5.1.4.3: Population by age classes (2020) (Source: Gemeente Rotterdam, n.d.a).

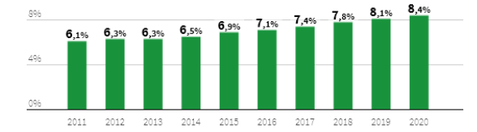


Figure 5.1.4.4: Population over 65 years old (2020) (Source: Gemeente Rotterdam, n.d.a).

According to the previous year, the majority of the population had migration background from Turkey and followed by Morocco, being the third biggest group Dutch people. However, Figure 5.1.4.5 shows that nowadays the Dutch population has returned to Spangen, becoming the first group again and similar to its last prosperous period. Turkey and Morocco still being the other big groups, followed by several EU countries, Suriname or Cape Verde.

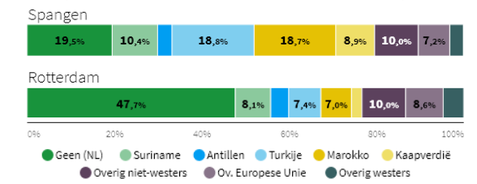


Figure 5.1.4.5: Population by migration background (2020). (Source: Gemeente Rotterdam, n.d.a).

The composition of households is mainly formed by single person or family with two parents.

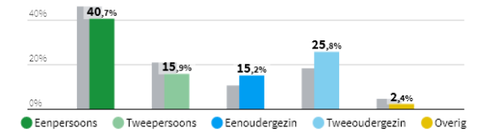


Figure 5.1.4.6: Composition of households (2020) (Source: Gemeente Rotterdam, n.d.a).

<u>·2- Economy & work:</u>

The employment rate is going downwards in Spangen, resulting in the current effects and social issues in the neighbourhood. Moreover, the average gross annual income in the Spangen area is low (17,800 euros), being the 4th lowest neighbourhood in the district of Delftshaven. But the majority of jobs are indefinite or long term.

5.1.4 ANALYTICAL DATA

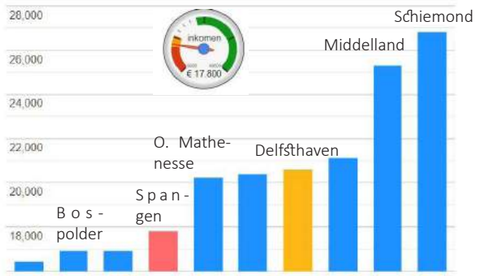


Figure 5.1.4.7: Average gross annual income in Spangen area and in relation to the other neighbourhoods of Delftshaven (2018).

·3- Safety & Liveability:

There has been a declination of crimes over the years (Figure 5.1.4.8), especially since 2013, increasing at the same time the safety index and people's perception (Figure 5.1.4.10). However, it is observed that crimes are greater during Winter time, coinciding with fewer hours of sun and fewer outdoor activities. Most of the crimes are related to violent and sexual crimes, followed by vandalism and crime against public order, thefts and sheds (Allecijfers.nl, n.d.).

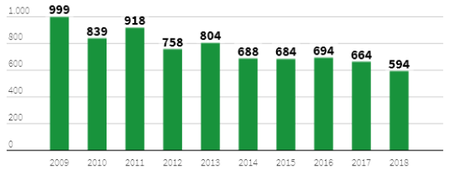


Figure 5.1.5.4: Number of crimes (2018) (S: Gemeente Rotterdam, n.d.a).

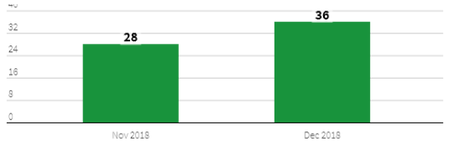


Figure 5.1.4.9: Crimes per month: November & December (2018) (Source: Gemeente Rotterdam, n.d.a).

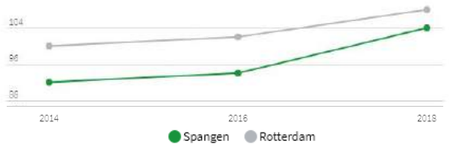


Figure 5.1.4.10: Safety index (2014=100; 2018) (Source: Gemeente Rotterdam, n.d.a).

Regarding liveability, in general, even though that people are being more responsible in Spangen, they are feeling more dissatisfied compared to the previous year (contrary to what happens in Rotterdam). This satisfaction is also related to the noise, house insulation, dirt on streets, etc. Moreover, young people can develop certain issues at home due to their social status, such as school dropout, loss of life orientation, disappointment, anxiety, among others (Wijnstekers, 2018).

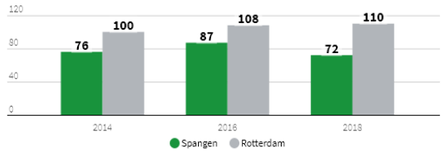


Figure 5.1.4.11: Satisfaction index in the neighbourhood (2018) (Source: Gemeente Rotterdam, n.d.a).

Connectivity to the neighbourhood is being improved due to social initiatives from different associations. This effort resulted in the improvement of connectivity feeling. However, efforts still needed for achieving as much as possible the level of Rotterdam city centre.

·4- Care & health:

Health in Delftshaven is usually worse than Rotterdam area, being the elderly the most disadvantaged.

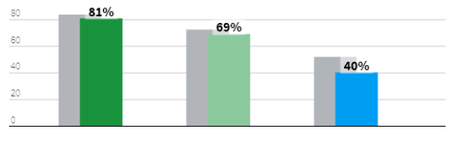


Figure 5.1.4.12: Experience health in Delftshaven district (2016) (Source: Gemeente Rotterdam, n.d.a).

·5- Leisure & culture:

According to bar charts, Spangen citizens are less likely to go for cultural events than the Rotterdam area (Figure 5.1.4.14). However, people from Spangen participate more in cultural activities than the city, but they prefer to visit cultural facilities rather than participate in them (Figure 5.1.4.13).

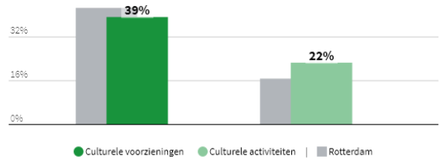


Figure 5.1.4.13: Share that visits cultural facilities or participates in culture activties/month (2018) (Source: Gemeente Rotterdam, n.d.a).

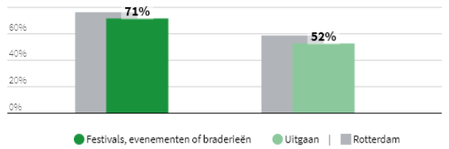


Figure 5.1.4.14: Share that goes out (monthly) or attends events (annually (2018) (Source: Gemeente Rotterdam, n.d.a).

5.1.5 SWOT ANALYSIS

Contrary to what it was planned, analytical surveys and questionnaires were not able to be performed to neighbours due to Covid-19. Instead, the previous information about the analytical data of Spangen along with additional research and existing Delftshaven initiative's reports, helped to form the base for the following SWOT analysis.
As observed in Table 5.1.6.1, mainly social and economical aspects are discussed. Focusing on the Strengths (S) and Opportunities (O) of the neighbourhood and through the combination of Lidl NL sustainability goals, future measures will allow improving the current Weakness (W) and enhance even more the (S), at the same time as reducing the future Threatens (T).

For example, the (S) about connectivity, people participation or increase of responsibility sense will be useful for faster implementation and acceptance of the final proposal within the community. Future social inclusion measures will result on one hand, in the improvement of loneliness, racism, integration of cultures and ages and overall satisfaction, among others, and on the other hand, the declination of exodus or vandalism. Moreover, by increasing activity during winter and nights, vandalism and crimes could be reduced, at the same time as increasing satisfaction, safety and people well-being. New jobs creation could improve the local economy and satisfaction, gender equality, racism, reduced employment rate and degradation or reduce exodus, to name a few.
However, the final and more detailed achievements are described in chapter 07 *Design Proposal.*

(S) STRENGTHS	Lidl SDGs
More people think there is no problems with the neighbourhood	3, 11
Rise of connectivity feeling	3, 11
Population growth	-
Rise of responsibility sense (awareness and consciousness)	3, 11
Majority of the jobs are indefinite or long term contract	8
Rise and return of Dutch native population	-
Decrease of crime	3, 11
Rise of safety	3, 11
Great number of visits of cultural facilities and events	3

(W) WEAKNESSES	Lidl SDGs
Low income	8
Majority of people living lonely at home	3
Rise of unemployed people	8
Number of robbers did not improve since 3 years	3
Few exodus people towards the rest of NL	-
Elderly with bad experience in health	3
Decrease of satisfaction (housing insulation, outdoor noise, dirt, excess velocity)	3, 11
Problems with Dutch language	3, 11
Scarcity /bad management of greenery spaces	3, 15

(O) OPPORTUNITIES	Lidl SDGs
Rise of elderly (healthy activities to reduce loneliness and disaggregation).	10, 11
Children, young and adult as main population (integration through diversity)	5, 10, 11
Great number of migrants (multicultural cohesion)	10, 11

(T) THREATENS	Lidl SDGs
Return of drug dealers & vandalism (violence)	3, 10, 11
Return of racism	3, 10
Urban and housing degradation	11
Increase of price housing	-
Exodus of Dutch people	-

Table 5.1.5.1: General SWOT analysis of Spangen related to SDGs Lidl NL (future improvements), based on previous analytical data (black colour) and other reports from district initiatives (grey colour).

5.2 | SELECTION OF MAIN FLOWS (F, W, A)

Once having an overview of the different flows in the built environment (chapter 01) and understanding the context of Spangen and other aspects to be considered, the selection of flows result much easier. However, it should be noted that city-scale (built environment) is not considered in the evaluation because it goes out of the scope of this report, but the solution for city-scale could be achieved and extrapolated by a modular approach and repetitive pattern of the future solution for the neighbourhood.

Achievement of further sustainable development goals (SDGs) in Lidl and Spangen is aimed in this report but for doing so, current SDGs situation related to flows context need to be known. Once challenges regarding SDGs are detected, possible measures and improvements can be thought within Lidl redesign. Therefore, the criteria for selecting the essential flows are related to scales (a: Spangen neighbourhood and b: Lidl supermarket) and Sustainable Development Goals (SDGs), following this order:

·1: Definition of scales and flows (+ social).
·2: Existing issues for each scale (a & b) and flows.
·3: Existing SDGs achievements for each scale (a & b) and each flows.
·4: Possible sustainable measures and room for improvements for each scale (a & b) and flow.
·5: Possible SDGs achievements if sustainable measures are applied for each scale (a & b) and each flows.
·6: Evaluation and selection of main interesting flows according to a greater room for improvements, further achievement of SDGs and greater impact in the Spangen neighbourhood.

The required information and respective sources for evaluating the selection of flows that can be of interest for the neighbourhood and Lidl are described in Table 5.2.3.1.

So the following process is performed, but not looking into very little details:

·1: Definition of the five flows (energy, water, food, air and materials) and social dimension within the different scales

SCALE	INFORMATION	SOURCE
·Spangen neighbourhood	·Main current issues of each flows	·Previous graphs in chapter 05 *Analytical data*, national reports "Associations of Dutch water companies" and field work.
·Spangen neighbourhood	·Main current SDGs challenges in each flows (based on Spangen issues)	·SDGs (UN, 2018) and fieldwork.
·Lidl supermarket	·Main current issues of each flows	·Lidl NL sustainability program report
·Lidl supermarket	·Main current achievements of each flows	·Lidl NL sustainability program report
·Lidl supermarket	·Main current SDGs achievements of each flows (based on Lidl achievemnts)	·SDGs (UN, 2018)
·Lidl supermarket	·Main future goals of each flows	·Lidl NL sustainability program report

Table 5.2.1: Required information and respective sources for the selection of essential flows of interest for Spangen and Lidl.

or context, being local scale referred to Spangen neighbourhood and building scale to Lidl supermarket.

·2a & 3a: **Energy:** The majority of the housing constructions have not been renovated since 1920, resulting in poor constructions (working inefficiently, having leaks) and infrastructures (lacking od local energy production, heat exchangers and other energy-saving systems) (Burgers & Kloosterman, 1996). / *(SDGs: -)*
Water: There are no rainwater collection tanks and sustainable water reuse measures (excluding the Waterbuffer experimental project in the Northern part of Spangen) in the Southern part, being water collected in roofs but then mixed in the urban sewage systems. Due to the socio-economical context, people are not able to afford water-saving amenities, resulting in leaks and higher water consumption. / *(Partial SDGs: 12, 13 14, 15)*
Food: Based on fieldwork, surplus and food waste (FW) that is not consumed in supermarkets and restaurants is

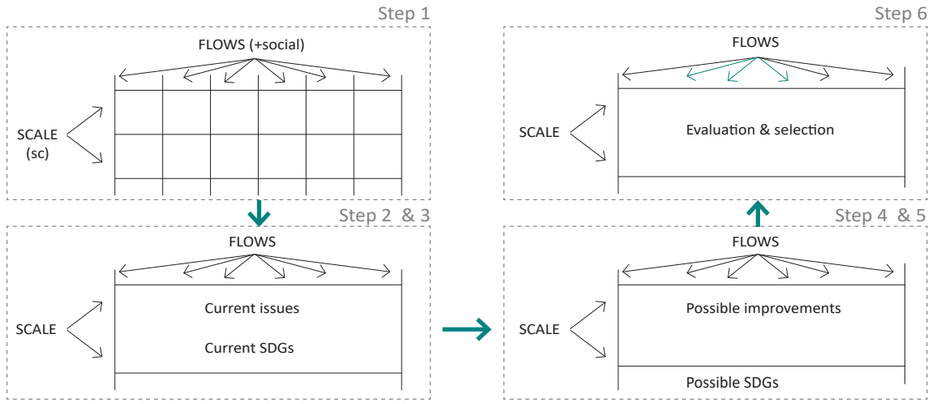


Figure 5.2.1: General steps for the selection of the final essential flows.

sent to the trash, accounting for several Kg every two days average. Moreover, there is a lack of local food production in the area, having other tertiary services such as several hairdressers and restaurants. The only fresh and organic products available come from the supermarkets rather than farmers (lack of market nearby). / *(SDGs: -)*
Air: Even though it has greenery spaces in the boundaries (ring) and Northern part of Spangen, the traffic is high and dense around the ring, producing undesired noise and air pollution. Moreover, according to statics, people experience a low level of health among adults. / *(SDGs: -)*
Materials: Due to old constructions, recircularity and material passports are difficult in Spangen. / *(SDGs: -)*
Social: There are little efforts for improving well-being, so Issues such as criminality and vandalism, social exclusion, dissatisfaction, deprivation, loneliness or inequality are common in Spangen. / *(Partial SDGs: 2, 3, 4, 5, 10).*

·2b & 3b: Even though that Lidl has achieved some goals in recent years, there is still much work left to do for achieving its sustainability targets.
Energy: There has been great energy production advances in their stores, but they are still relying on fossil fuels, achieving limited energy neutral./*(Partial SDGs: 7, 12, 13).*
Water: Supermarkets waste high amount of water mainly due to freezers and fridges, and due to the lack of water measures not appeared in its sustainability report, an assumption of zero water measures is concluded. / *(SDGs: -)*
Food: Lidl is proud of having donated a high number of meals, but this represent only a small percentage, being the rest sent to biodigesters to produce energy in return. Moreover, it does not solve its current surplus and waste food problem. / *(Partial SDGs: 2, 13).*
Air: Lidl does not have any air purification measure in their stores, an there is a high energy consumption due to conditioning and ventilation systems. / *(SDGs: -)*
Materials: 90% of packaging materials are recycled. Lidl is making progress towards re-circularity of construction materials, being demountable or respectful with nature but still not being totally circular. / *(Partial SDGs: 12, 13).*
Social: The few social achievements are focused mainly for Lidl employees, having little social interaction with their customers. However. Lidl organize some annual activities but only in some particular areas, so not every neighbourhood can enjoy them. / *(Partial SDGs: 11, 17).*

·4a & 5a: These are the first measures that could be implemented in Spangen:
Energy: Spangen count on several spaces for introducing solar energy production, not only in public spaces but also

CHALLENGES (current situation)

SCALE	LOCATION		ENERGY	WATER	FOOD	AIR	MATERIALS	(SOCIAL)
CITY	(Rotterdam)							
LOCAL	Modular apporach Spangen neighbourhood	Issues	· High E. Consumption (poor constructions & infrastructure) · No exchange of flows nor E.recovery · No energy saving systems · No local energy production	· High waste water · No water-saving amenities · Rainwater not collected · No reuse of water (except Waterbuffer project)	· High FW · No local food production · Non fresh food (no local market)	· Air pollution · Low health	· No material passsport · No recyclability of materials (old constructions)	· Criminality & vandalism · No social cohesion · Disatisfaction · No well-being ·Loneliness ·Deprivation ·Social exclusion (but there are 2 social clubs)
		Partial SDGs	-	*12:Responsible consumption & production* *13: Climate action* *14: Life below water* *15: Partnerships for the goals*	-	- -		*2: Zero hunger* *3: Good health & well-being* *4: Quality education,* *5: Gender equality,* *10: Reduced inequalities*
BUILDING	Lidl supermarket	Issues	· Limited E.neutral	· High water consumption	· High FW & surplus ·Little donations, more biodigesters	· E.consumption due to ventilation · No indoor air purification ·Little fresh air	· Still not totally circular (construction materials)	· Social initiatives for employees ·Some annual activities for specific neighbouhrood
		Part. SDGs	*7: Affordable & clean energy* *12* *13*	-	*2* *13*	-	*12* *13*	*11: Sustainable cities & communities* *17: Partnerships for the goals).*
		Goals	· E. neutral · Total gas disconnection (SDG: 7, 12, 13)	- (SDG: -)	· Reduce FW · Trasparent FW data (SDG: 13, 15)	· C02 reduction · Carbon footprint data (SDG:11, 15)	· Material circularity · Material passport (SDG:11, 15,17)	· Sustainable + healthy environment · Create social value · Youth / kids (SDG:3, 11)

Figure 5.2.2: Current challenges analysis with achieved SDGs and flows in Spangen and Lidl. Principal issues to be tackled (red colour) and secondary ones due to little SDGs achievements (orange). Step 2 & 3.

residential roofs. Moreover, the existence of Lidl supermarket allows reusing its waste heat from cooling area to the upper residential building (with additional underground storage). Heat exchangers, energy saving amenities, double glazing and better insulations could be introduced in the housing renovations. / *(SDGs: 7, 11, 12, 13).*

Water: Being a rainy area, Spangen has enough potential for rainwater collection in public spaces. Local treatment such as phytoremediation systems can be introduced and easily integrated, increasing the greenery in Spangen. Water-saving amenities, filtering and reuse of waste or greywater are other options. *(SDGs: 6, 12, 13, 14).*

Food: Due to the demand of food within the neighbourhood (social clubs, households, schools) and surplus from supermarkets and restaurants, a local food redistribution network could be introduced, therefore reducing food waste and providing service to people in need. Moreover, workshops for reducing food waste and profit unwanted parts of products could help to reduce FW at home. Local food production to reduce carbon footprint, prices and increase fresher products. Recovery of FW or surplus through the upcycling process, such as soap from kitchen oil, beer from bread, juices and jams from mature fruit or veggetables, etc. / *(SDGs: 2, 11, 13, 15, 17).*

Air: The introduction of greenery not only allows reducing air pollutants but also reducing undesired noise from dense traffic. Moreover, photocatalysts materials applied in public spaces could purify the air. / *(SDGs: 3, 15).*

Materials: Using recyclable materials coming from local sources, would boost local economy and reduce waste (closer loops). / *(SDGs: 11S, 15, 17).*

Social: There are few social clubs compared to the number of people in need, being necessary to introduce social spaces where people can meet, enjoy, be integrated and satisfied. However, spaces alone do not work, being also required organization of attractive activities, workshops, sessions, conferences for every type of gender, age and ethnicity. Moreover, activity occurs only in parks, being necessary to introduce life on streets, such as outdoor terrace, markets, etc. / *(SDGs: 3, 5, 10, 11).*

·4b & 5b: Lidl has achieved some of their sustainability goals but others are still a pending task, so further improvements could be introduced, for example:

Energy: Exchange of energy with other facilities would allow to achieve 100% energy neutral/ *(SDGs: 7, 11, 12, 13).*

Water: Water within the store could be reused and purified on-site for non drinking purposes, reducing pressure on water treatment plants. *(SDGs: 6, 12, 13, 14).*

Food: The goal of Lidl is to reduce food waste by increasing more donations, but surplus should be reduced first, by for example, designing an application where Lidl can know in advance the type and quantity demands of the products. Moreover, surplus food can be processed on-site for upcycling and getting new valuable products for selling them back at lower price, thus reducing transportation, packaging and waste. Other objectives are to increase the vegetables, fruit consumption, and healthier food practices, so through a local food production, these goals can be achieved, as well as adressing GHG emissions and local partnership. / *(SDGs: 2, 11, 13, 15, 17).*

Air: The majority of Lidl stores are characterized for having little natural lighting and little fresh air. Ventilation through mechanical systems rise the energy demand, so by adding for example simply green walls, indoor fresher air could be obtained, at the same time as increasing indoor atmosphere, aesthetics and smells. / (*SDGs: 3, 13).*

Materials: One of Lidl objectives is to reduce plastics and packaging, so a new packaging system that could be multifunctional could be designed. Moreover, by using universal connections, material passport, local recyclable materials, standard and modular dimensions, among others, circularity and waste reduction within the built environment could be assured. / *(SDGs: 11, 12, 15, 17).*

Social: Goals are mainly for Lidl employees, being necessary to create a comfortable working environment through gender equality, integration, woman representation, inclusion, etc. Similarly, Lidl could provide indoor zones in which customers could meet and exchange reactions, resulting in higher customer satisfaction and higher profits and engagement. Moreover, by teaching customers healthier buying practices or FW reduction measures, further benefits could be achieved for both (commitment, participation, activity, satisfaction, waste reduction, integration, job creation etc). / *(SDGs: 3, 5, 8, 10, 11).*

·6: The evaluation and selection of the main interesting flows can be performed after the previous challenges, potentials and hypothetical further achievement of SDGs.
One point to be considered on the selection of flows is that energy and material flows have been searched and analysed in the previous thesis for Lidl company, but there were still some limitations in their research. Another point is to take into account the aim of this thesis, which goes beyond the building scale and Lidl goals (mainly focused on economical savings and energy performance), by considering other very important flows such as food (food waste and scarcity) water (water scarcity) or air (air pollution causing deaths), which form the basics for life. Moreover, these selected flows (F, W, A) have not been searched in deep and they have more social potentials, providing more opportunities and exchange possibilities for the social improvement of the neighbourhood.

Nevertheless, the study of 3 flows could be too much to be addressed efficiently. So although these 3 flows will be considered and improved in the future design proposal, air flows have less synergistic potentials and consist on a complex range of factors (PMx, CO2, O2, etc), so it will be less studied and discarded from the analytical research.

POTENTIALS (proposal situation)

SCALE	LOCATION		ENERGY	WATER	FOOD	AIR	MATERIALS	(SOCIAL)
CITY	(Rotterdam)							
LOCAL	Modular apporach Spangen neighbourhood	First measures	·Local energy production in roofs & public spaces ·Reuse of waste heat from Lidl ·Heat exchanges & energy saving amenities ·Better insulations, double glass...	·Rainwater collection ·Local treatment for reusing water ·Water saving amenities ·Reuse of greywater and blackwater.	·Develop FW and surplus distribution network ·Workshops (healthier & upcycling FW) ·Local food production	·Greenery · Photocatalysts materials	·Use recyclable materials from local sources	· Social spaces ·Social activity program ·Life on streets, not only parks
		SDGs	*7: Affordable & clean energy 11: Sustainable cities & communities 12: Responsible consumption & production, 13: Climate action*	*6: Clean water & sanitation 12: 13 14: Life below water*	*2: Zero hunger 11 13 15: Life on land, 17: Partnerships for the goals).*	*3: Good health & well-being 11 15 17*	*11 15 17*	*3: 5: Gender equality, 10: Reduced inequalities 11*
BUILDING	Lidl supermarket	First measures	·Energy exchange with other buildings	·Rainwater collection ·On-site treatment ·Exchange of water flows	·Application to know exact the food demands ·Reprocess of FW on-site (nutrients recovery) ·Local food production	·Green walls (air purification and indoor comfort)	·New multifunction pakacging ·Universal connections ·Local recyclable material ·Standard measures ·Material passport	· Social indoor spaces for inclusion, integration, ... ·Provide workshops (sustainable & healthier education) (income for Lidl, waste reduction for customers, higher social interactions)
		SDGs	*7 11 12 13*	*6 12 13 14*	*2 11 13 15 17*	*3 13*	*11 12 15 17*	*3 5 8: Decent work & economic growth 10 11*

Figure 5.2.3: Analysis of future potentials with possible SDGs in different scales and flows. Step 4 & 5.

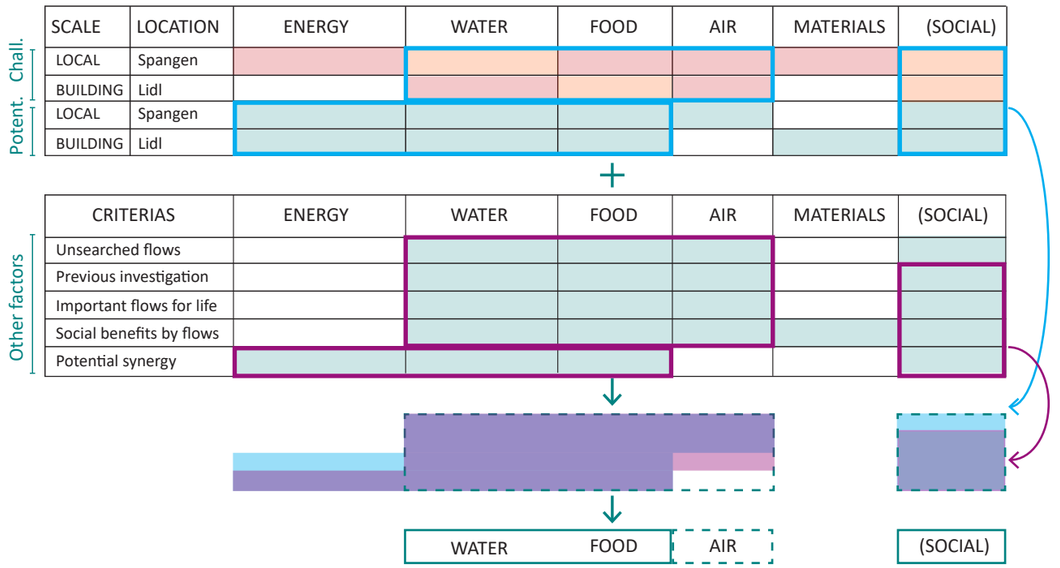


Figure 5.2.4: Evaluation for the final selection of essential flows (dark purple), considering previous analysis (blue) and new other factors (purple).

5.3 | DATA FLOWS IN NEIGHBOURHOOD

5.3.1 FOOD

To establish a synergy between different facilities inside Spangen, the food flows regarding solid avoidable food waste (FW) are explored due to its feasible reduction, including milk products and oil, and discarding unavoidable and liquid FW.
The facilities that are analysed are the ones located in the Southern area, as described in the chapter 5.1.2 *Urban Context & facilities,* being mainly: Households, restaurants, schools and other supermarkets. Due to lack of cooperation between facilities, personal interviews, national (Dutch), international (mainly from the UK) and general reports were used for identifying avoidable FW figures.

Households:
The total solid Dutch FW corresponds to 52.1 Kg/person/y, in which 34.3 is avoidable (constituting approximately 9.5% of purchased food/person going to waste) (The Netherlands Nutrition Centre Foundation: NNCF,2019).

Solid FW can be wasted via household and other routes:

SOLID FOOD WASTE (2019)			
	Minimum	**Average**	**Maximum**
	Kg/person/y	Kg/person/y	Kg/person/y
Household FW: (residual & VFG waste)	22.9	26.5	30.1
Other routes: (Sink & toilet, animals, compost)	4.6	7.8	11
TOTAL (including soups, fats, sauces & dairy products)	**27.5**	**34.3**	**41.1**

Table 5.3.1.1: Minimum, average and maximum solid FW in 2019 (Source: Adapted from NNCF, 2019).

According to the report, around 26.5 Kg/person/year corresponds to avoidable solid food waste (via households) in The Netherlands (Table 5.3.1.1 and 5.3.1.2). However, when considering a low-income neighbourhood such as Spangen, the general FW and thus avoidable solid FW (via households) is usually lower compared to wealth areas, being around **22.9 Kg/person/y** (Table 5.3.1.1). Therefore the above figures expressed in Kg/p/year are reduced in Spangen, as it can be seen in the 3rd column of Table 5.3.1.3. FW neighbourhood/year (4th column) is the result of the multiplication of FW/person/y (3rd column) by the number of population in the Southern study area (2,768 people), having a final FW result of **63,390 Kg/neighbourhood/y** and an economical lose of 221,234.1 Euros (considering an average spend of 3.49 Euros/Kg (NNCF, 2019).

	2010	2013	2016	2019
Food waste via household waste	66.7	64.3	63.1	52.1
Unavoidable	28.5	29.7	29.7	24.5
Avoidable	38.2	34.6	33.4	27.6
of which in VFG waste	*6.7*	*7.7*	*10.0*	*5.2*
of which in residual waste	*31.5*	*26.9*	*23.4*	*22.5*
of which prepared		*9.3*	*4.3*	*10.1*
of which unprepared		*20.1*	*23.8*	*12.7*
of which untouched		*5.2*	*5.4*	*4.8*
Avoidable after adjustment for water	34.6	32.2	30.4	26.5

Table 5.3.1.2: Distribution of food waste via household waste between avoidable and unavoidable, prepared and unprepared, and adjusted for water absorption (2010, 2013, 2016 and 2019) (Source: NNCF, 2019).

The 10 main products that are average wasted in The Netherlands correspond to the following, expressed in Kg/p/year (NNCF, 2019):

- ·1 Bread & bread-based products 7.3
- ·2 Dairy products 5.1
- ·3 Vegetables 3.7
- ·4 Fruits 3
- ·5 Potatoes 2.9
- ·6 Sauces & fats 2.7
- ·7 Meat & meat products 2.3
- ·8 Pasta 1
- ·9 Pastry & cake 1
- ·10 Sweets & snacks 0.8

In general, a standard person can buy around 377 Kg/year of food (NNCF, 2019), whereas citizens in Spangen can buy around 310 Kg/person/year, being a total purchase of **863,950 Kg/y** (Table 5.3.1.3).

AVOIDABLE SOLID FOOD WASTE (FW)						FOOD PURCHASED (FP)		
DESCRIPTION OF GROUP PRODUCTS	**PERCENTAGES**	**FW PERSON/Y**	**FW NEIGHBOURHOOD /YEAR**	**FW NEIGHBOURHOOD /DAY**	**WASTE FREQUENCY**	**FP HOUSEHOLD/Y**	**FP PERSON/Y**	**FP NEIGHBOURHOOD/Y**
(in order of most wasted)	%/person	Kg/person/y	Kg/neighbourhood/y	Kg/neighbourhood/day	every day, every 3 days, every week	Kg/household/y	Kg/person/y	Kg/neighbourhood/y
1- Bread & bread-based products	21.3	4.9	13,502	37.0	every day	74.2	33.9	93,776
2- Dairy products (mainly thick)	15.0	3.4	9,509	26.1	every day	82.4	37.6	104,166
3- Vegetables	10.8	2.5	6,846	18.8	every day	101.9	46.5	128,852
4- Fruit	8.7	2.0	5,515	15.1	every day	95.4	43.6	120,611
5- Potatoes	8.4	1.9	5,325	-	every week	49.9	22.8	63,099
6- Sauce & fats (butter)	8.0	1.8	5,071	-	every 3 days	35.2	16.1	44,468
7- Meat & meat products	6.7	1.5	4,247	-	every 3 days	71.6	32.7	90,477
8- Others (including gravy, frying far or oil)	6.6	1.5	4,184	11.5	every day	8.0	3.7	10,112
9- Pasta	3.0	0.7	1,902	-	every 3 days	5.9	2.7	7,420
10- Pastry & cake	2.9	0.7	1,838	-	every 3 days	24.0	10.9	30,298
11- Rice	2.4	0.5	1,521	-	every 3 days	4.6	2.1	5,814
12- Sweets & snacks	2.4	0.5	1,521	-	every week	38.5	17.6	48,651
13- Cheese	1.8	0.4	1,141	-	every 3 days	21.9	10.0	27,618
14- Eggs	1.0	0.2	634	-	every 3 days	12.4	5.7	15,674
15- Fish	0.7	0.2	444	-	every 3 days	7.7	3.5	9,720
(Leftovers from meals)	0.3	0.1	190	0.5	every day	50.0	22.8	63,200
TOTAL FOOD WASTE	**100.0**	**22.9**	**63,391**	**108.9**	-	**683.5**	**312.1**	**863,957**
TOTAL SPEND (3.49 euro/Kg)	-	**79.9**	**221,234.1**	**380.0**	-	**2,385.4**	**1,089.2**	**3,015,209**

Table 5.3.1.3: Avoidable solid FW and food purchased in Spangen (Southern part).

Restaurants:
45% of FW in restaurants comes from a poor food preparation, 21% correspond to food spoilage and 34% comes from customer plates (Waste and Resources Action Programme: WRAP, 2020). Due to the existence of standard restaurants but also fast food establishments, the Table 5.3.1.4 (based on WRAP) will be useful for the rough calculations of the FW of the restaurants of Spangen:

Restaurants					
Average food waste disposed of per day (kg)	**No. Employees**				
	1-9	**10-19**	**20-49**	**50-99**	**100-149**
Per employee	2.1	3.1	3.4	0.4	0.5
Per company	10.8	45.8	117	21.7	83.2
Quick Service Restaurants (QSRs)					
Average waste disposed of per day (kg)	**No. Employees**				
	1-9	**10-19**	**20-49**	**50-99**	**100-149**
Per employee	1.7	1.7	2.1	2.1	2.1
Per company	8.4	25.2	75.5	167.7	366.1

Table 5.3.1.4: Average amount of FW produced by restaurants and QSRs in the UK (kg/day) per company and per employee, broken down by size (number of employees) (Source: Wrap, 2020).

According to WRAP, 70% of FW in restaurants can be avoided (WRAP, 2020), therefore wasting around **1.47 Kg/employee/day** in standard restaurants:

NAME OF FACILITY	DESCRIPTION	TYPE OF FACILITY	EMPLOYEES	FACTOR FW	FW FACILITY	AVOIDABLE FW
-	-	(Restaurant /fast food)	Nº	Kg/employee /day	Kg/day	(70%)
Vishandel Ooms	Fish	Restaurant	4	2.1	8.4	5.9
Kebap Dürüm Evi	Turkish	Restaurant	4	2.1	8.4	5.9
Pizza Amore	Italian	"Fast food"	4	1.7	6.8	4.8
Onur Firini	Donner, pizza	Fast food	2	1.7	3.4	2.4
Eethuis Kon Moi	Chinese & suriname	Restaurant	5	2.1	10.5	7.4
Bakkerij Jamama	Desserts and bread	"Fast food"	3	1.7	5.1	3.6
Dürüm Evi	Turkish	Restaurant	4	2.1	8.4	5.9

Table 5.3.1.5: Summary of restaurants in Spangen, with the type of facility, employees and factor of FW.

The following tables consist of the avoidable solid FW of the restaurants in grams/day and Kg/year, taking into account their yearly timetable and doing multiplication by days: open every day: 365 days and one day/week closed: = 302 days). Moreover, the percentages are based on Lidl UK food waste and adapted for each kind of selling products, according to bread-based products, Chinese, fish products, etc. Moreover, oil kitchen needs to be replaced approximately once or even twice a week, thus generating liquid waste that could be useful for the future redesign of flows. Considering commercial fryer deeps of 40 lb (=18 L) for a standard restaurant, it will result in a oil waste of around **72 L/month**. Additionally, depending on the type of restaurant and frying products, less or more oil will be wasted, from **25 to 145 L/month.**

AVOIDABLE SOLID FOOD WASTE (Vishandel Ooms)				
DESCRIPTION OF GROUP PRODUCTS	**PERCENTAGES**	**FIGURES**	**FIGURES**	**FIGURES**
-	%/ Kg sorted	gr/supermarket /day	Kg/supermarket /y	L/restaurant /month
3- Vegetables	15.0	885	323.0	-
5- Fruit	14.0	826	301.5	-
4- Pastry & cake, bread-based products	15.0	885	323.0	-
2- (Ready meals)	16.5	974	355.3	-
1- Meat & meat products & fish, eggs	31.0	1,829	667.6	-
6- Dairy products (cheese, mainly thick)	6.0	354	129.2	-
7- Unwanted food from grocery ambient	2.5	148	53.8	
(Cooking oil)	-	-		145.0
TOTAL FOOD WASTE	**100.0**	**5,900**	**2,154**	**145.0**

AVOIDABLE SOLID FOOD WASTE (Kebap Dürüm Evi)				
DESCRIPTION OF GROUP PRODUCTS	**PERCENTAGES**	**FIGURES**	**FIGURES**	**FIGURES**
-	%/ Kg sorted	gr/restaurant /day	Kg/restaurant /y	L/restaurant /month
4- Vegetables	9.0	531	194	-
5- Fruit	5.0	295	108	-
3- Pastry & cake, bread-based products	17.0	1,003	366	-
2- (Ready meals)	24.0	1,416	517	-
1- Meat & meat products & fish, eggs	40.0	2,360	861	-
6- Dairy products (cheese, mainly thick)	5.0	295	108	-
(Cooking oil)	-	-	-	90.0
TOTAL FOOD WASTE	**100.0**	**5,900**	**2,154**	**90.0**

AVOIDABLE SOLID FOOD WASTE (Pizza Amore)				
DESCRIPTION OF GROUP PRODUCTS	**PERCENTAGES**	**FIGURES**	**FIGURES**	**FIGURES**
-	%/ Kg sorted	gr/restaurant/ day	Kg/restaurant /y	L/restaurant /month
5- Vegetables	6.0	288.0	87.0	-
6- Fruit	4.0	192.0	58.0	-
2- Pastry & cake, bread-based products	29.0	1,392.0	420.4	-
4- (Ready meals)	13.0	624.0	188.4	-
3- Meat & meat products & fish, eggs	18.0	864.0	260.9	-
1- Dairy products (cheese, mainly thick)	30.0	1,440.0	434.9	-
(Cooking oil)	-	-	-	25.0
TOTAL FOOD WASTE	**100.0**	**4,800**	**1,449.6**	**25.0**

AVOIDABLE SOLID FOOD WASTE (Onur Firini)				
DESCRIPTION OF GROUP PRODUCTS	**PERCENTAGES**	**FIGURES**	**FIGURES**	**FIGURES**
-	%/ Kg sorted	gr/restaurant /day	Kg/restaurant /y	L/restaurant /month
4- Vegetables	6.0	144.0	52.6	-
6- Fruit	4.0	96.0	35.0	-
1- Pastry & cake (bakery), bread & bread-ba	27.0	648.0	236.5	-
4- (Ready meals)	15.0	360.0	131.4	-
3- Meat & meat products & fish, eggs	21.0	504.0	184.0	-
2- Dairy products (cheese, mainly thick)	27.0	648.0	236.5	-
(Cooking oil)	-	-	-	145.0
TOTAL FOOD WASTE	**100.0**	**2,400**	**876.0**	**145.0**

AVOIDABLE SOLID FOOD WASTE (Eethuis Kon Moi)				
DESCRIPTION OF GROUP PRODUCTS	**PERCENTAGES**	**FIGURES**	**FIGURES**	**FIGURES**
-	%/ Kg sorted	gr/restaurant /day	Kg/restaurant /y	L/restaurant /month
5- Vegetables	10.0	740.0	223.5	-
6- Fruit	6.0	444.0	134.1	-
3- Pastry & cake, bread-based products	18.0	1,332.0	402.3	-
4- (Ready meals)	18.0	1,332.0	402.3	-
1- Meat & meat products & fish, eggs	28.0	2,072.0	625.7	-
2- Dairy products (cheese, mainly thick)	20.0	1,480.0	447.0	-
(Cooking oil)	-	-	-	130.0
TOTAL FOOD WASTE	**100.0**	**7,400**	**2,235**	**130.0**

AVOIDABLE SOLID FOOD WASTE (Bakkerij Jamama)				
DESCRIPTION OF GROUP PRODUCTS	**PERCENTAGES**	**FIGURES**	**FIGURES**	**FIGURES**
-	%/ Kg sorted	gr/bakery/day	Kg/bakery/y	L/bakery /month
1- Pastry & cake (bakery), bread & bread-ba	41.0	1,476.0	538.7	-
3- (Ready meals)	20.0	720.0	262.8	-
4- Eggs	9.0	324.0	118.3	-
2- Dairy products (cheese, mainly thick)	30.0	1,080.0	394.2	-
(Cooking oil)	-	-	-	70.0
TOTAL FOOD WASTE	**100.0**	**3,600**	**1,314**	**70.0**

Table 5.3.1.6: Avoidable FW of restaurants in Spangen.

Schools:
Facilities related to learning and social clubs should be considered, but only Maria school is analysed due to simplifications, unknown food data from the other facilities, and non-continuous use of kitchen services.
Mariaschool is a catholic primary school with a total average of 200 pupils. According to WRAP, FW in the UK is around 72 gr/pupil/day in primary schools and 42 gr/pupil/day in secondary schools. Moreover, the proportion of avoidable FW is found to be around 72%, split between the kitchen (not served; 36%) and canteen (not eaten; 36%) (WRAP, 2011). The Dutch academic year is 200 days when considering public holidays and summer. Therefore the final avoidable FW is **51.84 gr/pupil/day** and **2,660 Kg/school/y** {(51.84*200 pupil*200 days)/1000}.
Figure 5.3.1.1 represents the percentage of wasted products, being the fruits, vegetables and mixed (non- sandwich) the predominant products wasted in the UK. By doing some adjustments in comparison with the % of Lidl FW for the case of The Netherlands, Table 5.3.1.7 shows the final results for Mariaschool (primary school).

5.3.1 FOOD

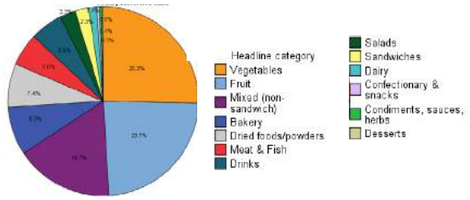


Figure 5.3.1.1: UK primary school FW composition (% by Kg sorted) (Source: WRAP, 2011).

AVOIDABLE SOLID FOOD WASTE (Mariaschool)					
DESCRIPTION OF GROUP PRODUCTS	PERCENTAGES	FIGURES	FIGURES	FIGURES	FIGURES
(in order of most wasted)	%/ Kg sorted	gr/person /day	Kg/person /y	gr/school /day	Kg/ school/y
1- Vegetables	28.5	14.77	3.0	2,954.9	591.0
2- Fruit	23.7	12.29	2.5	2,457.2	491.4
3- (Leftovers from meals)	16.8	8.71	1.7	1,741.8	348.4
4- Pastry & cake (bakery)	8.5	4.41	0.9	881.3	176.3
5- Potatoes, pasta, rice, eggs…	7.4	3.84	0.8	767.2	153.4
6- Meat & meat products & fish	5.6	2.90	0.6	580.6	116.1
7- Dairy products (cheese, mainly thick)	5.1	2.64	0.5	528.8	105.8
8- Bread & bread-based products (sandwich)	2.8	1.45	0.3	290.3	58.1
9- Sweets & snacks	1.2	0.62	0.1	124.4	24.9
10- Sauce & fats (butter)	0.4	0.21	0.0	41.5	8.3
TOTAL FOOD WASTE	100.0	51.84	10.4	10,368	2,074

Table 5.3.1.7: Avoidable FW in Mariaschool.

Supermarkets:

Other supermarkets apart from Lidl in the Southern part are: Toros Bakkerij (next to Lidl), Ooms and Slagerij Nador, being the two last ones similar and selling products and non-products. Toros is selling Turkish and prepared food, having higher FW compared to the other supermarkets.

By doing site visits, personal interviews and considering Lidl FW as a base, Table 5.3.1.8 is performed. Lidl FW in the UK is around 41 tonnes/year (Lidl GB, 2018), which results in about 7.49 Kg/employee/day. Moreover, around 7 Kg/employee/day of FW is produced in Swedish supermarkets, being 91% of FW avoidable (SEPA, 2013), thus resulting in **6.37 Kg/employee/day** of avoidable FW.

AVOIDABLE SOLID FOOD WASTE (Toros supermarket)			
DESCRIPTION OF GROUP PRODUCTS	PERCENTAGES	FIGURES	FIGURES
-	%/ Kg sorted	gr/supermarket /day	Kg /supermarket/y
2- Vegetables	22.0	5,605.6	2,046.0
1- Fruit	24.0	6,115.2	2,232.0
4- Pastry & cake (bakery), bread & bread-based	14.0	3,567.2	1,302.0
5- (Ready meals)	15.0	3,822.0	1,395.0
3- Meat & meat products & fish, eggs	15.0	3,822.0	1,395.0
6- Dairy products (cheese, mainly thick)	6.0	1,528.8	558.0
7- Unwanted food from grocery ambient	4.0	1,019.2	372.0
8- Frozen	-	-	-
TOTAL FOOD WASTE	100.0	25,480	9,300

AVOIDABLE SOLID FOOD WASTE (Ooms & Slagerij Nador supermarket)			
DESCRIPTION OF GROUP PRODUCTS	PERCENTAGES	FIGURES	FIGURES
-	%/ Kg sorted	gr/supermarket /day	Kg/ supermarket/y
2- Vegetables	25.0	4,778	1,743.8
1- Fruit	27.0	5,160	1,883.3
3- Pastry & cake, bread-based products	15.0	2,867	1,046.3
4- (Ready meals)	14.0	2,675	976.5
5- Meat & meat products & fish, eggs	8.0	1,529	558.0
6- Dairy products (cheese, mainly thick)	7.0	1,338	488.3
7- Unwanted food from grocery ambient	4.0	764	279.0
8- Frozen	-	-	
FOOD WASTE/EACH	100.0	19,110	6,975
TOTAL FOOD WASTE	-	38,220	13,950

Table 5.3.1.8: Avoidable FW in Toros, Ooms and Slagerij Nador supermarket.

Summary:

As a summary, the following tables represent the avoidable FW in the Southern area of Spangen, depending on the type of facility and description group products, including also Lidl NL supermarket. This results in a total avoidable solid FW of around **222 Kg/day** and **79,000 Kg/year**. For FW calculations, it has been studied the timetable of each establishment and considered the amount of Dutch public holidays, stated in 11 days. Therefore:

- 1 year= 52 weeks = 365 days
- Dutch public holidays: 11 days
  - 1 day closed: 52 days
  - 2 days closed: 104 days

AVOIDABLE SOLID FOOD WASTE (Southern part of Spangen)								
FACILITY			BLOCK	PRODUCTS DESCRIPTION	FIGURES	FIGURES	TIMETABLE	YEAR
TYPE OF FACILITY	NAME OF FACILITY	DESCRIPTION	letter	-	Kg/facility /day	Kg/ facility/y	Hour	Days
Learning / social activities	Kiddoozz	Kinder garden	D	-	-	-	M-F: 7.30-18.00 (Sat & Sunday closed)	250
	Mariaschool	Primary school	D	Total	0.1	13.0	M-F: 8.30-14.30 (Sat & Sunday closed)	250
	Stichting Openhaard	Social club	D	-	-	-	Tuesd-F: 9.00-16.00 (Sat & Sunday 10.00-15.00, Monday closed)	302
Supermarkets	Lidl	Supermarket	A	Total	112.1	40,900	M-Sat: 8.00-22.00 (Sunday: 10.00-22.00)	365
	Toros Bakkerij	Turkish food, also veggies & fruits	A	Total	25.5	9,300	M-Sat: 7.00-20.00 (Sunday: 8.00-20.00)	365
	Ooms	Also veggies & fruits	F	Total	19.1	6,975	24h	365
	Slagerij Nador	Also veggies & fruits	I	Total	19.1	6,975	M-S: 10.00-20.00	365
Restaurants / street food	Vishandel Ooms	Fish	F	Fish	5.9	2,154	M-Sat: 10.00-20.00 (Sunday: 12.00-20.00)	365
	Kebap Dürüm Evi	Turkish	F	Total	5.9	2,154	M-S: 9.00-24.00	365
	Pizza Amore	Italian	H	Total	4.8	1,450	Tuesd--S: 10.00-22.00 (Monday closed)	302
	Onur Firini	Donner, pizza	J	Total	2.4	876	M-S: 12.00-22.00	365
	Eethuis Kon Moi	Chinese & suriname	J	Total	7.4	2,235	Tuesd-Sat: 12.00-22.00 (Sunday: 14.00-22.00, Monday closed)	302
	Bakkerij Jamama	Desserts and bread	J	Total	3.6	1,314	M-Sat: 7.00-20.00 (Sunday: 8.00-20.00)	365
	Dürüm Evi	Turkish	J	Total	5.9	2,154	M-S: 9.00-24.00	365
Cafeterias / restaurants serving coffee	Bar Spangen	Coffee	F	Coffee	5.5	2,008	M-S: 12.00-22.00	365
	Satendam	Coffee	G	Coffee	5.5	1,661	Tuesd-Sunday: 10.00-17.00	302
	Maak Rotterdam	Coffee	H	Coffee	5.5	1,661	Tuesd-Sunday: 10.00-17.00	302
	Cyprus	Beer	E	-	-	-	M-S: 12.00-22.00	-
	Vishandel Ooms	Restaurant serving coffee	F	Coffee	4.0	1,460	M-Sat: 10.00-20.00 (Sunday: 12.00-20.00)	365
	Pizza Amore	Restaurant serving coffee	H	Coffee	4.0	1,208	Tuesd--S: 10.00-22.00 (Monday closed)	302
	Dürüm Evi	Restaurant serving coffee	J	Coffee	4.0	1,460	M-S: 9.00-24.00	365
TOTAL FOOD WASTE					240.2	85,956		

Table 5.3.1.9: Summary of avoidable solid FW in Southern part of Spangen organised by the type of facility.

Due to the high number of cafeterias and restaurants serving coffee in this area, a simple calculation of possible coffee ground waste was performed. An average cafeteria can generate around 60 Kg/week of coffee grounds or 5-8.5 Kg/day (Closed-loop, 2019). Considering that Spangen has a lower frequency of activity and lower coffee culture consumption compared to other areas, a quantity of 5.5 Kg/day was selected in order to be on the safe side.

AVOIDABLE FOOD WASTE (Southern part of Spangen)		
DESCRIPTION OF GROUP PRODUCTS	FIGURES	FIGURES
-	Kg/day	Kg/y
2- Vegetables	43.1	15,322
3- Fruit	41.8	14,923
1- Pastry & cake (bakery), bread & bread-based products	47.3	16,975
6- Meat & meat products & fish, eggs	25.3	8,980
7- Dairy products (cheese, mainly thick)	20.8	7,399
10- Other products (Seets, snacks, potatoes, pasta, rice)	0.9	223
9- Unwanted food from grocery ambient	7.2	2,566
11- Frozen	1.1	409
4- (Leftovers from meals, ready meals)	34.6	12,292
5- Coffee	28.5	9,458
8- Cooking oil (L/month)	0.55	6,600
Total (excluding coffee & oil)	222	79,089

Table 5.3.1.10 Summary of avoidable solid FW in Southern part of Spangen organised by the type of products (including Lidl).

5.3.2 WATER

The considered flows are the ones related to drinking water consumption rather than waste water flows. Inside the neighbourhood, the following facilities are analysed: Households, parks, restaurants and schools. Due to unavailable and specific data for the neighbourhood of Spangen, rough numbers are collected through several national and general reports.

· Households:

Viewin, an association of Dutch water companies, have performed surveys to Dutch households, in which the main uses of household drinking water go for showering (41%), toilet (29%) and laundry washing machine (Figure 5.3.2.1). There has been a fall of water consumption by 13% between 1995-2016 due to water reduction devices, efficient toilets or washing machines (Viewin, 2017).

	2013	2016
	litre per person per day	
Bath	1.8	1.9
Shower	51.4	49.2
Washbasin	5.2	5.2
Toilet flush	33.8	34.6
Hand washing of laundry	1.4	1.3
Machine washing of laundry	14.3	14.1
Handwashing of dishes	3.6	3.5
Dishwasher	2.0	2.5
Food preparation	1.0	1.2
Drinking coffee, tea and water	1.0	1.3
Other	3.4	4.5
Total	118.9	119.2

Table 5.3.2.1: Household water consumption in litres, 2013 &2016 (Source: Viewin, 2017).

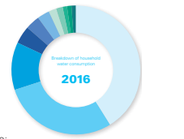


Figure 5.3.1.1: Household water consumption (%) (Source: Viewin, 2017).

The report explores the water consumption by the size of household and gender in 2016, being the younger people the group that use more water for showering and older people for flushing the toilet. Moreover, people that live in smaller households use more water per person that people who live in larger ones, due to sharing services (Viewin, 2017). According to Table 5.3.2.2, women use more water than men due to more frequent use of the toilet, about 9 L more per person/day.

	1-pers.	2-pers.	3-pers.	4-pers.	5+	Male	Female
	litre per person per day					litre/person/day	
Bath	0.4	1.5	2.2	3.5	3.5	1.9	2.1
Shower	45.2	47.6	57.1	50.6	45.1	49.9	48.7
Washbasin	5.4	5.3	5.2	4.8	5.2	5.5	4.9
Toilet flush	39.2	40.1	32.9	28.9	26.9	31.0	37.9
Hand washing of laundry	2.7	1.8	0.5	0.6	0.4	1.0	1.5
Machine washing of laundry	16.6	17.4	11.9	12.2	9.9	13.4	14.7
Handwashing of dishes	8.0	4.5	1.8	1.6	1.2	3.1	3.8
Dishwasher	0.8	3.4	2.4	3.0	2.2	2.7	2.3
Food preparation	1.5	1.1	1.7	0.9	0.8	0.9	1.4
Coffee/tea	1.1	0.6	0.8	0.8	1.0	0.8	0.8
Drinking water	0.4	0.4	0.6	0.4	1.1	0.5	0.5
Other	4.9	4.1	6.6	4.6	3.4	3.,9	5.0
Total	126.3	127.9	123.6	111.7	100.7	114.5	123.6

Table 5.3.2.2: Water consumption by size of household & gender (2016) (Source: Viewin, 2017).

The average water consumption is set around **119 L/person/day** and a total of **120,228,000 L/y** within the neighbourhood (=43,508 L/p/year*2,768 people).

· Parks:

Water demand for irrigating public parks (grass) is around 1.4 L/m2/day (Indian Standard, 1993) or 0.037 gallon / ft2/day (=**1.5 L/m2/day**) according to American book "Commercial and Institutional End Uses of Water" (Dziegielewski, 2000). However, considering that a variety of species is planted in a park rather than just grass (flowers, shrubs, trees, etc), water consumption is **3.5 L/m2/day.**

In the Spangen study area, there is only 46.8 m2 of greenery (grass), resulting in water demand of around **25,600 L/y** (=1.5L/m2/d*364*46.8). The rest of greenery consists of isolated trees, which converted into greenery area (2.25 m2/tree*119 trees) results in **342,000 L/y** and total water demand of **367,600 L/y.**

SPANGEN NEIGHBOURHOOD (Southern part)					
BLOCK	DESCRIPTION BLOCK	Nº TREES	AREA/TREE	TOTAL AREA	WATER DEMAND
Letter	-	Nº	m2	m2	L/y
A	Lidl	(4)	(2.25)	0	0
B	Upper left corner	16	2.25	36	45,990
C	Residence	20	2.25	45	57,488
D	School	32	2.25	72	91,980
E	Upper right corner	12	2.25	27	34,493
F	Bottom left corner	6	2.25	13.5	17,246
G	Left bottom	10	2.25	22.5	28,744
H	Middle bottom	10	2.25	22.5	28,744
I	Right bottom	6	2.25	13.5	17,246
J	Bottom right corner	7	2.25	15.75	20,121
TOTAL	-	119		267.75	342,051

Table 5.3.2.3: Conversion of number of trees into greenery area for water demand calculation.

· Restaurants:

In the same American book, there is a difference between Chinese restaurants (the most water consumers: 15,479 gallons/day=58,500 L/day), and fast food establishments (the lowest: 4,076 gallons/day=15,400 L/day). But in general and for simplifying calculations, a standard restaurant is chosen, being its average water consumption of around 7,736 gallons/day (=29,200 L/day) or 233 gallon/employee/day (=**880L/employee/day**) (Dziegielewski, 2000). Considering an average of 4 employees in the restaurants of Spangen, the water demand is around **3,520 L/day**.

· Schools:

The average water consumption of a school is around 1,761 gallons/day, according to the American book. However, there are differences depending on the type of school, being colleges and universities the highest consumers, followed by senior high, junior high and elementary schools (Dziegielewski, 2000). Due to the existence of primary schools in Spangen, the average of 13,260 gallon/day (=**50,195 L/day**) is finally chosen.

Variable	n	Mean	Standard Deviation	Minimum	Maximum
Average annual use for all schools (kgal)	138	11592.8	11446.0	1352.4	71165.5
Average daily use for all schools (kgal)	138	31.8	31.4	3.7	195.0
Average daily water use per employee (gal./employee)	138	341.2	216.3	29.9	971.0
Average daily water use per pupil (gal./student)	137	24.0	14.0	2.6	84.2
Average daily water use per building area (gallons/sf)	138	0.3	0.3	0.03	1.5
Average daily water use for grade schools (gallons)	60	13,260	7,792	5,100	41,420
Average daily water use for middle schools/junior high schools (gallons)	29	24,520	10,910	4,931	46,420
Average daily water use for high schools (gallons)	38	52,040	27,490	3,705	123,200

Table 5.3.2.3: School characteristics and average water use (Source: (Dziegielewski, 2000).

5.4 | DATA FLOWS IN LIDL SUPERMARKET

5.4.1 FOOD & WATER

Food:

Food waste data of Lidl NL is not publicly available but Lidl GB contains some useful data in its report and website. The latest and recorded food waste (FW) is around 40.9 tonnes per Lidl British store in 2018. Moreover, from around 41,800 tonnes of surplus food go to anaerobic digestion in the first place (95.5%), rather than to redistributions and donations (only 4.5%) (Lidl GB, 2018). This means that there is room for improvement if recovery of valuable nutrients can be performed on-site rather than send it back to the distribution centre (Lidl, 2015).

	2016	2017	2018
Food surplus (t)	38,617	37,701	**41,790**
Food surplus redistributed‡	469	533	**1,850**
Redistribution impact metric (meals donated)	1,116,689	1,269,073	**4,404,850**
Food waste to anaerobic digestion	38,148	37,168	**39,940**
Food waste per store	47.7	41.4	**40.9**

Table 5.4.1.2: Surplus and FW data (2016-2018) (Source: Lidl GB, 2018).

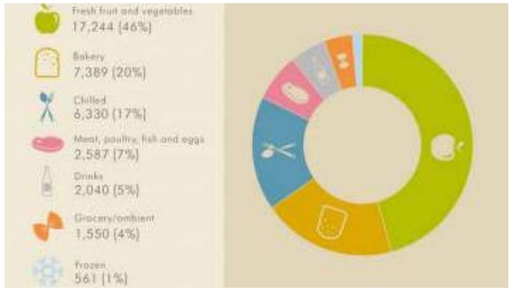


Figure 5.4.1.1: Food surplus and waste data in Lidl GB, being mainly fresh and vegetables the largest group (2017/18) (Source: Lidl GB, 2018).

However, FW differs from countries, being for example bread one of the most consumed product in The Netherlands. So, based on The Netherlands Nutrition Centre Foundation and Lidl UK data, some adaptations are performed for calculating the FW in Lidl NL (**40,900 Kg/y**).

AVOIDABLE SOLID FOOD WASTE (Lidl NL)			
DESCRIPTION OF GROUP PRODUCTS	PERCENTAGES	FIGURES	FIGURES
-	%/ Kg sorted	gr/supermarket /day	Kg/ supermarket/y
2- Vegetables	19.5	21,850.7	7,976
3- Fruit	18.5	20,730.1	7,567
1- Pastry & cake, bread-based products	26.0	29,134.2	10,634
4- (Ready meals)	15.0	16,808.2	6,135
6- Meat & meat products & fish, eggs	7.0	7,843.8	2,863
5- Dairy products (cheese, mainly thick)	9.0	10,084.9	3,681
7- Unwanted food from grocery ambient	4.0	4,482.2	1,636
8- Frozen	1.0	1,120.5	409
TOTAL FOOD WASTE	100.0	112,055	40,900

Table 5.4.1.3: Avoidable solid food waste in Lidl NL (Source adapted from Lidl GB, 2018).

Table 5.5.1.6 represents the estimation of Lidl purchased food (considering the sum of purchased food (FP) by households and FW of Lidl), after having adjusted the type of products from Lidl FW according to the purchased table list of products (Table 5.5.1.1), resulting in **904,800 Kg/y**. Restaurants and school purchased food are not considered due to another possible food supplier different than Lidl and according to specific cultures.

FOOD PURCHASED (FP) BY LIDL (rough assumptions: FW Lidl+FP households)			
DESCRIPTION OF GROUP PRODUCTS	PERCENTAGES	FIGURES	FIGURES
-	%/ Kg sorted	gr/supermarket /day	Kg/ supermarket/y
Vegetables	23.5	59,676	21,782
Fruit	18.5	35,839	13,081
Pastry & cake, pasta, rice, bread-based products	26.0	84,707	30,918
Ready meals	15.0	17,329	6,325
Meat & meat products & fish, eggs	7.0	22,432	8,188
Dairy products (cheese, butter, mainly thick)	9.0	53,153	19,401
Others	1.0	12,582	4,593
TOTAL FOOD PURCHASED (LIDL)	100.0	285,718	104,287

Table 5.5.1.6: Summary of purchased food (FP) by Lidl, assuming Lidl FW and FP by households (Source based on: Lidl GB, 2018; NNCF, 2019).

AVOIDABLE SOLID FOOD WASTE (FW) BY LIDL SUPERMARKET	
DESCRIPTION OF GROUP PRODUCTS	FW LIDL
-	Kg/y
Vegetables	9,612
Fruit	7,567
Pastry & cake, pasta, rice, bread-based products	10,634
Ready meals	6,135
Meat & meat products & fish, eggs	2,863
Dairy products (cheese, butter, mainly thick)	3,681
Others	409
TOTAL FOOD WASTE	40,900
TOTAL SPEND (3.49 euro/Kg)	142,741

Table 5.5.1.7: Avoidable solid FW in Lidl.

Water:

In general, grocery stores, including Lidl, have higher water demand than other retail operations due to refrigeration systems (coolers and freezers). Due to unavailable water consumption data of Lidl supermarket, the American book "Commercial and Institutional End Uses of Water" is used again as a reference to a typical supermarket, resulting in around 175 gallon/employee/day (660 L/employee/day) or 7,703 gallon/day (=**29,150 L/day**) (Dziegielewski, 2000), and an annual consumption of around **10,640,000 L/y.** According to EPA, water consumption in the retail can be around 3,00,000 gallon/year (=11,350,00 L/y) (EPA, 212), confirming that the previous result can be valid for this study.

Parameter	Coefficient Estimate	Standard Error	t	Prob > |t|
Intercept	4,977.213	890.724	5.59	0.0001
Employees	12.626	9.161	1.38	0.1803
Building area	0.020	0.018	1.13	0.2680
Employees * Floral department (0/1)	23.619	9.354	2.52	0.0183
Employees * Seafood department (0/1)	18.457	11.094	1.66	0.1087
Employees * Water vending (0/1)	36.804	15.586	2.36	0.0263
Employees * Irrigation (0/1) * Irrigated area	0.002	0.001	2.00	0.0568
Employees * Food prep sink (0/1) * Number of food prep sinks	3.347	2.553	1.31	0.2017

N = 33
R-square = 0.479
Root mean square error = 1,420.446
Dependent variable: Average daily water use (gallons) = 7,702.820

Table 5.4.1.4: Model for estimating supermarket water consumption (Source: Dziegielewski, 2000).

Variable	n	Mean	Standard Deviation	Minimum	Maximum
Average annual use (kgal)	33	3155.7	1264.6	1668.0	6659.4
Average daily use (kgal)	33	7.7	1.7	4.6	11.2
Average daily water use per employee (gal./employee)	33	174.9	88.6	50.8	489.9
Average daily water use per customer (gal./customer)	33	4.1	1.5	0.6	7.0

Table 5.4.1.5: Supermarket characteristic and average water use (Source: Dziegielewski, 2000).

5.5 | DATA FLOWS IN SPANGEN AREA

5.5.1 SUMMARY

This chapter tries to summarize the previous calculations, along with further ones located in chapter 10 *Appendix*, in order to clearly understand the current urban metabolism and its issues regarding the three essential flows.

- FOOD FLOWS: Mainly considering solid avoidable food waste, discarding unavoidable and liquid FW.

-Neighbourhood:

·Households:

In the Southern part of Spangen, the total purchased food is around **864,000 Kg/y** and avoidable FW is **63,390 Kg/y.** This means that around **80 Euros/y/person** is also lost through FW, so considering that Spangen is an area in need, people should not afford the right to waste food and money, thus teaching and FW reduction practices need to be introduced in the proposal.

·Restaurants:

They are responsible for a total avoidable solid food waste of around **12,280 Kg/y**: **9,460 Kg/y** of coffee grounds waste and **79,200L/y** of cooking oil waste

·School:

Mariaschool is the only school located within the study area, but it also have high amount of waste **(2,660 Kg/y).**

·Supermarkets:

Around **23,250 Kg/y** of avoidable FW is lost by the 3 supermarkets in the Southern part of Spangen.

-Lidl:

Around **904,800 Kg/y** is purchased and **40,900 Kg/y** is wasted every year in Lidl Spangen.

- WATER FLOWS: Related to drinking water consumption rather than waste water flows.

-Neighbourhood:

·Households:

The average water consumption is set around 119 L/person/day and a total of **120,228,000 L/y** (Viewin, 2017).

·Parks:

The average water consumption for a public park can be around 3.5 L/m2/day (Dziegielewski, 2000), being in the Spangen study area, a total water demand of **367,600 L/y.**

·Restaurants:

The average water consumption is around 7,736 gallons/day (=29,200 L/day) or 233 gallon/ employee/day (=880L/employee/day) (Dziegielewski, 2000). Considering an average of 4 employees in the restaurants of Spangen, demand is around **3,520 L/day (=1,240,000 L/y/restaurant).**

·School:

The average water consumption of a primary school is 13,260 gallon/day (=50,195 L/day) (Dziegielewski, 2000), resulting in total of around **15,6000,000 L/y.**

-Lidl:

Due to lack of data, an standard supermarket water consumption is considered (660 L/employee/day or 29,150 L/day), thus **10,640,000 L/y** (Dziegielewski, 2000).

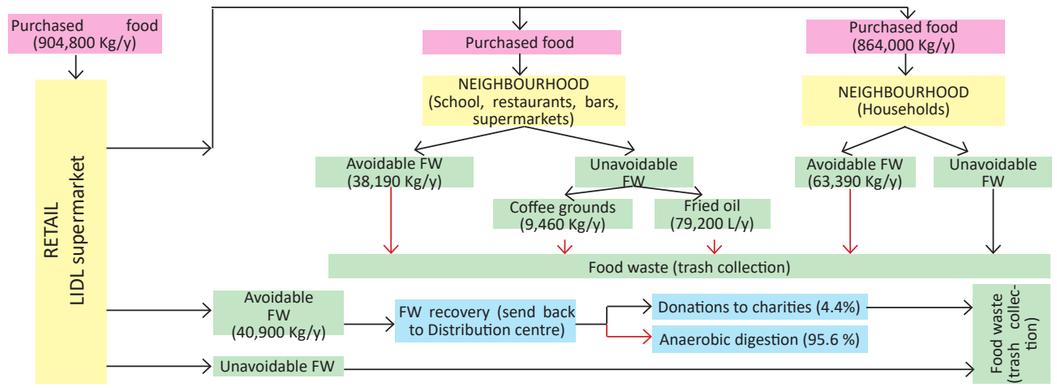


Figure 5.5.1.1: Diagram of current food flows, with avoidable flow direction in red colour (future reduction improvement).

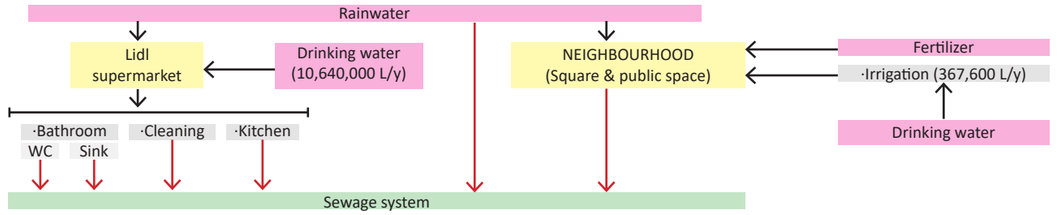


Figure 5.5.1.2: Diagram of current water flows, with avoidable flow direction in red colour (future reduction improvement).

06 RESEARCH BY DESIGN

6.1 | LOCAL CONTEXT

6.1.1 CONTEXT ANALYSIS

In order to apply efficiently the strategies from the design framework, and adapted to the local context, there is a need to follow several steps first:

·A Further study area analysis, considering local factors.
·B Challenges and potentials according to local factors in order to find spatial interventions (spatial locations).
·C Definition of boundaries (catalogue) according to spatial interventions.

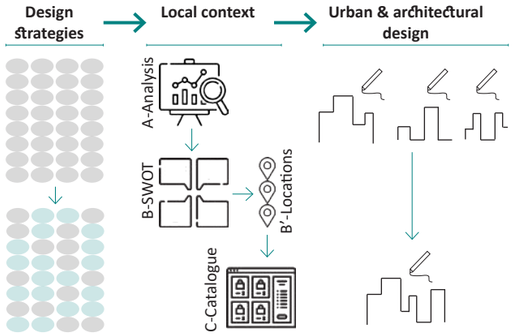


Figure 6.1.1.1: Summary of research by design chapter.

Therefore, within the context analysis, the following points are described and analysed:

- Urbanization around Lidl store:

The location of the supermarket is limiting with one of the boundaries (railway) that splits Spangen into two areas: Northern and Southern part (see chapter 5.1.2 *Urban context)* (Figure 6.1.1.2). Lidl is located in the Southern part (Mathenesserdijk 123, 3027 BG Rotterdam), on the ground floor of two residential blocks of 4 storey and 6 storey high (Figure 6.1.1.3). Although Lidl is not placed in a main road, it is located in a more quiet but central strategic street, allowing to have clients coming from different sides and have great views towards the rest of Spangen. The public space in front of Lidl is only used as a customer's car parking, with hard pavement and high transit during peak hours (Figure 6.1.1.3). The retail loading entrance and customer entrance are separated, being the first one located on the West side and the second in the North side, being located in the corner of a residential block and having an influence on both sides of the street.

Figure 6.1.1.2: Urban context around Lidl store. N

Figure 6.1.1.3: Street view of Lidl urban area (from North-East) (Source: Google maps).

- Lidl store program:

Due to lack of Lidl data, the following main characteristics have been discovered by fieldwork, observations and comparison to other supermarkets (indicated):

· Closest distribution centre: Waddinxveen (25 Km).
· Total building surface (GFA): 1,834.5 m2.
· Bake-off section with fridge (and external exit).
· Office for management at the entrance.
· Staff's room at the entrance: Dressing room, bathrooms, etc (Internal distribution by assumptions).
· Loading entrance with storage area (West side).
·Customer entrance with double door (from North side)
· 7 payment desks.
· 4 direct and 2 semi-direct emergency exit.
· Car and bike parking in front of the building.
· Little natural lighting inside the building (coming only from 3/4 parts of the North facade).

- Factors around Lidl store:

· Quality of air:

Very briefly, the universal air quality index in Spangen compared to other regions worldwide is "good", achieving a score of 76/100 points. But, the main dominant pollutants are PM10 and PM2.5, being slightly higher than average. However, when looking at the local index, there is a "moderate air quality", being O3 (ozone) the main pollutant (low amount) and followed by N02 (nitrogen dioxide) and C0 (carbon monoxide), being both above average (BreezoMeter, n.d; EPA, 2018).

Figure 6.1.1.4: Air quality overview: Universal index and local index in Lidl store (Source: BreezoMeter, n.d). N

· Sun orientation:

A simple sun path analysis is needed for studying the outdoor possibilities in front of Lidl and plant's cultivation possibilities. For example in March, the space in front of

6.1 | LOCAL CONTEXT
6.1.1 CONTEXT ANALYSIS

Lidl would receive sun rays at 8.00 h and 18.00 h.

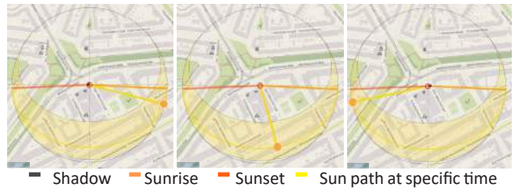


Figure 6.1.1.5: Sun and shadow path at 8.00, 12.00 and 18.00 h in Lidl store (in March) (Source: https://www.suncalc.org/#/51916,4.4371,17/2020.03.14/16:56/1/2). N

· Wind flows:

Considering the wind rose from chapter 05 *Analytical framework*, the outdoor spaces would receive these wind directions and intensities, considering also obstructions:

Figure 6.1.1.6: Wind direction and intensity. N

· Movement's flows:

Although there are several supermarkets, mostly Turkish, Lidl is the only supermarket chain that is located inside Spangen, being others 10 minutes walking distance from Lidl. Based on-site visits and although the railway and difference in the height of the ground constitute a physical barrier, Lidl has clients from the Southern and Northern part of Spangen, coming mainly by walk. There are car and bike parking too, which are quite full during peak hours, meaning that people can come from the exterior of Spangen neighbourhood or they do the weekly shopping.

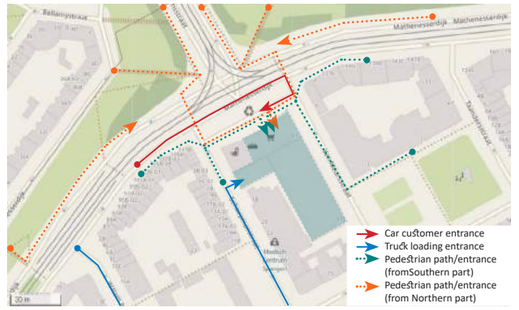


Figure 6.1.1.7: Movements flows by cars or pedestrians (Source adapted from: https://www.openstreetmap.org/export#map=18/51.91506/4.43827&layers=H). N

· Views:

This analysis is important for improving safety and reducing criminality in the area. Based on fieldwork, the facade of Lidl store is constructed by opaque walls except the North side, made by glazing and covered with few posters.

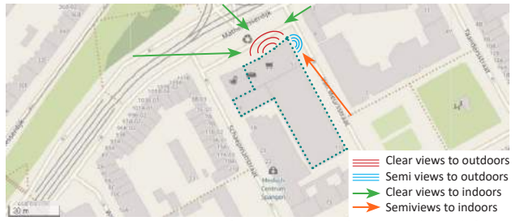


Figure 6.1.1.8: Views to and from Lidl store (Source adapted from: https://www.openstreetmap.org/export#map=18/51/4.7&layers=H). N

· Urban heat island:

The majority of public spaces around Lidl consist of hard pavement, increasing urban heat effect (2 more degrees). Moreover, apart from the greenery along the railway, there is little greenery in the rest of the area, being badly managed and focused on specific spots.

Figure 6.1.1.9: Urban heat island (Source: https://www.atlasleefomgeving.nl/kaarten N

- General quality criteria of public space (around Lidl):

The space in front of Lidl is important to be analysed because it could contribute to a better quality of life in the neighbourhood and increase the supermarket's sales because activity attracts people and boost well-being among Lidl customers. These 12 factors contribute to the analysis of the public space next to Lidl, and based on fieldwork:

Protection (P) from:		
Motorized traffic:	**Crime & violence:**	**Unpleasant & sensorial experience:**
-P for pedestrian & cyclists	-Active urban space	-Climate
-Direct access	-Passive surveillance	-Cold or heat
-Safe crossings	-Function's diversity	-Low noise levels
-Low speed traffic	-Adequate lighting	-Low contamination & unpleasant aromas
Comfort (Opportunities for):		
Walking & cycling:	**Standing up & be:**	**Sitting down:**
-Obstacles	-Spaces for standing	-Nice view orientated
-Maintenance	-Objects to lean or lie down	-Seat's variety
-Universal accessibility		
-Adequate distances to other amenities		
See:	**Speaking & listening:**	**Playing & exercise:**
-Pleasant views	-Low noise levels	-Elements for encouraging activities
-Few obstructions	-Seats for boosting conversations	-Cultural/commercial for increasing life
-Night lighting		
Pleasure (Enjoy of):		
Human scale:	**Climate & nature:**	**Aesthetics + sensorial**
-Right dimensions	-Desired orientation	-Good design, materials, details.
-Right distances	-Local trees & vegetation	-Good views
-Comfortable objects		-Sensory experiences

Table 6.1.1.1: Analysis of Lidl outdoor quality space: Meet this criteria (green), half (orange) or not (red) (Source based on: MINVU, 2017).

6.1.2 CHALLENGES & POTENTIALS SUMMARY

There is a wide range of spatial possibilities for the proposal that could meet the objectives of this thesis, so a summary of main challenges and potentials from the SWOT analysis in chapter 05 Analytical framework, is performed to look for optimal spatial interventions and narrow down the possibilities.

Table 6.1.2.1 represents the existing challenges and people demands, the location where these happen and the future achievement of SDGs if those challenges were improved. Based on people demands, possible improvements can be searched, resulting in different actions and represented by several spatial interventions, (a doable and more concrete physical approach). However, some of these interventions can be integrated and grouped in bigger constructions, as represented at the bottom of the Table 6.1.2.1. The remain 3 big interventions could be:

·Outdoor space
·Lidl refurbishment
·Greenhouse

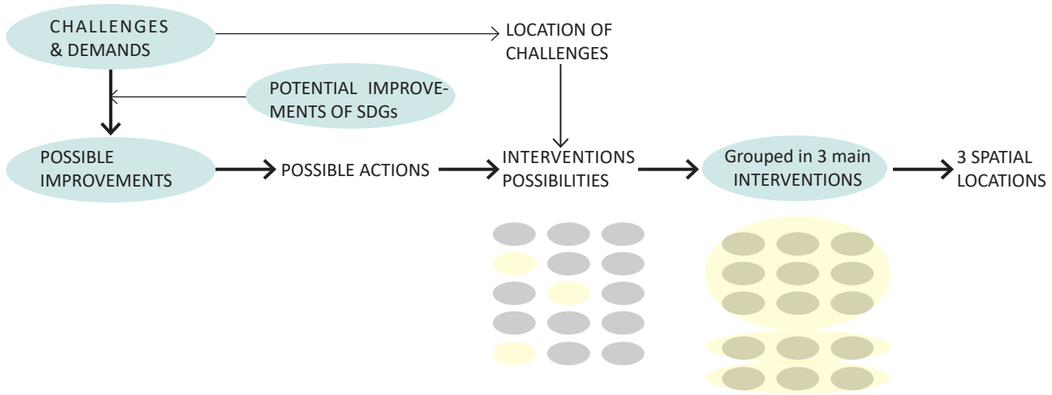


Figure 6.1.2.1: Summary of the process of Table 6.1.2.1, resulting in 3 intervention spaces

CHALLENGES & NEEDS (what):	SPATIAL CHALLENGES (where):	POTENTIAL SDGs
1- Low income & unemployment	1- Neighbourhood (citizens)	8, 17
2- Criminality & vandalism	2- Outdoor spaces (streets, housing, parks, etc)	3, 10
		3, 15
3- Bad health, scarcity & bad management of greenery spaces	3- Outdoor spaces (parks, streets)	
4- Loneliness, disaggregation, racism, dissatisfaction, difficulties for integration (Dutch language)	4- Neighbourhood (citizens)	3, 5, 10
5- Sustainability unawareness and ignorance	5- Households, Lidl, outdoor spaces (urban infrastructures)	2, 6, 7, 9, 11, 12, 13, 14, 15
POTENTIALS IMPROVEMENTS (what):	**POTENTIAL ACTIONS (how):**	**POTENTIAL INTERVENTIONS (where)**
1- Boost employment (local economy)	1- ·Chef, waiter, staff, assistant, ... ·Teacher, repairman, carpenter ... ·Farmer, cleaner, chef, staff, .. ·Maintenance, bodyguard, baby sitter...	·Cafeteria, restaurant ·Workshop rooms, physical activity area ·Urban greenhouse ·Lidl
2- Cohesion and integration through employment opportunities, talent's improvement...	2- ·Bodyguard, carpenter... · Builder, maintenance, repairman, ..	·Lidl, cafeteria, GH ·Outdoor space, GH
3- Satisfaction regarding air purification, experience through 5 senses.	3- ·Greenery parks, biodiversity, recreation ·Purification of indoor air (greenery)	· Outdoor space · Outdoor space

4- Cohesion, participation, integration, connectivity	4- ·Cultural events, dinner, musical lessons, art, painting, photography, language.. ·Physical & social activities, group games and activities, open gym ·Cooking, fresh & organic food ·Group study, gathering, social activity ·Workshops in collaboration with local companies, conferences, ... ·Fair and market	· Cafeteria, outdoor space, workshop rooms, art exposition space, dining area ·Outdoor space, Lidl, social rooms ·Kitchen room, GH ·Social rooms ·Workshop rooms, gathering space ·Outdoor area
5- Climate awareness & education, recyclability and reduction of waste, learning innovations... (sense of commitment , responsibility and positive feeling)	5- ·Education through sustainable workshops (cooking with FW, composting..), recyclability and upcycle processes (mushrooms from coffee grounds, soap from oil..) ·Sustainability (aquaponics, air exchange, PV, phytoremediation, water cycle...)	·Composting zone, kitchen room, GH, upcycling processes area, communal garden ·Outdoor space, GH

·Phytoremediation, water cycle, physical activity area, art exposition space, .. → ·Outdoor space
·Cafeteria, meeting and social rooms, gathering space.. → ·Lidl refurbishment
·Workshop rooms, restaurant, dining area, composting zone, upcycling processes area, meeting and social rooms, kitchen room, communal garden.. → ·Urban greenhouse

Grouped in 3 main interventions

Table 6.1.2.1: Challenges and potentials of Spangen context, with possible SDGs achievements and first ideas for interventions.

From the previous step, 3 types of interventions were concluded in order to meet citizen's demands, resulting in not only improvements for Lidl but also the neighbourhood. So, there is a need to act in all of interventions for achieving further SDGs, improving social context and urban metabolism in Spangen. Ought to this thesis is related to Lidl, it is logical to consider the locations next to it:

·1- Improvement of outdoor space: The square in front of Lidl or in front of the school (Mariaschool).
·2- Lidl refurbishment: Interior of Lidl
·3- New greenhouse: 2 possible rooftops above Lidl.

Figure 6.1.2.2: Spatial options of the 3 interventions: Greenhouse (green), Lidl refurbishment (red), outdoor space (yellow) (S: Google maps).

-Square:

The introduction of a square is crucial due to the benefits not only for Lidl but also the neighbourhood, such as:

·An active and well-designed square (meet, play, relax, observe, etc), result in increase of satisfaction and well-being.
·Improvement of existing outdoor public space.
·More outdoor activity attract people, meeting and sharing experiences, thus increasing participation, cohesion..
·If the square is attractive, it brings more people to it.
·If people stay in the square, they are likely to enter to Lidl.

The two spatial possibilities are in front of Lidl or school, having both the closest connection to Lidl supermarket. Finally, the area in front of Lidl is chosen due to higher benefits for Lidl and Spangen, and solvable downsides.

	In front of Lidl	In front of Mariaschool
Advantages	·In front of Lidl entrance (customer attractor). ·Greater improvements. ·Central location, improving connection between North and South.	·Children brings activity to the square. ·Safety and sunny square (South orientation).
Disadvantages	·Little sun due to North orientation. ·Possible safety issues due to the secondary road next to it.	·It is already used by children from school (being chaotic during school time. ·Far from Lidl (disconnection from it) ·Little space for improvement due to existing equipment.

Table 6.1.2.2: Advantages and disadvantages from the two location options of the square.

-Lidl refurbishment:

This refurbishment could provide a cafeteria service and relaxing spaces at night for example, thus reducing criminality and activating the area also during weekends. Only the entrance area of Lidl is refurbished due to higher potentials against criminality, connection to exterior space and independent management possibilities.

-Greenhouse:

A facility for local food production would allow accommodating other social spaces, achieving greater benefits for the social community and urban flows of Spangen. The location is based on optimal orientation and temporary construction possibility, so rooftops seem the best location for food production, profiting height and sun rays, safety area from public transit and close to Lidl. The final selected rooftop is the building 1 due to several criteria explained in chapter 6.3.4 *Spatial designs of Greenhouse.*

6.1.3 DEFINITION OF SYSTEM BOUNDARIES

The last step prior to the design process is to define in detail the type of uses and spaces needed and aimed for those interventions. Also, a definition of specific species for the greenhouse is required for evaluating later the required dimensions, conditions and ecosystem process.
So an analysis of possible spaces and species is conducted, resulting in a large catalogue that can be implemented in general in Spangen. However, only specific proposals from those catalogues are selected for those 3 interventions, based on local conditions, greater benefits and SDGs.

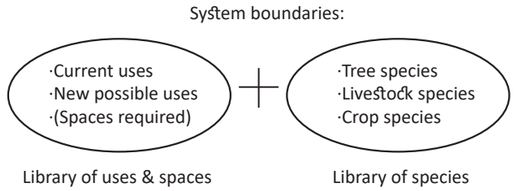


Figure 6.1.3.1: System boundaries (catalogue).

- Library of uses and spaces:

Based on fieldwork, district reports and private identities in Spangen, it is known that there are few social facilities in the neighbourhood. The only two existing social clubs are Westervolkshuis (Northern part) and Stichting Openhaard (Southern part), which is the main focus. The last facility is very closed to the GH, around 100 m (1 minute), giving great opportunities for a future social connection between Stichting Openhaard-GH space.

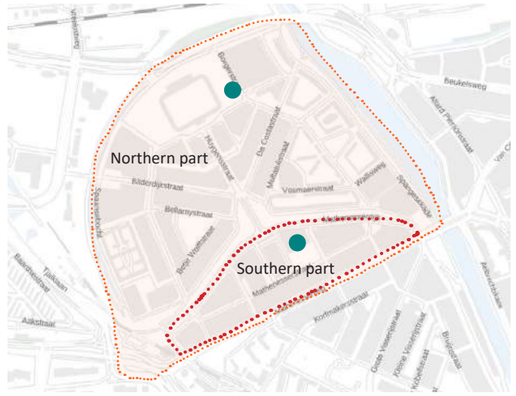


Figure 6.1.3.2: Social facilities in Spangen (Source: https://www.openstreetmap.org/export#map=18/51.91506/4.43827&layers=H).

As already described in chapter 5.1.4 *Existing initiatives*, Westervolkshuis works as a social building in order to boost community feeling, reduce loneliness, provide food to disadvantaged neighbours, and organize some cultural activities. Similarly, Stichting Openhaard organizes languages lessons, cooking activities, indoor football, conferences or dancing lessons through the help of several volunteers and internships.

However, the interior distribution and organization of the latest building is not attractive for the participation of society and could be much more improved. Moreover, as observed in Figure 6.1.3.4, it lacks lighting, comfort, healthy and interesting indoor working environment or motivational spaces, among other factors.

Figure 6.1.3.3: Unattractive interior distribution of Stichting Openhaard (Source: Stichting Openhaard, 2017).

With the proposal of the new greenhouse, not only some of the current activities (of the social club) could be moved there, improving indoor comfort, location and views, but also more social and health activities could be added in the GH agenda.

-Existing activities/uses in Stichting Openhaard:

- · Languages lessons
- · Instrument lessons
- · Photography
- · Kick-boxing
- · Cooking activities
- · Sewing courses
- · Turkish coffee
- · Dancing lessons
- · Conferences
- ·Art lessons
- · Indoor football
- · Reading
- · Informatics
- · Excursions

The previous activities were analysed in order to see its feasible option due to high social benefits that could bring to the GH. Certain criteria have been applied, for example:

- ·Group activities that boost integration and cohesion
- ·Calm activities
- ·Activities that requires small rooms
- ·Lightweight and simple equipment needed
- ·Cultural activities
- ·Activities that can boost sustainability awareness

In the end, the activities that result in interest for the uses of the new GH are the ones that meet higher criteria and could add interesting social values.

-Moved activities/uses to the new GH:

- · Language lessons
- · Guitar lessons
- · Photography
- · Kitchen workshops
- · Sewing courses
- · Coffee time
- · Dancing lessons
- · Conferences
- · Art lessons

Moreover, new additional activities according to the previous criteria could be added in the GH.

-New additional activities/uses in the GH:

- · Nutrition & FW workshops
- · Climate awareness, sustainability conference, upcycling & CE workshops
- · Low technology and innovation conferences
- · Table games
- · Agriculture lessons & harvesting
- · Animal feeding & care
- · Dinner events
- · Private plant ownership (commitment, care, good feeling, propriety feeling..)
- ·Social rooms, study area
- · Organization of indoor fairs, cinema or small events

Therefore the future required spaces in the GH should meet several spatial demands.

-Social spaces required in the GH:

- · Flexible learning and workshops spaces
- · Spatial space for kitchen workshops
- · Dining area with private zones
- · Flexible game's area (wide space, tables, etc)

It should be mention that the services of the current social clubs are mainly intended for the use of disadvantaged people, who account for around 80 neighbours and spend an average of 5 hours per day in social activities.
Due to the private feeling and reserved character of these particular citizens, the timetable of the new GH can be split in two: a period for local neighbours (mainly disadvantaged) and then a period for the rest of the citizens (including disadvantaged, local neighbours, visitors, students, children or the rest of population).

- Library of species:

· Tree species:
For the square in front of Lidl, several trees and plants are placed in order to increase not only greenery but also improve rainwater filtration, reduce flooding and UHI, or improve general well-being and landscape's aesthetics.

The first factor is the use of local species (native), not only for their better adaptability of the climate situation but also for the protection of autochthonous specimen and improvement of local feeling. In fact, according to the *Country report for the FAO First State of the World's Forest Genetic Resources for Food and Agriculture,* 95% of all native and non-native trees and shrubs are originated from another country, meaning that only 5% are original vegetation (autochthonous) (Ministry of Economic Affairs, 2012). Moreover, natural value is more valuable in this thesis context than economic importance.

Priority species			Reasons for priority
Scientific name	Tree (T) or other (O)	Native (N) or exotic (E)	
Pseudotsuga menziesii	T	E	Economic importance
Juniperus communis	T	N	Protected species, natural value
Prunus serotina	O	E	Invasive, priority for removal
Fagus sylvatica	T	N	Economic importance, natural value
Quercus robur	T	N	Economic importance, natural value
Quercus petraea	T	N	Economic importance, natural value
Populus spp.	T	N/E	Economic importance, natural value
Fraxinus excelsior	T	N	Economic importance, natural value
Acer pseudoplatanus	T	N	Economic importance, natural value

Table 6.1.3.1: Priority of species in The Netherlands (Source: Ministry of Economic Affairs, 2012).

Other considerations for the specific selection of species are represented on Table 6.1.3.2, being the main important factors: 1, 3, 4, 5.

Species (scientific name)	Native (N) or exotic (E)	Environmental importance value
Pinus sylvestris	N	1,3,5
Pseudotsuga menziesii	E	5
Larix spp.	E	5
Fagus sylvatica	N	1,3,4,5
Quercus robur	N	1,3,4,5
Quercus petraea	N	1,3,4,5
Populus spp.	N	1,2,3
Salix spp.	N	1,2,3
Castanea sativa	E	4
Prunus avium	N	3,4,5
Malus sylvestris	N	3,4,5
Alnus glutinosa	N	1,2,5
Acer pseudoplatanus	N	1,2,3,5
Tilia spp.	N	2,3,4,6

1 soil and water conservation including watershed management; 2 soil fertility; 3 biodiversity conservation; 4 cultural values; 5 aesthetic values; 6 religious values.

Table 6.1.3.2: Main tree species providing environmental services or social values (Source: Ministry of Economic Affairs, 2012).

The rest of factors for the final selection depend on the maintenance frequency, size (width and height), shape, type of leaves, climate conditions (North orientation, little sun rays), colours, flowers or fruits, to name a few. For example, deciduous trees tend to absorb nitrogen whereas conifers are good for particle matters (Ministry of Economic Affairs, 2012). Moreover, a combination of broad and perennial leaves, or flowers and non-flower trees are aimed in order to achieve a balance of colours, shades, textures and leaves vision throughout the whole year.
In the end, Table 6.1.3.5 shows the library of tree's species possibilities for the Lidl square (UK plant atlas, n.d.; Van den Berk BV (n.d.), with suggestion highlighted with a box and based mainly on colour, biodiversity attractor, height and orientation, among others.

· Livestock species:
Due to the location of the future GH in the top roof of an existing residential building, animal weight is a crucial factor to be considered. Moreover, the waste combination of animals and plants plays an important role in the balance of the natural ecosystem goal. The possibility to reduce FW from the neighbourhood in a natural and low technology way is also aimed, looking for animals that can either digest FW and provide food products.
Therefore the selection of terrestrial animals is based on

Specie name	General shape	Aesthetics	Main characteristics	
Acer pseudoplatanus			· Height: 15-20 m · Form: Deciduous · With flower (April) and fruit 3.5 cm · Moisture: Mainly on fresh soils of average dampness · Orientation requirements: Shade/sun	· Annual precipitation area: For 1083 mm · Temperature: Frost resistance (-18 to 35 degrees) · Wind resistance: Very good · Biodiversity attractor: Bees
Fraxinus excelsior			· Height: 15-20 m · Form: Deciduous · With flower (April) · Moisture: Mainly on humid soils · Orientation requirements: Semi-shade plant, rarely in full light	· Annual precipitation area: Resists short floods, for 1069 mm · Temperature: Frost resistance (-30 to 25 degrees) · Wind resistance: Good · Biodiversity attractor: Bees
Quercus robur			· Height: 25-30 m · Form: Deciduous · With flower (April) and fruits · Moisture: Mainly on fresh soils of average dampness · Orientation requirements: Plant generally in well lit places, but also occurring in	partial shade · Annual precipitation area: Resists short floods, for 1049 mm · Temperature: Frost resistance. · Wind resistance: Good · Biodiversity attractor: Butterfly, food for birds
Fagus sylvatica			· Height: 30-40 m · Form: Deciduous · With flower (May) · Moisture: Mainly on fresh soils of average dampness · Orientation requirements: Shade plant,	mostly less than 5% relative illumination · Annual precipitation area: Resists short floods, for 1061 mm · Temperature: Frost resistance · Wind resistance: Moderate · Biodiversity attractor: -
Pinus sylvestris			· Height: 10-30 m · Form: Coniferous · With flower and fruit · Moisture: Average humidity or dry · Orientation requirements: Plant generally in well lit places, but also occurring in	partial shade · Annual precipitation area: Resists short floods, for 1930 mm · Temperature: Frost resistance · Wind resistance: Good · Biodiversity attractor: Food for birds
Prunus avium			· Height: 15-20 m · Form: Deciduous · With flower and fruit 1.5 cm · Moisture: Mainly on fresh soils of average dampness · Orientation requirements: Shade/sami	shade tree · Annual precipitation area: For 1024 mm · Temperature: Frost resistance · Wind resistance: Reasonable · Biodiversity attractor: Food for birds, butterflies, bees
Malus sylvestris			· Height: 7-9 m · Form: Deciduous · With flower and fruit 4 cm · Moisture: Humid · Orientation requirements: Shade/sami shade tree	· Annual precipitation area: Resists short floods · Temperature: Frost resistance · Wind resistance: Good · Biodiversity attractor: Food for birds, butterflies, bees
Alnus glutinosa			· Height: 8-12 m · Form: Deciduous · With flower and fruit · Moisture: Very humid · Orientation requirements: Semi-shade plant, rarely in full light	· Annual precipitation area: Resists short and long floods, for 1100 mm · Temperature: Frost resistance · Wind resistance: Good · Biodiversity attractor: -
Tilia spp			· Height: 12-15m · Form: Deciduous · With flower and fruit · Moisture: Dry/humid · Orientation requirements: Semi-shade	plant, rarely in full light · Annual precipitation area: - · Temperature: Frost resistance · Wind resistance: Very good · Biodiversity attractor: Bees, butterflies

Table 6.1.3.5: Library of tree's species possibilities for the Lidl square (Source: https://www.pelckmans.net/nl/13257/acer-pseudoplatanus-2).

weight, local food culture demand, economic productivity and the possibility to reduce FW, among others. Based on the different ethnicities living in Spangen, food consumption behaviour is important, prevailing Moroccan, Turkish and Dutch culture. Chicken meat is one of the basics in all menus of citizens of Spangen, allowing to obtain also eggs. The second selected terrestrial animal is the rabbit, allowing to have more diversity, higher waste value as fertilizer and possible meat exportations to other neighbourhoods where Dutch people are living (Figure 6.1.3.4).

The waste that is produced by these two animals contains high nutrient values for the plants as fertilizer, and additionally, they are able to reduce the FW amount from the neighbourhood. For example, they are able to digest (Gaherprogra (n.d.); Hola, 2012):

- Chickens:
  ·All fresh vegetables and fruits (without seed).
  ·Others: Rest of meat and fish (including shredded bones), small seeds, bread, beans, peels, cereals, eggs shells and other sea shells, sand, invertebrate animals,

Representation	Specie name	Spangen culture (consumption)
	· Duck	Morocco, Turkey,
	· Rabbit	Morocco, NL
	· Turkey	Turkey
	· Chicken	Morocco, Turkey, NL, Suriname
	· Quail	Morocco

Table 6.1.3.4: Library of terrestrial species possibilities in the GH.

rice, pasta, legumes, mini stones...
·Exceptions: Avocado, garlic, onions, food with salt and sugar, citric, tomato leaves.

- Rabbits:
  ·All fresh green vegetables except: Cauliflower, leek, iceberg lettuce, green peas.
  ·All fruit without seed (including watermelon and melon skin) except: Figs, apricots, peach, citric,

Although worms from vermicomposst are not suitable for human consumption, they are a great nutrient for chickens and fish, fertilizer and digestors of FW (GRAMA, n.d):

- Worms:
  ·All vegetables and fruits.
  ·Others: Hair, shells, gardening waste, coffee grounds, peels, potatoes, cardboard, bread, ...
  ·Exceptions: Citric, meat and fish, oil, dairy products.

- Water species:

Regarding water species, a variety of fish and seafood could be produced in the NFT aquaponics system of the GH. However, due to simplifications, climate condition requirements, local culture demand of Spangen and economic productivity, Common carp and Nile tilapia are selected. They can productively coexist with each other, having the same economic yield/m2, similar stress tolerance and temperature requirement (FAO, 2014).

COMMON SPECIES USED IN AQUAPONICS				
Name of specie	Harvested period	Harvested weight	Optimal temperature	Crude protein in feed
-	months	grams	Degrees	%
Common carp	10	600	25-30	30-38
Nile tilapia	6	600	27-30	28-32
Channel catfish	10	400	24-30	25-36
Rainbow trout	15	1000	14-16	42
Flathead mullet	10	750	20-27	30-34
Giant river	5	30	26-32	35
Barramundi	10	400	26-29	38-45
Name of specie	Total ammonia nitrogen	Nitrite	Dissolved 02	-
-	mg/L	mg/L	mg/L	-
Common carp	<1	<1	>4	-
Nile tilapia	<2	<1	>4	-
Channel catfish	<1	<1	>3	-
Rainbow trout	<0.5	<0.3	>6	-
Flathead mullet	<1	<1	>4	-
Giant river	<0.5	<2	>3	-
Barramundi	<1	<1	>4	-

Table 6.1.3.6: Common water species used in aquaponics system (NFT) (Source based on: FAO, 2014).

· Crops species:

Similarly, crop species for the GH are selected according to economic productivity, seasonal period, local production depending on the climate conditions or local food culture demand. Moreover, they are chosen based these criteria: time, space and context (Table 6.1.3.7). But there is a difference between field crops (outdoor) and NFT aquaponics system (indoor), leading to produce different types of crops according to each limitation system.

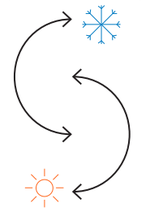
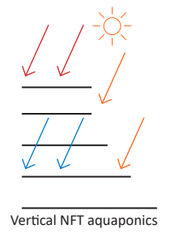
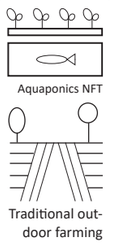
Time	Space	Context
		
Seasonal crops are exchanged (winter-summer period)	Space organization according to full sun, partial or shadow requirement	Crops specie depending on growing system

Table 6.1.3.7: Criteria (time, space, context) applied in the GH.

However, prior to providing a list of crop species, a brief study of the Dutch food market is performed, allowing to know weaknesses or scarcities, trends and valuable products in The Netherlands (Except, 2011; European Parliament, 2019):

· Fruits and vegetables: Dutch horticulture sector is largely developed, being one of the biggest in the world. However, 80% of fruits are imported, meaning that the fruit market has a good opportunity for producing it locally. Vegetables are produced and consumed locally (80%), being tomatoes, cucumbers, peppers, radishes and eggplants the most produced plants in greenhouses, and onions, leeks, carrots, brussels sprouts in field crops.
· Mushrooms: The Netherlands is one of the three biggest mushrooms producers in the world, in which around 75% of consumed mushrooms in the country are fresh, meaning that there is little importation. New trends are focusing on the development of mushrooms from coffee ground's waste, trying to replace the traditional bitterballen by veggie options.
· Herbs & spices: There is a limitation in the production of herbs and spices in the country. Around 75% are imported, consisting mostly of sage, oregano, mint and rosemary, being the domestic production focused on parsley, sage, dill, mint, savory and thyme. The main consumption herbs are thyme and oregano, but there has been an increase of marjoram, oregano, sage, thyme, bay leaves and coriander due to the international food consumption. Lastly, herbs are also being more used as natural preservatives and antioxidants, especially for meat products, leading to a future demand approach.

· Organic and ecological products: There has been a rise in the consumption of biological products by Dutch population since the last decade, and the focus on sustainable production at local, national or European level.
· Conclusions: Based on this simple analysis about the Dutch market, the first opportunities in the future design are focused on the diversity of local food products. Although large production of vegetable is already performed, they are oriented only on specific products, so by providing a wide range of products and locally, shipping costs, transportation, packaging, tariffs, time and importated products, could be reduced, thus increasing organic, fresh and sustainable products with direct access to the local community of Spangen.

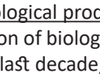
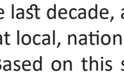
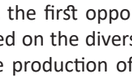
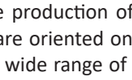
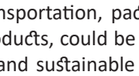
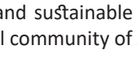
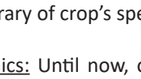
The following library of crop's species can be displayed:

A- NFT Aquaponics: Until now, over 150 different vegetables, flowers, small trees or herbs have been successfully grown in aquaponic systems (FAO, 2014). However, according to NFT system, Spangen culture demands and other mentioned factors, the final library of crop's species can be seen in Table 6.1.3.8 (Upstart University, 2016). Personal suggestions are highlighted with a box and based mainly on the harvesting period, culture demand, and height, among others. The result is a "polyponic" system, in which polyculture (variety) and aquaponics are combined. Other possibilities such as edible and non-edible flowers could be also plated within the NFT system, for example: *Nasturtiums, borage, pansies or lily flower.*

B- Open field crops: Products that need soil and have high demand in Spangen are aimed to be produced in the outdoor farm of the GH (World Food and Wine, 2005; Statista Research Department, 2017; Republic of Turkey, 2018). Around 40% of Dutch consumers are interested in buying more seasonal fruits and vegetables, so organic local production is desired (Statista Research Department, 2020; Old Farmer's Almanac, n.d; Masley, n.d.).

Spangen culture	Specie name
Morocco	Potatoes, onions, zucchini, carrots, and pumpkin, eggplant
Turkey	Tomato, cucumber, eggplant, cabbage, green beans, carrots, pepper, potato, zuchini
Netherlands	Broccoli, coliflower, spinach, green beans, asparagus, leek
Surinam	Cucumber, green cabbage, green beans, bean sprouts, tomato, eggplant, garlic

Table 6.1.3.9: Vegetables most typical or consumed according to the different cultures of Spangen.

	Specie name	Shape	Harvesting period	Spangen culture (consumption)	Main characteristics	
Leafy green plants	Lettuce		30 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 22 · PH: 6-7 · Light exposure: full sun (light	shading in warm temperatures) · Germination time and Tº: 3-7days, 13-21 degrees.
	Swiss chard		30 days	Morocco, Turkey, NL	· Optimal Tº (degree): 22 · PH: 6-7.5 · Light exposure: full sun (partial shade for temperatures	> 26 °C) · Germination time and Tº: 5 days, 25-30 degrees.
	Kale		50 days	Morocco, Turkey, NL	· Optimal Tº (degree): 26 · PH: 5.5-6.5 · Light exposure: Full sun	· Germination time and Tº: 5-8 days, 7 degrees.
	Bok choy		50 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 18 · PH: 6-7.5 · Light exposure: Full sun	· Germination time and Tº: 7-10 days, 7 degrees.
	Spinach, arugula or rocket, watercress		74 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 27 · PH: 6.5-7 · Light exposure: Full sun	· Germination time and Tº: 7-10 days, 7 degrees.
Fruity vegetables	Broccoli		80 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 13 · PH: 6-7 · Light exposure: Sun	· Germination time and Tº: 4-7 days, 18 degrees.
	Cucumber		60 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 23 · PH: 5.5-6 · Light exposure: Full sun	· Germination time and Tº: 6-9 days, 24 degrees.
	Tomato cherry		90 days	Morocco, Turkey, NL	· Optimal Tº (degree): 23 · PH: 5.5-6.5 · Light exposure: Full sun	· Germination time and Tº: 5-10 days, 20-30 degrees.
Fruits	Strawberries		40 days	Morocco, Turkey, NL	· Optimal Tº (degree): 20 · PH: 5.5-6.5 · Light exposure: Sun	· Germination time and Tº: 2-3 weeks, 20-30 degrees.
	Blueberry, brambles, cranberries, and raspberries		140 days	Morocco, Turkey, NL	· Optimal Tº (degree): 21 · PH: 5.5-6 · Light exposure: Sun	· Germination time and T: Not possible

	Specie name	Shape	Harvesting period	Spangen culture (consumption)	Main characteristics	
Fruits	Melon		80 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 25-33 · PH: 5.5 · Light exposure: Sun	· Germination time and T: 2 weeks, 30 degrees
Herbs	Basil		40 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 24 · PH: 5.5-6.5 · Light exposure: Sunny or	slightly sheltered · Germination time and Tº: 1 week, 20-25 degrees.
	Parsley		80 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 22 · PH: 6-7 · Light exposure: full sun;	partial shade at > 25 °C · Germination time and Tº: 9 days, 20-25 degrees.
	Mint		30 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 13 · PH: 6-7 · Light exposure: Full sun	· Germination time and Tº: 10-15 days, 20-25 degrees.
	Oregano		60 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 16 · PH: 6-8 · Light exposure: Sun	· Germination time and Tº: 7-15 days, 22-25 degrees.
	Thyme, sage, chive		90 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 20 · PH: 6.5-7 · Light exposure: Full sun	· Germination time and Tº: 7-10 days, 20 degrees
	Dill		30 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 18 · PH: 5.5-6.5 · Light exposure: Sun	· Germination time and Tº: 7-15 days, 18 degrees.
	Cilantro (coriander)		50 days	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 16 · PH: 6.5-7 · Light exposure: Sun	· Germination time and Tº: 7-10 days, 16 degrees.
	Rosemary		70 days	Turkey, NL	· Optimal Tº (degree): 27 · PH: 5.5-6 · Light exposure: Full sun	· Germination time and Tº: 1-2 weeks, 25
	Chamomile, lavender, anise		60 days	Morocco, Turkey, NL	· Optimal Tº (degree): 16 · PH: 5.5-7.5 · Light exposure: Full sun	· Germination time and Tº: 1-2 weeks, 16 degrees.

Table 6.1.3.8: Library of crop's species possibilities for the aquaponic system NFT in the GH of Spangen (Source: https://growerssupply.wordpress.com/2015/04/29/plantprofile- shiro-baby-white-stem-pac-choi/).

	Specie name	Shape	Harvesting period	Spangen culture (consumption)	Main characteristics	
Spring - Summer	Broccoli		4 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 18-21 · PH: 5.5-6.5 · Light exposure: Full sun	· Germination time and Tº: 4-7 days, 16 degrees.
	Eggplant		4 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 26-29 · PH: 5.5-6.5 · Light exposure: Full sun	· Germination time and Tº: 5-6 days, 26 degrees.
	Tomato		4-5 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 21 · PH: 6-7 · Light exposure: Full sun	· Germination time and Tº: 5-10 days, 21-27 degrees.
	Cucumber		2 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 20 · PH: 5.5-7 · Light exposure: Full sun	· Germination time and Tº: 4-10 days, 25-28 degrees.
	Zuchini		2-3 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 21 · PH: 6.5-7 · Light exposure: Sun	· Germination time and Tº: 7-14 days, 25-35 degrees.
	Cabbage		5 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 15 · PH: 6.5-7 · Light exposure: Partial sun	· Germination time and Tº: 3-4 days, 18 degrees.
Autumn - Winter	Garlic		9 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 10-24 · PH: 6.5-7 · Light exposure: Partial sun	· Germination time and Tº: 4-8 weeks, 4-10 degrees.
	Carrot		4 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 19 · PH: 5.5-7 · Light exposure: Full sun and	can tolerate partial shade · Germination time and Tº: 6-21 days, 15-21 degrees.
	Onion		5 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 15-30 · PH: 6-7 · Light exposure: Sun	· Germination time and Tº: 1-2 weeks, 20-25 degrees.
	Leek		5 months	Morocco, Turkey, NL, Suriname	· Optimal Tº (degree): 21 · PH: 6-7 · Light exposure: Full sun	· Germination time and Tº: 10-14 days, 21 degrees.

Table 6.1.3.10: Library of crop's species possibilities for the open field in the GH of Spangen, according to the seasonal period (Source: https://www.farmersweekly.co.za/crops/growing-garlic-opportunity-for-sa-farmers/).

6.2 | CIRCULAR SOLUTION ROUTES

6.2.1 SUSTAINABLE & LOW TECH MEASURES

Sustainable and circular measures are thought to be adapted to the current socio-economic situation of Spangen, so low tech measures are preferred. The boundaries considered for the research of circular solutions are:

-Essential flows: Water, air, food.

-3 interventions:

·GH (Lidl proposal)

·Refurbishment of Lidl (Lidl proposal)

·Square (Spangen neighbourhood)

Although the main focus is destined to the essential flows, the rest of the flows could be also improved with little effort or as an indirect consequence of the measures for the previous flows. Therefore small and easy solutions for these flows will be also described at the end.

Circular solution routes can be either applied at the building scale or in synergy with the rest of Spangen's facilities.

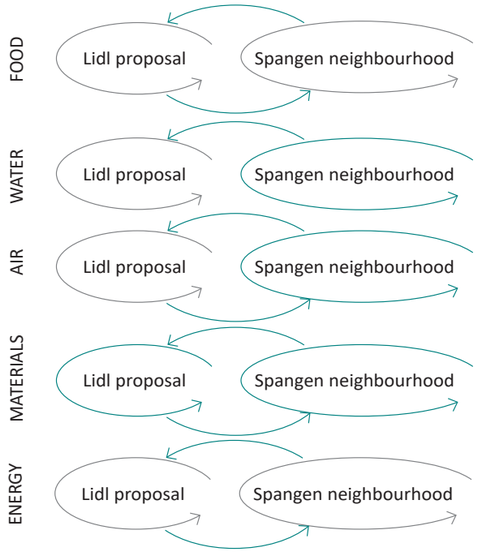


Figure 6.2.1.1: The first combination of possibilities, representing total (green colour) or limited (grey) circularity achievement possibility.

The majority of the circular measures are based on literature study from chapter 04 *Theoretical framework*, but only the main important ones are described. Moreover, they are better explained through the 3 R concept (reduce, ruse and produce), including the basic principles of circular economy regarding the reduction of current problems and high recyclability of resources. The representation of these measures are in chapter 7.4 *Diagram of flows.*

Figure 6.2.1.2: 3R of recyclability.

The circular measures highlighted in grey are discarded due to ethical, expensive, complex and feasible reasons.

· Food:

-Reduce:

·By teaching citizens how to store correctly the food, learning the difference between expiration dates, buying less but more frequent, freezing the food, preparing weekly menus, arranging a shopping list (buy only what they need) or teaching how to eat delicious skins, yolk and stalks, to name a few, through tasting samples.

·Surplus food from the neighbourhood (restaurants, other supermarkets and Lidl) can be donated directly to schools, existing social clubs or other people in need.

-Reuse:

·Upcycling food waste (FW) by recovering the essential nutrients and converting them into new valuable and saleable food products. For example: Beer from bread, juices or cakes from ripe fruits or bad looking vegetables, ...

·FW into valuable by-products. For example: Soap from kitchen waste oil, mushrooms from coffee grounds, etc. Moreover but out of the scope of this research, investigations about developing nutraceuticals, construction materials (insulations and bioplastics) or cosmetics from FW are being developed (University of Adelaide, 2019).

·Waste collection of veggies, fruits and other products for animal's feeding by new bins, and coming from neighbourhood facilities, GH or Lidl supermarket.

·Vermicomposting or cockroaches for reducing FW, at the same time as being nutrients for animals. Cockroaches liquid can be used for cosmetics and health treatments (La vanguardia, 2018).

·Rabbit waste can be reused as a valuable fertilizer for outdoor farming or greenery areas of Spangen, whereas chicken waste can be useful for fish feeding. For example, adding chicken waste to the aquaponics system increases primary productivity of phytoplankton, zooplankton and algae, which subsequently, they serve as an additional supplement for fish feeding. Moreover, poop sometimes can contain insect larvae, which when introduced in the fish tanks, they are converted to fish feeding once the larvae are developed (Little & Satapornvanit, n.d.).

·On-site biodigester, similar to the small scale biodigester located in a Portuguese supermarket (Seab energy, 2016).

-Produce:

·By introducing on-site and local food production, not only packaging, waste, transportation or costs is reduced, but

also supply of fresher, tastier and organic products.

The summary of circular measures regarding surplus and food waste could follow this hierarchy (Figure 6.2.1.3):

1-Surplus food from restaurants and Lidl are firstly and directly donated to schools and existing social clubs.

2- The rest of the surplus, along with school FW, is cooked and processed in the GH or Lidl to obtain new valuable nutrients and food products: juices, soup, cakes, etc.

3- Other specific wastes from restaurants (coffee grounds and fried oil) are used for growing mushrooms and doing homemade candles or soap for using or selling.

4- FW such as rest of vegetables, fruits and some other specific products from the kitchen, crop plantation of GH and customer's consumption of Lidl are collected in bins for chicken and fish feeding (vegetables) (Figure 6.2.1.4).

5- The rest of the previous FW (after checking FW products) is sent to the vermicomposter, in which mature worms serve again for feeding fish and chickens.

6- Other organic products are sent to the anaerobic digestion plant of Lidl in order to obtain energy in return.

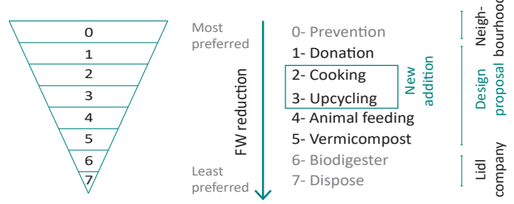


Figure 6.2.1.3: New food recovery hierarchy in the design proposal.

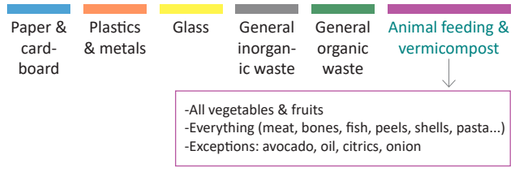


Figure 6.2.1.4 Types of recyclable bins within the proposal, being the purple the new addition.

· Water:

-Reduce:

·Hydroponics such as NFT system could help to reduce water and energy consumption for crop plantation, at the same time as the avoidance of soil use.

·Regarding sanitary uses, automatic and water- saving toilets and taps could be placed.

·Smart irrigation systems that could save water.

-Reuse:

·Greywater could be reused for toilet or irrigation after passing through natural biofilters. But a separated greywater treatment (halophyte) is aimed for avoiding contamination of the rainwater, which is cleaner.

·Reuse of condense water from the NFT system area.

·Reuse of urine for converting to fertilizer for the GH through Struvite reactor or reuse of backwater for obtaining compost by Joraform composter (Deceuvel, 2018).

-Produce:

·Rainwater collection could offer great opportunities after passing through natural biofilters (phytoremediation), being used for irrigation, crops, animals or other upcycling purposes. There is a trending increase of flooding in the country, being Spangen very affected due to hard pavements on urban outdoor areas. By introducing permeable surfaces and greenery areas, water infiltration could occur more easily during short heavy rainfalls for example.

· Air:

-Reduce:

·Greenhouse gases (GCG) are emitted by direct or indirect activities performed by human beings. With the introduction of local food production and waste reuse, packaging, plastics food transportation can be reduced.

·New greenery from crops and vegetation from the square and indoor space of Lidl, allow absorbing C02 and air pollutants, at the same time as providing proper air quality.

-Reuse:

·Combination of livestock and growing plant's space could offer benefits by the exchange of CO2-O2 (Except, 2011).

·Recovery of kitchen exhaust fumes for crops or heat.

-Produce:

·Increase of O2 and improve air quality through the introduction of greenery into indoor and outdoor spaces.

·Good smells to air atmosphere though aromatic plants.

· Materials:

-Reduce:

·Demountable constructions (no welding), disassembly design, universal connections and dimensions

·Material passport for facilitating later usage.

·Collaboration with local stores such as Buurman (materials supply and workshops), in charge of reusing wood and second-hand materials, as well as providing group workshops in its atelier in Bospolder neighbourhood.

·Leasing contract for the lift and other material.

-Reuse:

·Upgrade, repair and reuse of old materials on-site.

6.2 | CIRCULAR SOLUTION ROUTES

6.2.1 SUSTAINABLE & LOW TECH MEASURES

· Material sharing platforms

·Coco fibre over Rockwool in germination and NFT due to renewable, reutilization and composting properties.

·Second hand, biobased, recycled materials from refurbishments or other constructions is considered. For example, these materials could be reused:

· Glass (Lidl): Used again for GH or Lidl ground floor
· Brick pavement (square): For constructing bar counter.
· Concrete pavement (square): Chopped for filling spaces.

·Recycling from other constructions through "Harvest Map" (applied within the boundary of Rotterdam city, in order to minimise transportation and other costs), an online platform for collecting second-hand materials and reducing embodied energy. Figure 6.2.1.5 shows some proposed and recycled examples but they could be more:

· Metal structure: For GH.
· Wooden pieces: Constructing furniture.
· Fibre cement panel: As pavement flooring or walls.
· Metal mesh: For climbing plants or exposition structure.
· Sofa: Interior of Lidl or GH.

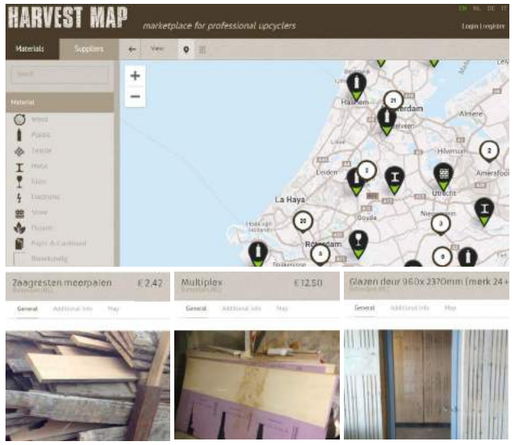


Figure 6.2.1.5: Harvestmap platform: Website overview and examples: square pavement, plywood for furniture and glass door for GH (Source: https://www.harvestmap.nl/).

· Energy:

-Reduce:

·Smart and passive design regarding the location and orientation of spaces (sun, shadow and cross ventilation).

·Use of PCM in partition walls, for regulating better the temperature (Greencastle innovation, 2018).

·Low energy consumption appliances (gas independence).

·LED lighting (optimized light spectrum) is optimal for the growth of plants, while producing and reducing energy demand, so LSC panels (Soliculture, 2017) are desired.

·Sensors (automatic devices) for reducing consumption.

-Reuse:

·Option A: The majority of GH are ventilated in summer to release excess heat and humidity. However, by designing a closed GH, heat could be absorbed in summer by floor cooling system that is connected with underground wells (with heat exchanger and photovoltaic thermal panels, PVT) in order to be used in wintertime and vice versa.
An example is the heat & cold storage system in Hoogeland, NL (Groen blaw, n.d.), but carries high cost.
·Option B: High amount of energy is needed for the cooling systems of supermarkets, being not reused and wasted. This waste heat can be kept in underground storage (with heat exchangers) and reused later in the GH depending on the seasonal period or energy demand.
·Option C: However, the most economical measure for Spangen could be to combine livestock and crop cultivation in order to exchange heat and obtain the maximum air benefits (Except, 2011). Also, heat exchangers (recovery) could be introduced in the climatization system.

·Heat recovery systems.

·Solar chimney.

- Produce: After reducing the current problems and reusing several flows, the last step is to produce the rest of the energy demand by own sustainable energy production.

·LSC panels on the roof and facade of the aquaponics area, can produce some energy and enhance their growth pace.

·PV panels on the roof.

·PVT on roof (photovoltaic and thermal panels).

· Other sustainable measures regardless flows:

·Reduction of urban heat island (UHI): Due to high amount of hard surfaces next to Lidl, UHI is a big problem, so vegetation can absorb and cool down the hot air, provide fresh odour and air, shadow and natural water filtration.
·Chemicals and toxic products for crops, pests: Herbs (dill, oregano and mint) and crops (garlic) are natural bactericide and fungicide. Flowers (borage or nasturtium) can also repel woolly aphids or whiteflies (Ecoinventos, 2020).
·Reuse of existing infrastructure: Public spaces usually carry political issues and restricted laws, so reusing unattractive top roofs for social and environmental benefits is aimed. Moreover, refurbishment of badly managed spaces (public square and indoor of Lidl) can be feasible.
-Facade pots: Flower pots along the facade, are beneficial for avoiding undesired lighting, providing a small growing space and converting a glass facade into a green wall.

6.3 | DESIGN PROCESS

6.3.1 SELECTED DESIGN STRATEGIES

As a reminder, this chapter is focused on the selection of specific strategies from the wide catalogue of strategies performed in chapter 4.6 *Design framework.* Afterwards, the grouping is needed in order to find in an optimal way, possible design solutions.

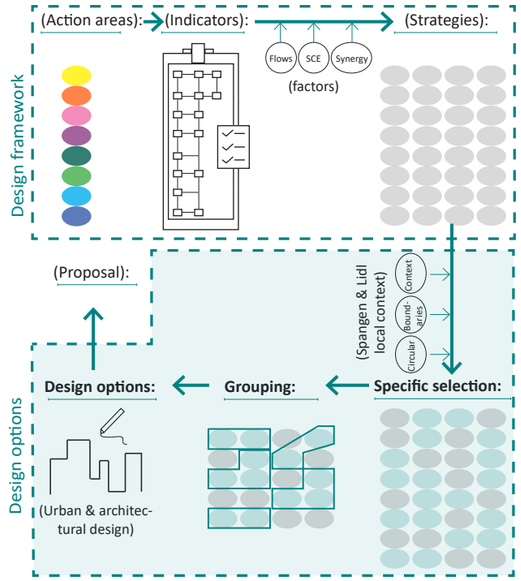


Figure 6.3.1.1: Summary of the design framework and rest of the process for achieving the final proposal.

· Objectives:

However, prior to the selection of design strategies to be applied for the design proposal, there is a need to establish specific objectives.
Based on the action areas from chapter 4.6 *Design framework*, detailed ambitions could be thought, considering at the same time the selected flows, circular solution routes and the three interventions:

1- Sources (material, water, energy, food & others):

· Minimum resources inputs from outside the system boundaries (local use of resources, collaboration with local companies if needed, demountability, lease, 2nd hand..).
· Climate awareness through visible use of natural resources.
· Clean and energy production when possible.
· Benefits from climatology (smart and passive design: shadows, ventilation, sun rays...).
· Rainwater and surplus food collection (upcycling).
· Circularity principles and smart use of resources (hierarchy, 3R, recovery and upcycling when possible).
· Closer and smaller loops of resources (water recycling, food production and selling point, air exchange...).

2- Life (ecosystems & species):

· Non-toxic chemicals and substances.
· Connection with the natural system.
· Natural and ecological processes (natural interaction between species, closing loops).
· Local species.
· Biodiversity & smart selection according to site conditions (thermal, lighting, moisture).
· Animal welfare & natural behaviour (organic and ecologic production).

3- Society (culture & economy):

· Active spaces (reduction of criminality and increasing activity in the area).
· Public, semipublic, semiprivate, private spaces (segregation of spaces, multifunctional).
· Teaching and learning process (workshops, expositions...).
· Physical, cultural and social activities (multifunction spaces and identity).
· Multifunction possibilities: Retail, social uses, education, agriculture, catering, ...).
· Attractiveness not only for local neighbours but also other visitors, students or workers who look for an inspiring environment.
· Representation and integration of different ethnicities (respond to local demands and cultures).
· Flexible design according to local necessities and culture.
· Quality over quantity.
· Job creation (support to a sustainable local business).
· Lightweight (GH) and low technology when possible (decreasing difficulty & increasing creativeness and desirable labour).
· Partnership with local stores and citizens involvement (maintenance, construction and decoration).
· Synergy between other neighbourhood facilities.
· Higher productivity/m2 when considering both space and time.
· Flexibility against fluctuations depending on a variety of products.

4- Individual (health & happiness):

· Direct access for everyone (also considering people with reduced mobility).
· Healthy, safe & enjoyable environment and spaces to work, study, stay in (enhancing pedestrians and cyclists, lighting, car's protection...).
· Mental health and well-being.
· Indoor and outdoor spaces (connection).
· Stimulation of 5 senses and new experiences through flows.
· Integration and participation for all genders, ages, ethnicities, groups and individuals).
· Identity and personal feeling through smart solutions

(name of the person in cups, name of neighbourhood in the menu, communal garden, etc), increasing community feeling, satisfaction, sense of belonging.
· The proposal is a source of enjoyment for the future owner and local residents (social role and relevance in the community).
· Integration of the proposal within the landscape, urban and social conditions.
· Smart use of greenery spaces for the improvement of air quality, reducing UHI and flooding.

As a summary, the previously detailed objectives of each stage will be considered for the final achievement of SDGs and thus, the whole sustainability concept (SCE).

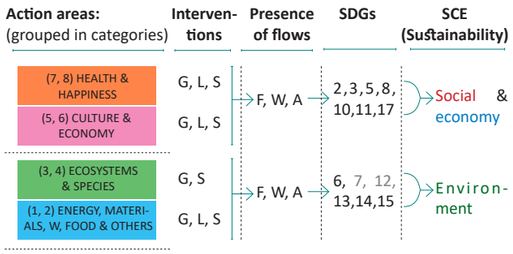


Figure 6.3.1.2: Summary of action areas, interventions (GH:G, Lidl:L, square:S), flows (food:F, water:W, air:A) and goals.

· Selection of strategies:

Based on the previous objectives for each action area, the following specific strategies are selected to be applied in the Spangen context, considering at the same time the essential flows and neighbourhood urban context:

A- Sources & materials (Sources):

Indicator	Strategy	Code
1-Biophilia	Smart use of local natural resources	A1
1-Biophilia	Profit of climatology	A2
1-Biophilia	Shelter against climatology	A3
2- Circularity	Low tech measures and circularity of water	A5
2- Circularity	Low tech measures and circularity of food	A7
2- Circularity	Low tech measures and circularity of air	A8

Table 6.3.1.1: Selected strategies for Sources and materials (Sources).

B- Species & ecosystems (Life):

Indicator	Strategy	Code
3- Closed ecological & urban processes	Connection to natural system	B1
3- Closed ecological & urban processes	Visible ecological processes	B2
3- Closed ecological & urban processes	Understanding ecosystem and preserve them	B3
4- Natural biodiversity	Natural biodiversity	B5
4- Natural biodiversity	Local species	B6

Table 6.3.1.2: Selected strategies for Species and ecosystems (Life).

C- Culture & economy (Society):

Indicator	Strategy	Code
5-Comfort & Multifunctionality spaces	Multifuncionality	C1
5-Comfort & Multifunctionality spaces	Active spaces	C2
5-Comfort & Multifunctionality spaces	Passive spaces	C3
5-Comfort & Multifunctionality spaces	Human scale	C5
5-Comfort & Multifunctionality spaces	Avoid sudden changes in level	C7
5-Comfort & Multifunctionality spaces	Climate	C8
6- Local economy & business	Business ecology	C10
6- Local economy & business	Gastronomy	C13
6- Local economy & business	Local employment	C14

Table 6.3.1.3: Selected strategies for Culture and economy (Society).

D- Health & happiness (Individual):

Indicator	Strategy	Code
7- Accessibility	Direct and welcoming access	D2
7- Accessibility	Universal accessibility	D3
7- Circulation	People circulation	D5
7- Air quality	Air purification	D7
7- Safety	Traffic protection	D8
7- Safety	Active and lively spaces 18h/day	D11
8-Equity & inclusion	Integration over segregation	D12
8-Equity & inclusion	Diversity	D13
8-Equity & inclusion	Gradients in privacy & public spaces	D14
8-Equity & inclusion	Visible identity	D15
8- Quality of experience	Stimulation of sight	D16
8- Quality of experience	Stimulation of hearing	D17
8- Quality of experience	Stimulation of smell	D18
8- Quality of experience	Stimulation of touch	D19
8- Quality of experience	Stimulation of taste	D20

Table 6.3.1.4: Selected strategies for Health and happiness (Individual).

6.3.2 SPATIAL DESIGN OF SQUARE

Spatial conversion from the previous strategies is searched in this chapter through urban and architectural design tools. Some of the previously selected strategies for outdoor and indoor spaces are omitted due to not applicability to the specific intervention area (e.g: safety from traffic in the greenhouse). Moreover, there is no specific order for applying each strategy but bottom to top is preferred. Moreover, due to the connection of some strategies, grouping is done for facilitating the design analysis.

All diagrams will have North orientation (N) and the design process will be structured according to internvetions:
·Square: In front of Lidl.
·Lidl refurbishment: Interior entrance area.
·Greenhouse: Rooftop of the first residential building.

The design process follows the same structure but with some different strategies for each intervention, so the first one (square) is explained more in detail than the others. During the process, a lot of sketching and new ideas arise but this chapter shows only a summary of the main important points. The final result of the design process is displayed in chapter 07 *Design proposal*.

· Square:

The strategies applicable in the square and independently of the order, are:

	Indicator	Strategy	Code
A- Sources & materials	Biophilia	Smart use of local natural resources	A1
A- Sources & materials	Biophilia	Profit of climatology	A2
A- Sources & materials	Biophilia	Shelter against climatology	A3
A- Sources & materials	Circularity	Low tech measures and circularity of water	A5
A- Sources & materials	Circularity	Low tech measures and circularity of food	A7
A- Sources & materials	Circularity	Low tech measures and circularity of air	A8

	Indicator	Strategy	Code
B- Species & ecosystems	Natural biodiversity	Connection to natural system	B1
B- Species & ecosystems	Natural biodiversity	Visible ecological processes	B2
B- Species & ecosystems	Natural biodiversity	Understanding ecosystem and preserve them	B3
B- Species & ecosystems	Natural biodiversity	Natural biodiversity	B5
B- Species & ecosystems	Natural biodiversity	Local species	B6

	Indicator	Strategy	Code
C- Culture & economy	Multifunctionality	Multifuncionality	C1
C- Culture & economy	Multifunctionality	Active spaces	C2
C- Culture & economy	Multifunctionality	Passive spaces	C3
C- Culture & economy	Comfort spaces	Human scale	C5
C- Culture & economy	Comfort spaces	Avoid sudden changes in level	C7
C- Culture & economy	Comfort spaces	Climate	C8
C- Culture & economy	Local economy & business	Business ecology	C10
C- Culture & economy	Local economy & business	Gastronomy	C13
C- Culture & economy	Local economy & business	Local employment	C14

	Indicator	Strategy	Code
D- Health & happiness	Accessibility	Direct and welcoming access	D2
D- Health & happiness	Accessibility	Universal accessibility	D3
D- Health & happiness	Circulation	People circulation	D5
D- Health & happiness	Air quality	Air purification	D7
D- Health & happiness	Safety	Traffic protection	D8
D- Health & happiness	Safety	Active and lively spaces 18h/day	D11
D- Health & happiness	Equity & inclusion	Integration over segregation	D12
D- Health & happiness	Equity & inclusion	Diversity	D13
D- Health & happiness	Equity & inclusion	Gradients in privacy & public spaces	D14
D- Health & happiness	Equity & inclusion	Visible identity	D15
D- Health & happiness	Quality of experience	Stimulation of sight	D16
D- Health & happiness	Quality of experience	Stimulation of hearing	D17
D- Health & happiness	Quality of experience	Stimulation of smell	D18
D- Health & happiness	Quality of experience	Stimulation of touch	D19
D- Health & happiness	Quality of experience	Stimulation of taste	D20

Table 6.3.2.1: Application possibility from selected strategies depending on square conditions.

Some of the previous strategies are linked to each other, so considering similarities and indirect relations, the following order and group of strategies can be followed:

1º A2+A3
2º A1+B1+A8+B5+B6+D7
3º D5+D2+D3+C7
4º D8
5º C2+C8+D14
6º C3+C8+D14
7º C10+C13+D18+D20
8º A1+B1+A5+B2+B3+D16+D17+D18
9º C1+D12+D13+C5
10º D15+D16
11º D19
12º (Retouches)

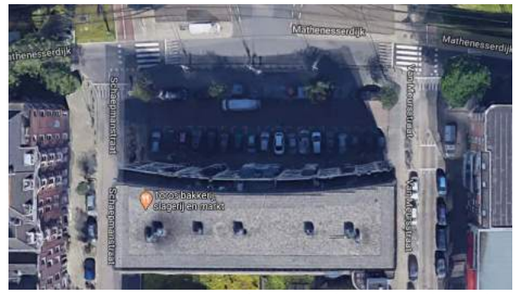


Figure 6.3.2.1: Current situation of the square (Source: Google maps).

·1º: A2+A3 (Profit of climatology & shelter against climatology):

Orientation is crucial in the square, being necessary to identify shadows, undesired windy areas sunny spots.

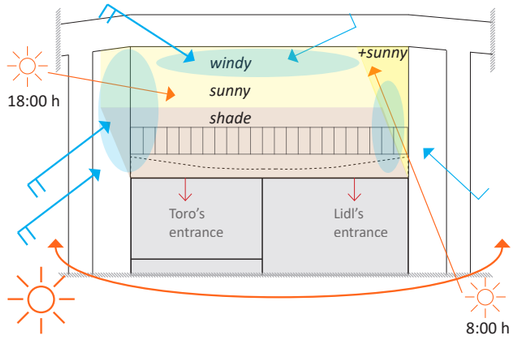


Figure 6.3.2.2: Orientation (sun, shadow, wind).

·2º: A1+B1+A8+B5+B6+D7 (Smart use of local natural resources, connection to the natural system, low tech measures and circularity of air, biodiversity, local species, air purification):

Windy areas (coming mainly from West, but also North and East) are improved by the introduction of greenery wind barriers such as shrubs and trees thus making people feel more comfortable (privacy and protection).

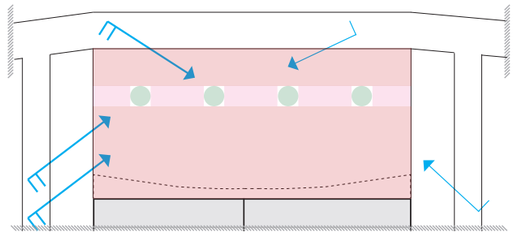


Figure 6.3.2.3: Current state regarding wind barriers (green colour) and remain protected (pink) and unprotected area (red).

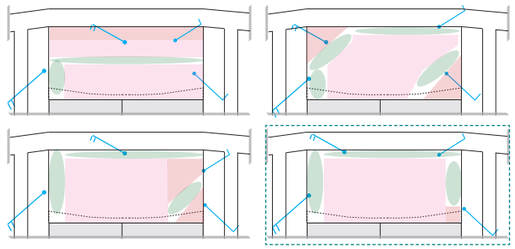


Figure 6.3.2.4: Several options for greenery wind barriers (green colour) and remain protected (pink) and unprotected area (red).

The last option is chosen due to the achievement of higher and more efficient protected area against wind flows. Moreover, the final angle position of wind barriers allows profiting better the spaces, minimising useless areas.

·3º: D5+D2+D3+C7 (People circulation, direct access, universal accessibility, avoid sudden change in levels):

Lidl and square current accessibility is affected by a change in levels (red line) and the presence of car flows in the middle of the square, obstructing people flows. The objective is to improve Lidl's and other flows, allowing universal accessibility and free movements in the centre.

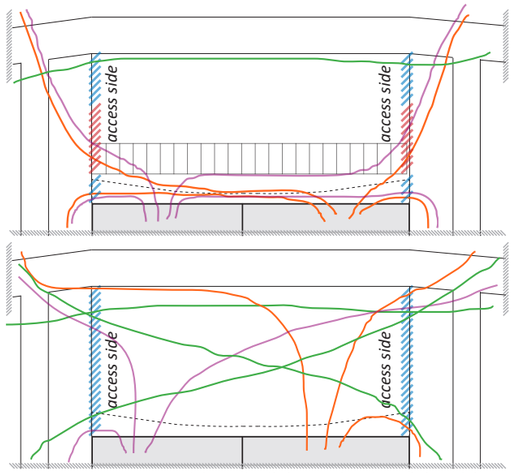


Figure 6.3.2.5: Current and desired Lid's (orange) and Toro's (purple) customer circulation, other people flows (green), limited accessibility (red line) and universal accessibility (blue line).

·4º: D8 (Traffic protection):

Safety is important for achieving an enjoyable square for people, so the car parking is relocated as far as possible, allowing to gain more pedestrian space but without removing the car service due to frequent usage from Lidl clients (existing bins are moved to the next sidewalk).

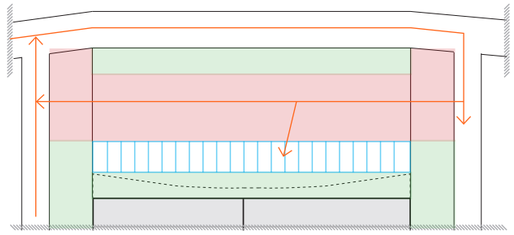


Figure 6.3.2.6: Current car parking with pedestrian barriers (red line), car flows (orange arrows), safe (green) and no safe (red) areas.

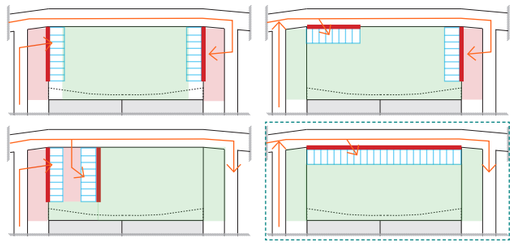


Figure 6.3.2.7: Car parking possibilities with pedestrian barriers (red line), car flows (orange arrows), safe (green) and no safe (red) areas.

The final option allows people to flow from lateral sides by reducing car flows, and keep the same parking spots.

·5º: C2+C8+D14 (Active spaces, climate, gradients in privacy & public spaces):

Active spaces consist of the public character of the square, with activity and exchange of experiences. North orientation is not an issue if other factors are considered, such active and passive spaces according to orientation (sun, shadow and wind), car and people flows. Active spaces do not need as much as sun as passive spaces, so they are placed in the shadow and next to higher people flows.

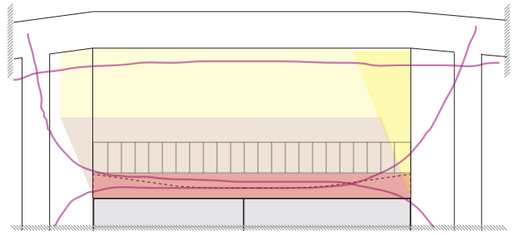


Figure 6.3.2.8: Current active areas (red) and people flows (purple).

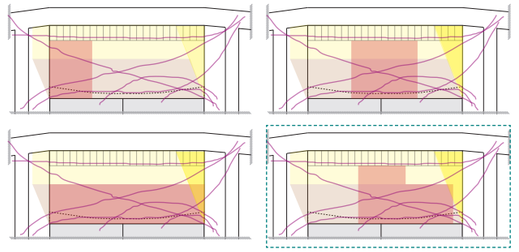


Figure 6.3.2.9: Active spaces possibilities (red), profiting shadow areas and higher concentration of new people flows (purple).

The final option is chosen due to higher flows, sunny spot and right dimension, leaving the rest for passive functions.

·6º: C3+C8+D14 (Passive spaces, climate, privacy, gradients in privacy & public spaces):

There are little passive spaces in the current situation, lacking benches and other factors to make possible to perform passive activities. Therefore, new passive spaces for relaxing and contemplating are placed in a sunny, more private area, and far from energetic activities or people flows. The rest of the spaces will have a semipublic or semipublic character.

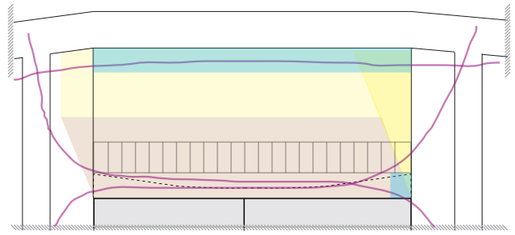


Figure 6.3.2.10: Current passive areas (blue colour) and people flows (purple), having low rate of attractiveness.

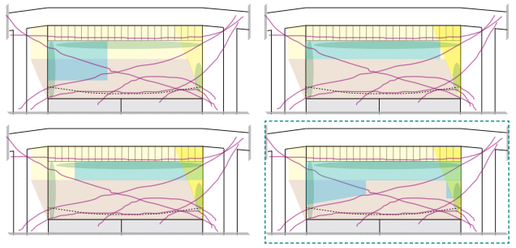


Figure 6.3.2.11: Passive spaces possibilities (blue), profiting sunny and protective areas due to windy barriers (green), and far from high concentration of new people flows (purple).

The final option profits more efficiently the surface for performing passive activities, being protected by wind barriers, far from people flows and sunny areas.

·7º: C10+C13+D18+D20 (Business ecology, gastronomy, stimulation of smell and taste):

Business and public spaces have symbiotic relation because spaces obtain great benefits from the business area (active space) and business obtain benefits from the proximity of streets, being a safe and nice area to walk and pass time. Moreover, gastronomy plays an important role, activating the spaces and gathering people. Due to the proximity of the Lidl entrance, a cafeteria with a terrace is aimed, boosting connection between exterior-interior, enjoying the outdoor atmosphere, profiting sun rays, bringing life to the square and increasing Lidl profits.

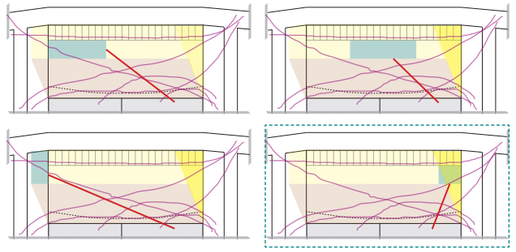


Figure 6.3.2.12: Terrace location possibilities (blue), next to Lidl entrance (red line), profiting sunny areas and a bit distant from high concentration of new people flows (purple).

The final option is chosen because there are higher sun rays (mainly in the morning for providing breakfast), located in a passive area for resting and closer to Lidl entrance.

·8º: A1+B1+A5+B2+B3+D16+D17+D18 (Smart use of local natural resources, connection to natural system, low tech measures and circularity of water, visible ecological processes, understanding ecosystem and preserve them, stimulation of sight, hearing and smell):

Based on fieldwork, it is noticed that the square lacks the presence of natural systems due to the hard surface and car flows. In the current state, there is no possibility for

integrating natural processes and living species, needing to remove hard pavement and bring back the greenery. By doing this, better permeability against floods, biodiversity, living species and natural atmosphere are achieved. Moreover, designing with basic natural elements such as water or earth brings great potentials to space, decreasing the need of outdoors inputs. For example, water enable to improve climate conditions during hot days, increase humidity, reduce Urban Heat Island (UHI), encourage game activities, biodiversity and coexistence between users.
When performing flows calculations, the addition of halophyte plants were considered for reusing greywater from kitchens. So phytoremediation and halophyte tanks need to be placed in the square, due to big dimensions requirement, involvement of people about climate awareness through visible examples, and short distance requirements between collection-consumption points. Water features could be related to passive activities, using its natural noise or smell for boosting relaxing mood, so its location is placed within the previous passive spaces.

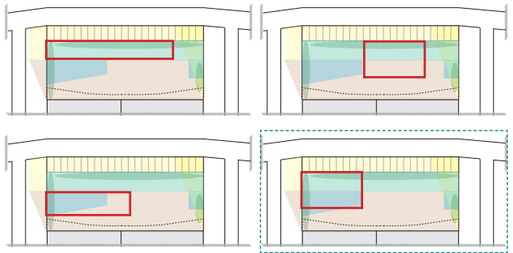


Figure 6.3.2.13: Final passive spaces (blue) and phytoremediation/halophyte possible locations (red square).

The final option is chosen due to big dimension requirement of biofilter tanks, passive area and the possibility to leave more space for performing other activities.

·9º: C1+D12+D13+C5 (Multifuncionality, integration over segregation, diversity, human scale):

All spaces should be designed according to the human scale, having furniture for the use of citizens and with the right height and dimensions (maximum of 3 meters). The following activities could be performed within the active and passive spaces of the square, being able to boost integration, diversity, multifunctional and diversity values:

· Active:
1- Sand playground: For kids or playing petanque
2- Children playground
3- Skate park: Teenagers
4- Open gym: Young and elderly
5- Open field: Frisbee, football or ball games, BBQ, picnic
6- Mini greenery elevations: Playing
7- Fountain: To attract biodiversity (animals) and people (playing, washing, refreshing...).
8- Canal: Recreation, biodiversity attractor and visible climate awareness

· Passive:
9- Stands at different heights: For relaxing, chatting, contemplating or as an observing space through different heights (like theatre stage)
10- Open field: Yoga, taichi, mediation, reading, having expositions, laying down, talking and gathering.
11- Mini greenery elevations: Resting
12- Benches and tables: For resting, eating, playing table games, etc.
13- Hammocks and larger benches: For resting
14- Phytoremediation/halophyte tanks: Climate awareness. Introduction of a walkable path (for walking, resting, observing..) for making people participant and connected to technology rather than only observing.

Figure 6.3.2.14: Example 4: Open gym for young and elderly (Source: / www.gametime.com/).

Figure 6.3.2.15: Example 6: Mini greenery elevations for playing (Source: https://www.agrodelnorte.com.mx/acondicionamiento_de_suelo.html).

Figure 6.3.2.16: Example 7: Fountain for water recreation for kids and other purposes (Source: https://www.vpdelta.nl/nl/delta-story/).

Figure 6.3.2.17: Example 8: Canal for water recreation for kids and biodiversity attractor (Source: www.metropolismag.com/architecture/landscape/new-urban-landscapes/

Figure 6.3.2.18: Example 12: Benches and tables for resting, eating, playing tables games (Source: www.barbourproductsearch.info/artform-urban-furniture-introduce-islolaurbana-news075679.html; www.chess.com/forum/view/chess-equipment/outdoor-park-chessboards-).

Figure 6.3.2.19: Example 14: Phytoremediation/halophyte tanks and with walkable paths on top (Source: https://ocw.tudelft.nl/course-readings/water-sensitive-urban-design/).

The following activities and spaces are discarded due to similar existing facilities in Spangen, big dimensions requirement, target to one specific group rather than boosting integration or unique function possibility, resulting in:

-Spaces and activities discarded:
2- Children playground
3- Skate par
9- Stands at different heights

-Spaces and activities selected:
·Active:
(0- Terrace)
1- Sand playground
4- Open gym
5- Open field
6- Mini greenery elevations
7- Fountain
8- Canal

·Passive:
10- Open field
11- Mini greenery elevations
12- Benches and tables
14- Phytoremediation/halophyte tanks

Due to the wide range of activities, there are several spatial possibilities that could fit in the square:

·Active:

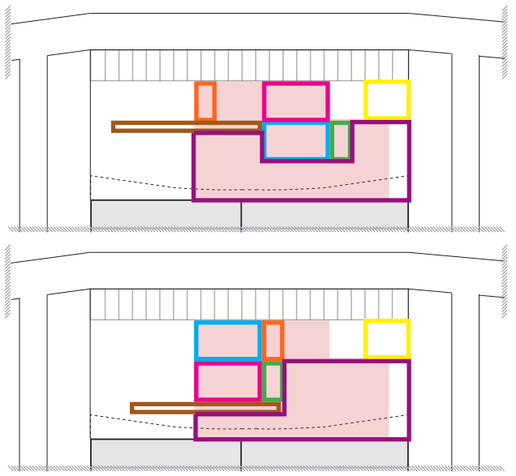
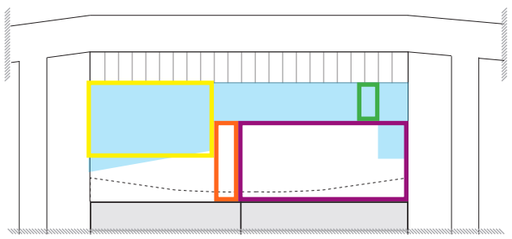


Figure 6.3.2.20: Spatial possibilities for active spaces and activities.

The final option is chosen due to these reasons:

(0- Terrace: Sunny area according to Figure 6.3.2.12).
1- Sand playground: Location in a sunny area, next to the terrace (watched by parents) and far from people flows.
4- Open gym: Location far from people flows and next to children area for boosting integration among ages.
5- Open field: This is the most multifunctional area, being wide and uniform space and delimited design for avoiding confusion among users. It matches well with people flows due to active values.
6- Mini greener elevations: Location preferred next to the sand playground (uniforming kids area) and in a sunny spot due to plant's conditions and multi-purpose value (active and passive space, needing sunny areas).
7- Fountain: Located in a sunny area (recreation), next to the biofilter tanks and children area if possible.
8- Canal: It needs a long space in order to have a presence in the square. Aso, it should be located next to biofilters and fountain for for collecting the water and send it back to the tank. On the other hand, it should allow to perform other activities and not disturb people flows.

·Passive:



6.3.3 SPATIAL DESIGN OF LIDL

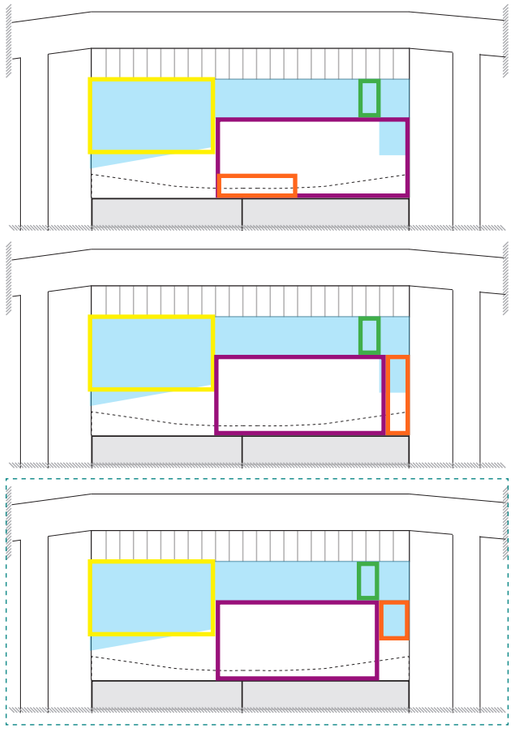


Figure 6.3.2.21: Spatial possibilities for passive spaces and activities.

The final option is chosen due to these reasons:

(10- Open field): Location fixed (Figure 6.3.2.20). Moreover, half of this space is not located in high transit of people flows so it allows to experience also calm activities.
(11- Mini greenery elevations): Same reasons as before, so its location is already fixed (Figure 6.3.2.20).
12- Benches and tables: Based on fieldwork, it is observed that some people wait outside Lidl supermarket, needing to provide benches and a nice area for them. Resting area next to Lidl could improve life's quality of of neighbours (having a nice panoramic view of the whole square) and satisfaction of customers (being calmer while shopping, entering one member to shop while the other is waiting outside, etc). So, the sitting area should be placed around Lidl entrance, allowing to act also as a wind barrier but without disturbing people flows.
(14- Phytoremediation/halophyte tanks): Location fixed according to Figure 6.3.2.13.

·10º: D15+D16 (Visible identity, stimulation of sight):

Identity is a qualitative value, very subjective and difficult to measure, but several identity actions could be considered within the refurbishment of the square, such as:

-Benches and furniture of terrace with flag colours of the different ethnicities.
-Names or logo of the countries written on floor.
-Tiles with colours, etc.

·11º: D19 (Stimulation of touch):

This qualitative value could be increased by the introduction of diverse vegetation on one hand, and different materiality of equipment on the other. For example: wood for the path on top of biofilter tanks, the stone of biofilter tanks, sand, grass, metal from open gym equipment, etc.

·12º: Retouches.

The previous steps helped to design the main characteristics of the square, needing later some retouches and adaptations for achieving the final result, for example:

-Bike lane: For increasing safety and avoid bike disturbances in the middle of the square, bike transit is moved away towards the car parking.
-Safety: Square is segregated from cars through the introduction of the sidewalk, bike line and trees zone.
-Trees: To provide shadow to the terrace and activity areas, hides the urban views and enhance nature inclusion (nature views and mental well-being).
-Grades in biofilter tanks: Grades are integrated on the edges of the ponds in order to be used as benches, observation or resting area.

· Lidl refurbishment:

The aim is to provide an additional space where people can experience more than just doing shopping:

· New experience by tasting/ buying fresh products from GH
· Try reprocessed food from surplus, increasing FW awareness.
· Enjoy purchased products directly after their shopping though dining area.
· Meeting, working, studying space.
· Breakfast, lunch and dinner (fresh, and organic low-cost menus).
· Recyclability and FW reduction among citizens.
· Welcoming place open on weekends and until 00:00 h for example, decreasing criminality or vandalism and boosting activity in the neighbourhood.

In order to achieve those objectives and improvements, designs are based on strategic points described in chapter 4.6 *Design framework,* similar to the square design process. The strategies applicable for the Lidl interior refurbishment, and independently of the order, are:

	Indicator	Strategy	Code
A- Sourc.& mat.	Biophilia	Smart use of local natural resources	A1
		Profit of climatology	A2
		Shelter against climatology	A3

6.3.3 SPATIAL DESIGN OF LIDL

	Indicator	Strategy	Code
A- Sourc.& mat.	Circularity	Low tech measures and circularity of water	A5
		Low tech measures and circularity of food	A7
		Low tech measures and circularity of air	A8
B- Species & ecosystems	Natural Closed ecological & urban processes	Connection to natural system	B1
		Visible ecological processes	B2
		Understanding ecosystem and preserve them	B3
	Natural biodiversity	Natural biodiversity	B5
		Local species	B6
C- Culture & economy	Multifunctionality	Multifuncionality	C1
		Active spaces	C2
		Passive spaces	C3
	Comfort spaces	Human scale	C5
		Avoid sudden changes in level	C7
		Climate	C8
	Local economy & business	Business ecology	C10
		Gastronomy	C13
		Local employment	C14
D- Health & happiness	Accessibility	Direct and welcoming access	D2
		Universal accessibility	D3
	Circulation	People circulation	D5
	Air quality	Air purification	D7
	Safety	Traffic protection	D8
		Active and lively spaces 18h/day	D11
	Equity & inclusion	Integration over segregation	D12
		Diversity	D13
		Gradients in privacy & public spaces	D14
		Visible identity	D15
	Quality of experience	Stimulation of sight	D16
		Stimulation of hearing	D17
		Stimulation of smell	D18
		Stimulation of touch	D19
		Stimulation of taste	D20

Table 6.3.3.1: Application possibility from selected strategies depending on Lidl interior conditions.

Similar to the square, this is the strategy grouping order:

1º	D11+D2+D3+C7	6º	B1+D16+D5
2º	D5	7º	A1+A8+B2+B6+D7
3º	C2+D5+D14	8º	C14
4º	C3+D5+D14	9º	D15+D18+D20
5º	B2+A7+C10+C13+D18+D20/ C1+D12+D13+C5	10º	D19
		11º	(Retouches)

Figure 6.3.3.1: Current situation picture of the interior of Lidl.

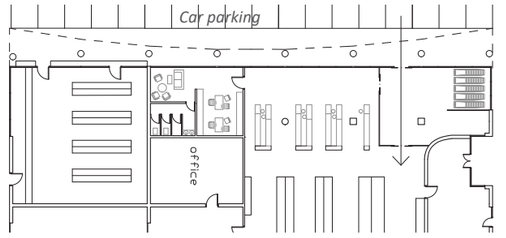


Figure 6.3.3.2: Current situation floor plan of the interior of Lidl.

·1º: D11+D2+D3+C7 (Active and lively spaces 18h/day, (direct and welcoming access, universal accessibility, avoid sudden changes in level):

Criminality and danger situations occur mainly at night and in outdoor environments. So it is important to keep the spaces active, illuminated, and connected to the exterior (vision to streets) for ensuring safety. Due to the limitation of Lidl schedule of 08:00-22:00 h and little connection to the outdoor environment, there is a necessity to divide the supermarket into two spaces:
-Supermarket: Current space for doing groceries.
-Cafeteria (entrance area): Penetrable and welcoming new space, with activity after 22:00 h and connected to the exterior environment through operable doors.

A glass barrier between the supermarket and the new space would allow both areas to still work independently, getting natural light and keeping the double security door use. It has been considered that cafeteria will be always open when the supermarket is open too, so it is not necessary to create independent entrances. Access to the cafeteria would be clear, welcoming for everyone and without any changes in level.

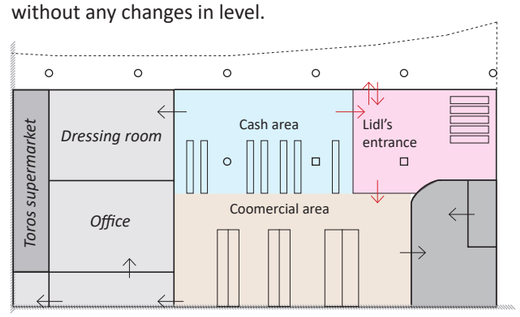


Figure 6.3.3.3: Entrance current situation, with entrance area (pink colour), cash area (blue) and commercial area (brown).

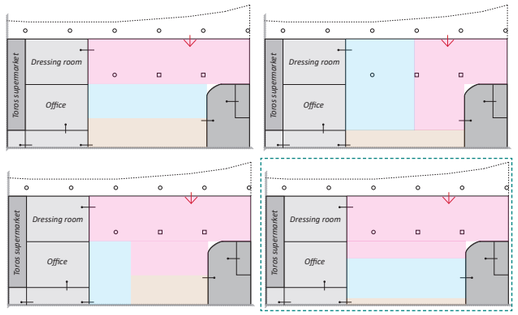


Figure 6.3.3.4: Entrance refurbishment possibilities, with entrance area (pink colour), cash area (blue) and commercial area (brown).

The final option is chosen due to uniform distribution and proper dimension for allowing sub-spaces.

·2º: D5 (People circulation):

Existing circulation is mainly focused on the cash and commercial area, having monotonous customer flows and valueless activity. So, there will be a combination of linear Lidl flows and other new from cafeteria that will boost activity and life and exchanging new experiences.

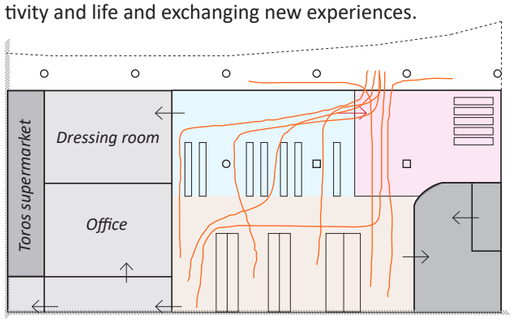


Figure 6.3.3.5: Circulation in the current situation with Lidl customer flows (orange).

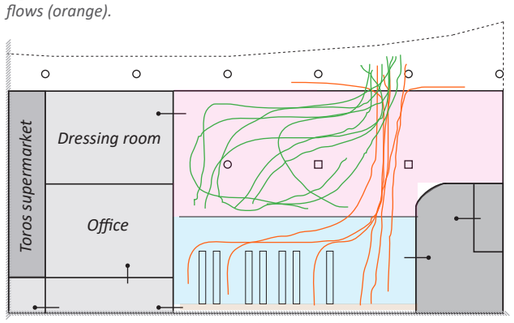


Figure 6.3.3.6: New circulation in the proposal situation with Lidl customer flows (orange) and other people flows (green).

·3º: C2+D5+D14 (Active, people circulation, gradients in privacy & public spaces):

There are only active spaces in the existing situation but the introduction of a cafeteria would allow having gradients of privacy and public spaces (passive and active).

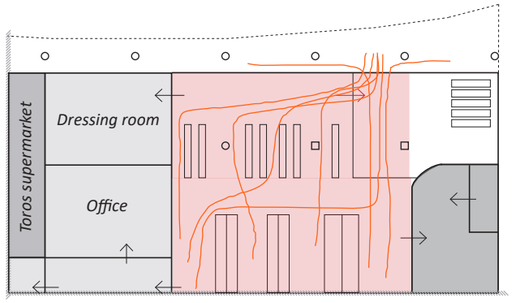


Figure 6.3.3.7: Active space in the current situation (red colour) according to people flows.

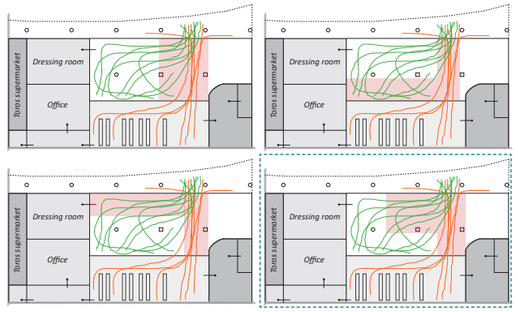


Figure 6.3.2.8: Active possibility spaces in the entrance (red colour), according to people flows.

The final option is chosen due to the wider area and proximity to people flows and exterior, leaving other spaces for private and passive activities.

·4º: C3+D5+D14 (Passive spaces, people circulation, gradients in privacy & public spaces):

Passive spaces for resting, eating, chatting, studying or reading in the cafeteria, should be far from Lid's flows.

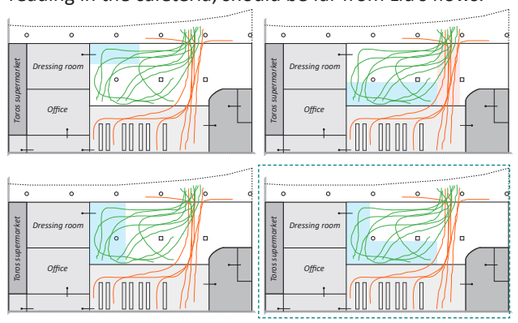


Figure 6.3.3.9: Passive possibility spaces in the entrance (blue colour) according to people flows.

The final option is chosen due to the proximity to private rooms and option to leave active areas next to the facade.

·5º: B2+A7+C10+C13+D18+D20/ C1+D12+D13+C5 (Visible

ecological processes, low tech measures and circularity of food, business ecology, gastronomy, stimulation of smell and taste/ Multifuncionality, integration over segregation, diversity, human scale):

Recyclability results hard when people are demotivated and there are not practical examples, so in order to make it more appealing and reducing FW, the cafeteria would provide low-cost menus by direct donations from the neighbourhood and Lidl (reprocessed food). So there is a necessity to introduce a small kitchen service and dining area. On the other hand, all spaces will be designed according to the human scale, having furniture right height and dimensions (maximum of 2 meters). These activities could be performed within the active and passive spaces of the Lidl entrance, being able to boost integration, diversity, multifunctional and diversity values:

· Active:

1- Tables: Playing games..
2- Singing stage: For evening concerts.
3- Children area: Playground, story telling, birthdays celebrations or entertainers, among others.
4- Pool, darts, table football

· Passive:

5- Big tables: Studying, eating meals, working, meetings
6-Small tables: Wworking, chatting, eating or drinking
7- Sofas: For sitting, reading, relaxing, observing
8- Hammocks: For resting and relaxing
9- Kitchen area: Offering menus, sandwiches, upcycled juices, etc
10- Bathrooms

However, the following activities are discarded due to big dimensions requirement, expensive equipment needed, individual activity rather than boosting integration or unique function possibility, resulting in:

-Activities discarded:

2- Singing stage: For evening concerts.
4- Pool, darts, table football
8- Hammocks: For resting and relaxing

-Activities selected:

·Active:

- 1- Big tables:
- 3- Children area:

·Passive:

- (5- Big tables)
- 6- Small tables
- 7- Sofas
- 9- Kitchen area
- 10- Bathrooms

There are several spatial possibilities for the activities that could fit in the cafeteria area:

·Active:

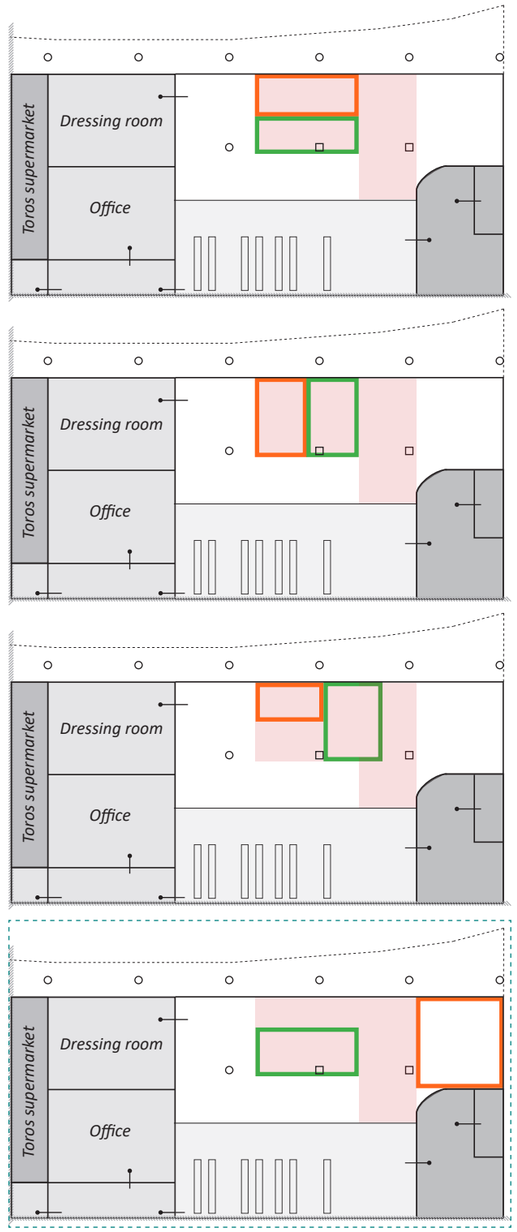


Figure 6.3.3.10: Spatial possibilities for active activities.

The final option is chosen due to the fact that meets most of the following reasons:

1- Big tables: Preferred location in the middle because it is the central activity where all the surrounding uses can take place. Moreover, this area should be appealing for food consumption and visible from all angles.

3- Children playground: The best place is next to the facade, with direct visuals from the outdoor terrace, the interior of the supermarket and cafeteria. Moreover, the benefit of this location is that it could be easily closed by glass walls in order to isolate noise from kids and do not disturb the rest of the indoor atmosphere space.

·Passive:

Figure 6.3.3.11: Spatial possibilities for passive activities.

The final option is chosen due to these reasons:

5-(Big tables): Location fixed according to Figure 6.3.2.10.
6- Small tables: Located next to the other big tables and sofas as additional support for eating and chatting.
7- Sofas: Next to the facade or the glass barrier, which have greater visions from both sides.
9-Kitchen area: Due to its more private character, it should be located next to the office and dressing room.
10- Bathrooms: Placed in far and isolated space, leaving the rest of useful areas for value activities. So the corner seems to be the perfect, reinforced with lateral walls .

However, the objective of the new area is to provide a comfortable but flexible space, so its configuration can be modified (multifunctional) thanks to movable furniture, allowing to be adapted and used as a working, meeting, eating and resting space, resulting in two other options:

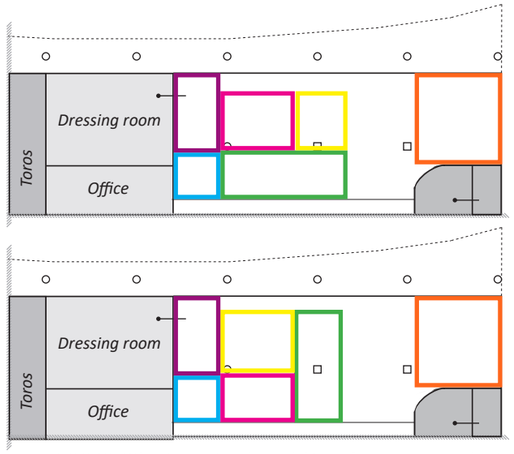


Figure 6.3.3.12: Other two optimal possibilities of passive spaces due to movable furniture.

·6º: B1+D16+D5 (Connection to natural system, stimulation of sight, people circulation):

Currently, there is little connection with the environment, so by introducing new active spaces, openings in the facade can be done (operable doors), resulting a permeable facade, enhancing exchange between interior-exterior and increasing indoor activity.

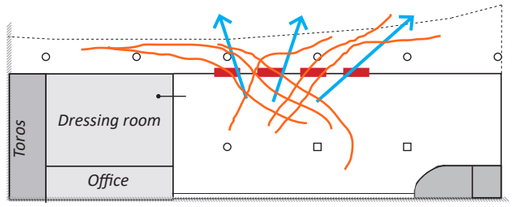


Figure 6.3.3.13: Openings in the facade (red dash line), allowing exchanging new people flows (orange) and visions (blue arrow).

6.3.4 SPATIAL DESIGN OF GREENHOUSE

·7º: A1+A8+B2+B6+D7 (Smart use of local natural resources, low tech measures and circularity of air, visible ecological processes, local species, air purification):

Lidl indoor spaces have a high energy demand due to climatization systems, among others. So, by introducing low technology measures in the form of green walls or flowerpots, air quality, humidity, well-being and nature environment presence in indoor areas could be improved:
-Curve wall in children area
-Movable furniture (green wall or flowerpots)
-Flower pots (North facade)

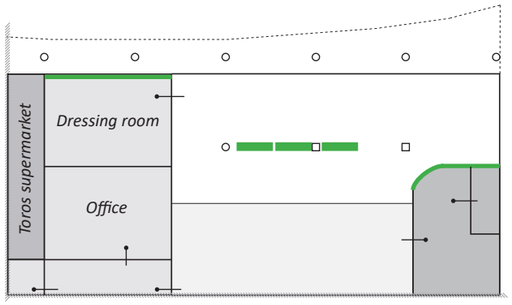


Figure 6.3.3.14: Greenery possibilities.

Figure 6.3.3.15: Movable green wall example (Source: https://nl.pinterest.5132382737).

Figure 6.3.3.16: Flowerpot example (Source: https://casaydiseno.com/13929jardineras-in-gantes.html).

Figure 6.3.3.17: Green wall example in the children area (Source: http://www.asia-greenbuildings.com/7928/perks-indoor-green-walls/).

·8º: C14 (Local employment):

The introduction of this cafeteria service not only benefit Lidl, but also the rest of Spangen through new valuable space and increase of local employment possibilities. These are the main selected job's possibilities, according to activities and low qualification requirements:
-Baby sitter in children area: Babysitter not only for taking care of kids while parents are shopping, in a meeting terrace, eating, etc, but also for other activities: Story telling, birthdays celebrations or entertainers,..)
-Chef: Providing a menu from surplus food such as juices from unwanted or ripe fruits, easy sandwiches from surplus vegetables, etc.
-Waiters: For providing services and maintaining the space clean and attractive.
-Security person: For increasing security in the area.

·9º: D15+D16+D18+D20 (Visible identity, stimulation of sight, smell and taste):

Several identity actions could be considered within the entrance cafeteria, such as:
-Benches and furniture with flag colours of the different ethnicities.
-Name of the plate on the food menu according to different countries.
-Customer names in each drink (similar to Starbucks)
-Variety of gastronomy according to food culture
-Etc

·10º: D19 (Stimulation of touch):

This qualitative value could be increased by the introduction of different materiality of surfaces. For example: wood for the tables, leather or synthetic on sofas, carton from cups, etc.

·11º: Retouches

The previous steps helped to design the main characteristics of the cafeteria, needing later some retouches and adaptations for achieving the final result, for example:

-Kitchen storage room: Need of a well-equiped kitchen, with a storage room next to it for placing safely the food.
-New garbage bins: Detailed FW separation are introduced for saving the most nutrients as possible. New bins for animals feed and vermicompost are introduced.
-High tables: Diversity of functions: quick drink, study area, eating individually or waiting for someone.
-New dressing room entrance from Lidl cash area.

· Greenhouse:

The strategies applicable for the greenhouse and independently of the order, are:

A- Sources & materials

Indicator		Strategy	Code
Circularity	Biophilia	Smart use of local natural resources	A1
		Profit of climatology	A2
		Shelter against climatology	A3
		Low tech measures and circularity of food	A5
		Low tech measures and circularity of air	A7
			A8

B- Species & ecosyst.

Indicator		Strategy	Code
Natural biodiversity	Closed ecological & urban processes	Connection to natural system	B1
		Visible ecological processes	B2
		Understanding urban factors and preserve them	B4
		Natural biodiversity	B5
		Local species	B6

Indicator		Strategy	Code
Multifunctionality		Multifuncionality	C1
		Active spaces	C2
		Passive spaces	C3

		Indicator	Strategy	Code
C- Culture & economy	Comfort spaces		Human scale	C5
			Avoid sudden changes in level	C7
			Climate	C8
	Local economy & business		Business ecology	C10
			Gastronomy	C13
			Local employment	C14
D- Health & happiness	Accessibility		Direct and welcoming access	D2
			Universal accessibility	D3
	Circulation		People circulation	D5
	Air quality		Air purification	D7
	Safety		Traffic protection	D8
			Active and lively spaces 18h/day	D11
	Equity & inclusion		Integration over segregation	D12
			Diversity	D13
			Gradients in privacy & public spaces	D14
			Visible identity	D15
	Quality of experience		Stimulation of sight	D16
			Stimulation of hearing	D17
			Stimulation of smell	D18
			Stimulation of touch	D19
			Stimulation of taste	D20

Table 6.3.4.1: Application possibility from selected strategies depending on Lidl interior conditions.

Some of the previous strategies are linked to each other, so considering similarities and indirect relations, the following order and group of strategies can be followed:

1º	D5+D2+D3+B1+D16
2º	A2+A3
3º	B4
4º	D5+D14
5º	C2+C8
6º	C3+C8
7º	A1+B2+D16+A7+C13+D18+D20/ B5+B6+A8+D7+A5
8º	C1+D12+D13+C5
9º	C14
10º	D15+D16+D18+D20
11º	D19
12º	(Retouches)

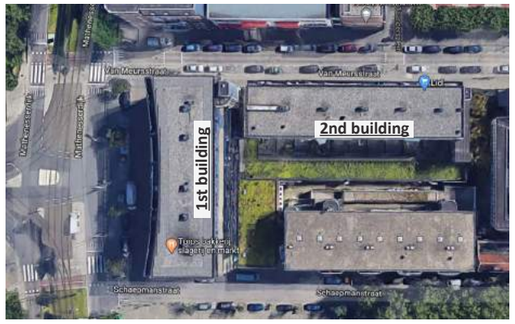


Figure 6.3.4.1: Current situation of the two rooftop possible locations for the greenhouse (Source: Google Maps). N

·1º: D5+D2+D3+B1+D16 (People circulation, direct and welcoming access, universal accessibility, connection to natural system, stimulation of sight):

GH location is selected based on the lifts of existing residential buildings, which are located in the lateral side of Lidl (Figure 6.3.4.2). There are two options the GH location, being the first residential building selected due to the following reasons (Figure 6.3.4.2 & 6.3.4.3):

-Direct and more comfortable connection with customers from Lidl cafeteria, increasing citizens participation and transit towards the rooftop (orange arrow).
-Food waste (FW) movements between Lidl-GH are reduced because connection (green) is closer to the trucks and surplus food area (red shadow).
-There are greater views due to more height and and central location, being able to observe the square and the rest of Spangen (Figure 6.3.4.3).

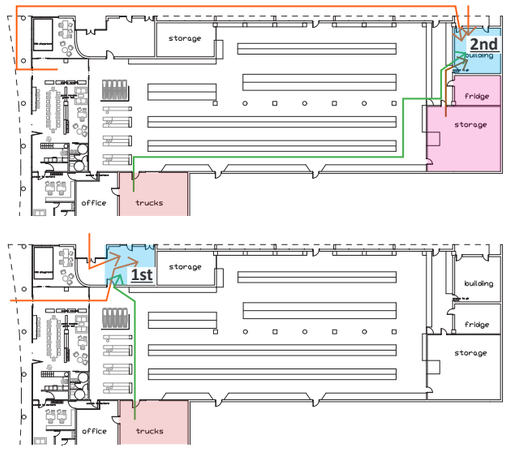


Figure 6.3.4.2: Comparison of the two locations for the greenhouse: First and second residential building, with vertical communications (blue shadow), customer flows (orange), FW connection (green), surplus and truck area (red shadow) and storage rooms (pink shadow). N

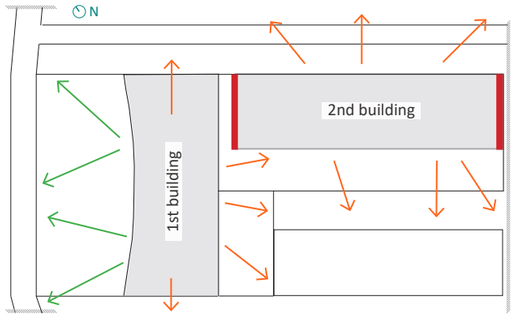


Figure 6.3.4.3: Comparison of views and relation to surroundings according to first and second building: Great/valuable views (green), medium views (orange), limitation of views due to height and visual barrier (red).

6.3.4 SPATIAL DESIGN OF GREENHOUSE

·2º: A2+A3 (Profit of climatology, shelter against climatology):

Orientation in the GH is crucial, needing to identify shadows, windy areas and sunny spots. But, the first building has great potentials due to height and South orientation.

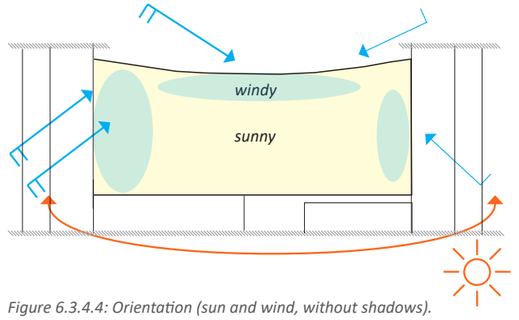


Figure 6.3.4.4: Orientation (sun and wind, without shadows).

In order to maximize the solar gains and strengthen ventilation, a small and brief research is conducted. According to experts, the best orientation of the greenhouse is along the West and East axes (aquaponics oriented in the North-S axes), where sunlight can be profited during all day (from early morning until late afternoon).

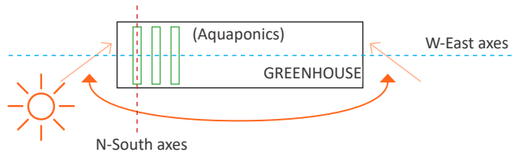


Figure 6.3.4.5: Best orientation for the greenhouse.

Shape analysis is conducted (in cross-section), selecting in the end the two pitched roof due to existing structure, solar energy production and simplicity. Due to acceptable natural orientation, a simple rectangular shape (matching with the existing building shape) is enough, without the need to incline walls for maximizing sun rays.

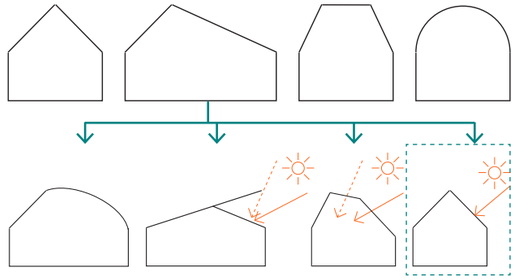


Figure 6.3.4.6: Shape optimization research according to sun orientation (cross section).

A brief study about natural ventilation is performed, concluding that a combination of both sidewalls and roof opening is the most beneficial one for enhancing natural cross ventilation. An important aspect of natural ventilation is that the vents should be placed over the plants in order not to damage them from the strength of the wind.

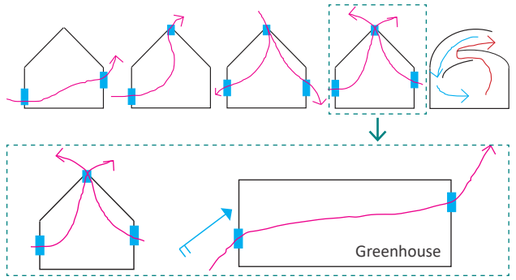


Figure 6.3.4.7: Ventilation research according to wind direction (cross sention and floor plan), with window or openings (blue square), ventilation flows (pink), hot and cold air (red and blue).

·3º: B4 (Understanding urban factors and preserve them):

The existing structure is an important factor due to the introduction of weight on top of the building, so the GH is aimed to be installed on the existing structure in order to minimize its impact. Owing to lack of building structure information, an assumption is based on Lidl ground floor and facade patterns, having beams every 6 meters. The existing chimneys need to be moved for the implementation of the GH, but it is not a problem since exhaust fumes can be easily moved around 2 m away.

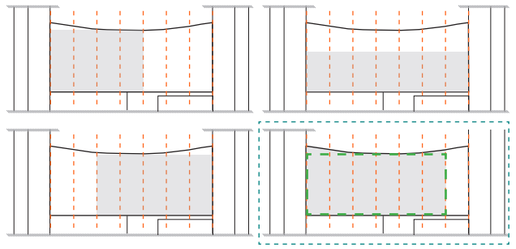


Figure 6.3.4.8: Real extension of the greenhouse (grey shadow) according to existing structure (orange) and simplification geometry (green).

The final option is chosen due to the greater space for food production and social meeting spaces, as well as leaving a small outdoor space for contemplating the views from the rooftop. For the future diagrams and due to simplification of shape, the green square will represent the real extension and geometry of the GH (Figure 6.3.4.8).

·4º: D5+D14 (People circulation, gradients in privacy & public spaces):

A free circulation of people is aimed around the whole facility, but it should profit as much as possible the valuable views towards the rest of Spangen (North facade). Moreover, circulation in the GH is influenced by the level of privacy of the spaces, needed to be later adapted to them.

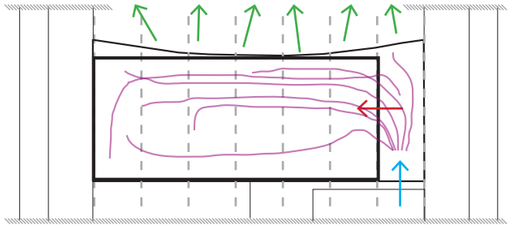


Figure 6.3.4.9: People flows objectives (purple), considering greenhouse entrance (red), lift location (blue) and valuable views (green).

Private spaces are placed in areas with valueless views and far from people flows. However, public spaces are placed next to great views and active movement of people.

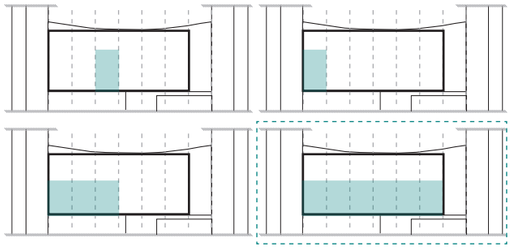


Figure 6.3.4.10: Space privacy possibilities according to people flows.

The final option is chosen due to high number of private spaces required for the efficient service of the greenhouse.

·5º: C2+C8 (Active spaces, climate):

Most of the spaces in the greenhouse are active in order to have recreation, production areas and in general, lots of social activities. Specific activities will need to be placed according to climate orientation, such as crop production.

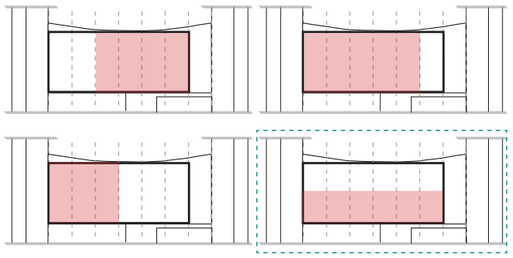


Figure 6.3.4.11: Active areas possibilities in the interior of greenhouse.

The final option is chosen due to orientation for food production and preferred longitudinal distribution.

·6º: C3+C8 (Passive spaces, climate):

There are few relaxing activities due to the objective to achieve mainly active social life. One passive space is located in the exterior, where people enjoy the breeze, views, eat and meet. The other passive space is the dining area, allowing to chat, eat or doing workshops.

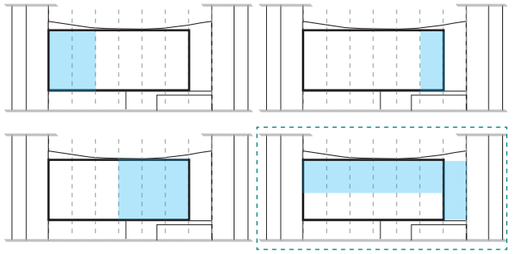


Figure 6.3.4.12: Passive areas possibilities in the greenhouse.

The final option seems to be the most beneficial due to the higher surface of natural light and valuable views for doing passive activities such as observation, resting, etc.

·7º: A1+B2+D16+A7+C13+D18+D20/ B5+B6+A8+D7+A5 (Smart use of local natural resources, visible ecological processes, stimulation of sight, low tech measures and circularity of food, gastronomy, stimulation of smell and taste/ natural biodiversity, local species, low tech measures and circularity of air, air purification, low tech measures and circularity of water):

Achieving close loops in crucial in the GH, reducing resource inputs from outside. So based on previous technology research, aquaponics NFT is introduced due to minimum water requirement, lightweight and closing system through fish and plants. Moreover, transparent walls between rooms are crucial to make visible ecological processes to people.Based on Polydome project, the combination of animals and plants can be beneficial (waste recovered as a nutrient for other species), improving biodiversity and variety of products. This mixed production carries constraints, in which animals and plants need to be together for exchanging C02-O2 through vents in walls, need of outdoor area for livestock (bio-production) and outdoor farm.

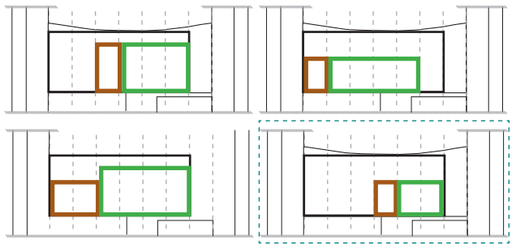


Figure 6.3.4.13: Combination possibilities of aquaponics NFT system (green) and livestock (with open space and open field crops) (brown).

The final option seems to be the optimal due to right dimension and option to leave more surface for other social purposes. By occupying only half of the width, other valuable and wide spaces can be introduced (rather than a simple corridor, like the first case). Moreover, they are

6.3 | DESIGN PROCESS
6.3.4 SPATIAL DESIGN OF GREENHOUSE

placed towards South and next to the entrance for welcoming people through an innovative system

·8º: C1+D12+D13+C5 (Multifuncionality, integration over segregation, diversity, human scale):

The GH is aimed to be a facility for boosting satisfaction, equity, integration and diversity through social activities, as well as providing local food production and climate awareness by food recyclability. So workshop rooms (recyclability activities), kitchen and dining area (practical example of food upcycling and enjoyable area to citizens) are needed. All spaces are designed according to the human scale and right dimensions. Moreover, these activities, including food production, could be performed within the active and passive spaces of the GH:

· Active:
1- Big tables: For playing, chatting, doing workshops, working, meetings, etc. When the furniture is removed, this space is used for multiple energetic activities.
2- Pool, darts, table football
3-Aquaponics NFT system: With the possibility to participate in harvesting or agriculture lessons.
4-Livestock production +outdoor farm: With the possibility to participate in animal feeding and care workshops.
5-Workshops rooms: For providing photography, art, music, languages classes, recyclability lessons, etc
6-Conference rooms: For teaching innovation, climate awareness, circular economy, etc
7-Kitchen facility: Cooking workshops with surplus food. Possibility to taste fresh products directly from the food production area.
8-Children area

· Passive:
9-Big tables: For studying, eating meals
10-Small tables: For working, chatting or, eating. This area can be used for people who want individual privacy.
11- Sofas: For sitting, reading, relaxing, observing
12- Bathrooms
13-Massage area: With frankincense to boost meditation and relaxation.
14-Communal garden: In order to have own planting space for boosting commitment, care, good feeling, propriety feeling, identity, etc.
15-Storage room: For storing all furniture and leave the area free of obstacles for performing other activities.

However, the following activities are discarded due to big dimensions requirement, expensive equipment needed, individual activity rather than boosting integration or unique function possibility, resulting in:

-Activities discarded:
2- Pool, darts, table football
8-Children area
13-Massage area
14-Communal garden

-Activities selected:
·Active:
1- Big tables
(3-Aquaponics NFT system)
(4-Livestock production + outdoor farm)
5-Workshops rooms:
6-Conference rooms
7-Kitchen facility

· Passive:
(9-Big tables)
10-Small tables
11- Sofas
12- Bathrooms
15-Storage room

Due to the wide range of activities, there are several spatial possibilities that could fit in the GH. However, due to the 12 m width limitation, only one or two spaces fit:
·Active:

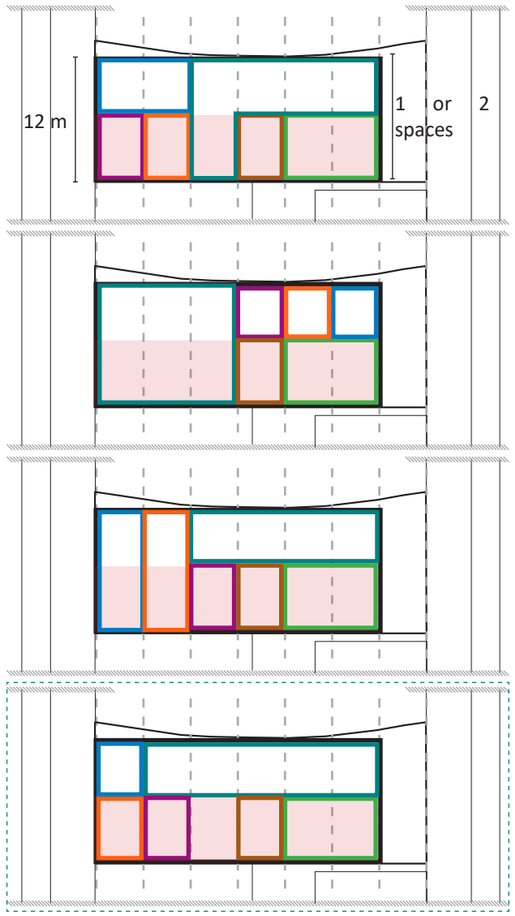


Figure 6.3.4.14: Spatial possibilities for active activities.

The final option is chosen due to the fact that meets most of the following reasons:

1- Big tables: Location preferably in the middle due to multifunctional property depending on the distribution of the furniture. But due to the width limitation of the GH, this space is located at the North facade for enjoying the views towards the neighbourhood and square.
3 and 4- Aquaponics and livestock production + outdoor farm: Fixed according to Figure 6.3.4.13.
5 and 6- Workshops and conference rooms: Workshop and conference room can work together and be one space, in which with the help of movable walls it could be converted into two spaces. One of the best places is the West corner, having a bit of privacy and also views towards the table area and the possibility to enlarge the space towards North and South facade.
7-Kitchen facility: The most beneficial position would be next to the production area, but due to hygienic reasons, it is located far from animals space, having also views towards the conference, workshop and dining area.

Although the previous distribution is the most beneficial one due to wider, private and passive areas, people flows and views, there are other multiple options that could also work if aquaponics and livestock were located different and other factors were not considered, for example:

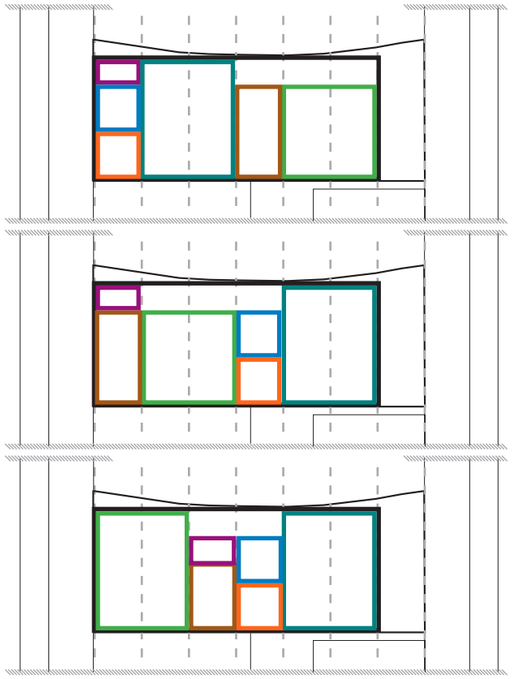


Figure 6.3.4.15: Other spatial possibilities for active activities if aquaponics and livestook rooms were organized different.

·Passive:

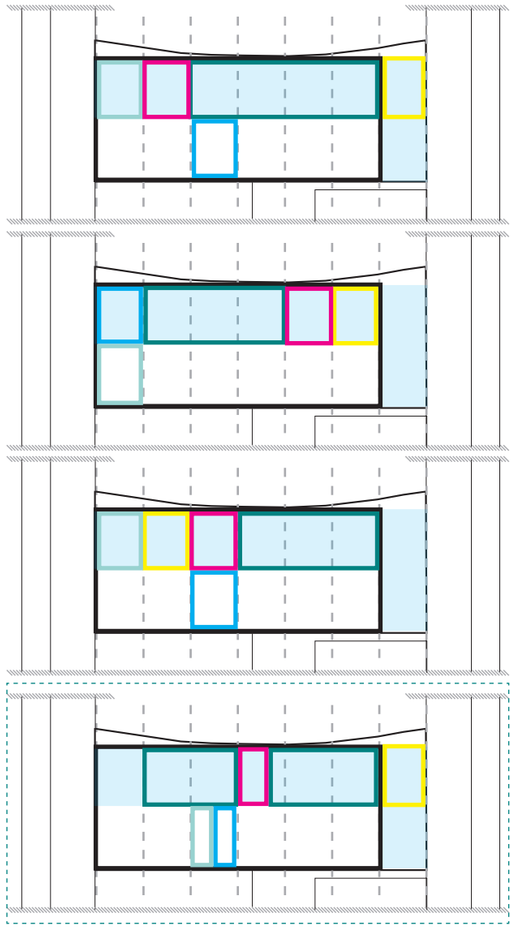


Figure 6.3.4.16: Spatial possibilities for passive activities.

The final option is chosen due to the fact that meets most of the following reasons:

9- (Big tables): Location fixed according to Figure 6.3.4.14, but adjustable in dimension.
10- Small tables: They should be located next to the other big tables as additional support for eating and chatting practice. In the end, the surface needed for this purpose is small, leaving the rest of the space for the placement of more big tables.
11- Sofas: The majority of greenhouse space is destined to provide social and active activities rather than passive ones, so sofas are aimed to be located outside in order to gain more indoor space. This area can profit the views, breeze and outdoor atmosphere for relaxing, contemplating, observing, etc. Moreover, due to the proximity to the dining area (big tables), eating can be also performed outdoors.
12- Bathrooms: Usually these unattractive spaces should be placed in far and isolated space, leaving the rest of useful areas for value activities. But at the same time, it should be next to the dining area and workshop spaces, therefore the middle location seems to be right.
13- Storage room: Similarly to bathroom spaces, it is aimed to be placed in corners and valueless areas, but due to the necessity of store the furniture from workshop rooms and dining area, its location should be central and next to them. Moreover, small dimension is enough rather than occupying more social useful space.

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·9º: C14 (Local employment):

The introduction of this greenhouse not only can benefit Lidl through on-site food production, but also the rest of Spangen thanks to new valuable and social space and increase of local employment possibilities.
Among the different possible jobs for this space, these are the main selected ones, according to activities and low qualification requirements when possible:

-Teachers: For providing musical lessons, sewing workshops, agricultural workshops, etc
-Entertainment person: For organizing social activities, table games for everyone, storey telling for kids, etc.
-Chefs: Providing a menu from surplus food such as juices from unwanted or ripe fruits, being creative with the ingredients available from surplus, providing cooking workshops with food waste, etc
-Farmers: For collecting, checking and feeding the aquaponics and livestock. Also for providing workshops and teaching people how to harvest or take care of animals and vegetables, etc.
-Waiters: For providing services and maintaining the space clean and attractive.
-Staff assistants: For moving furniture, surplus food from Lidl ground floor or the neighbourhood, etc.
-Cleaners: For cleaning the spaces and bathrooms.
-Security person: For increasing security in the area.
-Etc

·10º: D15+D16+D18+D20 (Visible identity, stimulation of sight, smell and taste):

Several identity actions could be considered, such as:

-Floor surface with flag colours of the ethnicities.
-Name of the plate on the food menu according to different countries.
-Customer names in each drink (similar to Starbucks)
-Variety of gastronomy according to food culture
-Providing small flowerpots to each member of community in order to have their own growing space.

·11º: D19 (Stimulation of touch):

This qualitative value could be increased by the introduction of different materiality of surfaces. For example: Wood for the tables, leather or synthetic on sofas, carton from cups, straw of animals, soft leaves from aquaponics, metallic surface from kitchen space, glass from walls, etc.

·12º: Retouches:

The previous steps helped to design the main characteristics of the greenhouse, needing later to refine and adapt several spaces in order to achieve the final proposal.

Example of retouches are:

-Flowerpots: Placed along the North facade, thus being perceived as a greenery facade from the exterior and for filtering and protecting the indoor space from undesired lighting or sun flashes during afternoon time. Moreover, a small area to plant own vegetables is given to neighbours (mini property), increasing people satisfaction and sense of belonging, identity, pride of individual growing crop, respectful from other's work, etc
-Kitchen storage room: It is important that the kitchen is well-equipped, having a storage room next to it where surplus food and others can be kept safe.
-Vermicompost containers can be easily introduced, being placed in outdoor space for livestock or within chickens rooms, reducing also its odour due to the proximity to aquaponics.
-New garbage bins: In order to make a real change among the citizens of Spangen regarding food waste, detailed separation of it should be introduced in order to save the most nutrients as possible. New bin for animals feed and vermicompost is introduced.
-Germination zone: This first stage for growing plants need to be placed next to aquaponics and separated from it due to specific climate conditions requirement.
-Movable and partition walls: Allow more privacy for Muslim culture, families, introverted or any people
-Buffet table: Due to the wide offer of food from surplus and waste, a buffet service is aimed, allowing to feed people in need and other customers for a very low price. The buffet table should be placed in the middle, being accessible from both sides of the dining area.
-Installations rooms: For conditioning equipment and other requirements.

Figure 6.3.4.17: Flower pots in North facade (Source: https://sp.depositphotos.com/208/green-facade-gardening-architecture-ecological.html).

07 DESIGN PROPOSAL

7.1- Description of the proposal
7.2- Graphical representation
7.2.1 Floor plan (Square, Lidl refurbishment, Greenhouse)
7.2.1 Visualizations (Square, Lidl, Greenhouse)
7.3- Calculations
7.4- Diagram of flows
7.5- Benefits
7.5.1 Comparison between original vs proposal situation
7.5.2 Achievement of SDGs

This chapter is a brief summary of the most important points from the previous chapter 6.3 *Design process,* explained over the final designs. The previous chapter needs to be read for understanding completely the intentions of the final design. All diagrams have North orientation. N

· Square:

Although square is thought to be disconnected from Lidl purposes, it is responsible not only for the rise of activity life and people integration in Spangen, but also increase of profits for Lidl. The main factors considered in this design are the orientation (sun, shadow and wind), car and people flow, and diversification of spaces (activity and resting), resulting in the introduction greenery wind barriers in windy areas, placement of people flows in shadow areas, resting areas and activities in sunny locations.

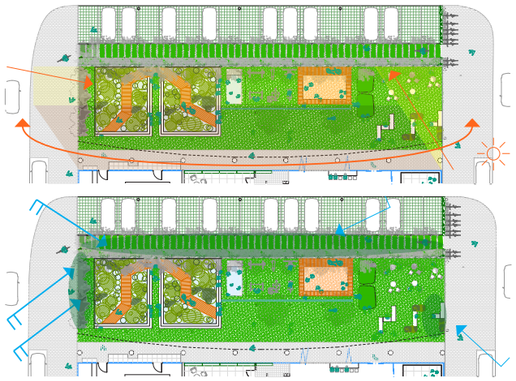


Figure 7.1.1: Orientation (sun, shadow, wind).

Safety is achieved by moving the car parking towards the main road (North side), allowing to gain more pedestrian space for citizens and free walk around Lidl supermarket, without being disturbed by cars and without removing the car service. Additionally, other pedestrians that do not want take part of the square activity or are in a rush, can walk easily and reach faster the next sidewalk through the path next to the car parking (Figure 7.1.3).

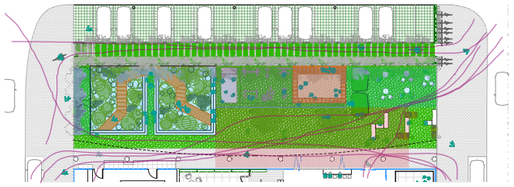


Figure 7.1.3: Active (red) and passive spaces (blue), and new people circulation (purple).

Segregation of spaces depends on views (privacy or not), sunny areas (relax and resting activities), people flows and connection with Lidl supermarket (cafeteria area) or other streets, among others. Within active areas, the following spaces and activities are chosen:

0- Terrace
1- Sand playground
4- Open gym
5- Open field
6- Mini greener elevations
7- Fountain
8- Canal

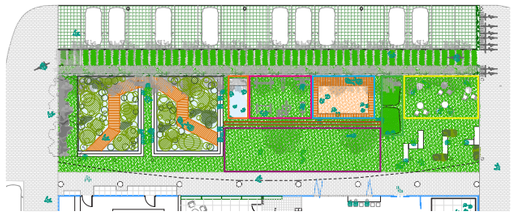


Figure 7.1.4: Spatial configuration of active spaces and activities.

On the other hand, the passive spaces and activities are:

(10- Open field)
(11- Mini greenery elevations)
12- Benches and tables
14- Phytoremediation/ halophyte tanks

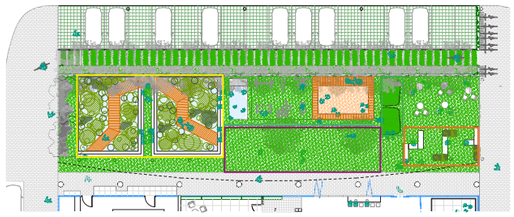


Figure 7.1.5: Spatial configuration of passive spaces and activities.

The way square is designed allows for integration and multiple interactions between citizens, not only outdoor conversations or views but also indoor-outdoor connections. Finally, identity and stimulation of senses are also encouraged through design choices.

· Lidl refurbishment:

The objective of the refurbishment of Lidl entrance is to provide an additional space where people can experience more than just doing shopping, for example:

· New food experience by tasting and buying fresh products from GH.
· Try and taste reprocessed food from surplus, increasing FW awareness.
· Enjoy purchased products directly after their shopping
· Meeting, working, studying space.
· Food menus (fresh and organic low-cost menus).
· Recyclability and reduction of FW among citizens
· Welcoming place open on weekends and until 00:00 h for example, decreasing criminality or vandalism and boosting activity in the neighbourhood.

There is a division of spaces in order to allow both areas to function independently, being the wall made by glass for allowing the entrance of natural sunlight (Figure 7.1.6).

There are only active spaces in the existing situation. However, based on people flows and different activities in the cafeteria, an organization of spaces in different gradients of privacy and public spaces is performed. Private areas are located far from people transit, next to the office and dressing room for employees (Figure 7.1.7).

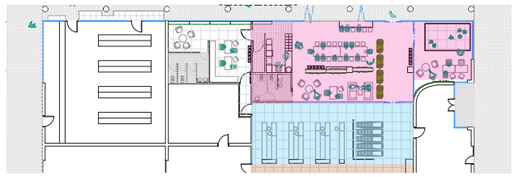


Figure 7.1.6: Lidl entrance refurbishment, with entrance area (pink colour), cash area (blue) and commercial area (brown).

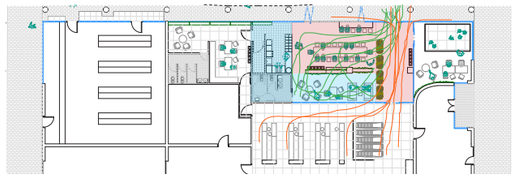


Figure 7.1.7: Active (red) and passive spaces (blue) in the Lidl entrance, according to cafeteria customer flows (green).

The following activities could be performed within the active spaces of the Lidl entrance, being able to boost integration, diversity, multifunctional and diversity values:

1- Big tables
3- Children playground

On the other hand, the passive spaces and activities are:

5- (Big tables)
6-Small tables
7- Sofas
9- Kitchen area
10- Bathrooms

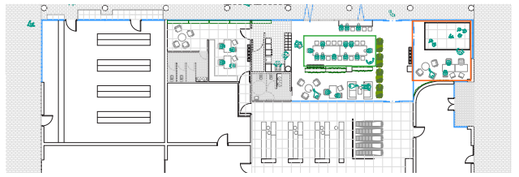


Figure 7.1.8: Spatial configuration of active spaces and activities.

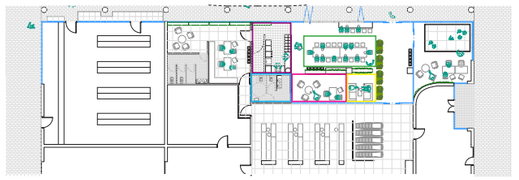


Figure 7.1.9: Spatial configuration of passive spaces and activities.

As already said, the new cafeteria area is comfortable and flexible due to movable furniture, allowing to be adapted and used as a working space, meeting area or eating and resting space, depending on people demands. Moreover, greenery is introduced in the form of simple pots or green walls for purifying the air, improving indoor air quality, well-being and presence of nature.

Finally, by profiting the introduction of several activities and spaces in the new entrance, new openings in the facade could be introduced (operable doors). This will result in more activity towards the interior of Lidl, being now a permeable and welcoming facade, and enhancing the interaction of people flows between Lidl facility and the surroundings (interior-exterior) (Figure 7.1.11).

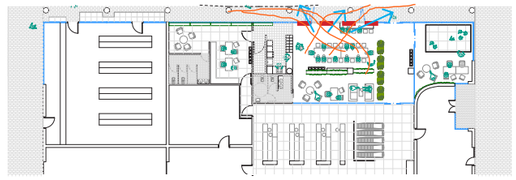


Figure 7.1.11: Openings in the facade (red dash line), allowing exchanging new people flows (orange) and visions (blue arrow) between interior-exterior.

· Greenhouse:

There are two possible locations for the GH, being in the end, the first residential building the most beneficial one:
-Direct and more comfortable connection with Lidl cafeteria customers, increasing participation and transit.
-Food waste (FW) movements between Lidl-GH are reduced due to closer distance from trucks loading area.
-Greater views due to higher building and central location, being able to observe the square and Spangen.

In order to minimise the impact of the GH, the new construction is aimed to be installed over the existing residential structure, being beams every 6 m approximately.

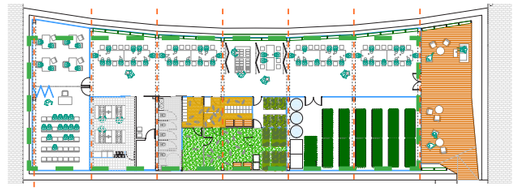


Figure 7.1.13: Adaptation to the existing structure (orange) and simplification geometry (green).

Aquaponics and field crops are orientated to South (N-S axes) for obtaining greater solar gains for the production. Taking advantage of strong winds from S-W, openings in the West facade and East are placed for cross ventilation.

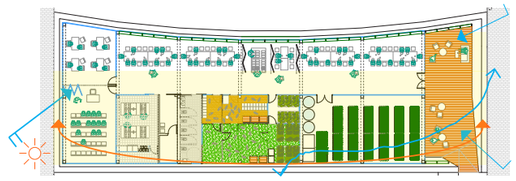


Figure 7.1.14: Orientation (sun and wind, without shadows).

Private spaces are placed in areas with valueless views and far from people flows, opposite of public spaces.

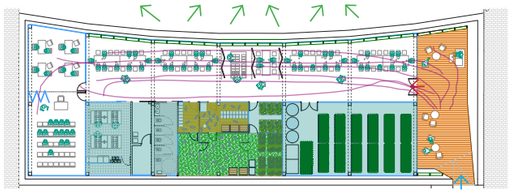


Figure 7.1.15: People flows (purple), considering greenhouse entrance (red), lift location (blue), valuable views (green arrow) and private area (green shadow).

Most of the spaces in the GH are active in order to have recreation, production areas and in general, lots of social activities, so there are only a few relaxing activities, being concentrated in the outdoor terrace and dining area.

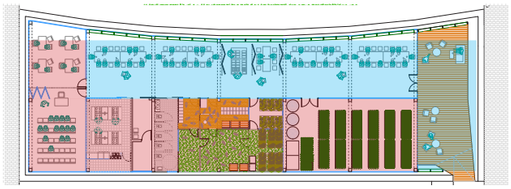


Figure 7.1.16: Active (red) and passive spaces (blue) in the GH.

There is a limitation of around 12 m width, being closed rooms concentrated towards one side of the facade and benefiting from South orientation. The rest of the space is used as a corridor and open dining space, benefiting from North orientation and maximising views towards the neighbourhood and square along the whole facade.

As said before, the GH is a facility for boosting satisfaction, equity, integration and diversity through the offer of several social activities, as well as providing local food production and climate awareness through recyclability of surplus and waste food. Therefore, the following active spaces and activities, including food production, are:

- 1- Big tables
- 3-Aquaponics NFT system
- 4-Livestock production
- + outdoor farm
- 5-Workshops rooms
- 6-Conference rooms
- 7-Kitchen

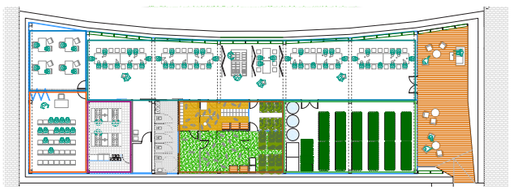


Figure 7.1.17: Spatial configuration of active spaces and activities.

On the other hand, the passive spaces and activities are:

- 9-(Big tables)
- 10-Small tables
- 11- Sofas
- 12- Bathrooms
- 15-Storage room

Figure 7.1.19: Spatial configuration of passive spaces and activities.

Movable and partition walls allows spaces being adapted to each requirement and privacy, increasing satisfaction among all type of customers. As a low-tech measure and substitution for blinds, flowerpots along the North facade are placed, converting it in a greenery facade, improving indoor air quality and providing individual farming.

The production components and spaces in the GH are:

-Hydroponics (NFT):
·High profit consisting of leafy plants, fruiting plants, fruits and herbs.
·Year-round production.
·Vertical stacking, until 5 times, leaving space underneath for mushroom production.
·Filtering and wastewater recirculation from the aquaculture system.
·Pest repelling crops are interplanted within commercial crops, reducing the need for pest control measures.

-Aquaculture:
·Waste water recirculation and filtered in NFT.
·High production/m2

-Open field crops:
·Year-round production, divided into 2 periods (spring-summer and autumn-winter).
·Reuse of manure from livestock.

-Livestock:
·Chickens (eggs and meat) and rabbit (meat).
·Livestock manure collected as compost.
·Process FW.
·Exchange of excess C02 and heat with aquaponics area.
·For several months of the year, chickens have free access to open field crops to till the soil and control pests.

-Mushrooms:
·Cultivation in unusable spaces (Phase 1 in the ceiling of the chicken room and phase 2 underneath of aquaponics, according to climate conditions).
·Released of CO2, used in aquaponics area.
·Year-round production and high value.

-Vermicompost:
·Process FW, animal and plant waste into valuable compost (solid) and fish supplement nutrients (liquid).
·Extra worms serve as feeding fish.

-Germination zone:
·With higher temperatures and early-stage growth area.
·Use of coconut fibre rather than Rockwool as a medium, because it is renewable and can be reused as mulch or composted.

6.3.5 FURTHER CONSIDERATIONS

In order to make the design proposal work, some parameters of the project need to be clarified so they are described in general terms, for example regarding food waste program, social activity program, economy and budget, etc. These considerations are intended to be suggestions for the feasibility of the project in case of future implementation.

· Timetable:
-Square: Open. Possibility to organize outdoor activities (depending on the organization of neighbourhood association) for bringing life and reducing criminality at night: Open night cinema, yoga classes, 2nd hand market, etc.
-Lidl refurbishment: Commercial area remains open until 22.00 whereas cafeteria can be open until 00.00 on weekdays (and Sunday) and until 02.00 h on Fridays and Saturdays, in order to provide night-life for young people for example.
-Greenhouse (GH): It should be mention that the services of the current social clubs are mainly intended for the use of disadvantaged people, who account for around 80 neighbours and spend an average of 5 hours per day in social activities. Due to the private feeling and reserved character of these particular citizens, the timetable of the new GH can be split in two: a period for local neighbours (mainly disadvantaged) and then a period for the rest of the citizens (including disadvantaged, local neighbours, visitors, students, children or the rest of population).

· Reorganization of interior distribution:
-Lidl refurbishment and GH: Movable furniture could be moved diary according to each person demand or else, changed every week according to weekly surveys for example.

· Employment:
In order to make effective the SDGs and create more impact through actions, the following people would be desired to be firstly hired:
-Woman
-People in disadvantaged condition (widow, reduced mobility, blind, etc)
-Unemployed young people

· Food waste recovery program:
These are the following ideas for recovering easily FW and providing it again to the customers:
-Lidl cafeteria:
·Free crisps, banana bread, etc made with food scraps (peel of potato, fried stalk, ripe banana..) with every consumed drink.
·3,5 Euro menu formed by: Soup + salad + juice. (Soup and juice cooked with surplus and FW, salad with the possibility to select the type of lettuce and 3 more ingredients from a variety possibility: ham, cheese, bread, fruit, raisins, etc).
-Greenhouse:
·Buffet offer cooked from mainly surplus and FW. Possibility to pay by weight or fixed price for example.
·Veggie bitterballen and meatball stampot from mushrooms production, avoiding using meat.
·Recovery FW possibilities: Homemade juices and smoothies, jam, cakes, breadcrumb and bread pudding from expired bread, fermented veggies, fruit compote, dried veggies, sauces, etc.

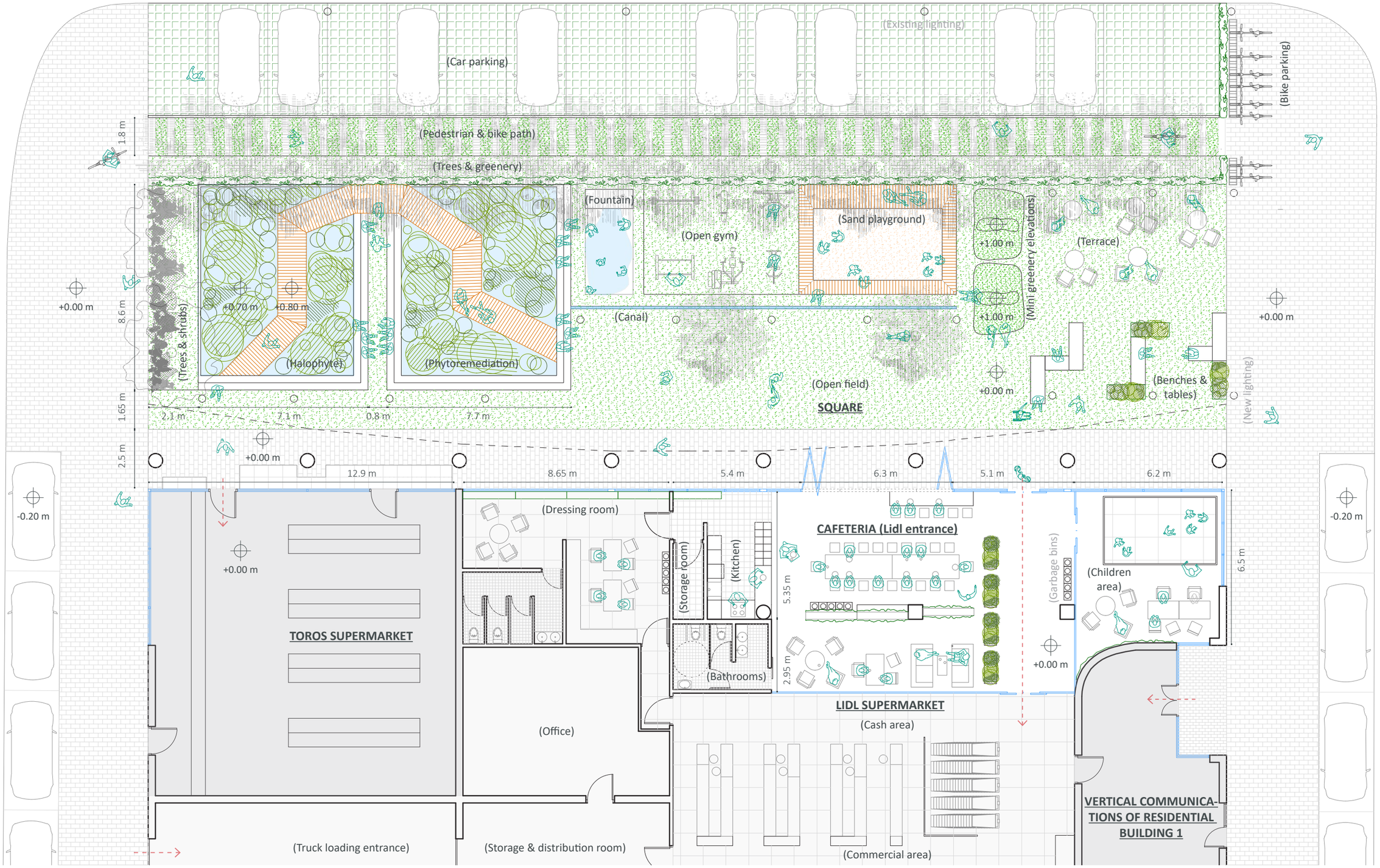
· Social activity program:
Furniture and facilities for diverse activities are not enough for ensuring the quality development of activities. There is a need to involve administrative organizations or neighbourhood associations in order to keep an active role in the organization and coordination of the activities. Moreover, they are likely to promote ongoing community development, which is crucial for improving or achieving social resilience.
-Square and GH: Run by the neighbourhood association. For example, each week, people from a different country could organize the cultural event, dinner event, cooking dish workshops, etc from a specific country.
-Lidl: Social activities could be run by Lidl itself, providing weekly changes. Moreover, pub crawl could be organized every 3 months with incentives for example, considering the bars on Spangen and including also Lidl cafeteria. This would result in the better connection among the rest of citizens, an increase of drink consumption, while enjoying together for example.

· Finance:
The proposal is thought to be mainly financed by Lidl company due to the first interested party, but several possibilities can be discussed:
-Square: Due to the public character of the square, this refurbishment could be supported and financed by the local council, together with some private companies (water recycling tanks).
-Lidl: Refurbishment financed by Lidl company. It could be run by Lidl (desired option) or also hired to another food business (with FW recovery program).
-Greenhouse: This could be firstly financed by Lidl but owned and run by the neighbourhood association. Food production and social activities are the sources of income of this facility (food production sold to Lidl), in which in several years, the association would be able to pay back to Lidl investments. In the end and after several years, the neighbourhood association would be the total owner of the greenhouse. PV installations and LSC panels can be financed by private companies. Moreover, wood furniture can come from the cooperation of local business like Buurman.

7.2 | GRAPHICAL REPRESENTATION

7.2.1 FLOOR PLAN (SQUARE & LIDL REFURBISHMENT 1)

N 0 1 5 10 m

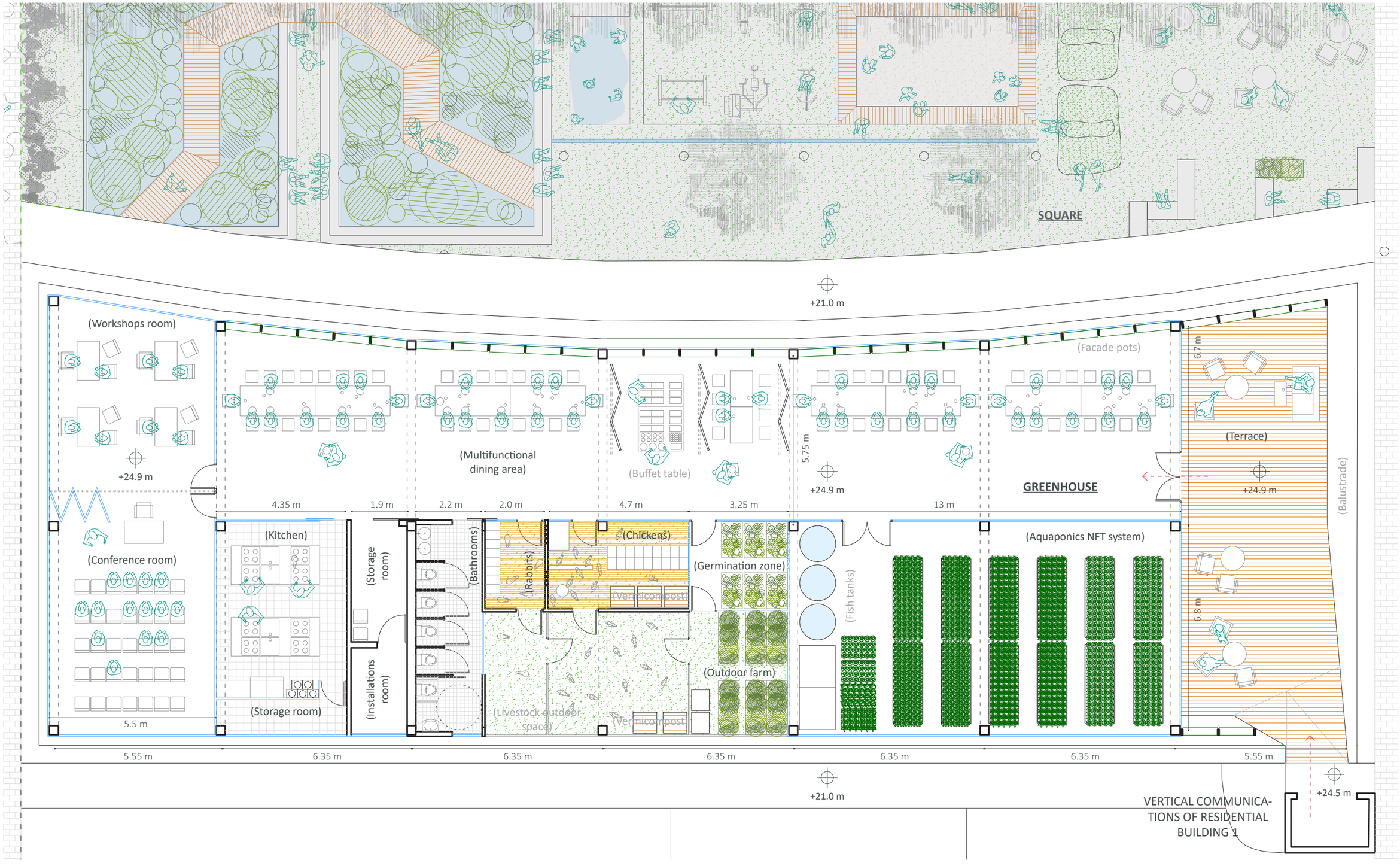


7.2.1 FLOOR PLAN **(GREENHOUSE)**

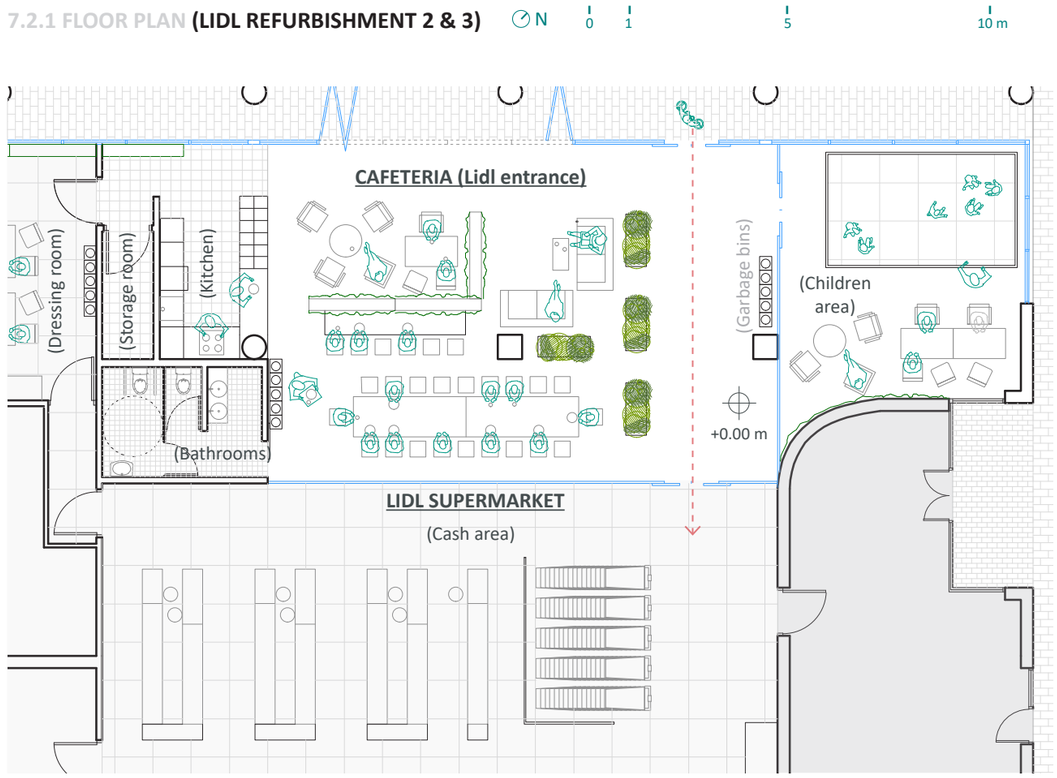
N 0 1 5 10 m

7.2 | GRAPHICAL REPRESENTATION

7.2.1 FLOOR PLAN (GREENHOUSE)



7.2.1 FLOOR PLAN (LIDL REFURBISHMENT 2 & 3)



CAFETERIA (Lidl entrance)
(Storage room)
(Kitchen)
(Bathrooms)
(Garbage bins)
(Children area)
+0.00 m
LIDL SUPERMARKET
(Cash area)

7.2.2 VISUALIZATIONS (SQUARE, LIDL, GREENHOUSE)

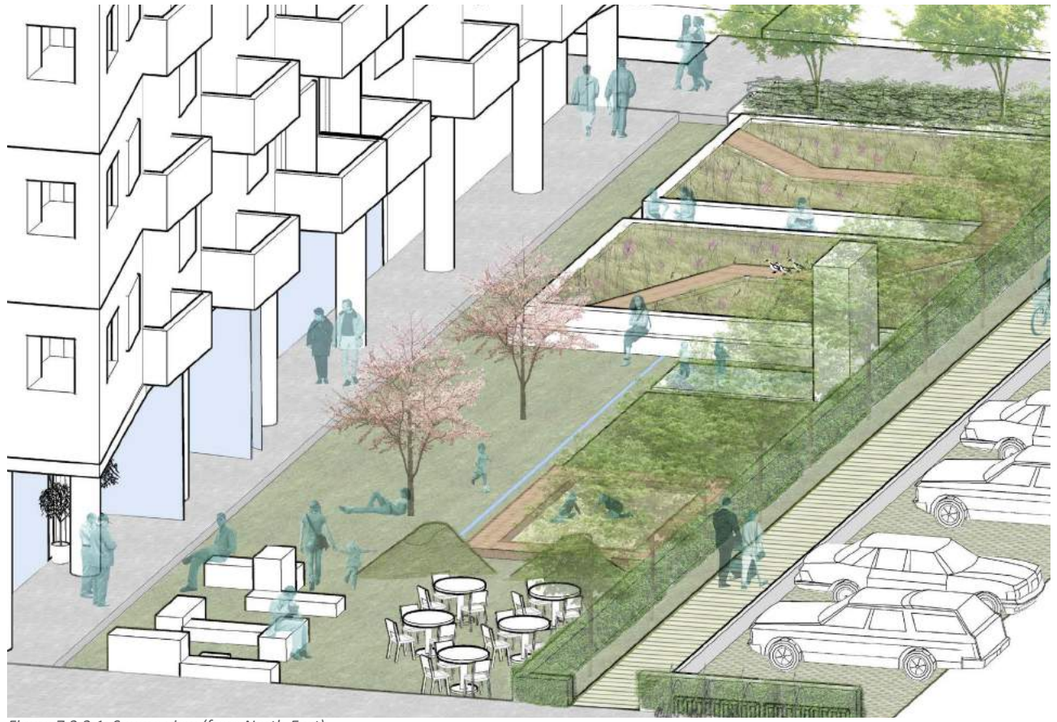


Figure 7.2.2.1: Square view (from North-East).

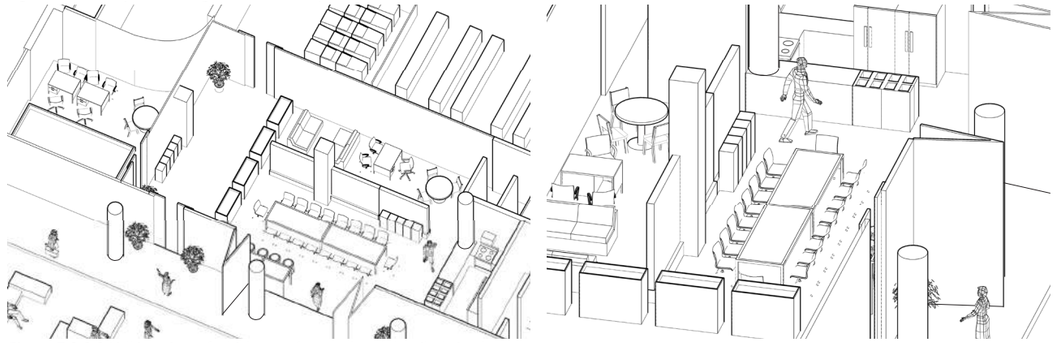


Figure 7.2.2.2 Lidl interior refurbishment (general and detailed view).

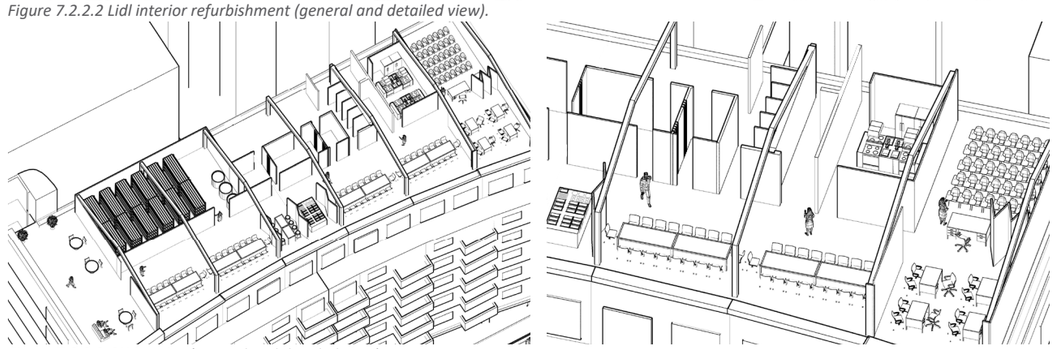


Figure 7.2.2.2 GH interior (general and detailed view).

7.3 | CALCULATIONS

7.3.1 FOOD FLOWS

This chapter consists of calculations of the 3 essential flows in order to support, validate and see the feasibility of the proposal. The calculations are divided according to the 3 interventions and measured through one year.
It should be mentioned that due to wide availability of space, production of mushrooms, soap, vermicompost and candles in the GH could be increased in future, depending on local consumption, workshops or exportations to other areas.

- FOOD FLOWS:

· Neighbourhood:
-Purchased food:
Based on chapter 5.3 *Data flows in the neighbourhood*, households buy around **864,000 Kg/y.**

-Waste reduction:
Waste reduction at home is possible due to FW workshops and teaching practices in the GH, which would have impact on the consumption behaviour and buying practice, reducing around 10% of FW (NNCF, 2019): **6,000 Kg/y.**

-Waste collection:
Based on chapter 5.3 *Data flows in the neighbourhood: Food*, valuable FW that can be upcycled is divided into avoidable (A) and unavoidable waste (UN), coming from the facilities in Spangen (without households and Lidl):
·(A): (**38,190 Kg/y**): Donation, cooking & recovery
·(UN): ·Coffee ground (**9,450 Kg/y**): Mushrooms
·Fried oil (**79,200 L/y**): Candles & soap.

Avoidable waste can be sent to school and social club, being a food consumption for schools of around **20,000** Kg/y (=0.5Kg intake/pupil/d*200 pupils*200 school days) and for social club **6,040 Kg/y** (=1 Kg intake/person/d*20 people*302 open days) (RIVM, 2018). So over **26,000 Kg/y** FW could be recovered through direct donations. Unavoidable waste is sent to the GH to produce new valuable products and send it back to the commercial chain (sell).

·Lidl supermarket:
-Cooking recovery (Lidl entrance/GH):
Lidl cafeteria and GH can upcycle surplus food from donations from the neighborhood, serving low cost menus. The project capacity is around **86 person/meal/d** (38p Lidl+ 48p GH), so similarly to social club participation (Westervolkshuis) of 20 people in need/meal/d and assuming 40 people extra, the total occupation can be around **60 p/meal/d** (20 p Lidl + 40 p GH). Considering a consumption of around 200 gr/meal (MHCSW, n.d.)=0.2*60p*3 meals*365=**13,140 Kg/y** FW can be reduced.

-Purchased food:
Due to lack of available information, an assumption of Lidl purchased food is the sum of household purchased food (864,000 Kg/y) + Lidl surplus food (41,000 (Kg/y), resulting in **41,864 Kg/y**.

· Greenhouse:
-Livestock products:
Ecological products and welfare of animals is aimed, so open areas and wider spaces are needed (BOPV, 2016; García, Berrocal, et al., 2014), being the final result:

·Chickens: ·Indoor: 6 chickens/m2 ⟶ 8.4 m2= **50 chickens**
·Outdoor: 4 chickens/m2 ⟶ 17.6 m2=70 chickens
·Rabbits: ·Indoor: 0.4 m2/rabbit ⟶ 4.6 m2=11= **8 rabbits**
·Outdoor: 1.8 m2/rabbit ⟶ 8.4 m2= 5 rabbits

The same breed of chickens is used for producing eggs or meat, being *Leghorn* commonly used in NL. Eggs are widely consumed whereas meat is being reduced, so more laying hens are desired, resulting in (BOPV, 2016):

·Laying hens: **30** ⟶ (Organic eggs: 250/y) ⟶ **7,500 eggs/y**
·Broiler chicken: **19** ⟶ (45 days and 2.1 Kg) ⟶ **319 Kg/y**
·Rooster: **1** ⟶ - ⟶ -

Laying hens loose productivity after 3 years, so they can be consumed as meat. Organic rabbits need to weight over 1,5 Kg and takes 3 months until harvesting (BOPV, 2016), being final benefits of 32 rabbits/y (=4 cycles*8 rabbits) or **48 Kg/y** (=32*1.5) of rabbit meat.

-Livestock feeding requirement:
The benefit is that they help to reduce FW from the GH and neighbourhood, digesting mostly everything (La madriguera, 2015):
·Chickens: 100 gr/d/chicken*50*365/1000= **1,825 Kg FW/y.**
·Rabbits: 100 gr/day/rabbit*8 rabbits*365/1000= **292 Kg FW/y**

-Livestock manure:
Layer chickens can produce around 120 kg/day/1000 birds and meat chickens: 80 Kg/day/1000 birds (FAO, 2009; BOPV, 2016; Pet Poo Skidoo, n.d.), so the total manure of livestock is around **2,073 Kg/y**:
·L. hens: 0.12 Kg/day/chicken*30*365= **1,314 Kg/y**
·B: chicken: 0.08 Kg/d/chicken*(19+rooster)*365= **584 Kg/y**
·Rabbit: 0.06 Kg/day/rabbit*8*365=**175.2 Kg/y**

-Vermicompost:
Surplus FW from animal feeding is introduced in the 5 vermicomposting boxes (total area A=2.8 m2) and performed 3 times per year (1 cycle=120 days), introducing wider variety of waste than for livestock feeding. The quantities recommendations for vermicompost are (Vermican (n.d.):

-Vegetables: 1kg/m2 or 200gr/plant	- Fruit trees and trees: 1-3 kg / tree depending size
- Seedbeds and substrates: 10-20%	- Rose and woody roses: 500gr-1kg
- Flowers: 150-200gr/plant	- Lawn: 500gr-1kg / m2

One worm can digest 50% of its weight (worm=w=1gr), so: 0.5 gr FW/w/day. Moreover, the optimum population

is around 9-18 Kg w/m2 (1 kg=2,000 w) or 20,000 w/m2, being able to digest 12 Kg FW/d/m2 (Vermican, n.d.). By doing rule of thumb, **12,000 Kg FW/y** can be digested:

· Optimum population: Considering 20,000 worms/m2 and A=2.8 m2, **56,000 worms/cycle (28 Kg worm/cycle)** are introduced (28*3 cycle=**84 Kg worm/y**).
· Digestion: 12 Kg FW/day/m2 and A=2.8 m2: **33.6 Kg FW/day** (33.6*120 days*3 cycles= around **12,000 Kg FW/y** is reduced).
· New fertilizer: 0.5 Kg worms produce 0.25 Kg compost/day, so 28 Kg will produce 14 Kg/day **(1,680 Kg/cycle=5,000 Kg/y)**.
· Extra worms: 2 kg extra worms/4 months in 1000 kg of fertilizer, so **3.36 Kg worms/cycle (**3.36*3 cycle= **10 kg worms/y**).

-Summary of livestock & vermicompost:

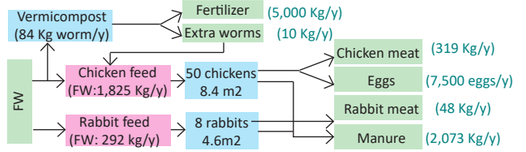


Figure 7.3.1.1: Food cycle summary of livestock and vermicompost in the GH.

-Mushrooms:
According to chapter 5.3 *Data flows in the neighbourhood: food,* 9.460 Kg/y (28.5 Kg/day) of coffee grounds can be collected in the Southern part of Spangen. Bags of 5L (3 kg fresh coffee grounds, 600 gr pasteurised straw, 300 gr of mushroom spawn) are placed in the GH, in which growing phase is divided in 2 depending on the temperature, sun rays and other conditions (Ten Berge, 2017):
· Phase 1 (growth): Room 20-25 degrees, 3 weeks, darkness.
· Phase 2 (fruiting): Room 15-20 degrees, 3 weeks, indirect lighting. (2d harvest: 2 weeks more, 3rd harvest: 2 weeks).

Phase 1 is done in the chicken room due to the optimum conditions, hanging around **100 bags** (0.1*0.1*0.5 m=5L) from the ceiling and covering by black layer. Later, bags are moved to the underneath space of the aquaponics, profiting the temperatures and indirect sunlight. 100 bags fit in 1.5 NFT unit, but 2 NFT units are preferred and used for a total fruiting period of 7 weeks (3 harvest cycles/y).

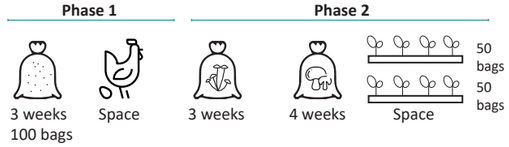


Figure 7.3.1.2: Growing phases and location of Mushrooms bags for a total cycle (phase 1+phase2).

Due to high amount of NFT and space, phase 1 can be done continuously so the production is not interrupted, being a total placement of 1,700 bags/y. However, phase 2 is the focus, so considering the production of an existing company of 27 Kg/d of mushrooms with 128 Kg coffee/d (Ten Berge, 2017), the total harvest in the GH by the rule of thumb could be **2,848 Kg/y (4,500 bags/y)**:

· 52/3 week average=17 cycles/y and 45 harvesting times
·Phase 1: 100 bags*17 cycles=1,700 bags/y
· Phase 2: 100*45 harvestings/y=4,500 bags/y
· 1 bag= 3 Kg coffee, so 4,500 bags/y*3= **13,500 Kg/y coffee** can be reduced (around 37 Kg/d).
·128 kg/d coffee=27 kg/d mushrooms, so 37 Kg/d= 7.8 Kg/d mushrooms (**2,848 Kg /y**)

-Fried oil:
Fried oil is a valuable source for making homemade, natural soap, and with less harmful particles Around 1 L of oil can produce 1.5 Kg of natural soap every 3 months (Gessinger, 2006) by using: 1 L fried oil, 0.4 L water, 130 gr soda and essence. Assuming a feasible production of 150 Kg soap/3months (100 L oil), the total production could be **600 Kg soap/y** (**400 L/y oil**). On the other hand, candles are also easy to make, being necessary for one candle jar/day: 100 ml oil, 3 spoons of wax, essence and cord (The greatest candle, n.d.). By assuming a production of 150 units/day (15 L/day oil), the total production could be **54,750 candles/y** (reduction of **5,475 L/y** oil). Due to unlimited space, the production of candles and soap could be increased if needed.

-Open field crops:
Considering distances between crops, available land area, diversity goal or season and cycles (Masley, n.d), the total crop production is **2,826 Kg/y** or around 930 units/y:

Season	Name specie	Nº of beds / season	Harvesting period	Nº of cycles/ season (6 months	Average distance between crops (in line)	Average distance bewteen rows	Available soil	Nº of crops /bed	Total number crops /y (crops* cycle)	Average fruit /crop	Total fruits / season	Average fruit weight	Total weight/season
-	-	nº	months	cycles	m	m	width*long (m*m)	nº	nº	nº	nº	Kg	Kg
Spring / summer (6 beds)	Tomato	2	5	1	0.6	0.9	1.8*0.8	3	6	30	180	4	720
	Cucumber	2	2	3	0.4	1.5	1.8*0.8	4	24	13	312	4.5	1404
	Zucchini	2	3	2	0.7	0.7	1.8*0.8	3	12	16	192	3.5	672
Autumn / winter (6 beds)	Carrot	2	4	1	0.08	0.25	1.8*0.8	66	132	1	132	0.1	13.2
	Onion	2	5	1	0.1	0.4	1.8*0.8	34	68	1	68	0.1	6.8
	Leek	2	5	1	0.15	0.4	1.8*0.8	22	44	1	44	0.22	9.68
Total								132	286	-	928	-	2,826

Table 7.3.1.1: Summary annual production for open field crops.

Fertilizer requirement for crops is around 0.017 Kg/m2 soil, so **0.15 Kg/y** is needed (Schröeder, Aarts, et al., 2007).

-Summary of mushrooms, oil and field crops:

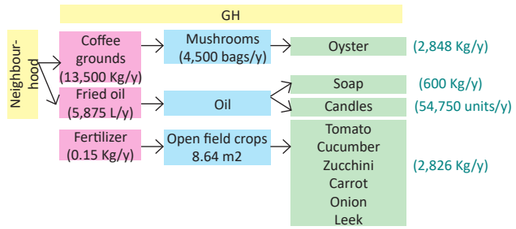


Figure 7.3.1.3: Summary cycle in the GH: mushrooms, fried oil and open field crops.

·Aquaponics NFT:
The fish tank is around **4,410 L** when applying the rule of thumb from book "*Aquaculture Production Systems"* (see next 3 pages). Considering the optimum fish density of 15 Kg/1000 L (FAO, 2014), 66 Kg fish (**110 units fish** =66/0.6

7.3.2 WATER FLOWS

Kg unit fish) are in the tank, being the annual production:
·Nile Tilapia: 600 gr every 6 months, so 70 fish*2 cycles/y =**140 fish (84 Kg/y)**
·Common carp: 600 gr every 10 months, so 40 fish*1 cycle/y= **40 fish (24 Kg/y).**

Considering space area, yields or harvesting period, the final crop production is **6,850 Kg/y** (Fernández, 2003):

Type	Name specie	Nº of NFT unit	Average rows of NFT (in height)	Average crop/ NFT unit	Harvesting period /crop	Cycles /year	Average fruit /crop	Total fruits/y	Average fruit weight /crop	Total weight /y	Total weight /y
-	-	nº	nº	nº	days	nº	nº	nº	Kg	Kg/y	Kg/y
Leafy green plants	Lettuce	2	5	70	30	12	1	8,400	0.4	3360	5,859
	Swiss chard	1	5	70	30	12	1	4,200	0.3	1260	
	Bok choy	2	5	70	50	7	1	4,900	0.11	539	
Fruity plants	Broccoli	2	5	70	80	4	1	2,800	0.25	700	
Fruits	Strawberry	1	5	70	40	9	40	126,000	3E-04	35.3	35.3
Herbs	Basil	1	5	70	40	9	1	-	0.07	220.5	955.5
	Mint	1	5	70	30	12	1	-	0.07	294	
	Oregano	1	5	70	60	6	1	-	0.07	147	
	Dill	1	5	70	30	12	1	-	0.07	294	
Total		12	-	630				146,300		6,850	6,850

Table 7.3.1.2: Summary annual production of NFT quaponics (plants).

-Facade greenery pots:
Pots could be owned by neighbours as a mini community garden, resulting in a general benefit of **120 Kg/y** (=8 crop/pot*2 cycles*25 pots*3 rows height*average 0.1 Kg) if for example onion wa considered (check Table 7.3.1.1).

- WATER FLOWS:

Similarly to food flows, the water consumption is divided according to the 3 interventions. The water storage tanks and biofilters are over-dimensioned in case of additional water supply is desired in future.

· Square:
-Rainwater collection:
Rainwater coming from GH roof, square pavement, residential roof and others is collected in a common underground water buffer tank situated in the square (Figure 7.3.2.1), accounting for a total of 1,473 m3/y= **1,473,000 L/y**) (Azagra Paredes, 2006; (Meteoblue, n.d.):

$$\text{Total water collection (m3/y)} = \frac{\text{annual precipitation (mm/y)} \times \text{collecting surface (m2)} \times \text{runoff ratio}}{1000}$$

Equation 7.3.2.1: Rainwater collection.

Location	Spangen annual precipitation	Collecting surface	Runoff ratio	Description runoff ratio	Total water collection
-	(mm/y)	(m2)	-	-	(m3/y)
Square	782	828	0.3	Greenery, park	194.2
Residential building	782	580	0.7	Concrete roof	317.5
GH roof	782	465	0.7	Like concrete roof (impermeable)	254.5
Rest of roofs	782	1,304	0.7	Concrete roof	713.8
Total	782	3,177	-	-	1,473

Table 7.3.2.1: Annual rainwater collection in each location of the project.

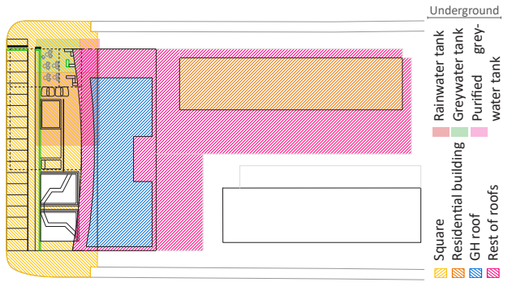


Figure 7.3.2.1: Rainwater collection surfaces and underground water tanks. N

Considering the total monthly rainwater collection and a limitation of 2m depth, the underground rainwater tank dimensions should be over 200 m3 of capacity, designing in the end **16x18.5x2 m** of capacity (592,000 L/month) and allowing to store rainfall for 5 months (Figure 7.3.2.1).

-Rainwater purification:
Based on *Urban Waterbuffer* project in the Northern part, purification and reuse of water is aimed in the South.

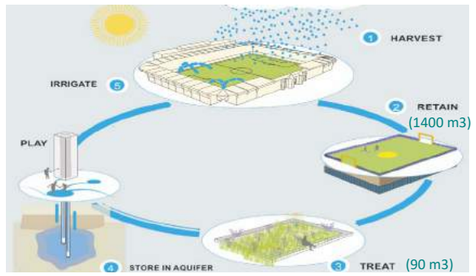


Figure 7.3.2.2: Urban Waterbuffer project in Spangen (Northern part).

According to the project, from a rainwater collection of 30,000 m3/y, around 15,700 m3/y of purified water is obtained (KWR, 2019), due to evaporation and other factors. Similarly and by doing the rule of thumb, the final purified water in the thesis could be 770.9 m3/y=**770,900 L/y.** On the other hand, based on water storage capacity of 1400 m3 and treatment area of 90 m3 (Figure 7.3.2.2) in the *Urban Waterbuffer*, the proposed phytoremediation area should be **above 38 m3**, by applying the rule of thumb. However, for leisure and aesthetics reasons, this phytoremediation area is over dimensioned: **52 m3** (8x6.5x1m).

-Irrigation demand:
Based on water demand in chapter 5.3 *Data flows in the neighbourhood*, the irrigation requirement for the square is 3.5 L/m2/day: **438,700 L/y** (=3.5*343.4 m2 greenery*365 days). Due to water collection limitation, irrigation for the rest of greenery in Spangen is not considered.

-Fountain recreation demand:
Based on *Urban Waterbuffer* project, the existing fountain has a water velocity of 1.5 m3/h. Assuming that the fountain can work around 2 hours/day during 6 months, the annual water consumption would be **547,500 L/y.** However, this amount will not affect to water demand figures due to the fact that this water goes back to the biofilter.

-Total summary:
Water collection, filtration and storage is concentrated in the square, being the water later sent to the rest of the spaces of the project for its responsible consumption.

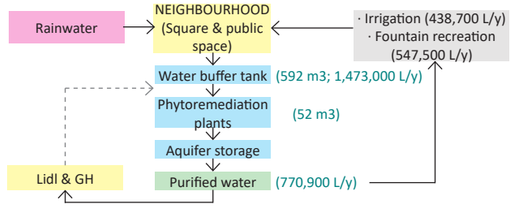


Figure 7.3.2.3: Water cycle summary in the square in front of Lidl.

· Lidl supermarket:
-Kitchen:
Based on water demand in chapter 5.4 *Data flows in the supermarket*, the water requirement for kitchen purposes is 12.7 L/d/employee, resulting in **8,992 L/y** (2 employees and 11 holidays throughout the year: 354 days). Due to lack of greywater information in supermarkets, the same figure is considered for water demand and greywater.

-Bathroom:
Water consumption of toilets is not calculated due to the high demand per year. But greywater from bathroom's sinks is reused and sent to the storage tank and halophyte plants located in the square.

-Facade greenery pots:
Similarly to the green park of the square, the final consumption is **3,610 L/y** (=1 L/m2/d*0.66m2*15pots*365).

· Greenhouse:
-Kitchen:
Based on chapter 5.3 *Data flows in the neighbourhood*, the total water requirement for an average restaurant is 880 L/day/employee, resulting in **1,246,080 L/y** (4 employees and 11 holidays throughout the year: 354 days). A percentage of 31% for water bathroom demand can be assumed (EPA, 2019), resulting in around **386,285 L/y.** Considering 52% for the kitchen (Figure 7.3.2.5), final water consumption is around **647,960 L/y**.

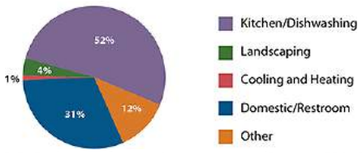


Figure 7.3.2.5: End uses of water in restaurants (Source: EPA, 2019).

Greywater from Lidl (8,992 L/y) and GH (647,960 L/y) is stored in a buffer tank (Figure 7.3.1.1), resulting around **476,950 L/y** (=476.95 m3/y) and 40.4 m3/month (=476.95/354*30days). The storage should be over 80 m3, but it is over dimensioned: **187 m3** (11x8.5x2 m), being able to store greywater for 4.5 months.

-Total greywater purification:
Based on the treatment capacity of the *Urban Waterbuffer* (15,700 m3/y cleaned out of 30,000 m3/y) and by doing the rule of thumb, the final purified water is around **250,000 L/y.** Similarly, considering the capacity of the *Urban Waterbuffer* (90 m3 for treatment area and 1400 m3 for storage), the proposed halophyte area should be **above 18 m3**. However, for leisure and aesthetics reasons, this halophyte is over dimensioned: **52 m3** (8x6.5x1m). Purified water storage is calculated in the same way, being **85 m3** (5x8.5x2 m) of capacity (around 4 months).

-Total greywater summary:
Greywater comes from the bathroom sinks and kitchens of Lidl and GH, being the collection, filtration and storage concentrated in the square.

Figure 7.3.2.6: Greywater cycle summary in the GH, with Lidl entrance.

-Livestock:
Livestock water consumption depends on the weight, climate conditions or maturity of the animals, but in general terms (Tabler, 2003; PET MD (2010):
·Chickens: 0.3-0.5 L/day/chicken
·Rabbits: 0.5 L/day/rabbit or 50-150 mL/day/kg body.
Therefore, considering the worse situation:
·Chickens: 50 chickens*0.5 L/day/chicken*365 days= **9,125 L/y**
·Rabbits: 8 rabbits* 0.5 L/day/rabbit*365= **1,460 L/y**

-Mushrooms & soap:
Mushrooms need to be sprayed with water so assuming in the worse scenario that every bag needs around 4 L during its period of 10 months (around 1 year) (Ten Berge, 2017), the total water demand would be **18,000 L/y**:
· 52/3 week average=17 cycles/y
·Phase 1: 100 bags*17 cycles=1,700 bags/y
· Phase 2: 100*45 harvestings/y=4,500 bags/y
·4,500*4L=18,000 L/y
Regarding soap, 0.4 L of water is needed for producing 1.5 Kg soap/3 weeks. If the total soap production is 600 kg/y, the total water demand is **160 L/y .**

7.3.3 AIR FLOWS

-Open field crops:
Open field crops need water for transpiration and evaporation (evapotranspiration), expressed usually in mm/day, mm/month or mm/season. Water demand of a crop (ET crop) depends on several factors, being the formula for a complete cycle (FAO, n.d.):

·ET crop = ETo * Kc (crop factor)
·ETo (mm/day)= K pan * E pan

Ecuation 7.3.2.2: Calculation for water demand of a crop (ET crop) (Source: FAO, n.d.).

After several calculations performed on the website of FAO, the final water demand of tomato is: 786 mm/crop cycle. However, there is a summarized table of all crops, where mm/crop cycle of each crop is (FAO, n.d.):

-Spring/summer season:
·Tomato: 400-800 (786)
·Cucumber: 200-600
·Zucchini: 400

-Autumn/winter season:
·Carrot: 400-500
·Onion: 350-550
·Leek: 370-400

In order to simplify calculations, the following water demand (mm/crop cycle) is chosen for each crop:

-Spring/summer season:
·Tomato: 750
·Cucumber: 400
·Zucchini: 400

-Autumn/winter season:
·Carrot: 400
·Onion: 400
·Leek: 400

The final water consumption in open field crops is around **10,240 L/y**, by applying this equation:

$$\text{Crop water demand (L/cycle)} = \frac{\text{Crop water consumption (mm/crop)} \times \text{area plantation (m2)} \times \text{coverage percentage (90)}}{100}$$

Equation 7.3.2.3: Water demand per crop/cycle (L) (Source: (Coquimbo Regional government, 2000).

Season	Name specie	Nº of beds	Harvesting period	Nº of cycles/season	Crop water consuption	Area plantation	Total water consuption
-	-	nº	months	cycles	mm/crop/cycle	m2	L/y
Spring / summer	Tomato	2	5	1	750	1.44	1,944
	Cucumber	2	2	3	400	1.44	3,110
	Zucchini	2	3	2	400	1.44	2,074
Autumn / winter	Carrot	2	4	1	400	1.44	1,037
	Onion	2	5	1	400	1.44	1,037
	Leek	2	5	1	400	1.44	1,037
Total		5/season			2750	8.64	10,238

Table 7.3.2.3: Water consumption of open field crops.

-Summary:

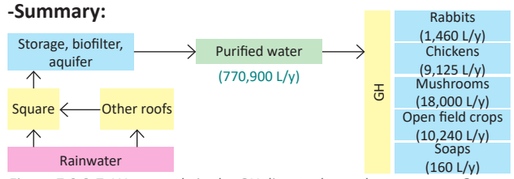


Figure 7.3.2.7: Water cycle in the GH: livestock, mushrooms, soap & open field crops.

-Aquaponics NFT:
According to the book *"Aquaculture Production Systems"*, fish tank should be: 1m3 fish tank/2 m3 hydroponics, therefore by applying the rule of thumb (Tidwell, 2012):

·NFT tube= 0,34 m2*0.08 m=0.0272 m3
·NFT unit= 5 tubes= 5*0.0272=0.136 m3 → x5

·12 NFTs= 0.136*12*5 rows= 8.16 m3 (102 m2) → x12
·2 m3 plants: 1 m3 tank->8.16 m3: >**4 m3 tanks**

Due to available space, final dimension is **4.41 m3/tanks** or **4,410 L/tanks** (area=pi*r²; 3.14*0.6²*3 tanks, 1.3 m height). However, water consumption is higher, being necessary 100 m3 water/Kg fish (Tidwell, 2012), so **6,600 L/y** when there is a production of 66 Kg fish/y). Also, germination area consumes 30 mm/seed/2week (FAO, n.d.), so by considering Equation 7.3.2.3, the total water consumption is: 0.03m*0.84 m2*6 beds*26 cycle= **3,930 L/y.**

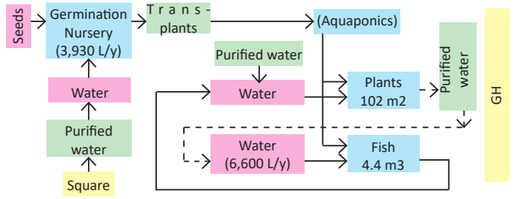


Figure 7.3.2.8: Water cycle of aquaponics NFT in the GH.

-Facade greenery pots:
Similarly to open field crops, facade pots would need **13,500 L/y** (=400 mm/crop/cycle*0.25 m2*25 pots*3 row*average 2 cycles*90%).

- AIR FLOWS:

The introduction of greenery, in indoor but mostly outdoor areas of the proposal, is beneficial due to absorption of air polluting substances (CO2, NOx, SO2), particulate matter (PMx), reduction of UHI, improve aesthetic values and reduce global warming trends, to name a few. Due to its complex composition, the main focus is on CO2 sequestration and O2 production within boundaries of the proposal and leaving other greenery areas around Spangen. When data cannot be founded and there are no similarities between species, calculations are not performed.

· Square:
-People:
A person needs an average of 179 Kg O2/p/y (Mcpherson, 2005), so considering an average daily occupancy of 50 persons in the square, a total of **8,950 Kg O2/y** is needed. Each person expires around 450 mL CO2/minute, which means a final of 400 mL/min. Each gram of C02 occupy a volume around 556 ml, so by doing rule of thumb, a final of 0.72 gr/min is released (Alvy, 2007):

·0.72 gr/min*60 min*24h= 1036.8 gr/day/person
·1036.8*365 d/1000=378.4 Kg/p/y= 0.378 tons/p/y
·378.4 * 50 persons=18,920 Kg/y

In the end, around 1035 gr CO2/day/person and **18,920 Kg CO2/y** can be released. According to another source, around 950-1200 gr of CO2/day/person (El periódico, 2009) can be released, being the previous value (1037 gr/day/person) valid for these calculations.

-Trees:
An average size tree produces an average of 18 Kg O2/y/tree and has a carbon sequestration rate of 3.4-5.9 Kg/y/tree (Nowak et al., 2007; Lal & Augustin, 2012). Based on Table 6.3.2.4, 4 specific types of tree are selected, accounting for a total of 21 deciduous trees and resulting in **378 Kg O2/y** (=18 Kg O2/y/tree *21 trees) and 424 Kg CO2/y (=5.5 rate*21 trees*3.67 conversion C to CO2).However, a more rigorous CO2 calculation is performed by the "American method for carbon sequestration", resulting in **370 Kg/y CO2** (similar to the previous result of 424 Kg/y and validating it) (U.S. Department of Energy, 1998):

Tree type	Name specie	Growth rate	Assumption of tree age	Nº of trees planted	Survival factor	Nº of surviving trees	Annual sequestration rate	Total carbon sequestred	Total carbon sequestred
-	-	Slow, moderate, fast	nº	nº	-	nº	Pound/tree	Pounds/y	Kg/y
Deciduous	Fraxinus excelsior	F	10	11	0.589	6.479	19.3	125.0	56.7
	Fagus sylvatica	S	10	2	0.568	1.136	5.5	6.2	2.8
	Prunus avium	F	10	4	0.589	2.356	19.3	45.5	20.6
	Tilia spp	F	10	4	0.589	2.356	19.3	45.5	20.6
Total			10	21					
Total								222.2	100.8
Total								815.6	370

Table 7.3.3.1: Carbon sequestration calculation of planted trees in the square (Source based on: U.S. Department of Energy, 1998).

-Shrubs and grass:
Shrubs have a carbon sequestration of 0.07-0.23 Kg/y/shrub and grass 25-204 g/m2/y (Lal & Augustin, 2012), resulting **14.3 Kg/y CO2** for shrubs (=average 0.15 Kg/y/shrubs*26 average shrubs*3.67 conversion) and **225.4 Kg/y CO2** for grass (=av. 0.114 Kg/m2/y*538.8 m2*3.67).

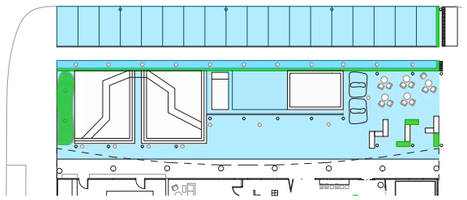


Figure 7.3.3.1: Grass (blue colour) and shrubs (green) in the square. N

-Phytoremediation & halophyte plants:
Both plants are assumed to be the same for simplifying calculations, so considering phytoremediation plants have carbon sequestration of 1.1 Mg/ha/y (Chandra & Singh, 2020), a total sequestration of **41.8 CO2/y** is found:

· 1 ha=10,000 m2
· A=52 m2
· 1.1 Mg/ha/y=1,100/ha/y= 0.11 Kg/m2 /y
· 0.11 Kg/m2/y*52 m2*3.67=**20.9 Kg CO2/y**
·20.9*2 biofilters= 41.8 CO2/y

Assuming biofilter plants as green walls (next paragraph), **89 Kg O2/y** for both plants (=1.712 Kg/m2*52) is found.

· Lidl supermarket:
-People:
Based on the diary occupancy of around 20 people and previous calculations the total O2 needed would be:

·Average 179 Kg O2/y*20 people=**3,580 Kg O2/y**
On the other hand, the CO2 released is:
·1036.8*365 d/1000=378.4 Kg/p/y= 0.378 tons/p/y
·378.4 * 20 persons=**7,570 Kg CO2/y**

-Movable green walls & facade greenery pots:
Based on living walls, the results can be (Ottelé, 2011):
·Movable furniture: 2.15*0.3*1 m (A=2.15 m2)
·CO2 absorption: 2.351 Kg/m2*2.15*5 units=**25.3 Kg/y**
·O2 production: 1.712 Kg/m2*2.15*5 units=**18.4 Kg/y**
Similarly, facade pots can result in **23.3 Kg CO2/y** (=2.351 *0.66 m2*15 units) and **17 Kg O2/y** (=1.712*0.66*15).

·Greenhouse:
-People:
Based on the diary occupancy of around 40 people and previous calculations, the total O2 needed would be:
·Average 179 Kg O2/y*40 people=**7,160 Kg O2/y**
On the other hand, the CO2 released is:
·1036.8*365 d/1000=378.4 Kg/p/y= 0.378 tons/p/y
·378.4 * 40 persons=**15,136 Kg CO2/y**

-Open crop field:
Similarly to green walls, an assumption of **20.3 Kg CO2/y** (=2.351 Kg/m2*1.44 m2*6 beds) is absorbed and **14.8 Kg O2/y** (=1.712 Kg/m2*1.44 m2*6 beds) can be released.

-Aquaponics NFT:
Green walls are considered due to lack of data, resulting in **222.2 CO2/y** (=2.351 Kg/m2*0.0225 m2 surface plant*14 plants*5 rows*12 NFT units*5 rows in height) and **161.8 Kg O2/y** (=1.712 Kg/m2*0.0225 m2 surface plant*14 plants*5 rows*12 NFT units*5 rows in height).

-Facade greenery pots:
Considering pots as living walls, the final results can be **44 Kg CO2/y** (2.351 Kg/m2*0.25 m2*75 units) and **32.1 Kg O2/y** (1.712 Kg/m2*0.25 m2*75 units).

-Livestock:
Although this is not greenery, it is calculated for verifying the possible exchange of CO2-O2 between animals and plants, assuming 50% of CO2 for O2 due to lack of data:
·94.6*50 chickens/2=4,730 CO2 Kg/y/2=**2365 Kg O2/y**
·94.6*8 rabbits/2=756.8 CO2 Kg/y/2=**378.4 Kg O2/y**
Dog's C02 rate is considered due to lack of data of chicken and rabbits. The volume leaving the dog's lungs is around 200 ml/minute (Norkus, 2019), so considering that each gram of C02 occupy a volume of 556 ml (Alvy, 2007), the result is 0.36 gr/min. At least 1/2 is the dimension of livestock compared to dogs, so 0.36/2= 0.18 gr/min:

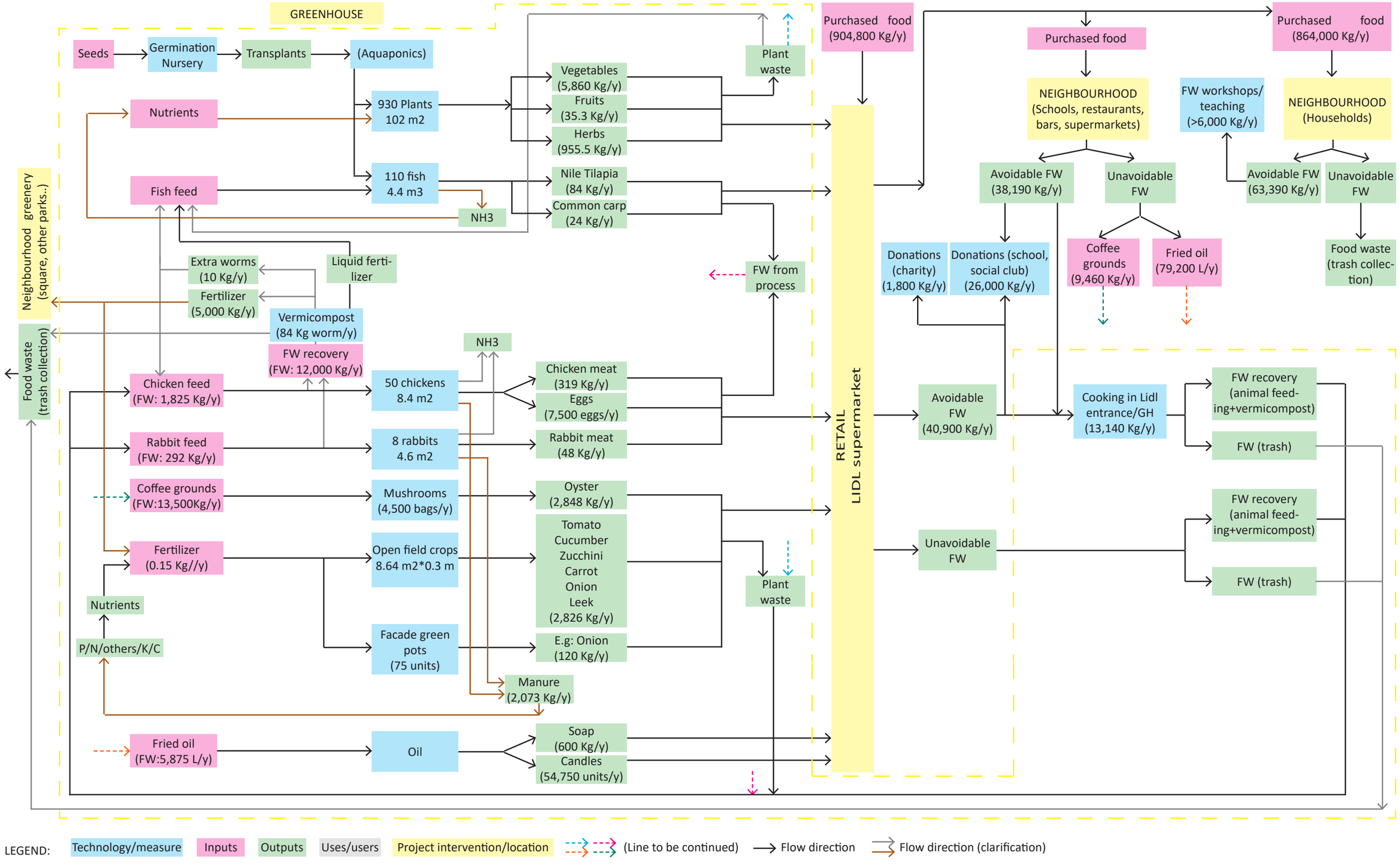
·0.18gr/min*60min*24h= 259.2 gr/d/animal
·259.2*365 days/1000= 94.6 Kg/animal/y
·94.6*50 chickens=**4,730 CO2 Kg/y**
·94.6*8 rabbits=**756.8 CO2 Kg/y**

7.4 | DIAGRAM OF FLOWS

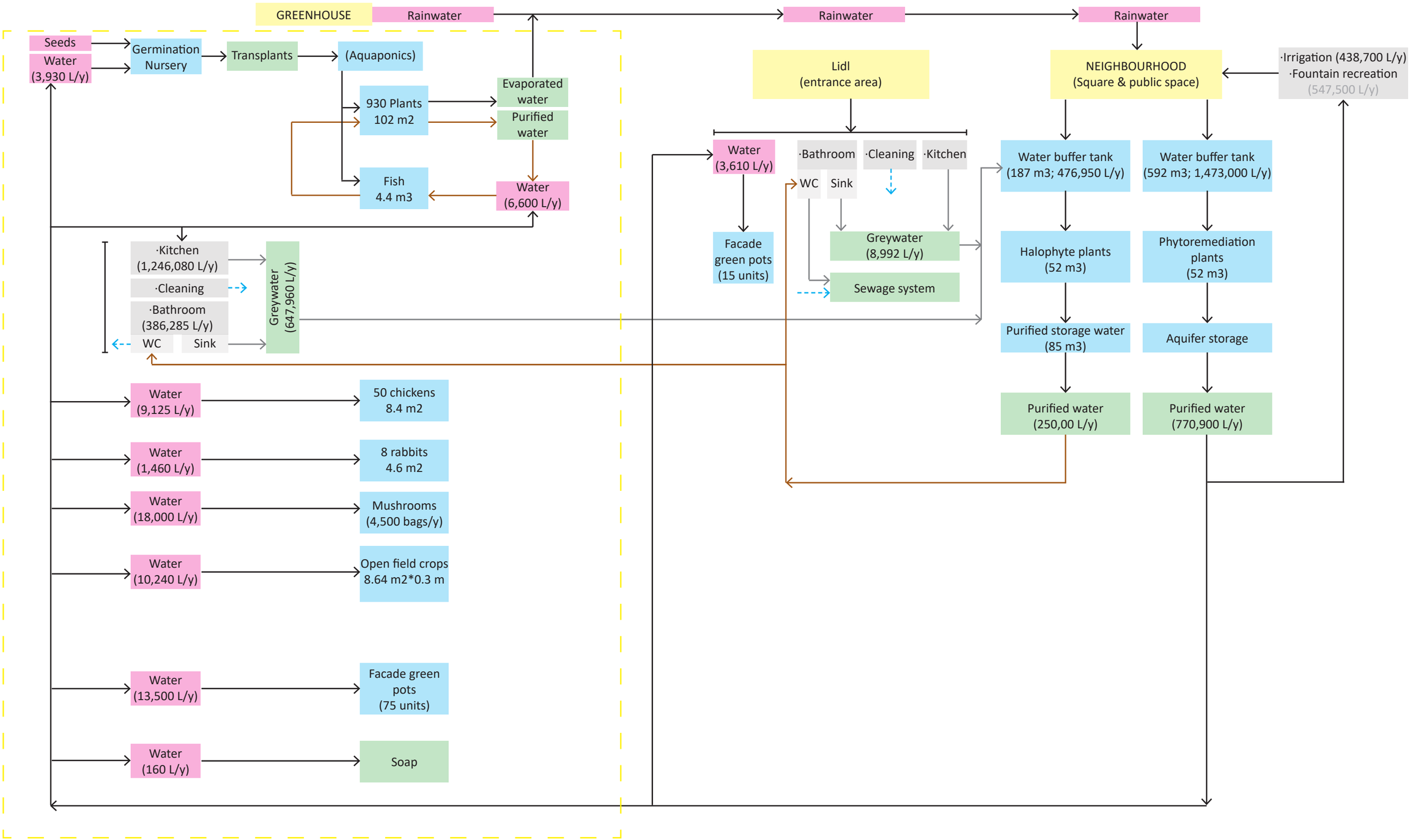
7.4.1 FOOD FLOWS

7.4 | DIAGRAM OF FLOWS

7.4.1 FOOD FLOWS



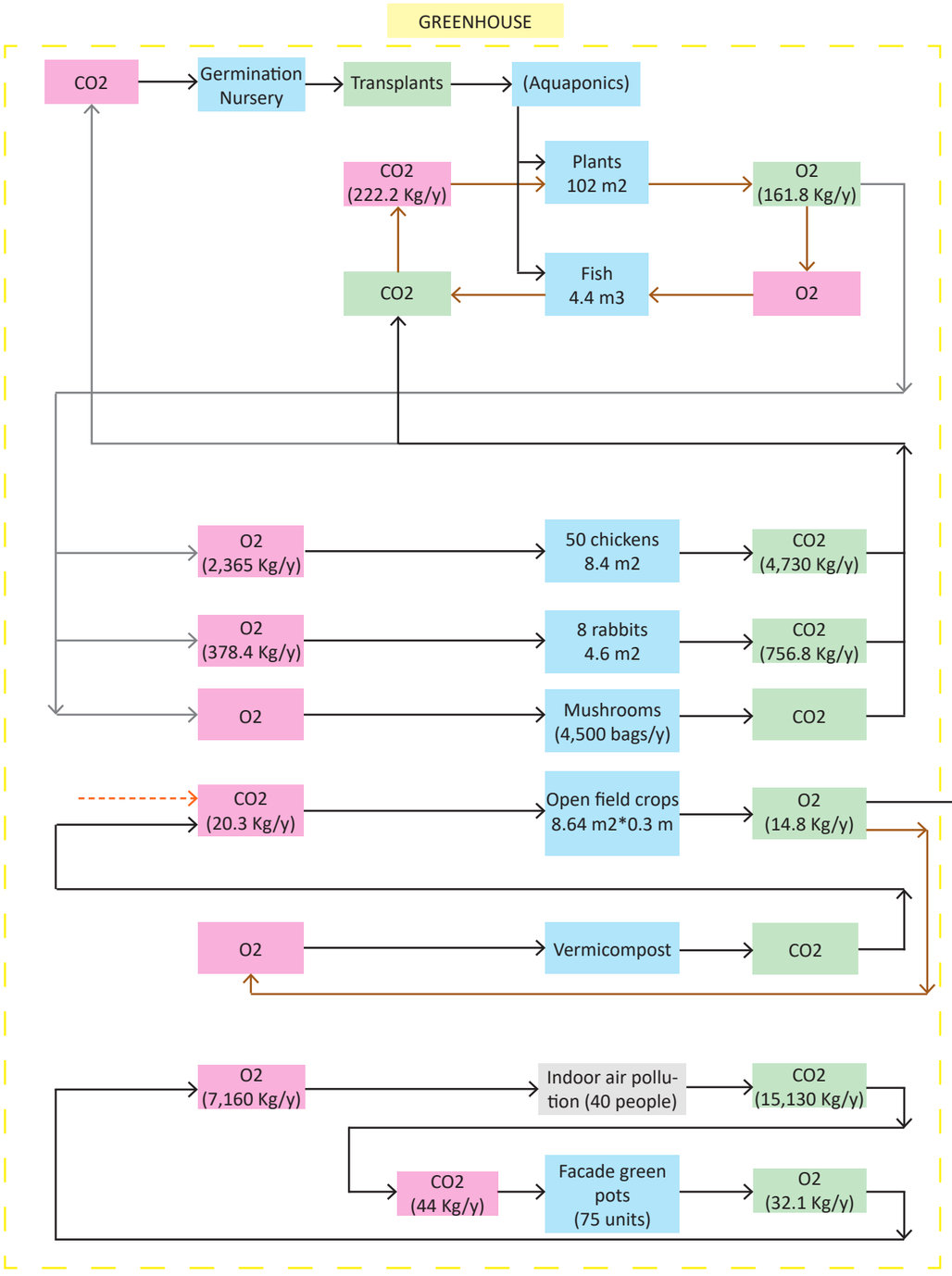
7.4.2 WATER FLOWS

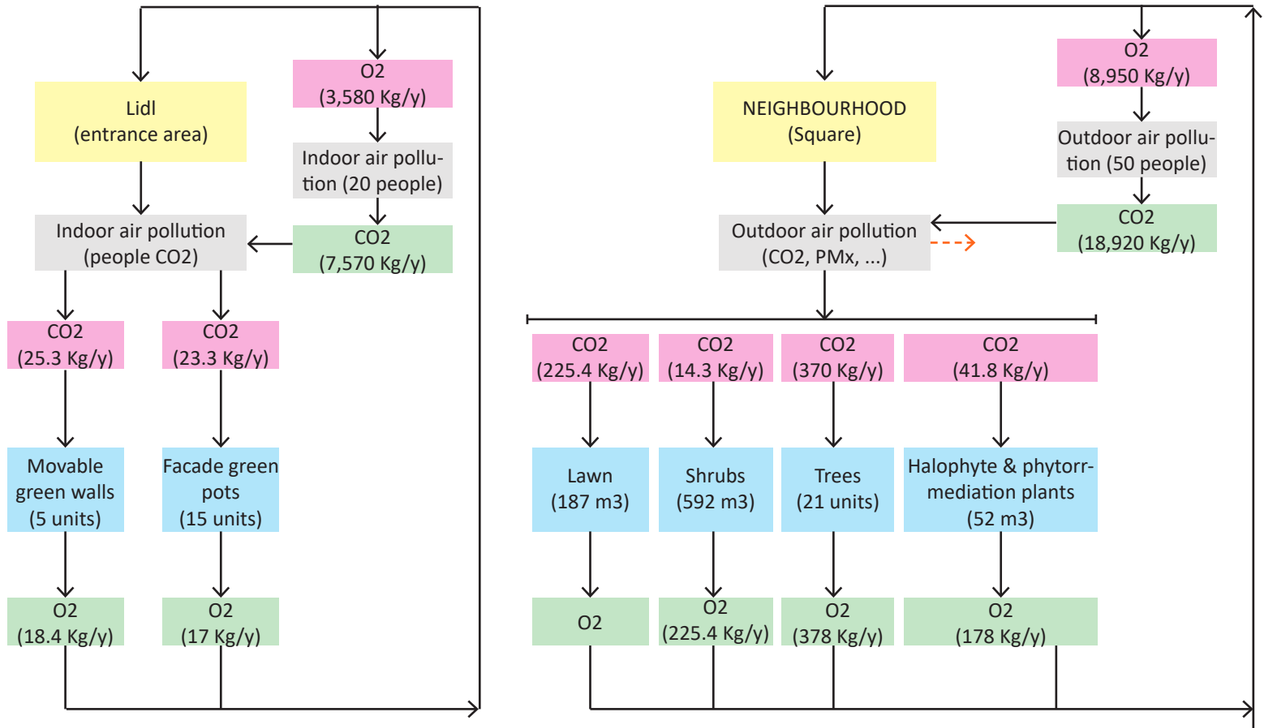


LEGEND: Technology/measure | Inputs | Outputs | Uses/users | Project intervention/location | (Line to be continued) | Flow direction | Flow direction (clarification)

7.4 | DIAGRAM OF FLOWS
7.4.2 WATER FLOWS

7.4.3 AIR FLOWS





LEGEND: Technology/measure | Inputs | Outputs | Uses/users | Project intervention/location | (Line to be continued) | Flow direction | Flow direction (clarification)

7.5 | BENEFITS

7.5.1 COMPARISON BETWEEN ORIGINAL VS PROPOSAL

A brief comparison between original state and proposal is aimed within this chapter, considering at the same time the three flows: Food, water and air.

Table 7.5.1.1 represents the benefits (green arrow), disadvantages (red) and equal state (orange) of the new proposal compared to the original situation.

Flows	Description	Original situation	Proposal situation
FOOD	**-HOUSEHOLDS:** ·Avoidable FW	**-HOUSEHOLDS:** ·Avoidable FW: 63,390 Kg/y	**-HOUSEHOLDS:** ·Avoidable FW: Around 10% of possible reduction through workshops, teaching and change of behaviour (NNCF, 2019): ↓ >6,000 Kg/y
	-RESTAURANTS +SCHOOL+BARS+ SUPERMARKETS: ·Avoidable FW ·Unavoidable FW: -Coffee grounds -Fried oil	**-RESTAURANTS+SCHOOL+BARS+ SUPERMARKETS:** ·Avoidable FW: 38,190 Kg/y ·Unavoidable FW: -Coffee grounds: 9,460 Kg/y -Fried oil: 79,200 L/y	**-RESTAURANTS+SCHOOL+BARS+ SUPERMARKETS:** ·Avoidable FW: Donation to school & social club: ↓ 26,000 Kg/y ·Unavoidable FW: -Coffee grounds: Production of mushrooms: ↓ 13,500 Kg/y -Fried oil: Production of candles & soap: ↓ 5,875 L/y
	-LIDL: ·Purchased food ·Avoidable FW -Donations -Anaerobic digestion	**-LIDL:** ·Purchased food: 904,800 Kg/y ·Avoidable FW: 40,900 Kg/y -Donations (4.4%)= 1,800 Kg/y -Anaerobic digestion (95.6%)= 39,100 Kg/y	**-LIDL:** ·Purchased food: ↓ 13,570 Kg/y ·Avoidable FW: ↓ 27,260 Kg/y -Donations (4.4%): ↔ -Anaerobic digestion (95.6%): ↓ **-GREENHOUSE:** ·Reduction of FW: -Livestock feed: ↓ 2,117 Kg/y -Vermicompost: ↓ 12,000 Kg/y -Cooking recovery in GH/Lidl: ↓ 13,140 Kg/y ·Production: -Vegetables: ↑ 9,761.5 Kg/y -Mushrooms: ↑ 2,848 Kg/y -Fruits: ↑ 35.3 Kg/y -Fish: ↑ 108 Kg/y -Meat: ↑ 367 Kg/y -Eggs: ↑ 7,500 eggs/y=450 Kg/y -Candles: ↑ 54,750 units/y= 5,475 kg/y -Soap: ↑ 600 Kg/y -Manure: ↑ 2,073 Kg/y -Fertilizer: ↑ 5,000 Kg/y -Extra worms: ↑ 10 Kg/y 32,790 Kg/y
WATER	**-HOUSEHOLDS:** ·Water consumption	**-HOUSEHOLDS:** ·Water consumption: 63,390 Kg/y	**-HOUSEHOLDS:** ·Water consumption: An estimation of 8% possible reduction through workshops, teaching and change of behaviour (Viewin, 2017): ↓ >5,000 L/y.
	-SQUARE & PUBLIC SPACE: ·Water collection ·Water consumption	**-SQUARE & PUBLIC SPACE:** ·Water collection: None ·Water consumption: 367,600 L/y	**-SQUARE & PUBLIC SPACE:** ·Water collection: Phytorremediation: ↑ 770,900 L/y ·Water consumption: ↔ -New square: ↑ 438,700 L/y
	-LIDL: ·Water consumption ·Water reuse	**-LIDL:** ·Water consumption: 10,640,000 L/y ·Water reuse: None	**-LIDL:** ·Water consumption: ↔ -Facade pots: ↑ 3,610 L/y ·Water reuse: -Halophyte for greywater: ↑ 250,000 L/y
			-GREENHOUSE: ·Water consumption: -Aquaponics NFT: 6,600 L/y -Germination zone: 3,930 L/y -Open farm: 10,240 L/y -Livestock: 10,585 L/y -Mushrooms: 18,000 L/y -Facade pots: 13,500 L/y -Soap: 160 L/y -New bathrooms: 1,246,080 L/y -New kitchen: 386,285 L/y ↑ 1,695,300 L/y

7.5 | BENEFITS

7.5.1 COMPARISON BETWEEN ORIGINAL VS PROPOSAL

Flows	Description	Original situation	Proposal situation
AIR	**-SQUARE & PUBLIC SPACE:** ·O2 demand ·CO2 produced	**-SQUARE & PUBLIC SPACE:** ·O2 demand: 8,950 kg/y ·CO2 produced: 18,920 Kg/y	**-SQUARE & PUBLIC SPACE:** ·O2 demand: ↔ ← ·O2 production: -Biofilters: ↑ 178 Kg/y -Trees: ↑ 378 Kg/y -Shrubs: ↑ 225.4 Kg/y -Lawn: ↑ ·CO2 produced: ↔ ← ·CO2 sequestrated: -Biofilters: ↑ 41.8 Kg/y -Trees: ↑ 370 Kg/y -Shrubs: ↑ 14.3 Kg/y -Lawn: ↑ 225.4 Kg/y
	-LIDL: ·O2 demand ·CO2 produced	**-LIDL:** ·O2 demand: ·CO2 produced:	**-LIDL (entrance):** ·O2 demand: 3,580 Kg/y ·O2 produced: -Facade pots: ↑ 17 Kg/y -Movable green walls: ↑ 18.4 Kg/y ·CO2 produced: 7,570 Kg/y ·CO2 sequestrated: -Facade pots: ↑ 23.3 Kg/y -Movable green walls: ↑ 25.3 Kg/y **-GREENHOUSE:** ·O2 demand: ← -Fish: ↑ -Chickens: ↑ 2,365 Kg/y -Rabbits: ↑ 378.4 Kg/y -Mushrooms: ↑ -Vermicompost: ↑ -People: ↑ 7,160 Kg/y ·CO2 produced: ← -Fish: ↑ -Chickens: ↑ 4,730 Kg/y -Rabbits: ↑ 756.8 Kg/y -Mushrooms: ↑ -Vermicompost: ↑ -People: ↑ 15,130 Kg/y ·O2 produced: -Germination zone: ↑ -Aquaponics plants: ↑ 161.8 Kg/y -Outdoor farm: ↑ 14.8 Kg/y -Facade green pots: ↑ 32.1 Kg/y ·CO2 sequestrated: -Germination zone: ↑ -Aquaponics plants: ↑ 222.2 Kg/y -Outdoor farm: ↑ 20.3 Kg/y -Facade green pots: ↑ 44 Kg/y

Table 7.5.1.1: Beneftis comparison between original situation and proposal one.

-Food flows:

·Food demand/production:

-Original food purchased of Lidl: **904,800 Kg/y**

-Proposal food production: **32,790 Kg/y**

-New food purchased of Lidl: **13,570 Kg/y**

-New valuable production: candles, soap and fertilizer.

-Food production: Food supply of **1,5 %** for Lidl.

·Food waste reduction:

·FW reduction in households: **10%** through awareness lessons and workshops in the GH.

·FW reduction (from Lidl+neighbourhood) through Lidl and GH interventions: **70%**:

-Original FW: 38,190+40,900= **79,000 Kg/y** FW

-Final reduction FW: 26,000+1,800+2,117+12,000+13,140= **55,000 Kg/y** FW reduction

·Coffee grounds reduction (from restaurants and cafeterias): **100%**, being possible to take more coffee grounds from the Northern part of Spangen.

-Original coffee ground waste: **9,460 Kg/y**

-Final coffee ground reduction: **13,500 Kg/y**

·Fried oil reduction (from restaurants): **7.5 %**

-Original fried oil: **79,200 L/y**

-Final oil reduction: **5,875 L/y**

-Water flows:

·Water collection:

-Available purified rainwater: **770,900 L/y**

-Available purified greywater: **250,000 L/y**

·Water consumption:

·Water reduction in households: **8%** through awareness lessons and workshops in the GH.

·Rainwater consumption: **65%** is consumed by the new interventions (without considering kitchens and bathrooms), so there is still **35%** than can be used for kitchen and bathroom purposes:

-Rainwater consumption (without considering kitchens and bathrooms): 6,600+3,930+10,240+10,585+18,000+13,500+160 L/y= **500,000 L/y**

·Greywater consumption: Only **2.4%** of reused greywater would cover Lidl water demands.

·Lidl water consumption: **10,640,000 L/y**

-Air flows:

·CO2 (production/sequestration):

-Total CO2 production: **47,113 Kg CO2/y.**

-CO2 sequestration: **984 Kg CO2/y.**

·O2 (demand/production):

·Total O2 demand: **22,430 Kg/y**

·Total O2 produced: **1,025 Kg/y:**

·O2 production in the square: 780 Kg/y, which means that an additional **4.3 persons** could benefit from this greenery.

·O2 production in Lidl cafeteria: 35.4 Kg/y, being not sufficient compared to the demand.

·O2 production in GH: 209 Kg/y, being very far from livestock O2 requirement, people and others.

7.5.2 ACHIEVEMENT OF SDGs

The sustainable measures applied and introduced within the interventions of the new proposal can be briefly summarized and grouped according to the three dimensions of sustainability. Moreover, each number represents the action areas according to chapter 4.6 *Design framework* (Figure 7.5.2.1).

The final SDGs achieved can be displayed in Table 7.5.2.1, which are associated with each sustainable measure considered in the final proposal.
However, each SDGs consist of several indicators but due to the scale of the project, only a few indicators can be achieved. In order to know more in detail which specific indicators of each SDGs are achieved with the project, chapter 10 *Appendix* can be read.

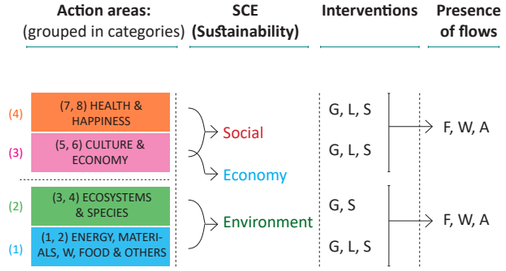


Figure 7.5.2.1: Summary of action areas, interventions (GH:G, Lidl:L, square:S) and flows (food:F, water:W, air:A).

7.5 | BENEFITS

7.5.2 ACHIEVEMENT OF SDGs

The original state of Spangen (S) and Lidl (L) had the following partial SDGs (regarding the essential flows):
- SDG 2: Zero hunger (S, L)
- SDG 3: Good health & well-being (S)
- SDG 4: Quality education (S)
- SDG 5: Gender equality (S)
- SDG 10: Reduced inequalities (S)
- SDG 11: Sustainable cities & communities (L)
- SDG 12: Responsible consumption & production (S)
- SDG 13: Climate action (S, L)
- SDG 14: Life below water (S)
- SDG 15: Life on land (S)
- SDG 17: Partnership for the goals (L)

The following SDGs are also partially achieved within the final proposal, but with a greater number of obtained indicators (green colour represents the new SDGs achieved compared to the original state):
- SDG 2: Zero hunger (S, L)
- SDG 3: Good health & well-being (S, L)
- SDG 5: Gender equality (S, L)
- SDG 6: Clean water & sanitation (S, L)
- SDG 7: Affordable & clean energy (L)
- SDG 8: Decent work & economic growth (L)
- SDG 10: Reduced inequalities (S, L)
- SDG 11: Sustainable cities & communities (S, L)
- SDG 12: Responsible consumption & production (S, L)
- SDG 13: Climate action (S, L)
- SDG 14: Life below water (S, L)
- SDG 15: Life on land (S, L)
- SDG 17: Partnership for the goals (S, L)

ECONOMIC & SUSTAINABLE BUSINESS

SDG 7, SDG 17, SDG 5, SDG 8, 10, SDG 2, 12, SDG 14

- (1) Clean and energy production when possible (LSC red panels and PV).
- (3) Lightweight (GH) and low technology when possible (decreasing difficulty & increasing creativeness and desirable labour).
- (3) Partnership with local stores (Buurman) and citizens involvement (maintenance, construction and decoration).
- (3) Synergy between other neighbourhood facilities.
- (3) Quality over quantity.
- (3) Higher productivity/m2 when considering both space and time.
- (3) Job creation (support to local business, woman, disadvataged people, youth, etc).
- (3) Local and sustainable food production
- (3) Diverse food production (fish, meat, fruits, vegetables, products...)

SUSTAINABLE ENVIRONMENT

SDG 12, SDG 12, SDG 6, 13, SDG 2, 11, 12, SDG 6, 13, SDG 15, SDG 12, 15, SDG 3, 12, SDG 3, 11

- (1) Minimum resources inputs from outside the system boundaries ((local use of resources, collaboration with local companies if needed, demountability, lease, 2nd hand..)
- (1) Benefits from climatology (smart and passive design: shadows, ventilation, sun rays...).
- (1) Rainwater collection, biofiltration and recircularity.
- (1) Surplus food and FW collection. Circularity principles and smart use of resources (hierarchy and upcycling).
- (1) Closer and smaller loops of resources (water recycling, selling point, air exchange...).
- (2) Natural and ecological processes (natural interaction between species).
- (2) Local species, natural biodiversity & smart selection according to site conditions (thermal, lighting, moisture).
- (2) Animal welfare & natural behaviour (organic and ecologic production).
- (2) Non toxic chemicals and substances.
- (4) Smart use of greenery spaces for the improvement of air quality, reducing UHI and flooding. Air purification.

SOCIO-CULTURAL WELLBEING

SDG 12, 13, 17, SDG 11, SDG 3, SDG 5, 10, SDG 11, SDG 11, SDG 11, SDG 3

- (2) Climate awareness through visible use of natural resources, (3) connection with natural system.
- (3) Teaching and learning process (workshops, expositions, sustainable conferences, innovations...). Conference from partnership with local business and other interesting institutions.
- (3) Active spaces (reduction of criminality and increasing activity in the area).
- (3) Physical, cultural and social activities. Multifunction possibilities: Retail, social uses, education, agriculture, catering, ...). Flexible design according to local necessities and culture. (4) Mental health and well-being.
- (4) Public, semipublic, semiprivate, private spaces (segregation of spaces).
- (4) Integration and participation for all genders, ages, ethnicities, groups and individuals. Representation and integration of different ethnicities (respond to local demands and cultures). Diversity.
- (4) Integration within the landscape, urban and social conditions. Design according to human scale.
- (4) Direct and welcoming access for everyone, without sudden changes in level (also considering people with reduced mobility).
- (4) Healthy, safe & enjoyable environment and spaces to work, study, stay in (enhancing pedestrians and cyclists, lighting, car's protection...). The proposal is a source of enjoyment for the future owner and local residents. (3) Attractiveness not only for local neighbours but also other visitors, students or workers.
- (4) Indoor and outdoor spaces (connection). Stimulation of 5 senses and new experiences through flows, materiality, views, etc.
- (4) Identity and personal feeling through smart solutions (facade greenery pots, name of the person in cups, name of neighbourhood in menus...), increasing community feeling, satisfaction, sense of belonging.

Table 7.5.2.1 Final benefits of the proposal, grouped according to the three dimensions of sustainabilty and its respective achieved SDGs.

08 CONCLUSIONS & DISCUSSION

8.1 | RESEARCH CONCLUSION

Lidl NL has been putting efforts on implementing Circular Economy principles in their sustainable operations, but the lack of social aspects and integration to the local context was still needed for obtaining a total sustainable and balanced system. The Southern part of Spangen was the study case due to poor urban metabolism and social aspects, being very far from the Sustainable Development Goals established by the United Nations.

So the main research question of this thesis was:

To what extent the sustainable redesign of Lidl supermarket can improve the social context, urban metabolism related to essential flows and help to achieve Sustainable Development Goals (SDGs) in Spangen?

· Direct conclusion:

Lidl redesign, through the help of three interventions (square, Lidl and greenhouse), allowed to improve in general the current situation regarding social context and urban metabolism of Spangen and Lidl, but at different levels of success. In the end, apart from several achievements of SDGs indicators, there has been obtained new SDGs in both Lidl and Spangen.

On one hand, the proposal enabled to enormously improve the existing social context by providing new comfort spaces for having healthy, enjoyable, interesting, well-being, cohesive, integrational, climate awareness workshops and new social activities. Moreover, not only indoor spaces were improved regarding sociability among citizens (Lidl and GH), but also outdoor public space (square) was converted into a safer, nicer, social, interesting, enjoyable space to stay and interact with each other. The three interventions were socially connected to each other, being an integrated design and achieving the following SDGs related to social dimension: 5, 8, 10, 13, 17.

On the other hand, the main accomplishment of urban metabolism regarding essential flows was achieved with food flows, especially in food waste reduction (hierarchy re-circularity). On-site processing of surplus and avoidable solid food waste (FW) allowed a reduction of 70%. Other FW measures allowed reducing 7.5% of fried oil, 100% of coffee ground and in general reduce waste and resources from outside, at the same time as allowed providing new saleable products (soap, candles, fertilizer), boosting local business, identity and synergy between the neighbourhood's facilities. The downside was that the new local food production only covered 1.5 % of the demand due to the focus on social aspects rather than intensive farming.
The introduction of new rainwater and greywater collection tanks and on-site local treatments (biofilters), enabled the proposal to work almost self-efficiently. Around 65% of rainwater (without considering bathrooms and kitchen demands) was used within the interventions, leaving 35% of remain rainwater for other purposes such as toilets. However, only 2.4% of greywater was able to cover the total water demand of Lidl.
Air flows were in general terms slightly improved, providing nicer indoor and outdoor air quality through biodiverse and local greenery species, but O2 supply was very far from covering O2 demands. The consolidation and achievement of SDGs related to environmental dimension were: 2, 3, 6, 7, 11, 12, 13, 14, 15, 17.

· Conclusion by sub-questions:

To answer the research question, the following sub-questions were put forward:

1- What are the essential flows of interest for Spangen neighbourhood and Lidl supermarket regarding SDGs?
2- What is the current urban metabolism, related to essential flows, between Lidl supermarket and the local neighbourhood?
3- What are the existing social initiatives for the local community and which ones could be improved or introduced through Lidl redesign?
4- What are the main circular opportunities that can be achieved through Lidl redesign for the improvement of the urban metabolism and according to the socio-economic context of Spangen?
5- Which Sustainable Development Goals result from the synergy between Lidl redesign and the neighbourhood?

The first sub-question is answered from the analysis in chapter 5.2 *Definition of flows*. In general, existing challenges regarding SDGs were detected to find possible improvements within the Lidl redesign. Afterwards, the selection of the final flows (Water, Food, Air) were evaluated according to greater improvement possibilities, SDGs, social impact and further factors. But, although these 3 essential flows were considered in the future design, air flows had less synergistic potentials and consisted on a complex range of factors (PMx, CO2, O2, etc), so it was discarded from the further analytical research.

The current urban metabolism (sub-question 2) can be answered from chapter 5.5 *Data flows in Spangen area*, in which the diagram of flows represents clearly the existing linear urban metabolism occurring in Spangen.
Great amount of avoidable food waste (FW) was thrown away and without any recovery measure, accounting for around 142,500 Kg FW/y and a loss of 80 Euros/y/person, so considering that Spangen was an area in need, people should not afford the right to waste food and money. The only FW recovery measure, accounting only for 4.4%, was the Lidl donations to national charities but without relation to Spangen citizens, being the rest sent to anaerobic digestion. Likewise, there were not water recycling measures or rainwater collection, being sent and mixed with the sewage urban system and reducing possibilities for urban synergy. Lastly, there was bad management of

greenery spaces, being very scarce and predominating hard pavements, thus decreasing the opportunities from greenery in favour of airflows benefits.

The existing social initiatives (sub-question 3) are explained in chapter 5.1.3 *Existing initiatives,* being reduced in recent years and only remaining two social clubs with social activities and basic services to people in need. Stichting Openhaard was the only social club established within the study area (South) but based on chapter 6.1.3 *Definition of system boundaries*, its interior distribution and spaces were not attractive due to lack of lighting, comfort, healthy, motivational or working environment, so these issues led to new possibilities and social improvements within the Lidl redesign.
The previous sub-questions (1, 2, 3) proved that at least three types of interventions were needed for achieving further SDGs, improving social context and urban metabolism in Spangen: Square, cafeteria and greenhouse (GH). The latest allowed to relocated activities from the social club and introduce new activities for increasing social offer and boosting well-being among citizens.

-Existing activities/uses in Stichting Openhaard:

· Languages lessons
· Instrument lessons
· Photography
· Kick-boxing
· Cooking activities
· Sewing courses
· Turkish coffee
· Dancing lessons
· Conferences
·Art lessons
· Indoor football
· Reading
· Informatics
· Excursion

-Moved activities/uses to the new GH:

· Language lessons
· Guitar lessons
· Photography
· Kitchen workshops
· Sewing courses
· Coffee time
· Dancing lessons
· Conferences
· Art lessons

-New additional activities/uses in the GH:

· Nutrition & FW workshops
· Climate awareness, sustainability conference, upcycling & CE workshops
· Low technology and innovation conferences
· Table games
· Agriculture lessons & harvesting
· Animal feeding & care
· Dinner events
· Private plant ownership (commitment, care, good feeling, propriety feeling..)
·Social rooms, study area
· Organization of indoor fairs, cinema sessions or small events

Circular solution routes (sub-question 4) were searched and described in chapter 6..2.1 *Sustainable and low tech measures,* considering the socio-economic situation (low tech measures) and intervention type. In the end, only a few were selected, discarding others due to ethical, feasible, complex and expensive reasons. These are the selected circular opportunities, organized through the 3 R concept (reduce, ruse and produce):

-1 Food flows:

·Reduce: By local and direct donations to school, social clubs or other people in need, and changing the behaviour and buying practices through FW workshops.
·Reuse: Reprocess FW on-site (upcycling) into edible products (juices, cakes, ice cream from ripe fruits and vegetables, etc) and by-products (soap and candles from kitchen waste oil, mushrooms from coffee grounds...). Collecting FW for animal feeding and vermicomposting in the GH (through new trash bins) and reusing animal waste as fertilizer or fish feeding.
-Produce: Local food production (aquaponics NFT, outdoor farm, livestock) allow reducing packaging, waste, transportation or costs, and providing new jobs, fresher, tastier and organic products to Spangen.

-2 Water flows:

·Reduce: NFT hydroponic system enable to reduce water, energy consumption and the need of soil.
·Reuse: Greywater reuse and bio-filtration.
·Produce: Rainwater collection and bio-filtration.

-3 Air flows:

·Reduce: By the introduction of local food production, waste reuse and introduction of greenery.
·Reuse: CO2-O2 exchange between livestock and crops.
·Produce: New outdoor and indoor greenery for O2 production and improvement of air quality.

Lastly, by considering the previous steps, several SDGs (sub-question 5) were achieved within Spangen and Lidl redesign, shown in chapter 7.5.2. *Achievement of SDGs.*
Overall, not only further indicators of each SDG were achieved in Spangen (S) and Lidl (L), but also new SDGs such as SDG6 and SDG8 (highlighted in green colour):

· SDG 2: Zero hunger (S, L)
· SDG 3: Good health & well-being (S, L)
· SDG 5: Gender equality (S, L)
· SDG 6: Clean water & sanitation (S, L)
· SDG 7: Affordable & clean energy (L)
· SDG 8: Decent work & economic growth (L)
· SDG 10: Reduced inequalities (S, L)
· SDG 11: Sustainable cities & communities (S, L)
· SDG 12: Responsible consumption & production (S, L)
· SDG 13: Climate action (S, L)
· SDG 14: Life below water (S, L)
· SDG 15: Life on land (S, L)
· SDG 17: Partnership for the goals (S, L)

Therefore, as mention at the beginning, by answering the previous 5 sub-questions, it was possible to develop an optimum result (with the limited available data and socio-economic constraints), being social context, food flows and SDGs much more improved.

8.2 | DISCUSSION

8.2.1 GENERAL DISCUSSION & FURTHER RESEARCH

· General discussion:
This research concluded with the necessity to act in three different interventions, providing specific services and spaces for the improvement of the local social context, urban metabolism and achievement of SDGs in Spangen and Lidl. Nevertheless, the final result did not represent the only solution as there was room for discussion.

1· Food production and social activity in 1 location or 2:
Due to limited food production compared to supply, another location would need to be considered. From the two possible rooftops, only the first building was chosen due to views, food wate distribution or direct connection to Lidl cafeteria. However, although the second building had lower benefits regarding orientation, it could serve as an additional space for social purposes, thus leaving the first building for only food production. But this would result in higher consumption of resources, building construction labour and economic costs, being far from the objective of keeping the lowest construction and costs.
2· Profitable food production:
Food production objectives were focused on animal welfare and treatment, providing fresh, ecological and organic food. This resulted in wider spaces and fewer production of crops or livestock, so if economy and profitability were desired, better-exploited spaces would be needed, thus allowing to fulfil food demands in Spangen.
3· Wider indoor refurbishment of Lidl supermarket:
The ground floor where divided in Lidl and Toros supermarket, occupying 3/4 of front facade by Lidl and 1/4 by Toros. The indoor refurbishment design was aimed to be at the entrance of Lidl, modifying the least interior distribution and using the least commercial surface as possible, resulting in an elongated shape. However, if the space occupied by Toros supermarket was available for Lidl, greater benefits for the square and restaurant design could have been achieved, but resulting in higher distribution modifications, costs and possible conflicts with Toros.
4· Increase of water collection surface:
Water collection surfaces were not enough for the efficient management of the final proposal (when considering bathrooms and kitchen consumption, so, more water capturing surfaces would be needed, for example by considering other rooftops and streets nearby. This could lead to legal and property issues with neighbours or city council for letting get benefits for only Lidl, but could be a valuable and feasible option if an agreement was reached.

· Recommendations for further research:
Introducing urban farming practices, social interaction among users, and implementation of circular routes have been independently achieved enough level of success in several projects. However, the combination of all these aspects in one location, through social circular economy principles and for the final achievement of SDGs, could be something new or barely studied, needing for this inclusive design further research in the following domains:

1· Financial feasibility:
Investments and financial costs have been considered in the design but they were not further developed in detail. Due to Lidl supermarket's thesis, it was thought that Lidl would be the main investor for the cafeteria and greenhouse, being the city council the main interested party for the improvement of the square (public identity). The greenhouse could be funded by Lidl but owned by the community association, paying gradually back until reducing the Lidl loan. Howoever, other financial possibilities would need to be searched, involving potential stakeholders, city council, Lidl and private companies, etc.
2· Relation to the rest of the flows:
Only the main essential flows have been studied in detail, but the relationship and impact to the rest of the flows (energy, emissions, packaging...) would need to be considered too in order to see the real feasibility of the project.
3· Food production variety and competitiveness:
Although food consumption habits was performed, a further study would be needed for finding the most effective food production and definition of type of species. The quality, fresher and organic products from the greenhouse was considered to have great acceptance to local consumers, but research (economical and environmental) and comparison of the new impact on the Lidl food supply chain would be needed.
4· Social activity variety:
New social activities were based on current social challenges from national statistics data and the desire to maximise social relationship among users. However, due to Covid-19 limitations, a further analysis of specific social activities adapted to local neighbours would be necessary for increasing their well-being and satisfaction.
5· Other circularity routes:
Mostly low tech and inexpensive measures according to the socio-economic circumstances of Spangen were introduced, being necessary to search for other innovative and more efficient possibilities (if costs are not considered).
6· On-site biodigester possibility:
A great part of surplus and food waste from the Southern part of Spangen was able to be re-processed and reduced on-site. With the introduction of a biodigester, food waste from the Northern part and production of energy could be achieved, but carrying ethical issues and regulations.
7· Decentralization and transferability:
Decentralization solutions were indirectly aimed for giving independence and higher benefits to small areas of a city. By solving efficiently local issues (neighbourhoods), the big scale (city) could be easier improved by applying repetitive patterns in the rest of the conflict areas. This research found at some extent, a general methodology that could be applied to any degraded urban context.

8.3 | REFLECTION

1· Methodology, approach and research methods:
The methodology of this thesis was elaborated based on predictive research (design by research). By critically identifying the causes and effects of the current issues and predict possible solutions in align with the SDGs (design exploration), this research project seeks to improve tthe spatial and societal issues occurring in Spangen and Lidl.

Furthermore, this graduation project is based on applied research, which begins from a particular situation: the socio-economical situation of Spangen and how this affects the urban metabolism and social community. Seeking social reintegration, cohesion and improvement of flows with minimal economic aids and difficult social context result in a challenging task. Therefore, this research aims to find a solution through a Lidl store redesign in order to improve the social context and urban metabolism, and in line with social sustainability and SDGs.

The conceptual approach follows an order that starts with the analysis of the baseline (formed by SDGs, Lidl position, flows and the social context), followed by the improvement phase (with circular solution routes, interrelations and design process) and ending with the evaluation of the design proposal. The design process is the most challenging part due to the need to consider efficiently the previous baseline analysis into optimal spatial translations. Degraded socio-economic environments are delicate areas that require careful attention mostly on social aspects, thus it is necessary to find a method that covers environmental but also social dimensions. ELSI framework seems to be the best option due to the inclusion of the 3 aspects of sustainability and ease to address and achieve the SDGs in a systematic and efficient way. After some adjustments, the final design framework was developed, including some smart strategies through circular solutions and spatial improvements. Moreover, prior to the design process, further analysis of local context was performed for recognising specific interventions, social spaces, species required, circular routes and detailed strategies.

2· Relationship between research and design:

In this graduation project, the design follows the research, which is divided in theoretical and analytical framework. All the theoretical research plays an important role for the understanding of the general case study situation and interpretation of the theoretical concepts (such as circular economy principles, social sustainability, urban metabolism, synergy, etc), in which important data is collected for finding at the end, ways to translate the theory into spatial desings. Afterwards, there has been found and identified several design objectives and general strategies (through design framework) in order to address the current challenges. Analytical research is also important for understanding in more detail the causes and effects of social challenges and urban metabolism , and finding possible improvements adapted to the local situation.

Afterwards, those objectives and strategies were able to be integrated into the final design proposal through performing "research by design". Research by design consisted of finding first the potential zones of interventions, identifying the species and spaces needed, circular solution routes by a thorough and further analysis of the local context and needs. Therefore, at the end of the design process, optimal spatial designs were presented.
Design in this project is a tool for inclusive architectural design and urban development within the framework of addressing and improving the essential flows and local social issues. Design strategies were aligned with the SDGs, sources, species and ecosystems, culture and economy, health and happiness, at the same time as considering urban symbiosis and social sustainability approach.

3· Relation between the graduation project topic, the studio topic, the master track and the master programme:
-Graduation topic, studio topic and master track (building technology):

Building technology is carried out within the only studio "Sustainable Graduation Studio", in which students can choose to focus their graduation topic in two fields, from façade, climate, structural design or design informatics. This research fell within the field of climate design and buiding physics and services, covering topics realted to the indoor and outdoor environment and the dividing skin in-between, essential flows that enable living, working and travelling (energy, water and materials), and other important themes with societal and scientific value.
The purpose of this research topic is to study the local urban metabolism and improve societal issues through the investigation of the circular economy and circular routes, social sustainability, upcycling process, sustainable technology innovations, and resource flow, among others. Therefore, this graduation project is aligned with the workflow of the tutors and the scope of the sustainable graduation studio.

-Graduation topic and master program:

The Dutch government has established a goal for achieving a circular economy by 2050, thus TU Delft has already started to study this principle since years. The graduation project is in very closed relation with the master program of MSc Architecture, Urbanism and Building Sciences, in which experience in architecture design, spatial planning and the built environment is developed. Specifically, skills in design practice, from the physical and social sciences, technology and urban planning, to name a few, were ex-

plored in order to find ways of creating sustainable development and integrated solutions for the built environment, thus in line with the scope of the thesis too.

4a· Societal relevance:
Rotterdam is a wealth region but nevertheless, it is formed by different districts that still undergoing social, economical and degradation issues, representing a great problem that leads to a lower rate of satisfaction and well-being for the local citizens. In particular, Spangen is constituted by a complex social structure, in which different ethnicities, ages and gender try to live together. However, far from profiting this variety of factors for enhancing social life, prosperity and interactions among neighbours, little social efforts and urban improvements have been made for fighting against the current degraded image of Spangen.

By solving and improving the existing social issues within this area, it could contribute to a better equity, quality of life, satisfaction, individual empowerment, inclusion, diversity, integration and in general, better well-being, coexistence, happiness and social relation among citizens. Moreover, the benefits would not only be focused on the social dimension but also economical aspects would be also improved as a result, increasing economic prosperity, partnership with local companies, commitment, inspirational ideas or productivity...

In general, several social initiatives have been organized by different associations in order to solve these current social issues in the area, but only a few seemed to be really effective and with enough engagement among local citizens. Opposite to other initiatives, this research project were not focused only on the provision of a wide range of social activities. This graduation project seeks to offer alternative multifunctional spaces for performing selected social activities that are aligned with the enhancement of integration, cohesion and participation of local citizens. Moreover, an increase of personal satisfaction, identity, community feeling, sense of belonging, stimulation of sense through new experiences, etc, at the same time as the introduction of climate awareness, teaching innovate technology and circular principles were searched through the different interventions of the proposal.

The positive fact is that the final social measures could serve as an inspiration and be transferred to other areas that experience similar processes of degradation or struggle with similar issues, getting benefit not only from a sustainable and economical point of view but also in order to increase their social quality of life. Therefore this thesis has societal relevance at different scales: from the local neighbourhood to an entire city, because by applying certain measures and according to local demands inside a specific neighbourhood (decentralization systems), bigger scales could be improved through repetitive patterns along with the territory.
The thesis does not respond to a unique answer at a specific location, but it could affect the future architecture and built environment design through social sustainability and synergetic approach with the surroundings.
Moreover, this research could also contribute to the achievement of Lidl sustainability goals and develop further the social inclusion and role of the supermarket within the community, in order to enhance customer satisfaction, exchange experiences and integration.

4b· Scientific relevance:
On one hand, the United Nations has established several Sustainability Development Goals focusing on social aspects and sustainability targets. The social circular economy is a concept that has a direct relation to the sustainability concept, but it has been barely applied efficiently through urban and architecture disciplines. From a scientific perspective, the goal of the thesis was to create a link that could interpret and translate the social circularity thinking towards spatial urban designs in order to find answers for a feasible and balanced sustainability system. In the end, the results allowed understanding the spatial relationships and social impacts of the social circular economy principles, so it enabled to set a good base for future researchers and other groups that might be interested in this type of research.

On the other hand, urban metabolism is in continuous expansion and transformation, differing from regions and countries, trying to integrate social, cultural, economic and political perspectives in order to shape sustainable environments. The form in which different flows could be combined in synergy with the urban environment would be inspiring not only for municipalities but also other researches or companies, in which further benefits than economical and sustainable measures were achieved, such as social well-being.

Moreover, the way this thesis tried to apply decentralization systems for addressing the issues at big scale through repetitive interventions at smaller scale could contribute to different scientific discussions about urban planning.

4c- Link to other professions:
Briefly, the thesis tried to establish a link between the circular economy and sustainable measures with urban design practices. However, waste collection, treatment systems and food production, among others, are actions that require help from different disciplines, such as architecture, administration, interior design, urban design, agriculture, etc to make them work. For example, reducing and recycling flows would need an approach from different disciplines because the urban design would not be

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able to solve all the issues alone.

5· Ethical perspective:
The cultural variety of Spangen can be an advantage for boosting integration, diversity and cohesion between different backgrounds, but also a challenging task due to privacy culture, closed-minded or particular behaviour. However, realistic social benefits remain unknown due to the impossibility to perform the expected questionnaires about the final proposal due to Covid-19, so perhaps some citizens would refuse to participate in social activities. But, this issue could be reduced by providing them some motivation (discounts, prizes,…).
Lidl has not been involved during the thesis, so its level of cooperation and objectives in the neighbourhood are unknown, although they agreed on establishing more connection with the community. This led to more open possibilities, but its willingness to invest in the new proposals and have an economical agreement with the food production in the greenhouse is still unsolved. Another issue is related to the stakeholders or Lidl food suppliers, which would be reduced due to new local food production.

By putting efforts on closing food, air and water loops through cradle to cradle principles, visible and enjoyable examples, people would be part and involved in these sustainable measures and would be able to learn and be more conscious about it, thus increasing sensibility, responsibility, awareness, cooperation, commitment and community feeling for improving common benefits for Spangen. An almost zero net waste facility could be able to achieve if fully cooperation between citizens is engaged, thus developing a proud feeling and sense of belonging to a healthy and sustainable community.

6· Personal reflection, results of research, expected results, results applicable in practice:

-Personal reflection:
This project helped me to develop a critical and analytical thinking, as well as extending my knowledge through research, analysis and strategy development. It was helpful to understand the importance of social sustainability for the improvement of degraded urban areas in social terms but also for the development of the other two dimensions of sustainability (economy and environment), and in which the link between these three dimensions allows to obtain much greater benefits than only focusing on a few. Addressing these three dimensions was a challenging task due to the socio-economic context of Spangen, but the new design framework helped to achieve further SDGs and in general, a better sustainable balanced system in the neighbourhood. Finally, this research enabled to change my way of thinking and perception on several notions, such as public space, degraded areas, urban planning, socio-economic context, and the role of the architect within the society and environment.

-Research approach:
From my perspective, the methodology was adequate to answer the research question and sub-questions. However, several factors that were out of my scope such as lack of cooperation of private identities (Lidl and neighbourhood's facilities) and Covid-19 situation, led to uncertain results, thus adding some weaknesses points to the research. However, the lack of flows data and citizens feelings or requirements were efficiently solved by national statistic reports, newspapers, fieldwork and international reports, which provided general data in standard facilities.

The final result was slightly different from what I expected, being more detailed, completed and well-argued through the extent research framework. The analytical research conducted in Spangen and Lidl allowed me to understand the magnitude of their waste problem and urban metabolism, lacking local sustainable measures. The identification and improvement attempt of the urban metabolism regarding essential flows and the achievement of further SDGs and social aspects made my design proposal coherent, allowed perhaps to increase their relevance (social and also scientific) and created a great impact on social and environmental aspects (and a bit in economical one).
In the end, I believe that the final design could strongly influence Spangen in a positive way, improving the quality of life of citizens, safety and health, boosting the local economy, people's satisfaction and participation, and integrating all variety of citizens under one area, among others, at the same time as implementing sustainable measures in the new social environment. Moreover, Lidl could obtain benefits from this research as synergy between the local neighbourhood could be much more beneficial for its commercial operations, as well as their increase in profits and customer satisfaction. Lidl could be the first supermarket that could play a prominent role within a community by in improving social cohesion through sustainable and circular principles.

-Applicability:
In terms of transferability, even though that each territory has inherent characteristics and properties, the broad idea could form a valuable base for initiating another different and future project. Moreover, the idea of this thesis could help to the improvement of other regions with similar degradation issues and contribute to their sustainable development. However, using the decentralization concept cannot assure the effectiveness and success of the new study territory, but by changing and adapting different parameters, I believe it could also work and help to achieve their sustainable goals.

09 APPENDIX

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9.2 | APPENDIX

9.2.1 CALCULATIONS OF FOOD FLOWS

AVOIDABLE SOLID FOOD WASTE			
DESCRIPTION OF GROUP PRODUCTS	NAME OF FACILITY	FIGURES	FIGURES
-	-	gr/facility/day	Kg/facility/y
2- Vegetables	Mariaschool	2,955	739
	Lidl	21,851	7,976
	Toros Bakkerij	5,606	2,046
	Vishandel Ooms	885	323
	Slagerij Nador & Ooms	9,555	3,488
	Kebap Dürüm Evi	531	194
	Pizza Amore	288	87
	Onur Firini	144	53
	Eethuis Kon Moi	740	223
	Dürüm Evi	531	194
TOTAL VEGETABLES		**43,085**	**15,322**
3- Fruit	Mariaschool	2,457	614
	Lidl	20,730	7,567
	Toros Bakkerij	6,115	2,232
	Vishandel Ooms	826	301
	Slagerij Nador & Ooms	10,319	3,767
	Kebap Dürüm Evi	295	108
	Pizza Amore	192	58
	Onur Firini	96	35
	Eethuis Kon Moi	444	134
	Dürüm Evi	295	108
TOTAL FRUIT		**41,770**	**14,923**
1- Pastry & cake (bakery), bread & bread-based products	Mariaschool	1,172	293
	Lidl	29,134	10,634
	Toros Bakkerij	3,567	1,302
	Vishandel Ooms	885	323
	Slagerij Nador & Ooms	5,733	2,093
	Kebap Dürüm Evi	1,003	366
	Pizza Amore	1,392	420
	Onur Firini	648	237
	Eethuis Kon Moi	1,332	402
	Dürüm Evi	1,003	366
	Bakkerij Jamama	1,476	539
TOTAL PASTRY, CAKE, BREAD PRODUCTS		**47,345**	**16,975**
6- Meat & meat products & fish, eggs	Mariaschool	581	145
	Lidl	7,844	2,863
	Toros Bakkerij	3,822	1,395
	Vishandel Ooms	1,829	668
	Slagerij Nador & Ooms	3,058	1,116
	Kebap Dürüm Evi	2,360	861
	Pizza Amore	864	261
	Onur Firini	504	184
	Eethuis Kon Moi	2,072	626
	Dürüm Evi	2,360	861
TOTAL MEAT, MEAT PRODUCTS & FISH, EGGS		**25,293**	**8,980**

Table 9.2.1.1: Detail description of avoidable solid FW in Southern part of Spangen organised by the type of products and facilities, including Lidl. (continue in the next page).

AVOIDABLE SOLID FOOD WASTE (FW) BY RESTAURANTS	
DESCRIPTION OF GROUP PRODUCTS	FW RESTAURANTS
-	Kg/y
Vegetables	1,074
Fruit	744
Pastry & cake, pasta, rice, bread & bread-based products	2,653
Ready meals	2,374
Meat & meat products & fish, eggs	3,461
Dairy products (cheese, butter, mainly thick)	1,975
Others	-
Coffee	9,458
Cooking oil (L/month)	6,600
TOTAL FOOD WASTE (excluding coffee & oil)	**12,281**
TOTAL SPEND (3.49 euro/Kg) (excluding coffee & oil)	**42,861**

Table 9.2.1.2: Avoidable solid FW in restaurants.

AVOIDABLE SOLID FOOD WASTE (FW) BY SCHOOL	
DESCRIPTION OF GROUP PRODUCTS	FW SCHOOL
-	Kg/y
Vegetables	739
Fruit	614
Pastry & cake, pasta, rice, bread & bread-based products	293
Ready meals	435
Meat & meat products & fish, eggs	145
Dairy products (cheese, butter, mainly thick)	208
Others	223
TOTAL FOOD WASTE	**2,657**
TOTAL SPEND (3.49 euro/Kg)	**9,273**

Table 9.2.1.3: Avoidable solid FW in school (Mariaschool).

AVOIDABLE SOLID FOOD WASTE			
DESCRIPTION OF GROUP PRODUCTS	NAME OF FACILITY	FIGURES	FIGURES
-	-	gr/facility/day	Kg/facility/y
7- Dairy products (cheese, mainly thick)	Mariaschool	570	208
	Lidl	10,085	3,681
	Toros Bakkerij	1,529	558
	Vishandel Ooms	354	129
	Slagerij Nador & Ooms	2,675	977
	Kebap Dürüm Evi	295	108
	Pizza Amore	1,440	435
	Onur Firini	648	237
	Eethuis Kon Moi	1,480	447
	Dürüm Evi	295	108
	Bakkerij Jamama	1,404	512
TOTAL DAIRY PROUCTS		**20,775**	**7,399**
10- Other products (Seets, snacks, potatoes, pasta, rice)	Mariaschool	891.6	222.9
TOTAL OTHER PRODUCTS		**891.6**	**222.9**
9- Unwanted food from grocery ambient	Lidl	4,482	1,636
	Toros Bakkerij	1,019	372
	Vishandel Ooms	-	-
	Slagerij Nador & Ooms	1,529	558
TOTAL BAD LOOKING FOOD		**7,030**	**2,566**
11- Frozen	Lidl	1,121	409
TOTAL FROZEN		**1,121**	**409**
4- (Leftovers from meals, ready meals)	Mariaschool	1,742	435
	Lidl	16,808	6,135
	Toros Bakkerij	3,822	1,395
	Vishandel Ooms	974	355
	Slagerij Nador & Ooms	5,351	1,953
	Kebap Dürüm Evi	1,416	517
	Pizza Amore	624	188
	Onur Firini	360	131
	Eethuis Kon Moi	1,332	402
	Dürüm Evi	1,416	517
	Bakkerij Jamama	720	263
TOTAL READY MEALS		**34,564**	**12,292**
5- Coffee	Bar Spangen	5,500.0	2,007.5
	Satendam	5,500.0	1,661.0
	Maak Rotterdam	5,500.0	1,661.0
	Vishandel Ooms	4,000.0	1,460.0
	Pizza Amore	4,000.0	1,208.0
	Dürüm Evi	4,000.0	1,460.0
TOTAL COFFEE		**28,500.0**	**9,457.5**
8- Cooking oil	Kebap Dürüm Evi	90	1,080
	Pizza Amore	25	300
	Onur Firini	145	1,740
	Eethuis Kon Moi	130	1,560
	Dürüm Evi	90	1,080
	Bakkerij Jamama	70	840
TOTAL OIL (month)		**550**	**6,600**

Table 9.2.1.1: Detail description of avoidable solid FW in Southern part of Spangen organised by the type of products and facilities, including Lidl. (continued from the previous page).

AVOIDABLE SOLID FOOD WASTE (FW) BY SUPERMARKETS	
DESCRIPTION OF GROUP PRODUCTS	FW SUPERMARKETS
-	Kg/y
Vegetables	6,464
Fruit	5,999
Pastry & cake, pasta, rice, bread & bread-based products	3,395
Ready meals	3,348
Meat & meat products & fish, eggs	2,511
Dairy products (cheese, butter, mainly thick)	1,535
Others	-
TOTAL FOOD WASTE	**23,252**
TOTAL SPEND (3.49 euro/Kg)	**81,149**

Table 9.2.1.4: Avoidable solid FW in supermarkets.

9.2.2 ACHIEVEMENT OF SDGs (indicators)

Specific indicators of each SDGs that can be achieved within the project are described as followed (UN, 2019):

-SDG 2: Zero hunger:
2.1- By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round
2.3- By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment
2.4- By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

-SDG 3: Good health and well-being:
3.4- By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being
3.9- By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

-SDG 5: Gender equality:
5.1- End all forms of discrimination against all women and girls everywhere
5.5- Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life
5.A- Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws

-SDG 6: Clean water and sanitation:
6.3- By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
6.4- By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
6.6- By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
6.B- Support and strengthen the participation of local communities in improving water and sanitation management

-SDG 7: Affordable and clean energy:
7.1- By 2030, ensure universal access to affordable, reliable and modern energy services

-SDG 8: Decent work and economic growth:
8.1- Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries
8.3- Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services
8.5- By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value
8.6- By 2020, substantially reduce the proportion of youth not in employment, education or training
8.8- Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment
8.9- By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products

-SDG 10: Reduced inequalities:
10.1- By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average
10.2- By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status
11.2- By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons

-SDG 11: Sustainable cities and communities:
11.3-By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
11.6- By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
11.7- By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

-SDG 12: Responsible consumption and production:

9.2.2 FOOD FLOWS

12.1- Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries
12.2- By 2030, achieve the sustainable management and efficient use of natural resources
12.3- By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
12.4- By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
12.5- By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
12.6- Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
12.7- Promote public procurement practices that are sustainable, in accordance with national policies and priorities
12.8- By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature
12.B -Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products

-SDG 13: Climate action:
13.2- Integrate climate change measures into national policies, strategies and planning
13.3- Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
13.B- Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities

-SDG 14: Life below water:
14.4- By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics
14.6- By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation
14.7- By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism

-SDG 15: Life on land:
15.4- By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development
15.5- Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species
15.6- Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed
15.8- By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species
15.9- By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts
15.A- Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems
15.C- Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities

-SDG 17: Partnerships for the goals:
17.6- Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism
17.7- Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed
17.16- Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries
17.17- Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships