CONSTRUCTION WASTE

A HUMAN PERCEPTION INSTEAD OF ACTUAL REALITY?

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ABSTRACT

The building industry is one of the largest producers of waste materials worldwide. Construction waste can include various materials such as concrete, wood, glass, metals, plastics, and hazardous materials. These wastes streams can pose significant environmental challenges and contribute to pollution and depletion of natural resources. However, they can also be considered potential resources that can be reused, recycled and/or repurposed, contributing to a circular economy and sustainable development. Dealing with construction waste in the built environment has become a crucial aspect of contemporary architecture. It requires a balance between the need for resource efficiency and waste reduction on the one hand, and the design and functionality of buildings on the other. However, waste could also be considered to be a potential 'raw material'. From this perspective it is to be argued if 'waste' is a valid term? Maybe is the way society interprets 'waste' just a perception based upon a sincere lack of knowledge how to transform and reuse these residues?

This paper examines the issue of construction waste and whether the perceptions associated with the term are related to the actual reality or are the result of a severe bias.

The research question of this thesis is: **Are waste materials in the built environment a problem (pollution) or a solution (resource)?**

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INTRODUCTION

No material, virgin or transformed should ever be labelled 'waste'.

In this study, the Dutch definition of 'Construction waste' is leading. 'Construction waste' refers to all (construction) material left over and released during construction, renovation or demolition of buildings. (Deloitte, 2015)

The history of construction waste dates back to the earliest civilizations, such as the ancient Egyptians and Mesopotamians, who created vast structures using mud, straw, and other natural materials. As these structures aged, they would eventually deteriorate and needed to be repaired with similar materials or become unusable, resulting in natural residuals, the building waste avant-la-lettre. (Hoffman, 1977)

Before the start of the Industrial Revolution, construction waste was handled differently. As resources used for building materials were scarce and much more valuable making reuse and recycling of materials logical and common. Besides this, transforming basic materials was difficult and demanding making basically every man-made artifact valuable. Therefore, construction waste management was much more circular than it is today, despite the fact that there was no awareness of sustainability as this was a non-existing issue.

However, the modern concept of construction waste as known today began to emerge during the Industrial Revolution in the 18th and 19th centuries. The rise of mass production and urbanization led to an increase in construction activity, which in turn resulted in a corresponding increase in actual construction waste. The growing population and higher standards of living led to increasing and even overconsumption leading to resource depletion creating awareness about the phenomena 'Construction waste' and related to this, environmental impact, sustainability and circularity. For a long time, construction waste was not dealt with and dumping as landfill was the standard. However, this led to significant environmental problems such as soil contamination and additional pollution. (Kumar, 2011)

In the early 20th century, the advent of new commodity building materials such as concrete and steel further contributed to the problem of construction waste. The widespread use of these materials resulted in a greater amount of waste being generated during production and construction processes, as well as after buildings were demolished or renovated. Also, to build for a limited timespan (e.g. 50 years) not to be combined with design for reuse and/or recycling contributes to the enormous amount of construction waste. Besides this the production of concrete, steel and glass are characterized by high energy consumption leading to high CO2 emissions.

Only in the past 30 years, mainly due to proven evidence of severe climate change, there has been a more widely growing awareness of the environmental impact of the build environment and as a consequence its produced construction waste. Efforts have been made to reduce the amount of waste generated and increase recycling and reuse. Today, many countries have regulations and policies in place to manage construction waste, including requirements for waste reduction and recycling during construction and demolition activities. (Hebel, 2014)

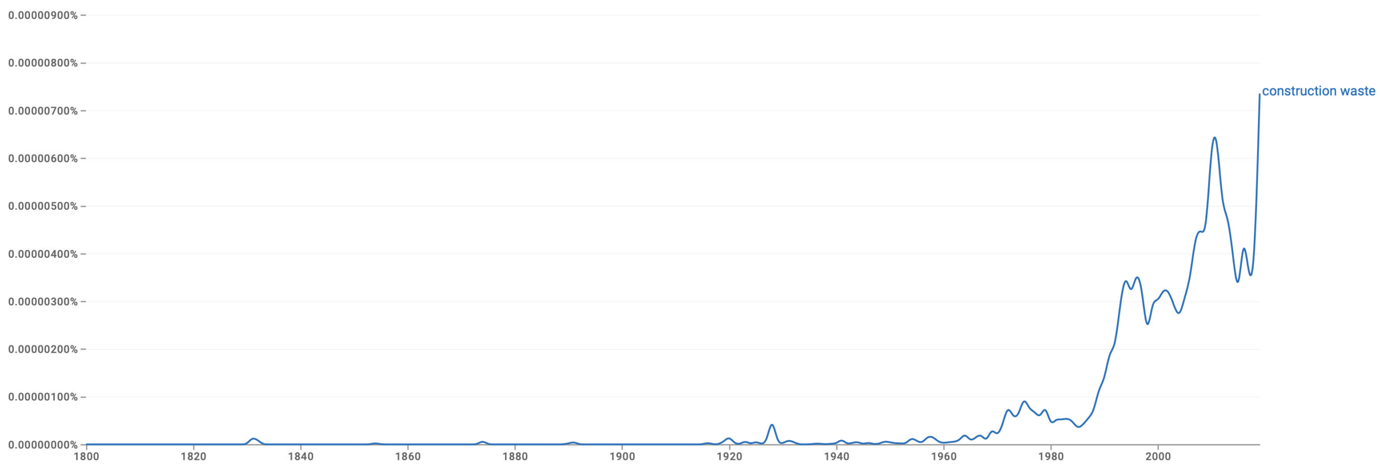

Figure 1: Fluctuating but increasing interest in the word 'construction waste' (Google Ngram Viewer, 2023)

The diagram shows the peaks in relevance of construction waste during time. During the Great Depression new building materials were expensive and therefore reuse was common. The reconstruction of damaged cities, starting a few years after both World Wars also led to an increase of reusing available existing construction materials. At the end of a war, many of the still standing buildings were still demolished as a safety measure. However, just after wars, there is a shortage of housing and building materials. Demolition and construction waste are thus forced into reuse and waste disposal is minimal. (Al-Qaraghuli, 2017)

In 1972 'The Limits of Growth' was published by the Club of Rome, which created awareness of the finite nature of the world's resources and the need to approach and manage them sustainably. The book analyzed the impact of human activity on our planet and predicted that if we continued approaching and consuming the available resources at the current rate, a point of collapse would eventually be reached. During the industrial revolution the motto 'Take, Make, Waste' had come to existence. At this point, construction waste was dumped and only repurposed at the time of material shortage. Waste was not a problem and got dumped without any awareness about environmental issues. The amount of waste from the construction industry ending up in landfills became slowly but steadily a problem in only the past 60 years. (Hebel, 2014) Among other things, the new idea of The Limits of Growth changed this approach towards waste, which led to the development of construction waste management plans and resulted in the development of environmental regulations and policies aimed at reducing waste and promoting reuse and recycling of building materials. In 1975, the European Union's Waste Framework Directive was a milestone for modern waste management in Europe. (Zhang, 2022) In 1976, the Resource Conservation and Recovery Act in the US became into effect. (US EPA, 2022)

Since the late 1980's there has been an increasing awareness due to scientific evidence in respect of climate change and global warming. In 1997, the Kyoto Protocol was adopted by the United Nations Framework Convention on Climate Change. (A&E Television Networks, 2016) The protocol committed signatory countries to reduce their greenhouse gas emissions by an average of 5% by 2012 compared to 1990. This agreement highlighted the role of construction waste in climate change and the need for more sustainable waste management practices. (European Commission, 2008)

In 2002 the book Cradle to Cradle by architect William McDonough and chemist Michael Braungart was published. Versus the 'Take, Make, Waste', an entirely contradictory view, where the concept of 'waste' is completely eliminated. The book is a manifesto that wants to change the Cradle-to-Grave model to a Cradle-to-Cradle model. Every source or material has to be reduced, reused or recycled, also within the building environment. The methodology and approach are more explained in Chapter 1.

The LEED (Leadership in Energy and Environmental Design) Certification is developed by the U.S. Green Building Council, which became an international standard for designing buildings with less environmental impact. In 2010 LEED V4 introduced a construction waste management strategy. The new version consisted of a materials and resources section, directly advising the new strategies relative to waste management. (U.S. Green Building Council, z.d.)

In 2016 the European Commission Construction and Demolition Waste Management Protocol was developed, as construction waste is the largest waste stream in Europe. In this protocol the quality of the recycled construction waste materials is questioned for the first time. Besides only focusing on managing the principles of reducing, reusing and recycling, the objective is to achieve higher quality of the repurposed waste-materials.
The EU ambition is to achieve this by:

a) Improved waste identification, source separation and collection;
b) Improved waste logistics;
c) Improved waste processing;
d) Quality management;
e) Appropriate policy and framework conditions.

(European Commission, 2016)

Despite various large-scale initiatives, the concerns about the environmental impact of construction waste are still growing. Ever since 2016 even more awareness and discussion regarding construction waste management and how to manage it beneficially are initiated.

In a sustainable perspective, waste can be defined as any material or resource that is no longer needed for its original purpose and is discarded of. However, instead of seeing waste as a problem that needs to be eliminated, sustainable thinking recognizes the potential value of waste as a resource that can be repurposed, reused, or recycled. Therefore, waste in a sustainable perspective is not a dead-end, but rather a part of a circular system where materials and resources are continuously reused and regenerated, minimizing waste generation and promoting resource efficiency. A sustainable approach to waste management requires a shift from a linear 'take-make-dispose' model to a circular 'reduce-reuse-recycle' model, where waste is viewed as an opportunity to create value and minimize the negative impact of human activities on the environment.

The history of construction waste identification and management based on literature review forms the basis for this study. The research method is largely qualitative, involving literature review, analysis of data and information based on a case study and critical evaluation of the current and future approach to construction waste management. The research question "Are waste materials in the built environment a problem (pollution) or a solution (resource)?" is relevant to the topic of construction waste management discussed in this research. The different approaches and models related to construction waste management, as well as the case study of the Netherlands, will be examined in the context of this research question.

Chapter 1 discusses various approaches and models related to construction waste management and explores how these approaches and models perceive and categorize construction waste as either a pollution or a potential resource, for reuse or recycling. The models and their implications and will be examined and based on the conclusion an analytic framework will be made.

In Chapter 2, the Netherlands will be used as a case study, with focus on the framework formed in chapter 1. The Netherlands has set ambitious goals for achieving a nearly fully circular economy by 2050 reflecting a perception of construction waste as a potential resource rather than a problem. The examination of the current status of construction waste and circularity in the Netherlands will shed light on how waste materials in the built environment are perceived and managed in practice.

Based on the current status of construction waste and circularity in the Netherlands, Chapter 3 will critically evaluate the existing approach to construction waste. The focus will be on assessing whether the current perception of construction waste is sufficient to achieve a fully circular system in the future, or if a shift in perception is required.

CHAPTER 1 / THE PERCEPTION OF CONSTRUCTION WASTE

Over time, different approaches towards the existence and management of construction waste have developed. In addition, evolving mentalities played a role. In this chapter multiple models that describe different approaches on how construction waste and its possible circularity can be perceived will be discussed.

1.1 Building Material Lifecycle

Building materials flow through three different phases during the life span of a building. These three phases are shown in Figure 2.

1.1.1 The Pre-Building Phase

In this phase, the origin and production of the material, among others, are of great importance. The method of transport and the state in which the material finds its place on the construction site also belong to this phase. What distance has the product travelled by which vehicle and how is the material packaged? Each step of this phase has a negative impact on the environment. Thus, this phase is important where a sustainable choice of building materials is concerned.

It is crucial in the research on improving the circular economy to be aware of all the processes that materials go through from origin to each further transformation. The basis of any building product comes from natural resources. These raw materials can be divided into renewable and finite resources. The aim is to avoid finite raw materials in a sustainable world. Renewable raw materials are accepted as sustainable only when the time of production exceeds the time of human consumption of the resource.

1.1.2 Building Phase

This phase starts when the building material is assimilated into the structure of the building. All maintenance and repair the material endures are also part of this phase. The moment the period of use of the material as part of the building is over, the post-building phase starts. During construction and installation, a severe amount of residual waste is generated that is not directly considered part of the building. The processing and possible recycling of these materials is therefore to be taken into consideration during this phase.

1.1.3 Post-Building Phase

When materials are no longer of use to a building and are removed or a building is demolished, the post-building phase begins. Choices about the future of a material is determined in this phase. Can it either be reused in its entirety, recycled or needs a material to be processed as waste. Demolition has a negative impact on the environment and processing waste must be avoided as much as possible. When a material is recycled, it ends up back in the pre-building phase, while reuse ends up in the building phase. (Kim & Rigdon, 1998)

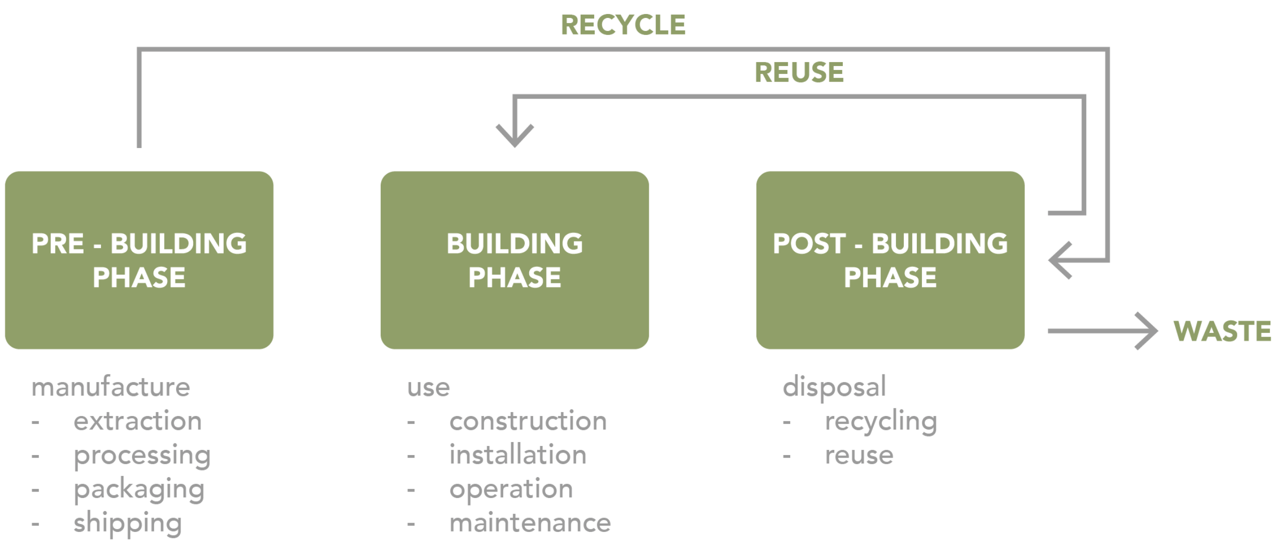

Figure 2: Building material lifecycle in three phases (Kim & Rigdon, 1998)

1.2.1 Triple R-model (1970)
The Triple R-model was the earliest hierarchy created for waste management and was one of the start principles for creating a circular system within our economy. (Zhang, 2022) The 'reduce-reuse-recycle' model focusses on the prevention of waste generation and the shift in value. (Petzet & Heilmeyer, 2012) It was one of the first models that stood for a change in our perception towards waste to a reusable resource.

The three R's where a measurer for the level of circularity, from high to low value.

Reduce: decrease and avoid using raw materials.
Reuse: the direct use of a material or resource again.
Recycle: the properties of the material are changed, but the goal is to save the material stream with the highest possible value.

(Bekkering, 2020)

1.2.2 Ladder of Lansink (1979)
In 1979 the Ladder of Lansink was developed by a Dutch politician and environmentalist, Ad Lansink. From this point on the model was included in the Dutch waste management plan, with the goal of reducing waste and minimizing harm to the environment. (Kwakman, 2019)

Three more levels were added to the Ladder of Lansink:

a) Prevent, which can be considered the same as reduce.
b) Reuse
c) Recycle
d) Energy recovery: using waste as a fuel to generate electricity or heat or for other means of energy generation
e) Incinerate: waste products are removed by burning them turning them into heat energy.
f) Landfill: waste is disposed. Landfill is still an option. This model is based on the fact that the concept of waste remains and that it cannot yet be thought out of the world of circularity, despite the fact that it is desired.

(Zhang, 2022)

1.2.3 Cradle-To-Cradle (2001)
The Cradle-to-Cradle principle sees the future of waste as a resource that will circulate as a material for centuries from harvest. Each time, the material must be put to beneficial use again, which will eventually end resource depletion. The entire community, so both product and construction development will function as an ecological system, effectively using all resources in a cyclical manner. This will ultimately eliminate the Cradle-to-Grave system, the linear economy.

If the Cradle-To-Cradle system is to be sustainable in the construction sector, all materials in construction must be kept clean and mixing must be avoided. The separation systems must be applied correctly from the beginning. (McDonough & Braungart, 2010)

1.2.4 EMF model (2013)
The model from the Ellen MacArthur Foundation, a charity working to improve the environment, consists of two flows of materials within the circular economy. The biological cycle and the technical cycle, in both cycles materials are kept circular through different processes.

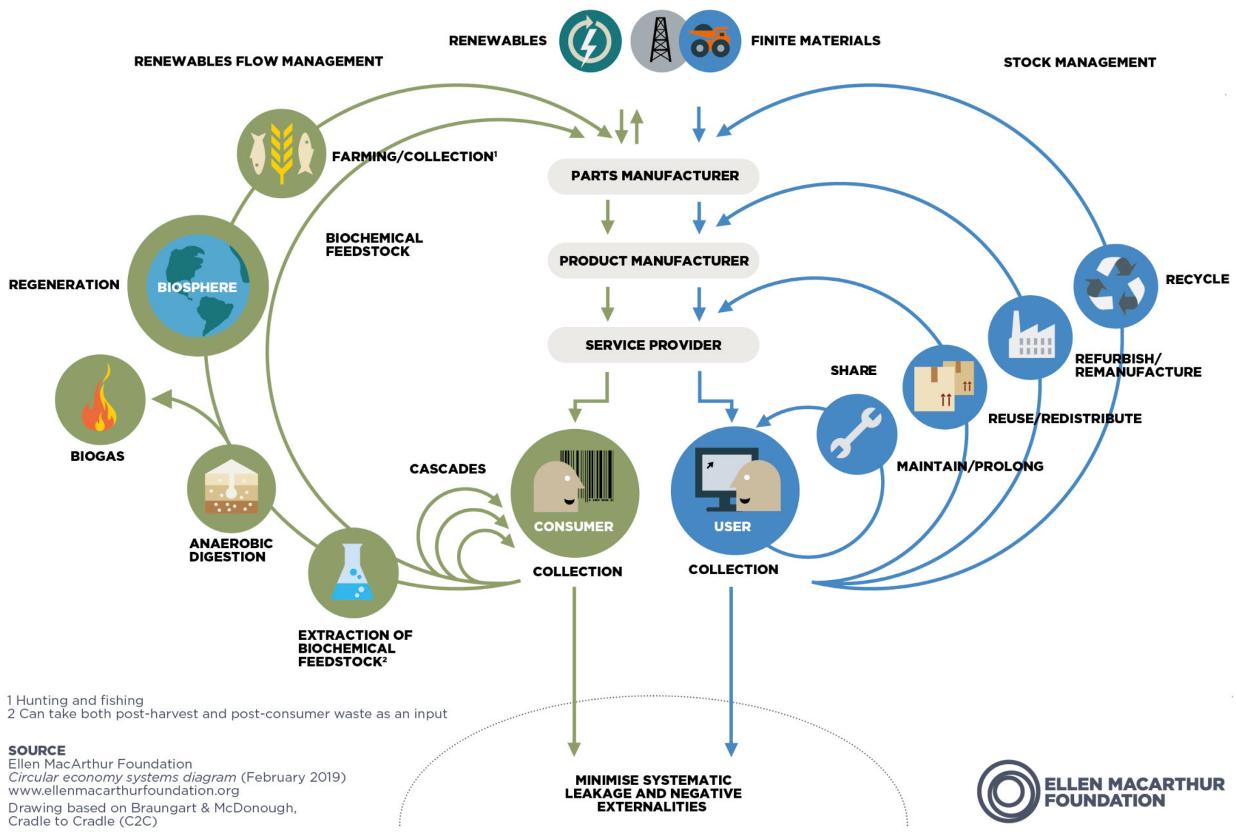

Figure 3: The Butterfly Diagram (Ellen MacArthur Foundation, 2013)

The technical cycle

a) Maintain and prolong
b) Reuse and redistribute
c) Refurbish and remanufacture
d) Recycle
e) Energy recovery
f) Landfill

(Ellen MacArthur Foundation, 2013)

The biological cycle

a) Regeneration: building natural capital and stopping resource depletion.
b) Farming: a way of sustainable agriculture, where resources and materials are in use for as long as possible.
c) Cascades: use biomass in as many different ways as possible.
d) Composing and anaerobic digestion: process by which organisms naturally convert organic waste into a nutrient-rich fertilizer.
e) Extraction of biochemical feedstock: converting a biological material into another form of fuel or energy product.

(Vrzel, 2022)

Every circular model focuses only on the technical side of circularity, which is where this model stands out. Using renewable biological raw materials in construction is also a good sustainable design solution. The biological cycle of the EMF model is therefore also important within architecture. (Circular Construction Economy Transition Team, 2022)

1.2.5 10R-Principal Cramer (2017)

In 2017, one of the most recent and comprehensive models describing the different levels of circularity was developed. The 10R model, which elaborating on the Ladder of Lansink, takes the earlier Three R principle and the Ellen MacArthur Foundation model as its basis. However, it excludes disposing of material on a landfill. The term waste is banished again.

The 10R-principal is based on more differentiated approaches than previous models:

a) Refuse: avoiding raw material use, in this model this level is separated from reduce.
b) Reduce: decrease raw material use.
c) Renew: redesign the product in the view of circularity.
d) Reuse
e) Repair: maintain and repair product.
f) Refurbish: revive the product.
g) Remanufacture: make a new product from second hand.
h) Repurpose: reuse product but with other function.
i) Recycle
j) Recover: incinerate waste with energy recovery.

(Cramer, 2017)

This model originally finds its basis in circular product design, so how exactly do we interpret it in construction? When applied in the construction environment, the emphasis is mainly on transformation and on adjustments to the design process, for example, incorporating some of the construction waste management into the design process. Not only the 10R model but all such models are the inspiration for new design strategies. (Bekkering, 2020) Consider, for example, demountable construction, flexible construction, building with biodegradable or renewable materials and material-driven design.

There is only minimal development yet on creating a design strategy completely focused on the top approaches of the model. If these models consist of so many steps and really need to ensure circularity in the end, should we accept the bottom R's of the model?

1.3 Analytical Framework

Many models share the common principles of reduce, reuse, and recycle, which can be collectively referred to as the Triple-R model. Upon critical examination, it becomes evident that not every approach of different models presents an entirely new vision. Even the most differentiated model, the 10R-principal, can be traced back to the basic ideas of reduce, reuse, and recycle. Therefore, it is necessary to reconsider the model and establish a clear distinction between the main principles and the examples of approaches that fall under them. For instance, refuse can be viewed as a part of the reduce principle, while renew, repair, refurbish, and repurpose can be seen as examples of reusing materials. Furthermore, remanufacture can be categorized as a way of recycling. Based on these reasons, our study focuses on these three main approaches: reduce, reuse, and recycle.

The other principles, which cannot be placed under reduce, reuse and recycle, i.e. energy recovery, incineration and landfill, are excluded in this analytical framework. The exclusion is based on the premise that these principles result in the complete loss of useful material value. The conversion of materials into energy, incineration, or disposal in landfills leads to a deterioration in material quality and often has negative environmental impacts. Furthermore, these approaches categorize materials as 'waste', making them unlikely to be considered as potential raw material for reuse. In a positive vision of circularity, where construction waste is seen as a solution, minimal to no reliance on these approaches is desirable. On the contrary, this study rejects the viability of the current models that promote these approaches as solutions in achieving a fully circular system.

Chapter 2 of this study will employ a case study approach, focusing on the Netherlands as the subject of analysis. The developments and progress in the realms of reducing, reusing, and recycling within the Dutch context will be examined. Through this investigation, the study aims to draw conclusions regarding the effectiveness and suitability of these three levels as a foundational framework for achieving a fully circular system.

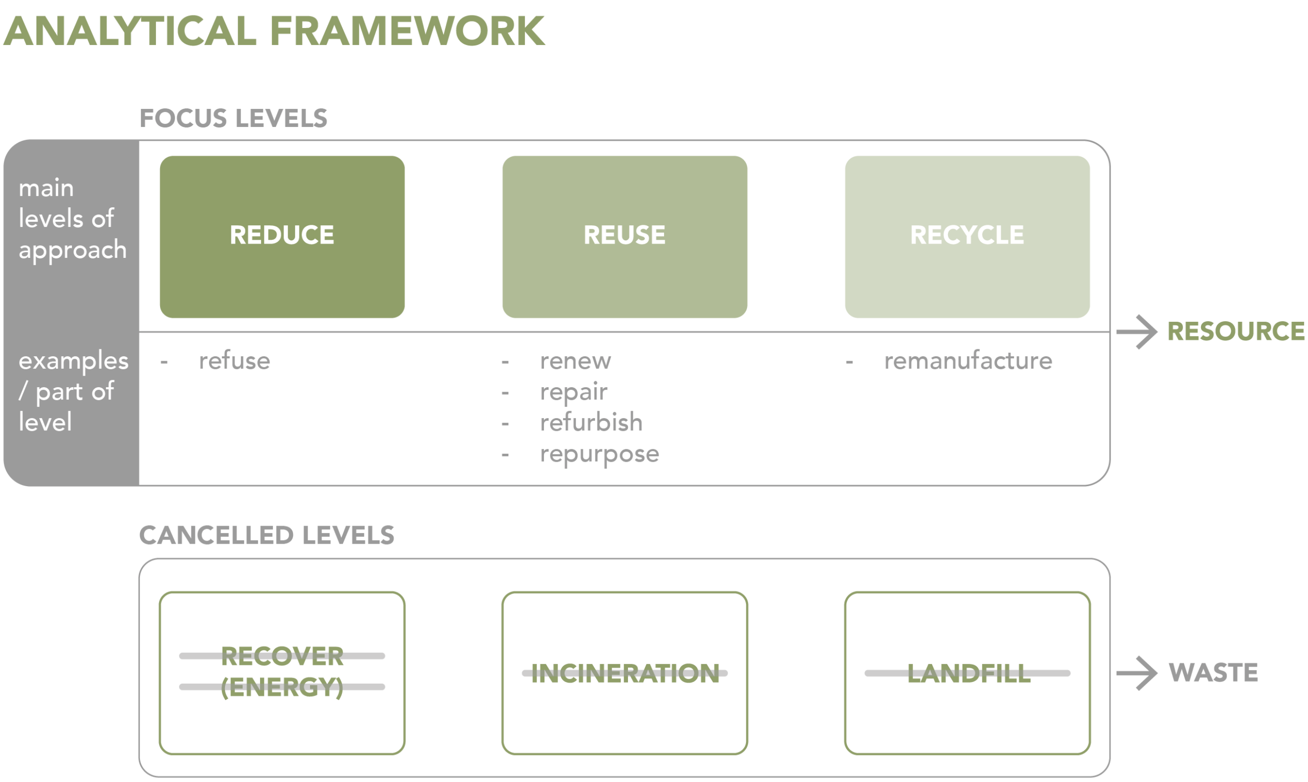

Figure 4: Model of analytical framework for this research

CHAPTER 2 / ACTUAL STATUS OF CONSTRUCTION WASTE IN THE NETHERLANDS

For this research, the Netherlands will be used as a case study. As the country has the ambitious goal to create a complete circular building industry by 2050, where waste should be completely eliminated. (Ministerie van Infrastructuur en Waterstaat, 2022) This means all left-over building materials, during the post-building phase will need to be given a new function in any sustainable way possible. The Ellen MacArthur Foundation, which is a global leader in promoting the circular economy, has recognized the Netherlands as a leader in the circular economy. The foundation has praised the country's initiatives such as the Circular Economy Program for Construction and the Material Passport as examples of best practices in circularity. What have been the developments to reach their goal? And what are the problems to reach their goal? Is it possible to completely eliminate waste out of the building process and use all surplus materials as new resources? Is waste actually really the problem, when it comes to reaching the goal of a circular economy? In this chapter developments and goals within the construction waste management in the Netherlands are explained.

The Netherlands is in transition to a circular economy in the field of construction materials. The country has an ambitious goal to have a completely circular economy by 2050, with the construction sector being one of the five priorities. (Ministerie van Infrastructuur en Waterstaat, 2022) This means that the Netherlands wants a (construction) waste-free economy in 2050. Every building material released during construction, renovation and demolition will have to be reused or recycled in some way. In addition, the focus is on using only renewable and sustainable raw materials.

The largest flow of waste in the Netherlands comes from the construction and demolition industry. It produced 41% of the total waste production in 2018. This involved 25.12 million tons of construction and demolition waste. 97% of these waste-materials have been returned to a useful application in the form of reuse, recycling, recovery and other operations on gaining a secondary purpose of the material or resource. (StoneCycling, 2021)

The framework of this study assumes that methods which align with the principles of reducing, reusing, and recycling materials and resources are considered conducive to a circular system. Hence, this chapter focuses on examining the methods employed in the Netherlands as a case study, to determine their potential contribution to a 'fair' portrayal of Dutch circularity. Specifically, the study seeks to investigate the veracity of the claim that 97% of Dutch construction waste is repurposed, and whether these numbers are measured on an equitable manner.

2.1 Reducing in The Netherlands

The generation of construction waste can be reduced by effective construction planning and incorporating strategies for reusing and recycling materials. One prominent example of such approaches is the Dutch platform, Madaster, which is dedicated to reducing construction waste through various initiatives and techniques. The platform allows for the creation of a 'material passport' for buildings, which is a digital record of all the materials used in a building, their quantities, and their locations within the building. By creating a comprehensive inventory of building materials, Madaster facilitates the identification of opportunities for material reuse, recycling, or repurposing, extending the lifespan of materials and reducing the need for new materials to be extracted and manufactured. Also, the system provides a platform for stakeholders involved in the construction and real estate sectors to collaborate and share information digitally. This reduces the reliance on paper-based documentation and promotes more efficient and transparent communication, which can help prevent errors, delays, and waste in the construction process. Besides that, Madaster collects data on building materials, which can be used for decision making during the design, construction, and maintenance phases of a building's lifecycle. This is a data-driven approach, which will help to optimize material use, reduce over-ordering, and minimize waste. They also raise awareness about the importance of reducing building waste and promotes education and training on sustainable construction practices. (Madaster, 2022)

Madaster is an example of a platform that recognizes the significance of proactively understanding how materials have to be managed in the future, even before they are incorporated into a design for the first time.

2.2 Reusing in The Netherlands

One of the recent developments within the reuse of materials in the construction world is 'oogstkaart.nl', developed by architectural firm Superuse Studios in Rotterdam Netherlands. The idea behind this platform is based on the term 'urban mining'. Urban mining is the recovery of valuable materials from waste generated in urban areas. The term 'mining' is used metaphorically to describe the process of extracting valuable raw materials from existing waste streams, just as traditional mining extracts minerals and metals from the earth's crust. The focus of this term is on raw materials previously used by humankind. Buildings could be seen as mines, if you look at every material hidden in a building as a potential alternative for new building activities. In addition to environmental benefits, urban mining can also be economically advantageous. Reusing and recovering valuable materials from waste streams can generate new sources of income and will reduce the costs associated with waste disposal. (Koutamanis, 2018)

The sources of residual streams that can be offered on the Oogstkaart-platform have different backgrounds as waste:

- End-of-life cycle: Due to wear and tear and obsolescence, it can no longer fulfil its current and original function.
- Construction and demolition: From buildings that have lost its function or become obsolete.
- Dead stock: Parts from productions that are no longer marketed and are therefore left over and are seen as new products.
- Production waste: From the production process but does not meet the requirements for the desired function because it has not reached the requested quality.
- Fast-life: High-quality materials that have only been used for a short time, e.g. short events such as exhibitions. They are used resources but with little wear and tear.

The platform is focused on the Netherlands, as it is desired to keep material flows as local as possible. Countries could therefore take an example from this initiative. The moment a plan is made to demolish or renovate an existing building, the possibility of 'harvesting' materials from this local source can be considered. When dismantling, the materials should be retained in a as high as possible quality and then offered as reusable materials on the platform. Local ongoing projects can monitor the platform and apply the available materials in a new sustainable way. (Kayleighlettow, 2022) Nowadays, a building should be built in advance with a view on harvesting the materials for use in the future. If the materials are easily disassembled, they can be 'harvested' in the future and offered on a platform like oogstkaart.nl for subsequent reuse in new building plans.

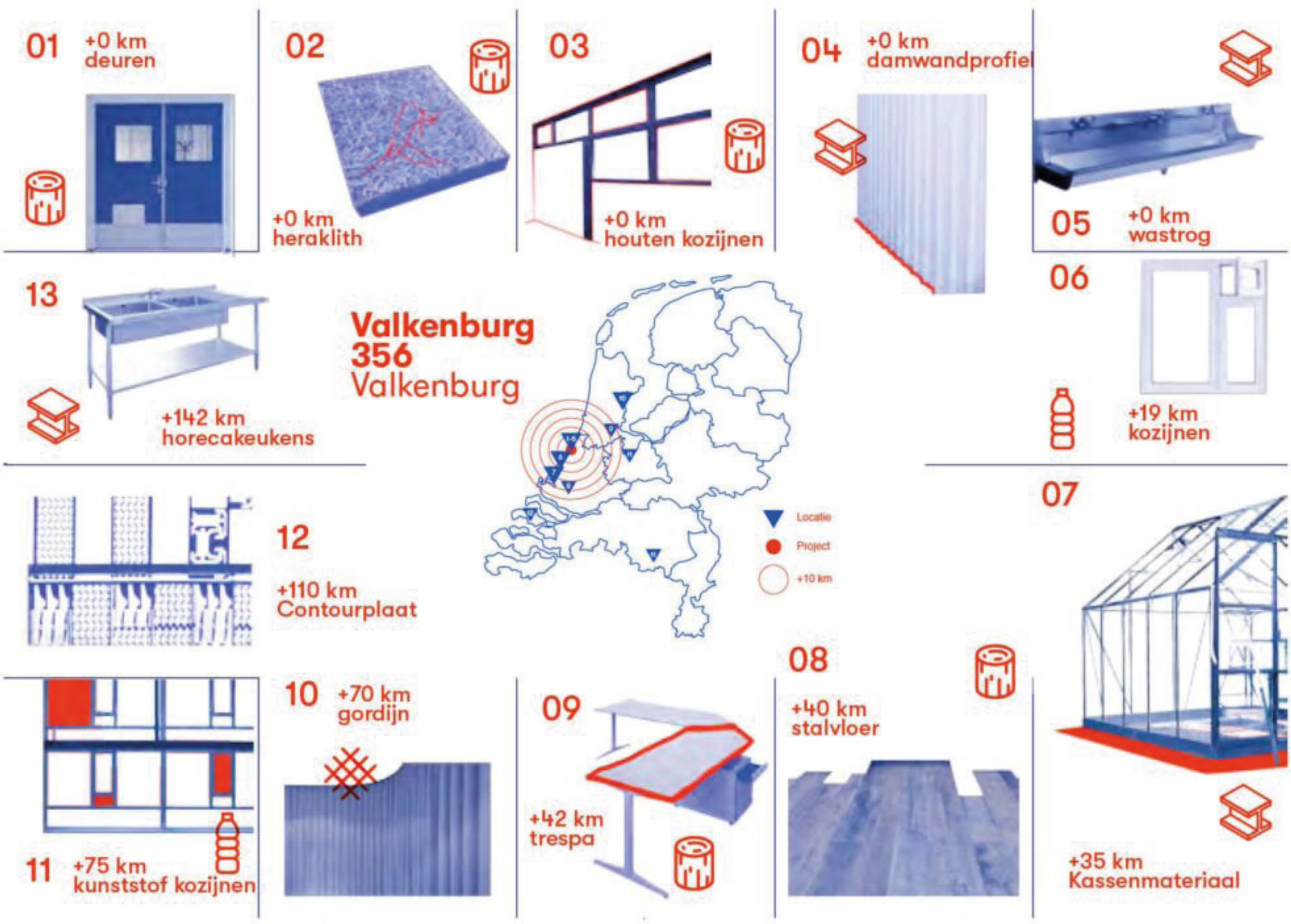

Figure 5: Example of an Oogstkaart, based on local materials in The Netherlands available on oogstkaart.nl (Superuse Studios, 2023)

2.3 Recycling in The Netherlands

According to the statistics The Netherlands has the highest recycling rate in Europe. Almost 30% of our total construction material usage is recycled. The percentage of recycling is due to multiple waste policy developments in the Netherlands, starting with the Ladder of Lansink. Also, the landfill tax and a landfill prohibition were introduced in the Netherlands, in the years 1995 and 1997. (Mulders, 2013) These two developments changed the way construction waste and its potential was handled. The problem had changed, due to the developments over time and discarding was no longer the solution.

Recycling as a solution is never high on the list of the approach-levels of the circular models in chapter 1. Nevertheless, this less appreciated method of circularity is clearly the most promoted. The Netherlands may be relatively far along in its development but reduce and reuse methods are still little expressed. Besides the fact that making the difference is using higher approaches towards construction waste and its management, according to the models, there is another problem. There is a huge lack of confidence in the quality of the recycled and reused construction materials. (European Commission, 2016) With recycling the goal is to achieve a higher or equal quality material, if not the term 'downcycling' is used. At this moment, most of the construction waste-materials are being downcycled. This is still a way of repurposing a material, but it is a form of 'greenwashing' when labeling it as 'recycling'.

The Netherlands has made significant progress in implementing sustainable initiatives, such as Madaster and oogstkaart.nl, which exemplify proactive approaches to addressing the future of materials beyond their initial use in buildings. These initiatives embody the concept of 'first-value purpose' by considering the optimal use of materials already before their primary lifespan, as well as the concept of the materials' 'second-value purpose'. The consideration of materials' potential for subsequent use beyond their initial purpose reflects a forward-thinking and visionary approach towards achieving a full circular economy, where materials are continuously looped back into the system to maximize their value and minimize waste.

Despite notable progress in sustainability initiatives, the Netherlands still faces challenges in achieving its ambitious goals for 2050. The claim that 97% of construction waste is repurposed may be seen as a form of greenwashing, as it often involves downcycling where the quality of materials is diminished. Additionally, energy recovery and incineration, which are included in this percentage, result in a loss of materials, which is undesirable within the context of a circular economy. This study argues that a paradigm shift in perception is needed to redefine what constitutes a 'fair' circular system. It highlights the importance of transparently reporting accurate figures regarding the management of residual waste in the construction sector to ensure an honest assessment of progress towards sustainability goals.

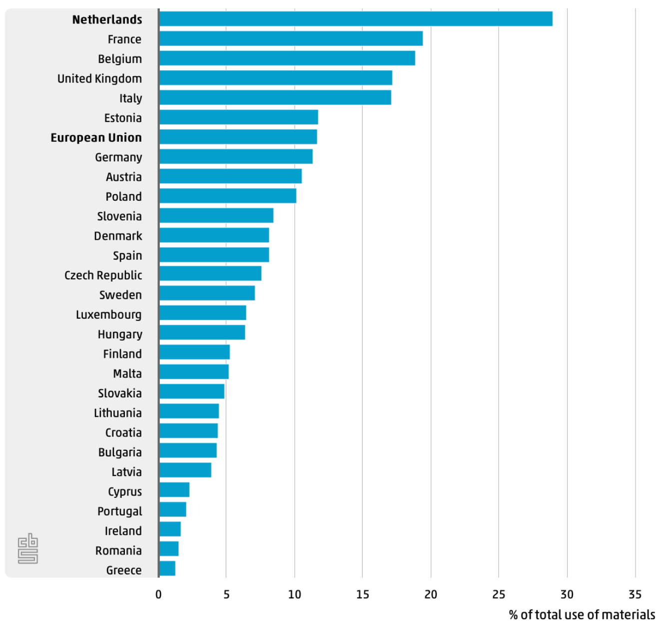

Figure 6: Recycling rates (construction sector) in the EU (CBS, Eurostat, 2016)

CHAPTER 3 / A CHANGE OF PERCEPTION: THE FUTURE IS GENUINE CIRCULARITY OF CONSTRUCTION RESIDUES

Currently, what to do with residual materials is usually not considered until the post-building phase. This is problematic for achieving a circular economy. The research in chapters 1 and 2 show that at the start of any building plan, one should already be thinking about the moment the building has reached the end of its life phase. Prior to the pre-building phase, choices must already be made, or awareness created about how the building materials that are used, after reaching the post-building phase, can be used in the following life. This is already relevant from the moment raw materials have to be harvested for use and application. To achieve genuine circularity, the product should already be seen as future construction material from the very start.

The present infrastructure of the built environment has a strongly conservative character, which is at the expense of innovation in the broadest sense of the word. This applies not only to the development of new materials based on recycling but also to the lack of knowledge and vision on urban planning, the way buildings are built and how they can be transformed. The existing consensus is to build and demolish after the active and/or economic life or, at best, reuse after intensive renovation. Little transparent claims regarding sustainability and circularity are a (significant) part of the marketing strategy of companies, small and large. This so called 'greenwashing', the phenomenon that companies, organizations and even governments pretend to be greener or more socially responsible than is actually the case, is common practice.

The reason this is possible in the current era is because there is little to no clear independently validated reporting. For example, all uses of residual streams outside landfill, which is still allowed in principle by exception, are classified as recycling. A good example is the confusing term 'thermal recycling', an euphemism for incineration as heat is not recyclable. With both energy recovery as incineration, the materials, which can be repurposed, get lost. It is not fair to include this in the idea of a full circular system. Therefore, it is excluded from the framework formed in this study.

The perception regarding circularity and, from that perspective, recycling is that it is a predominantly interpretation and not validated circularity. Basically, circularity is still completely at the beginning of development.

It is important to distinguish two basic levels, artifacts based on new raw materials; 'first-value purpose' artifacts and artifacts made from materials derived from already used artifacts; 'second-value purpose' artifacts. If it is seldom possible to apply a first-value purpose artefact in a circular manner, this artefact should, in whole or in part, be converted as raw material for a second-value artefact, whereby the sustainability impact should be accurately determined through life-cycle analysis validation.

A brick manufactured from clay is an example is a first-value purpose artefact. After use, due to damage and/or mixing with, for example, masonry mortar, it can very rarely be reused as a brick. Usually, the brick is pulverized and then applied as a foundation material for road construction (Trade Association BRBS Recycling; Information sheet - Application possibilities for recycling granulates, 2016) instead of being used again as grit as a basic raw material for a second-value purpose artefact, from circularity perspective preferably a building element. Here, it is essential that the overall impact of the realization of a second-value purpose artefact is lower than the realization of a comparable first-value purpose artefact.

Based on a validated data-driven vision, a moral appeal should be made to 'the architect' to design the built environment on the principle of 'Design for reduce, reuse and recycle', as the framework shows, leading to the necessity to create highly modular building concepts.
Architects need to be aware of their crucial position in respect of environmental consequences as they are responsible for important, necessary and in its manifestation enormous artifacts; complex compositions of many and various larger and smaller artifacts with a severe energy and material consuming impact.

Ensuring minimal waste will be the challenge of the future and that future starts now.

CONCLUSION

In conclusion, this study examined the issue of construction waste and whether the perceptions associated with the term are related to the actual reality or are the result of a severe bias. The research was focused on the question:

Are waste materials in the built environment a problem (pollution) or a solution (resource)?

The present inquiry aims to address the issue of current perceptions and the necessary adjustments that must be made to achieve the optimal outcome. The investigation aims to determine the factors contributing to the heightened attention given to the issue of construction waste, which has been observed through a Google Ngram scan and subsequent review of relevant literature. The topic was historically overlooked, however, with recent progress in the areas of circularity and other important advancements, the discourse has shifted, leading to an increased discussion on the issue. The study employs a combination of data analysis, literature review and a case study analysis to answer the research question and support the underlying vision.

This study aims to investigate the current perception of construction waste by comparing and juxtaposing existing models that take into account the life cycle of (construction) materials. The models, based on the principles of circularity, are divided into three approaches, namely reduce, reuse and recycle. Based on the analysis of the models, a framework was developed that focuses on these three fundamental principles, as they encompass the same mentalities covered by this foundation. However, the framework excludes energy recovery, incineration and landfill, as the material is completely lost in these forms of processing, thus excluding its potential as a 'new' raw material. In fact, the quality of the material deteriorates, immediately labelling it as 'a form of waste'. The current perception of construction waste needs to overcome this interpretation in order to develop a 'fair' circular system.

The developed framework has been reflected on the Netherlands as a case study, as their ambitious goals for achieving a nearly fully circular economy by 2050 create a perception of construction waste as a potential resource rather than a problem. The Netherlands has taken significant steps towards achieving a circular economy through initiatives such as Madaster and oogstkaart.nl, which prioritize the optimal use of materials beyond their initial purpose. However, challenges remain in achieving the country's sustainability goals for 2050.

The current discourse on recycling in the construction industry mainly focuses on downcycling, where waste materials are converted into products of lower value and quality. Despite its perceived positive associations and low costs, downcycling leads to a reduction in the quality of materials and reinforces the idea of accepting sub-optimal solutions. In contrast, to truly achieve a circular economy, it is crucial to adopt a broader perspective that considers all materials as valuable resources, with solutions that emphasize reuse and true recycling. It is s only a solution when it can be reused and genuine recycled.

It is imperative to adopt a forward-thinking approach in the construction industry, where considerations extend beyond the primary lifespan of materials. As such, materials ought to be utilized in ways that maximize their value and promote circularity, beyond their initial intended purpose.

This study calls for a shift in perception to redefine what constitutes a truly circular system and stresses the importance of transparent reporting to accurately track progress towards sustainability goals.

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