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To Reuse in Landscape Architecture

Taale Kjøs
Landscape Architecture

Mineral Sources. Granite blocks i a garden just outside Oslo. This garden is now turned into a construction site. The granite is reclaimed and will be reused in-situ. Ph: Taale Kjøs

TO REUSE IN LANDSCAPE ARCHITECTURE

A Study on Environmental Impacts Caused by Construction of The Built Environment and How Realizing Reuse in Constructional Landscape Projects Can Mittigate the Effects Based on Circular Principals.

Master Thesis 2022 - Taale Kjøs - NMBU

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Introduction

The industrious human nature and advanced techniques for survival, have made homo sapience the most successful species in the blue planets' 4,5 billion-year-old history. Since industrialization, human societies have accelerated their impact on earth's surfaces, and have over the last seven decades expanded their sphere of influence into the crust and oceans and out beyond the atmosphere. These achievements have entitled humankind its geological epoch – the Anthropocene. In 2022, we are working out how to execute our role as a geological agents. Being in command of a biosphere is a complicated and demanding task. Humankind knows what it is that needs to be fixed and has a pretty good idea of how to fix it. The environmental crisis is a complex problem that influences the world society on all levels, in all regions. The problem cannot be solved by one sector alone but as a joint effort from all, working together to overcome the biggest threat we have ever faced.

Plan your dive, and dive your plan! This project is about understanding better how landscape architects can contribute even more to the cause. Landscape designers are already mimicking ecological systems, and the way to rebalance the biosphere is to work with nature, not against it. To reuse in landscape architecture is one of many ways to increase the profession's contribution. Especially within the construction sector, there is huge potential for reusing instead of adding virgin components. Further, there is a lack of executing leaders in the transformation, which can be viewed as an opportunity to cease. This project aims to theoretically explain the complexity of our problems, the opportunities in the solution, and a way to do the changes we all want and need to see. After all, reuse is a verb.

Methods

To define the scope of this thesis, I wanted first to establish a bottom-line reason for the need to change to a circular approach in general. Since I am not educated in the field of environmental science, I chose to follow the UN's work on the global situation. This means that I have used secondary sources when establishing the macro-scope of the thesis.

In part two I have varied between primary and secondary sources to narrow get a better understanding of the varieties that is in circular theory. Further, I have turned the focus towards my region, Europe and Scandinavia, to be able to utilize my own experiences as a reuse agent.

In the final part, I have based most of my work on the experiences I have had over the last year, working with Resirqel, a reuse broker and consulting company in Oslo. This makes this part less academic than the two first parts, but I have tried to link the experiences to examples and cases. When that has not been sufficient, I have turned to literature to verify or disqualify my understanding. At the end of part two, there is a section with many open questions. This is partly because of time and capacity on my part, but I believe that it still should be included given the importance it has in creating a solid market for reused materials.

Definitions

Landscapers in construction industries

The definition of the construction industry follows the OECD's definition as – 'economic activity directed to the creation, renovation, repair or extension of fixed assets in the form of buildings, land improvements of an engineering nature' (OECD, 2001). Landscape Architecture is about much more than construction and the built environment. If we look at the International Federation of Landscape Architects' definition, landscape architecture is to 'plan, design, and manage natural and built environments, [..] By leading and coordinating other disciplines, landscape architects deal with the interaction between natural and cultural ecosystems' (IFLA, 2020a). It is also worthy to note that some literature refers to the construction and buildings sector, which is a combination of the construction of the built environment and the operation of buildings within their life cycle. So, when we work with constructions in a project we are at least a part of it, and I will therefore use that definition in this project.

Socio-Economic Metabolism

Sometimes referred to as social or industrial metabolism, is a concept for describing and understanding the input (of resources) and the output (of wastes). It is a holistic approach to the biophysical patterns and dynamics of socio-economic material and energy flows (Pauliuk & Hertwich, 2015)

Decoupling

Decoupling is often mentioned when discussing how economic prosperity and sustainable development. The idea is that if both economic and environmental prosperity is to be possible, the economy must decouple from resource use and waste emission (both solid and volatile). Absolute decoupling is when material use declines as GDP grows, while relative decoupling signals that the material productivity of an economy is improving, but not necessarily that material use is declining in absolute terms (Krausmann et al., 2017).

Resilience

Linguistically, it means to recover quickly

from, or deal readily with, negative impacts of a human, or return quickly to its original shape or position if an object is described as resilient (chambers Dictionary, 2022b). Originally, the concept stems from natural science but has over the last decade been adapted by many disciplines, including urban planning and architecture.

Embodied Energy (EE)

EE is the total energy required for extraction, processing, manufacturing, and delivery of building materials, and only the front-end aspect of the impact. It does not include the operation or disposal of materials (European Commission, No date). EE is measured in gigajoule per tonne.

Life-Cycle Assessment – LCA

Environmental life-cycle assessment (sometimes analysis) is a method of evaluating the environmental impact of a product. It has been around since the 1960s and started as a comparative method between products. Over the decades it has become a tool for evaluating the full life cycle of products, from 'cradle to grave'. Today LCA exists in many varieties, but in the context of material reuse it is defined as the 'compilation of and evaluation of the inputs and outputs and the potential environmental impacts of a product system throughout its life-cycle (Guinée et al., 2011)

Deconstruction

Selective disassembly of a building our a part of a building at the end of its lifecycle to recover materials or components for reuse or recycling for later economic gain (Gorgolewski, 2018).

Design for Disassembly/Deconstruction (DfD)

Designing constructions like buildings for easier disassembly at the end of the lifecycle of the building or project (Gorgolewski, 2018)

Reclaim

Reclaiming in circular construction is to withdraw a component or material from the waste stream.

The Anthropocene

The term Anthropocene (translated to the age of humans) has been used as a cultural description of our time since the year 2000 when Paul Crutzen first publicly mentioned it at a Conference in Mexico together with Eugen Stermer. Later that year, Crutzen published an article on the subject (Crutzen, 2010). The term raised some academic controversies, with the debate going in if it was only a cultural term, or if it actually could be defined as a geological epoch. Anyway, the Anthropocene has been widely used and in 2009 the Working Group On the 'Anthropocene' (AWG) was established to examine the question formally. In 2017 the AWG concluded 'that the Anthropocene represents a distinct change of geological processes, that are reflected in stratal characteristics' and a clear majority of the group voted for starting a formal process to constitute a new unit of geological time as a part of Holocene"(Zalasiewicz et al., 2017). The AWG stated the mid-20th century as the starting point for the Anthropogenic area.

Urbanization in the Anthropocene

The world is becoming increasingly urbanized. While 30% of the world's population resided in urban areas in 1955, the share has risen to 55% in 2018 according to the United Nations Populations Division (United Nations, 2018a). The same division's 2018 revision - World Urbanization Prospects – predicts a further growth estimating that by 2030 60% of the world population will live in urban settlements. While there in the year 2000 were 371 cities with 1 million inhabitants or more, the number had raised to 548 cities in 2018, and in 2030 the estimation by the UN says 706 cities will have 1 million inhabitants or more (United Nations, 2018b). Further, the Population division projects that the world population could grow to around 8,5 billion by 2030, 9,7 billion by 2050, and 10,9 billion by the year 2100 (United Nations et al., 2019). The conversion of land surface to urban uses is estimated to increase by 1 527 000 km2 from the year 2000 till 2030 (Seto et al., 2011).

Resilience: Three Fraxinus Exelsior's and a Taraxacum Officinale adapts and adjusts to a life between concrete and asphalt. Photo: Taale Kjøs, 2022

PART ONE: THE GLOBAL INVENTORY

'However, it seems likely that, as humans continue to operate collectively as a major geological agent, with modulation, and in some cases amplification, by feedback effects – such as that of albedo changes in polar regions – human impacts will become increasingly significant.

From AWG's Summary of Evidence and Interim Recommendations.

(Zalasiewicz et al., 2017)

Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions are by all scientific evidence causing global warming and unbalancing our biosphere. GHG emits from a variety of sources, both natural and human-made, but it is the human's urge for energy that is the main driver behind the unprecedented influx of GHGs in the atmosphere (Masson-Delmotte et al., 2021). In August 2021, the Intergovernmental Panel on Climate Change released their Sixth Assessment Report (AR6): The Physical Science Basis. AR6 reiterated that human influence has warmed the atmosphere, ocean, and land, the changes we see are unprecedented, and the effects of climate change are felt in all regions of the world. If a deep reduction of carbon dioxide and other GHG emissions does not happen, global warming of between 1,5°C and 2°C, the goal agreed on in the Paris Agreement (United Nations, 2015) will be exceeded. With current temperature trajectories, we are heading to a 3.2°C warming with severe consequenc-es(IPCC, 2021). The 2021 conference in Glasgow (COP26) resulted in the Glasgow Climate Pact, an agreement to extend the national and international commitment to mitigating negative climate effects (UNFCCC, 2021)

The construction and buildings sector's share

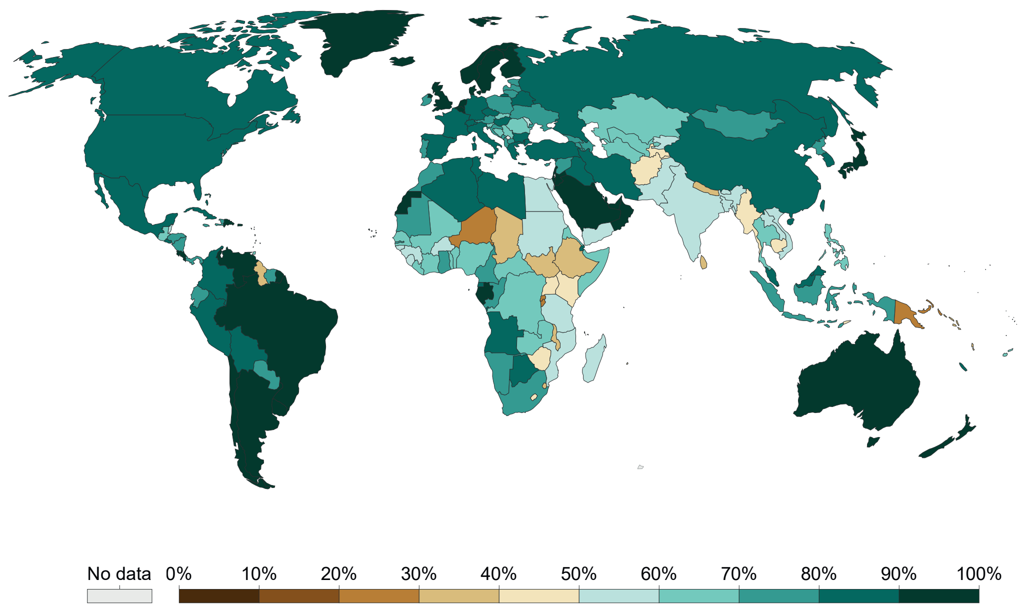


Figure 1. Source: OWID based on UN World Urbanization Prospects 2018, published online at OurWorldInData.org. Retrived from; https://ourworldindata.org/urbanization#what-share-of-people-will-live-in-urban-areas-in-the-future. Accessdate 15.05.2022

of the global energy-related GHG emissions in 2015, the year of the Paris agreement, was 38,% and one of the biggest emitters of GHG. In 2020 the sector's emissions had dropped by 10%, but the impact of the COVID-19 pandemic may have influenced the decrease. To achieve the goals set in Paris, the global construction and buildings sector must be as good as decarbonized by 2050. Among energy optimization, the building industry will also have to address embodied carbon stored in building materials. At the construction end, emissions from materials and construction processes must be addressed so that buildings that are built today are optimized for low-carbon solutions of the entire life cycle, and rethink every design idea in a whole life-cycle way, to minimize carbon impacts (United Nations Environment Programme, 2021).

Resources

Natural resources are divided into five groups; metals, non-metallic minerals, fossil fuels, biomass, water, and land. (United Nations Resource Panel, 2019). It is also a distinction between resources and reserves, where resources include the total amount of a material that the earth contains and reserves are the amount that we know how to extract.

The building blocks of our society and the backbone of our economy are natural resources. Natural resource depletion for input factors in production, combined with land conversion puts pressure on our economy, and development, and poses great risks to our environment. Since 1970, the use of natural resources has tripled and is continuing to grow. Without clear and urgent action against the inefficient use of natural resources, the pressure on the environment and the ecosystem health will increase exponentially (United Nations Resource Panel, 2019). OECD estimates that global materials demand will more than double from 2011 – to 2060, from 79 gigatons to 167 GT. More than 50% of the total material use comes from non-metallic minerals such as sand, gravel, and rock types. Management and activities related to materials are connected with 50% of GHG emissions (OECD, 2019).

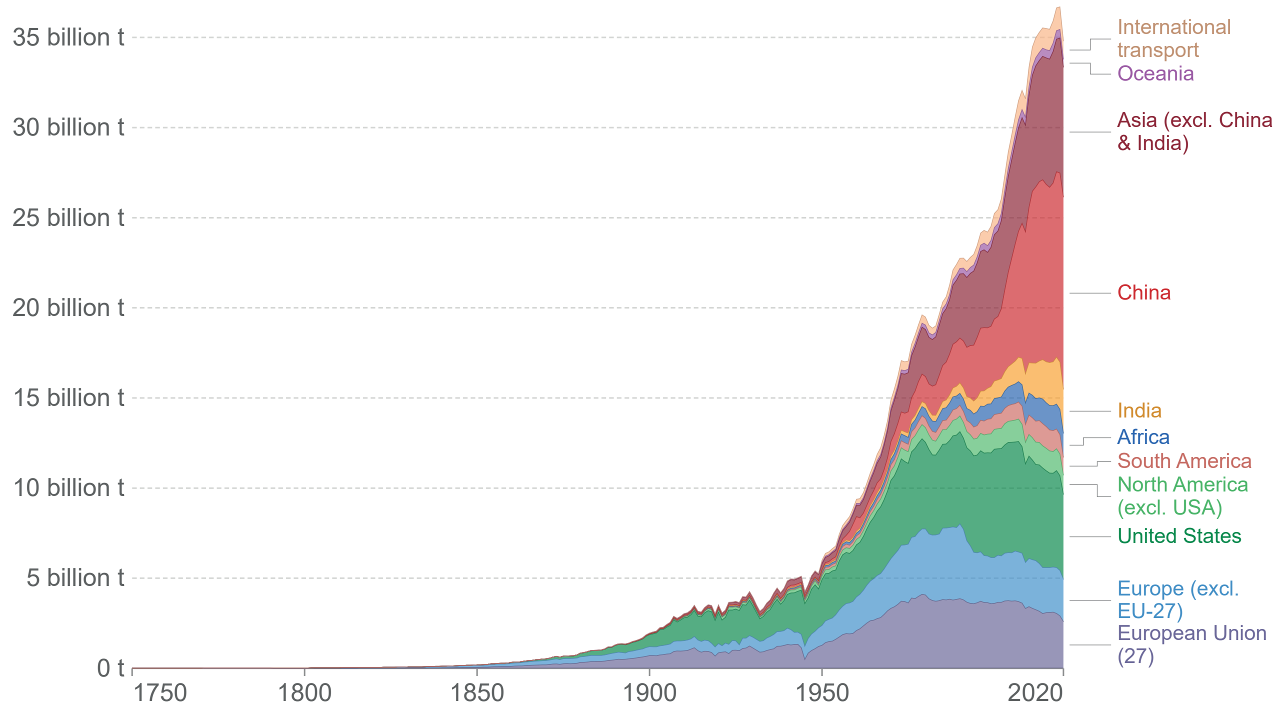


Figure 2. Source: Global Carbon Project 2021. Retrieved from: https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions, Creative Common License: http://creativecommons.org/licenses/by/4.0/deed.en_US Date accessed: 15.05.2022

Already today, pressure on raw materials is high, and if the predicted demand for raw materials follows OECD's projections, it is needless to say that the pressure will increase and that we are in danger of running out of essential materials.

The EU has recognized access to resources as a strategic security question to fulfill its ambition to become climate neutral by 2050 and launched the Raw Material Initiative (RMI) to establish a list of critical raw materials (CRM), and to secure non-energy raw materials for EU industrial value chain. CRMs are classified as of high economic importance and high supply risk. The 2020 assessment identified 30 CRMs (European Commission, 2020). The list contains crucial raw minerals in many parts of the industrial value chain for producing components for other production sectors like renewable energy, electric vehicles, digital, space and defense components.

The construction sector consumes a large part of the global natural resources annually, even though it dropped from 40% in 1990 to 32% in 2013 (Benachio et al., 2020). The construction industry consumes resources from all five groups, especially metallic and non-metallic resources.

Metallic resources

Metals are one of the societies developing backbones, from the construction of large-scale infrastructure and production lines to personal commodities like cars, computers, and tools. From 1980 until 2008, the global metal demand increased by 87% up to more than six billion tonnes annually (United Nations Environment Programme, 2013). The annual

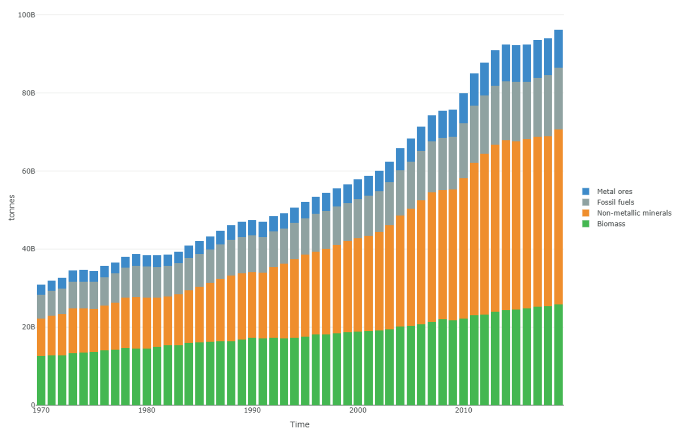


Figure 3. Source: UN IRP Global Material Flows Database; WU Vienna (2022): Material flows by material group, 1970-2019, Retrieved from: http://www.materialflows.net/visualisation-centre/ Available at: http://visualisations.materialflows.net:81/?#shiny-tab-bar_chart_1 Accessed: 15.05.2022

global demand for steel is almost 1,4 billion tonnes, and the construction industry accounts for approximately 50% (Cullen et al., 2012) If the developing economies are going to acquire the same suite of technology and lifestyle as developed economies, the global in-use of metal would be 3-9 times higher than today (Krausmann et al., 2009). Metal production uses energy at all levels, but there are differences in requirements depending on the end product produced. From mining minerals to extraction and refining, and fabrication. Mining metals impact land, water, air, and biodiversity (United Nations Environment Programme, 2013).

Non-metallic Resources

Non-metallic resources are in general different kinds of aggregated non-biotic natural minerals. A key component in building our society is sand and gravel which is used in a wide range of sectors – glass production, electronics, construction, and land reclamation(United Nations Environment Programme, 2014). Concrete for example is made out of about 30% sand. Sand as a resource has the largest volume of solid material extracted worldwide. UNEP point to a conservative estimate of 40 billion tons a year (United Nations Environment Programme, 2014). Following the increase in resource use over the last decades, lack of regulations, and awareness, we are also heading for a sand crisis if we don't do something. Extracting sand has serious consequences for biodiversity, land losses, landscapes, climate, and infrastructure.

Sand and gravel

Of the estimated 47-59 million tons of materials mined every year (Steinberger et al., 2010), aggregated minerals like sand and gravel have the largest share between 68% and 85%, and the fastest extraction increase (Krausmann et al., 2009).

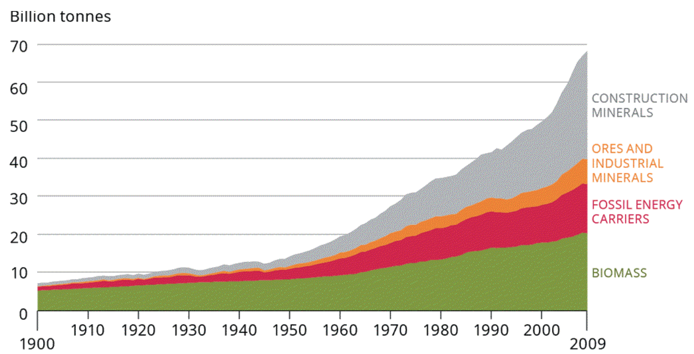


Figure 4. Data Source: Global Total Use by Resource Type, Krausmann et.al.(2019), Retrived at: https://www.eea.europa.eu/soer/2015/global/competition Creative Common License: http://creativecommons.org/licenses/by/2.5/dk/deed.en_GB Accessed: 16.05.2022

Aggregated minerals are used in a wide range of production, like buildings and roads, natural gas fracking, silicone chips, and cosmetics (Da & Le Billon, 2022). In addition, the largest amount of aggregated minerals is used in land reclamation, shoreline developments, and road embankments. UNEP did a calculation on the use of aggregated minerals in 2014 and made a conservative estimate of 40 billion tons consumed annually (United Nations Environment Programme, 2014). In 2020, global trade with sand alone was at 1.86 billion US dollars (Observatory of Economic Complexity, 2020). The natural sedimentation of sand through weathering of rocks and mountains releases approximately one billion grains per second, and human activity still uses 3- 7 times more than that (Hackney et al., 2020).

Sand is mined in various ways, by hand or by extensive industrial mining, and can be found in dunes, broken down from rocks, bottoms of lakes, rivers, and shorelines. The different sources for extraction influence the quality of the sand, and the labor that has to be put into making it suitable for further production. In-stream mining from riverbeds is regarded as the best and cheapest way to mine aggregates for concrete production, requiring little processing for a high-quality end product, while marine aggregates require thoroughly washing to remove salt to avoid corrosion of metal structures. Wind eroded dessert aggregates are too round to be used in both concrete and land reclaiming (United Nations Environment Programme, 2014).

Sand extraction comes at a price both socially and environmentally. Habitat destruction, loss of biodiversity, pollution from dust and chemicals, degradation of water quality, flooding, increased salination, erosion, and destabilization of coastal areas are some of the impacts found in a new review on the effects of unregulated sand mining (Da & Le Billon, 2022). So, even on a resource as common and seemingly abundant as sand and gravel, human activity tends to go beyond the global resource boundary.

Concrete

Concrete is not a natural resource, but an artificial stone made of aggregates like sand and gravel, mixed with water and cement. The cement is the glue that binds the aggregates together, and today Portland cement is the most common binder. Portland cement is made of a mixture of limestone and clay that gets heated up to 1 400° C. Admixtures are additives that can be used to accelerate curing in cold environments (Britannica, 2021).

Concrete's high compressive strength, ability to, when poured, take any shape and inflammability have made it the most commonly used building material in the world. Annually, 4 billion tonnes of cement are produced globally accounting for approximately 8% of GHGs (Chatham House Report, 2018). Depending on the type of concrete being produced, cement makes up about ten percent of the concrete, water 20%, and 70% aggregates (The Portland Cement Association, 2019). So, to produce concrete of 4 billion tonnes of cement would require 8 billion liters of water, and 28 billion tonnes of aggregate, giving us 40 billion tonnes of produce every year. |Concrete's impact on GHG emissions largely stems from processing cement and transportation. In addition, it is a large consumer of aggregated sand and is hard to recycle.

Waste

Waste is a broad concept, but in this project, it is solid waste that is unwanted or discarded. In this definition, I follow UNEP's line as noted in the Chambers 21st Century Dictionary – "rejected as useless, unneeded or excess to requirements" (Chambers Dictionary, 2022a).

Annually, the world's Anthropogenic waste generation is 2.01 million tons. Out of this at least 33% is not managed properly, and since uncontrolled waste does not get measured the number can be a lot higher (United Nations Environment Programme, 2016). If the world keeps on generating waste at the same rate as today, waste generation will increase by approximately 75% to 3.4 million tons of waste (Kaza et al., 2018). Waste as a byproduct of human activity is a global issue and affects both public health and the environment. If not properly managed, waste pollutes both the surface and groundwater, landfills emit methane gas (GHG), and waste to energy incinerators releases carbon dioxide and other GHGs. The ICPP estimates that solid waste management accounted for around 3% of global GHG emissions in 2010, its short-term potential for mitigation of GHGs can be around 15- 20% with a maximum effort by better management. The construction industry produces 40% of the global solid waste on average (United Nations Environment Programme, 2016).

Reflections on the inventory

To sum my reflections up in an image, we are burning the candle on multiple ends, and the combined heat makes the candle wax melt faster. Further, much of the literature and science I

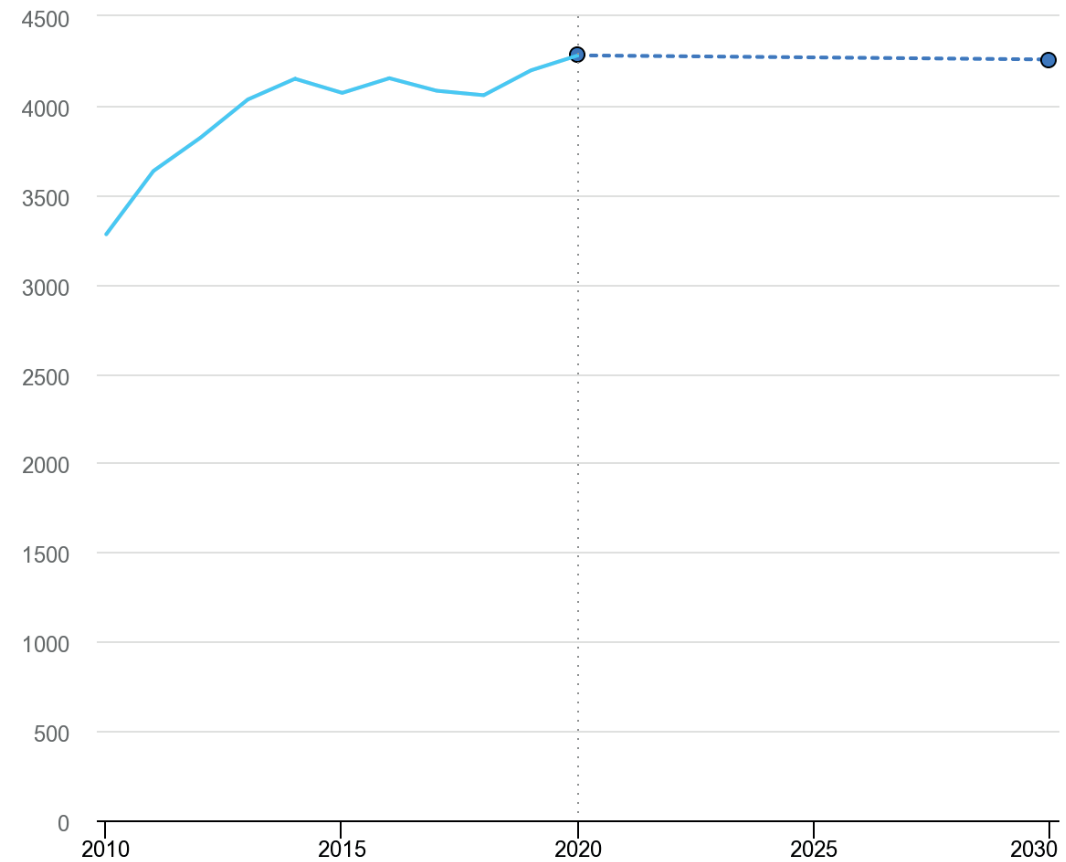


Figure 5. Global Cement Production in mega tonn. NZE projection after 2020. Source: IEA, Global cement production in the Net Zero Scenario, 2010-2030, IEA, Paris Retrieved from: https://www.iea.org/data-and-statistics/charts/global-cement-production-in-the-net-zero-scenario-2010-2030 Accessed: 15.05.2022

have used in this part has been written 5-6 years ago and urges for acceleration in changing our environmental behavior. 2030 has been by major institutions pointed at as the moment we need to see proper improvements to avoid critical effects. As the AR6 just recently stated, we are still going in the wrong direction at a fast pace. Like deadline day for master's students, it seems to come way too fast for the world to get the ship turned around.

As we slowly, yet gradually accept and internalize the fact that our world is a single globe, with a large, yet limited, reserves of resources,

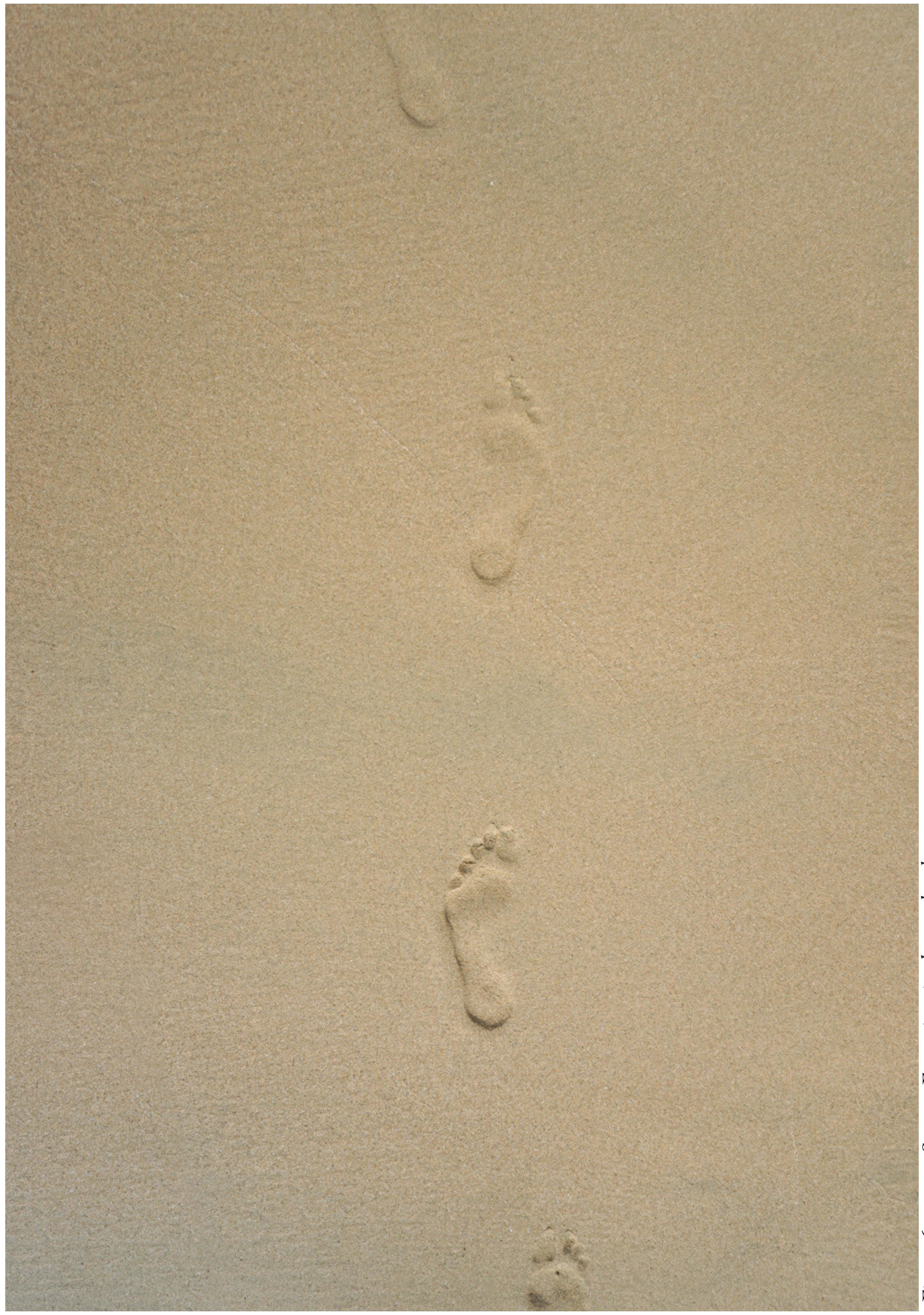


Figure 6. Source: Footprints in the sand.psd

PART TWO
REORGANIZING

‘The closed economy of the future might similarly be called the “spaceman” economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for the extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy.’

Kenneth E. Boulding on the need to adjust our economic system to avoid running out of resources in 1966 (Boulding, 1966)

and that humans act as key agents in changing the composition of the biosphere, new conceptualizations of sustainable developments have been developing for almost as long as the challenges of the environment has been on the agenda. The concept of a closed-loop system has been around since the nineteen-sixties when the English-American Kenneth E. Boulding argued for a more cyclic view of resources in business and industry (Boulding, 1966). West Germany and Japan used closed-looped economics already in the 1980' (Williams, 2021) and CE has in the decades since become the closest we have gotten to a consensual economic strategy to become more sustainable. Almost all sectors of society, so also the construction sector, has utilized some sort of circular approach to realize their share of the Paris agreement. CE theory is today an established alternative to the traditional linear economy and is embraced by many sectors' business models. But actions are not always where the mouth is, and even with all the capabilities, resources, and knowledge we got in 2022, the transition is going slow.

Definitions of Circular Economy

The key principle of CE is to move away from the ‘take, make, waste’ practices of the linear economy and start looping resources in a cyclic system of 'cradle to cradle' design. The design of CE is mimicking the balanced input (resources) and output (waste) alimentary cycle. As mimicking is an interpretation of someone or something else, CE has materialized in different variations. This has created some confusion and even some concerns about the credibility of CE as a solid framework. So when looking for definitions, three definitions have made it to this project. The reason for bringing three definitions in is because of their different fields of function. The Ellen MacArthur Foundations' definition is widely internalized. The two others are based on scientific methods where one is CE in general while the other is specifically for the construction industry.

Let us start with the one that has been broadest internalized. The Ellen MacArthur Foundation (EMF), a charity organization that seeks to inform about -and accelerate the transition to – the circular economy defines the circular economy as three principles – eliminate waste and pollution, circulate products at their highest quality and regenerate nature (Ellen MacArthur Foundation, 2022).

The EU claims to follow EMF's line of understanding and defines it as 'an economic model based inter alia [sic: among other things] on sharing, leasing, reuse, repair, refurbishment, and recycling, in an (almost) closed-loop, which aims to retain the highest utility of products, components, and materials at all time (European Union, 2016).

Turning to scientific intersectoral definition leads to Kirchherr and his partner. Their approach is a qualitative research based on the

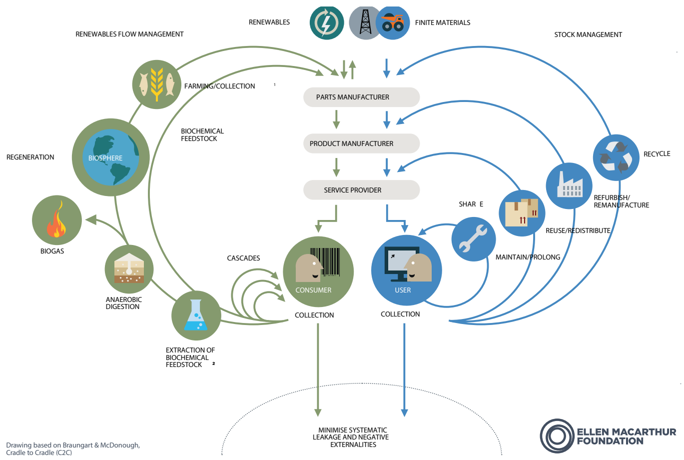


Figure 7. Source: Ellen Macarthur Foundation , Circular Economy Systems Diagram (2019), Retrieved from: https://ellenmacarthurfoundation.org/circular-economy-diagram, CCL: http://creativecommons.org/licenses/by-nc/4.0/ Accessed: 15.05.2022

literature on 114 definitions of CE in 2017. It concluded that there is no coherent definition of CE. The definition varied depending on the intended use, whether it be by persons, organizations, or sectors. The review showed that repeating concepts of CE were a combination of reducing, reusing, and recycling activities and that the main aim is considered to be economic prosperity followed by environmental quality. Kirchherr and his colleagues give the critics partly right in their claim that a lack of coherent practices could undermine CE as a solid framework (Kirchherr et al., 2017).

The third definition that is included here, is the one for the construction industry. In 2020, Gabriel Luiz Fritz Benachio led literature research into the scientific field of CE in the built environment. Their first research analysis aimed to find a common definition for CE in the built environment that distinguished itself from the general definition of CE. Based on the criteria of differentiating, they landed on 'the use of practices, in all stages of the life stages of a building, to keep the materials as long as possible in a closed-loop, to reduce the use of new natural resources in a construction project (Benachio et al., 2020).

How Circular is the World Economy?

According to the Circularity Gap Report Global (CGRG), an annual report made by a non-profit CE-accelerator Circle Economy (Circle Economy, 2022), the world is only 8,6% circular. The CGRG report is based on the share of cycled resources of the total resource consumption at a national stage and adjusted for import and export. The reports from the different nations are compiled into the global report. According to 'The Circularity Gap Report Norway' the Norwegian economy is only 2,4% circular (Norway, 2020).

More Critique of CE

In addition to the critique for being incoherent, CE has been criticized for being too focused on circular transition in the business and the industrial end of society, and therefore oriented against the production systems to become more economically efficient with an environmental up-side. By focusing on the production systems, CE detaches the effects from its spatial connection, since the economy is separated from the physical environment it operates within. On the other hand, cities, or municipalities for that matter, is much more to be counted as consuming entities that are spatially bound (Williams, 2021). I think this argument stands under scrutiny, and that this is something for the urban planner branch of landscape architecture to be aware of. If we want to turn circular, we need to make the cities and societies that enable CE circular too.

Circular Landscape Architecture

The International Federation of Landscape Architecture (IFLA) does not include CE directly. IFLA's 'Climate Action Commitment' does state that Landscape Architects around the world will work to 'drastically reduce operationally and embodied carbon in our work' and to take leadership 'in the built environments response to the crisis through collaboration with other actors (IFLA, No date). Further, IFLA has released a landscape architecture guide to the United Nations sustainable development goals (IFLA, 2020b), with examples of projects, but without a clear approach to circulating materials.

The European branch of IFLA, the European Federation of Landscape Architects (EFLA), released 2021 a position paper on CE in landscape architecture. EFLA refers to the Association of Danish Landscape Architects as an example of

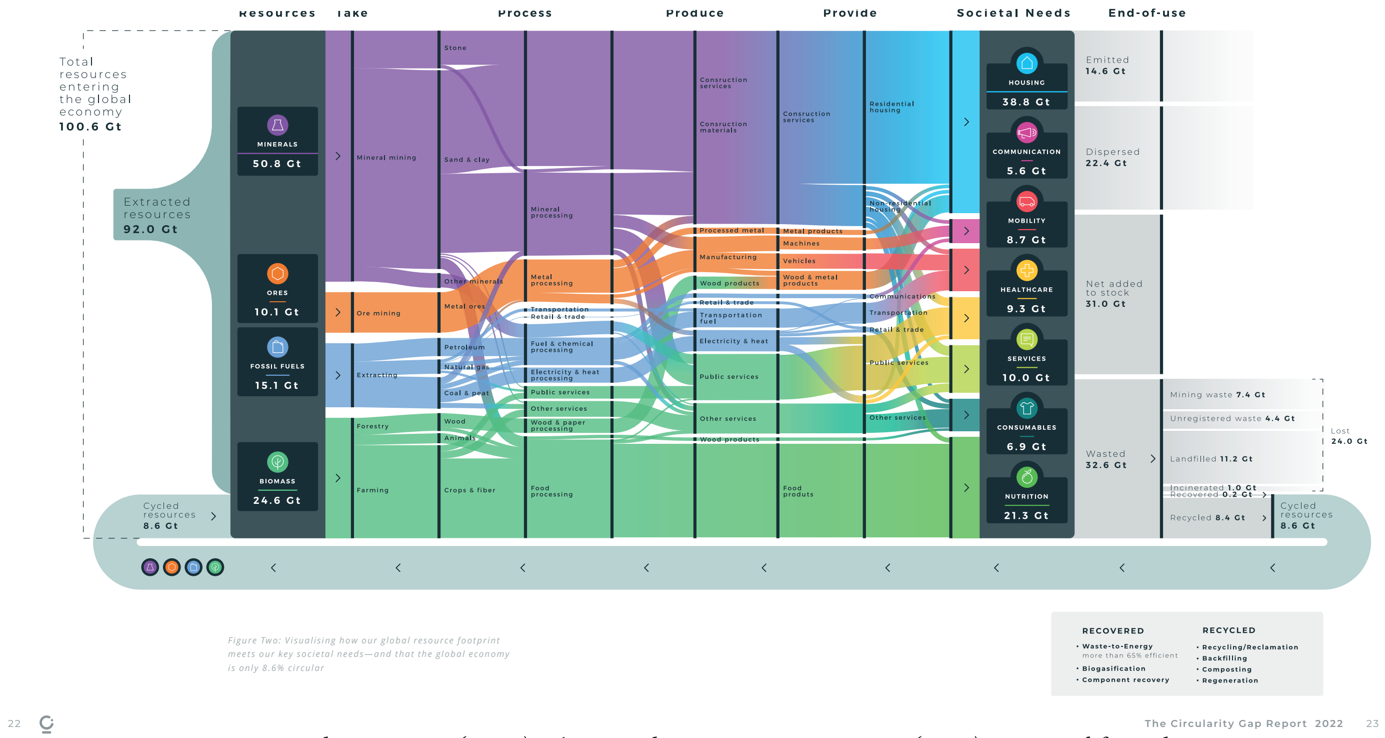


Figure 8. Source: Circle Economy. (2022). The Circularity Gap Report 2022 (P.22) Retrieved from: https://www.circularity-gap.world/2022#Download-the-report. CCL: Creative Common Attribution-ShareAlike 4.0 International License. Accessed: 15.05.2022

CE thinking in landscape architecture, which will be presented here later. Reuse of buildings and products, retention of materials within our circle, and use of products in a manner that ensures a healthy outcome for both humans and the environment. EFLA states that the link between landscapes, ecology, the built environment, and the local communities must be strengthened, and that landscape architecture is an agent in this linkage (IFLA Europe, 2021).

If we move across the Skagerrak strait to Denmark, the process of a coherent definition of circular landscape design has gotten further. The Association of Danish Landscape Architects (DLA) released an updated 2nd edition on the subject in March 2022. The guide translates EMF's all-inclusive steps to a circular economy to landscape architecture, which you can read in its entirety on the next page (The Association of Danish Landscape Architects, 2022). DLAs approach is as I read it a framework to design within. It chops up the huge concept of circular landscape designs into digestible pieces. It has high standards for what is circular, but it opens up adjusted ambitions for those who want to go circular. Even if we are in a hurry to combat the environmental decline, creating a circular ecosystem has to be tangible for more than the idealists.

The Norwegian Association of Landscape Architects has not yet produced any coherent guide for approaching circularity in landscape architecture. But there is a growing number of projects that are adding circular principles into the design. In light of the lack of coherency in CE definitions, it is hard to make a bold statement about CE in Norwegian landscape architecture.

Reflection on a circular solution

The circular economy has its critics, and some rightly so, but at the moment CE is the most obtainable way I have found that can change the dynamics at an industrial scale. Some argue that it does not go far and wide enough, some want to get out of the capitalistic frame in general, and some want to connect it closer to ecology. Given the timeframe we have to turn things around, CE has the potential to be implemented widely, which makes CE a reasonable path to follow. In Europe CE and landscape architecture is developing fast, and the connection between the built, the ecological, and the public seems to be the preferred scope for landscape architects. But when looking at how the American landscape society (ASLA) deals with CE, it is apparent that they look at landscape architecture from a slightly different angle than the Europeans. ASLA, as IFLA does, emphasizes the duty of landscape architects to take part in the fight for a sustainable world, but without pointing at CE as a solution. There are examples of reuse that ASLA advocates as well, but focus more on the connection made between people and landscape, keeping the built environment at a distance, like a backdrop for landscape projects. Also, my impression is that both IFLA and ASLA less focus on resource consumption in their positions, which surprises me, given the large volumes that are being used for land expansions, infrastructure, and construction to name a few. It might be my Scandinavian and European cultural background that makes me question this, so I will not be a judge for who is more right.

Reuse in Landscape Architecture can be divided into four different categories: materials, plants, soil and masses, and landscapes. Applying

'We defined CE within our iteratively developed coding framework as an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes. It operates at the micro-level (products, companies, consumers), meso level (eco-industrial parks), and macro-level (city, region, nation, and beyond), to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity, and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers'.

114 definitions of CE were analyzed to make this definition in Conceptualizing CE (Kirchherr et al., 2017)

Circular Landscape Architecture

The Inner Circle:

The fewer changes you need to apply to a site, to parts of a site – or the less you need to refurbish a structure or a material to reuse it – the higher the potential savings on energy and water, and labor are. The keys to the Inner Circle are retaining existing project parts, for instance: plantings, soil, sub- or base layers, or entire paved areas, as they already are on site.

The Long Term Circulation:

The longer a structure or a material can last, the fewer natural resources are needed in long-term perspectives. Long Term Circulation is ensured by designing and constructing structures in a way that allows for easy maintenance, partial replacement, and eventually disassembly and recirculation. Long Term Circulation is any effort intending to prolong the lifetime of structures, and/or minimize the resources needed for maintenance.

Cascade Use:

Through light reprocessing or refurbishment, used materials or construction parts can extend their lifetime and be reused as parts in new projects. This keeps the materials in circulation, even in reshaped or refurbished forms, thereby minimizing the need for extraction of new, virgin material resources and lowering the environmental footprint in general.

Pure Circles:

If a construction material retains its purity and quality, it is easier to reuse the material, than it has been processed or mixed – for instance, if it has been coated or jointed through casting or gluing. Pure materials often have a higher resale, even often increasing in value over time.

(The Association of Danish Landscape Architects, 2022)

PART THREE: TO REUSE

'To reuse is a verb'

Lasse Kilvær, Partner Resirqel

reuse in all these four categories can help on mitigating GHG emissions, reduce resource consumption, strengthen biological systems, and lower the land conversion rate. This thesis is about material reuse in constructed landscapes, which could have included all four categories, but only focuses on hard, non-living, materials. The complexity of each of the materials – life cycles, methods, techniques, logistics, functions – demands and deserves a proper and individual focus.

To reuse materials in design the first thing that is needed is a material bank on which to base the reuse design. Starting with developing the design before searching for materials is a risky approach. Large structures, spatial configurations, and functions are safe to start establishing, but colors, materials, shapes, tactility, and so on are dependent on the materials available and should be open to changes. This does not mean that the designer cannot influence the final expression, it might just turn out a little bit different than what the designer first envisioned. By keeping parts of the design process open for coincidences and letting the local material circles play a role in the design, it usually works out nice. Reuse projects often have a different types of aesthetical layers to them, with long historical lines told through marks, scratches, fades, and compositions humanizing the design, and the design process often adds another layer to the story.

Besides the aforementioned, designing with reuse differs in the process from a conventional design process. I have not come across processual descriptions for landscape architects specifically, but there are some directed towards architects.

Figure 9. Photo: Lasse Kilvær, Cortesy of Resirqel. 2022

Design-wise there are differences between the two branches, but my experience is that the design processes are quite similar. When working with Resirqel I have been blessed with learning from experienced professionals, and the reference work for understanding reuse as a process has been 'Resource Salvation. The Architecture of Reuse' by Mark Gorgolewski (Gorgolewski, 2018). The book combines scientific findings with experiences and case examples. I mention this book because of its comprehensive approach to architecture with reuse, and the impact it has had on my introduction into the field. Gorgolewski says it better than I, and is well recommended for those who want to dig deeper into the topic. Gorgolewski also had an entry during a seminar by Buildings as Material Banks (BAMB, 2015), which is a condensed version of the book (Gorgolewski, 2019)

Building a Material Bank

There are different ways to build up a material bank on. Buying access to a reuse-brokers catalog is the closest thing to a streamlined

Figure 10. Reuse Material Bank, Courtesy of Resirqel. 2018

approach you can get, at least in today's market. Brokers can help with material-specific searches, organizing deconstruction, dismantling, reclassifications, and other services that let the designer focus on the design.

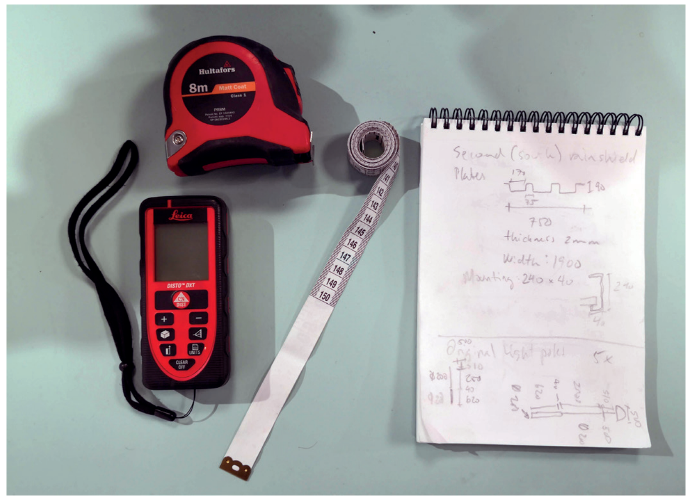
Experiences from mapping materials

Knowing what materials to look for is a matter of experience, after all, materials that have been used for decades will be influenced by age, weathering, wear, and use. Buildings and

Material Mapper, Photo Taale Kjøs, 2021

constructions have many layers, like interior, exterior, and constructional materials. The way materials were manufactured and assembled at the time of assembly, can be quite different from today's techniques. The understanding and use, of chemical components, have also changed a lot, and it is important to take safety precautions. Mapping hazardous toxins are conducted in an environmental survey. Safety equipment like helmets and protective footwear is mandatory.

In addition to safety equipment, a camera, a notebook, and measuring tools are the material mapper's starter pack. A laser measurer is perfect for long, straight, distances and for measuring



Material Mapping Starter Kit. Photo: Taale Kjøs

lengths you cannot reach. A laser measurer of a certain quality can calculate heights and incline, but my experience is that demands too much pre-work to be effective, at least for a preliminary mapping of potential materials. The steel spring measuring band and ruler is the quickest tools you can have and does not run out of power. For measuring curved objects, a measuring tape comes in handy. A mobile camera does the job for visual registration, but remember to bring a notebook and a power bank. The power supply can be disconnected in vacated buildings, so a flashlight too can be useful. Do not bring too much equipment that you have to carry around. A proper mapping takes time, effort, and focus, so you do not want to carry too much things or run around looking for things you miss placed.

The actual mapping process is fun and challenging. Discovering the obvious materials are easy, but to maximize the outcome, you have to apply a bit of imagination. How was the object constructed, and what is the future potential of the materials you are mapping? Looking for rhythms, shapes, joints, and connections in the structure will help you understand better how it once was put together. Here of course background information obtained like floor and garden plans are of great help, but not always updated or obtainable.

Single housings

This is my favorite object to map, especially when it has a lush garden. Small artifacts and savored old materials, wooden structures, natural stone, and other details that are easy to deconstruct, and easy to add to designs. Green plants demand a solid system to become possible to salvage for a larger market, but are salvageable if there is a place to plant them.

Urban complexes

Mapping large urban complexes demand planning, precision, and perseverance. But the results of the mapping can be rewarding, given the number of materials and volumes you can discover. Especially when it comes to structural elements and façades you can be lucky and hit a gold mine.

Architectural Edge zones

Where landscape and buildings connect,

A parish in a garden just out side Oslo. Sadly, it was not retrieved. Photo: Taale Kjøs 2021

material potentiality increases. The materials that architects and landscape architects work with often have different qualities, but in the architectural edge zone, our quality demands often coincide.

Material specific mapping

Concrete

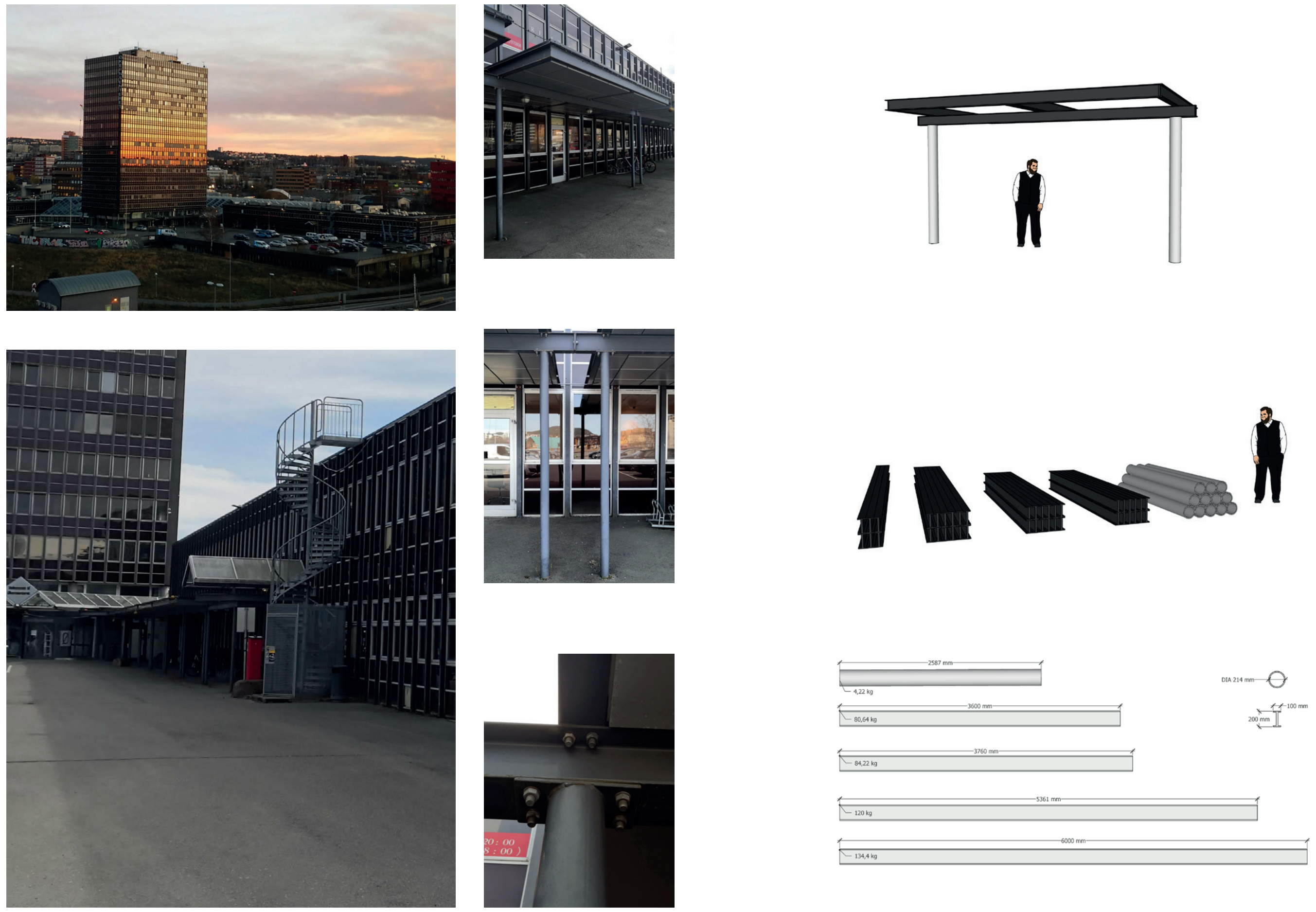
As addressed in the section on resources, concrete is the most commonly used building

Montage below: This is a visualization of volumes that can be salvaged from large urban structure like Økernveien 145. The volume is from the six rain covers in front of the building, which is modeled in the top left corner.

The buildings are a business center from 1969, and is mainly cast-on-site concrete, steel and glass. This is also where I reside while writing this thesis.

Parts of the construction will be demolished over the next years, and Resirqel has conducted a mapping.

Photos and illustrations: Taale Kjøs



material which leaves a large carbon footprint and consumes a lot of raw materials. Concrete's hardening process merges the three different components into a uniform material that is difficult to separate back to its original states. Recycling concrete as an aggregated admixture in new concrete is quite normal and appears environmentally smart. Recycled concrete reduces resource consumption by up to 50%, but has a limited effect on GHG emission (processing and transport) with a 50% higher water footprint than virgin concrete (Mostert et al., 2021). Another use of discarded concrete is downcycling to a base layer for foundation work. Without any good options for recycling, making the world's most in-use building material circular will be close to impossible without reducing and reusing.

In the built environment, concrete appears mainly in two forms – cast-on-site or prefabricated elements. Cast-on-site concrete is difficult to reuse without either cracking or cutting it into smaller pieces. Cutting concrete is expensive and energy-demanding (Tegnestuen Vandkunsten, 2016), while braking is hard to control, and

Figure 11. *Demolishing concrete structures. Steel reinforcments are visible. Photo: Lasse Kilvær, Courtesy of Resirqel. 2019*

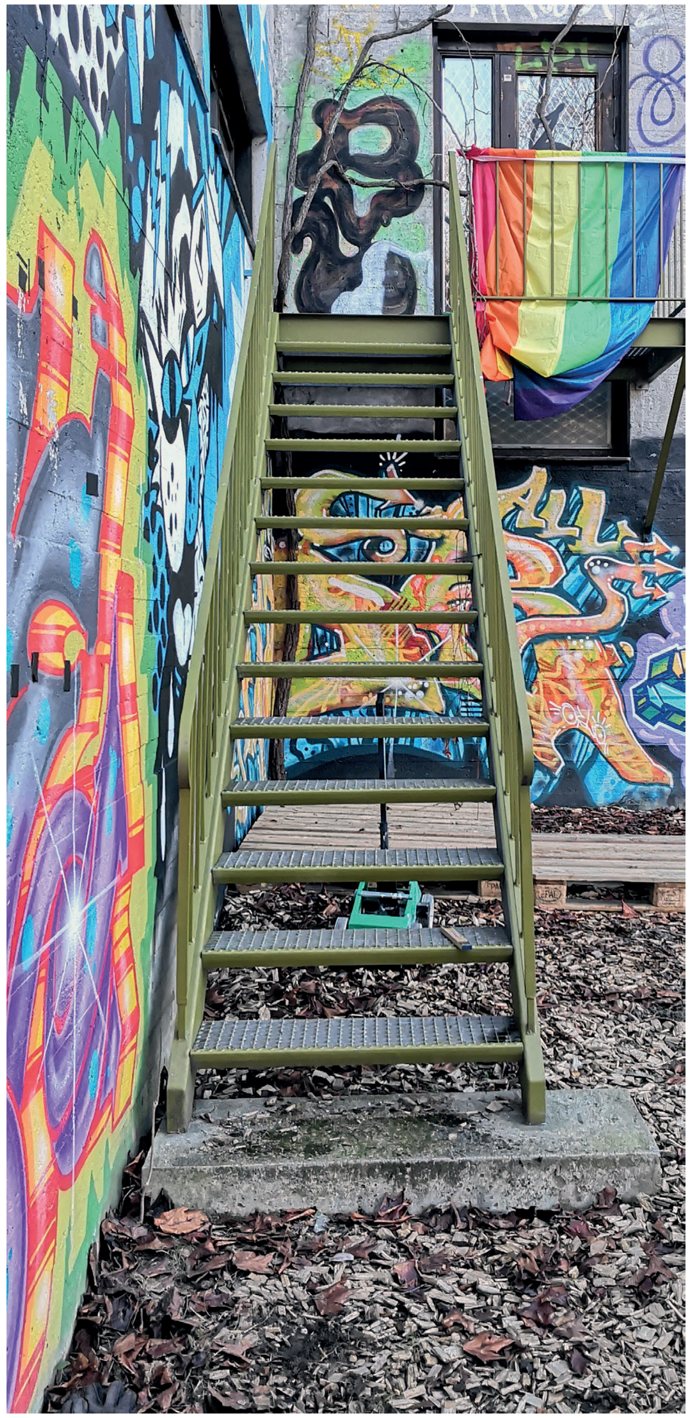
thus reuse. Prefabricated concrete elements are reusable as is, but are often connected with glue and difficult to separate. Reusing the original function of the concrete structure is by far the best option in the short term while reducing the use of concrete in construction design is the best long-term solution.

Steel

Steel is another common component in the built environment. It is not as voluminous as concrete but is an important part of reinforcing concrete. As a design component, steel is a lot easier to reuse than concrete. Recycling steel is an established and circular waste management approach, and reduces carbon footprint and resource consumption. Steel, and production of steel, vary according to quality and treatment, with reductions in GHG emissions up to 50% (Allwood, 2014). Working with reused steel enables the designing of larger constructions, functions, and design features. Steel is adaptable to needs by bending, cutting, and welding.

Reuse of Functional Objects

Reuse is not only about reusing specific material components, and the prefab of reuse is



Staircase mapped downtown Oslo. Photo: Taale Kjøs 2022

functional objects. Staircases, furniture, apparatuses, and other objects that can be utilized if it fits. This is an effective way of saving energy, time, and resources, but adjusting the component to its new environment needs a hands-on approach.

In-Situ Reuse Design

This is the pinnacle of material reuse, which is to add existing materials at the site of the project to the project design. Whether such an approach is possible or not depends on the state of the site, wherein the project pipeline the designer enters, and the resources the project team has available. In-situ reuse done right minimizes GHG emissions, resource consumption, waste production, and transport, but will demand a high level of engagement, research, and imagination from the design team.

Aesthetics in reuse

Materials and components that have been used carry marks on them from their previous function and use. The marks will appear in individual expressions depending on the function it served, how exposed it was to the environment, the level of maintenance conducted in its lifetime, and of course age. As it has been mentioned, designing with reuse can be a longer path than designing with off-the-shelves materials. This prolonged journey can also connect the designer to the materials in a much more intimate way. Through studies, tests, and history a deeper understanding of the materialistic abilities can appear and when it does a relationship is established. Designing with reused materials can evoke nostalgia. The love for used materials has made the Belgian reuse cooperation Rotor research how wear and tear influences material. 'Usures. How things stand' is available online on Rotor's website and is well worth a look. It is a solid work to better understand the possibilities and challenges in designing with reuse (Rotor et al., 2010).

Safety and Liability in Reuse

Trading with used construction materials demands the same level of documentation as

Figure 13. Source: Core City Park Detroit, MI, Spring 2021. Photo courtesy Prince Concepts and The Cultural Landscape Foundation-64.jpg Retreieved from: https://www.tclf.org/julie-bargmann-wins-inaugural-cornelia-hahn-oberlander-international-landscape-architecture-prize. Accessed: 16.05.2022

Figure 12. Source: Core City Park Detroit, MI, Spring 2021. Photo courtesy Prince Concepts and The Cultural Landscape Foundation-12.jpg. Retrieved from: https://www.tclf.org/julie-bargmann-wins-inaugural-cornelia-hahn-oberlander-international-landscape-architecture-prize. Accessed: 16.05.2022

Julie Bargmann: D.I.R.T Studio

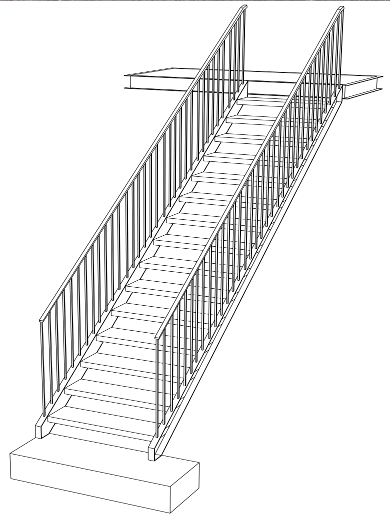
When talking about aesthetics and in-situ-reuse, it is impossible not to give a shout-out to Julie Bargmann. A professor of Landscape Architecture at the University of Virginia, and the founder of Dump it Right Here Studio (D.I.R.T). In 2021, Julie Bargmann won the inaugural Cornelia Oberlander Prize in Landscape Architecture. The pictures are from Core City Park in Detroit, Michigan. It is really recommended to check out the work on www.dirtstudio.com to see how reuse in landscape architecture can be.

Walk the Talk - Økern Activity Park

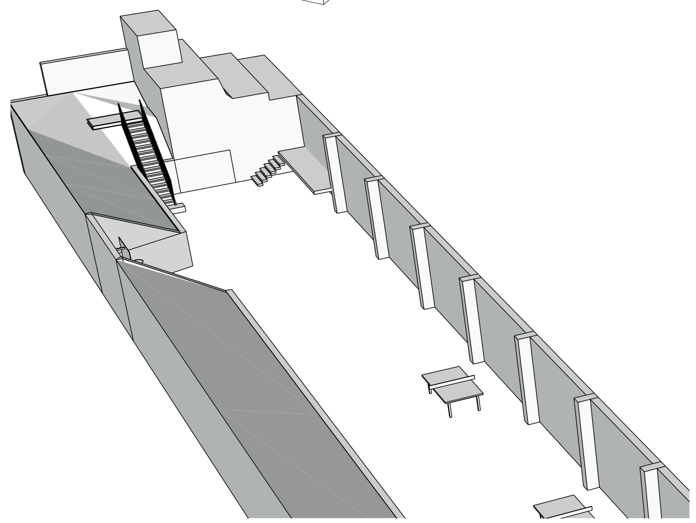
Økern Activity Park was supposed to be an integral part of my thesis but balancing academic coherence and building a park was too hard to follow through. I still want to include the work as proof that I too will do reuse.

In January 2022, Lasse Kilvær of Resirqel discovered this staircase at a mapping downtown Oslo.

After agreeing to the design, a thorough registration of the dimensions was conducted to create a 3D model of the staircase.



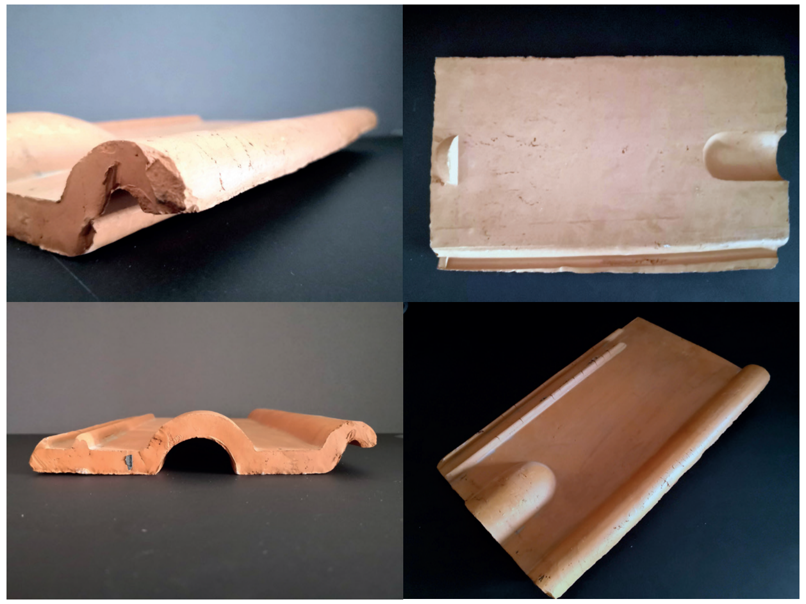
The model of the staircase was tested in a 3D model of the space, and we understood it would fit the purpose with some adjustments.



In May 2022, the staircase was dismantled and deconstructed for transport. The same day, it was reassembled and secured.

Even though I did not manage to see through the project during the time I was writing this thesis, it is a project that will be continued in the weeks ahead. Økern Activity Park will be an urban site for one-to-one testing of urban landscaping reuse.

Courtesy of Resirqel who arranged and executed the project, together with Srikom, a deconstruction start-up. Photos and illustrations by: Taale Kjøs



Vollebekk Torg – Studio Oslo Landskap (SO:La)

At Vollebekk in Oslo, Obos and SO:La are doing reuse in a public square project. I have been working with Resirqel to gather materials for the project, and managed to salvage some old clay roof-tiles from a project just outside Oslo June 2021 (picture 1). The tiles was then measured and registered (picture 2), so SO:La could start working with design possibilities. November 2021, a small-scale test was started to see how the tiles did in winter conditions (Pic 3) Mid-January 2022, a deconstruction company retrieved and packed the tiles (picture 4). April 2022, and the construction of the new square is well underway.

All photos by Taale, Courtesy of Resirqel

new materials and must comply with the EEA Construction Product Regulation. This means that every reused material has to be by requirements made for new materials. Further, other technical requirements must be assessed by regulations most often at the designer, consultant, and developer's responsibility (Nordby, 2019). It is different rules for different types of components, but the liability of the product rests at the hand of the retailer. Reclassification of materials adds costs and uncertainty to the whole value chain.

Reused Material Markets

All the x-factors in doing reuse in construction projects have weakened the market which diverts professional actors in the construction industry to invest in, and converting to, reuse (Nordby, 2019). This creates a catch-22 where the actors that have the resources to invest in, and the materials to supply to, the market do not risk engaging too much in the reuse market. A lack of opportunities and materials available to select from makes it difficult for designers like landscape architects to promote and suggest reuse in projects.

Logistics of Reuse

Working with salvaged materials from the construction industry is, because of its volumes, weights, and variform, an exacting operation. Large areas are necessary for storage, and the variform of the components makes it hard to streamline the storage setup. The weight and shapes necessitate powerful machines and space to handle the components. Timing is also essential in organizing a storage and supply line for reuse, given that both supply and demand from projects are based on factors that are out of the control of the organizers.

Digitalization and materials passports

To realize reuse of materials is only possible when the physical handling of materials is in place. When a physical material bank is in place, digital tools can help organize and simplify adapting to reuse in a project. As an inventory database, information hub, and point of sale tool, digitalization can help develop the market. The physical material stock is emphasized because there are a lot of digital tools developed for the market already, but too few materials available in the market. Registering materials in centralized registers, connecting classifications and guarantees to individual materials, and statistical extractions

to better understand the market will contribute to a further solidification of the market. Furthermore, a solid digital framework can be the foundation for establishing material passports as a way to improve efficient information flow in the material stream. Material passport's biggest advantage is for future materials, using Building Information Modelling (BIM) to connect materials to buildings with information on its uses, deconstruction method, embodied energy, and end-of-life strategy (Atta et al., 2021)

Reclaiming From Waste Streams

Materials that are taken out of the waste stream are a value diverted from one economy to another, which will come at a cost. It is important to keep this in mind when working to reclaim materials. Often is the value of the waste calculated in the contract with the demolition company. Getting the legal framework right is an easy fix on something that can get uncomfortable.Conclusion

Conclution

Circular economy, in any form, is way better than linear. That circular economy is not perfect, and is at risk of losing integrity over lack of coherency does not change my opinion. There is no other theory that has proven to work, which also gets a majority of actors on board. Engaging the masses is of paramount importance to be even close to avoiding irreversible consequences of climate change. And as I understand the inventory part, we simultaneously must reduce our resource consumption. Where the planet has renewable energy in abundance, it only has a limited volume of resources to offer.

For landscape architects to turn circular, is a no-brainer, and it already is happening. But my impression is that we as a profession should talk more with each other, and louder to others. Landscape architecture's deep connection to the environment, the public, and the built environment entitle us to have a bigger say in how we can do things. But for us to take the lead, someone else has to step back, and that does not come without standing up for our visions and knowledge. I have a great belief in landscape architects become key agents for change.

For landscape architects to reuse materials in projects, there is possible to do so within today's framework, but it is a challenge that makes it mostly for the idealists. To realize reuse on a scale big enough to make an impact, there needs to be rapid development on all levels of the economic ecosystem. This goes for all actors within the value chain, and leading positions is up for grabs for those who can offer solutions. Still, there is a need to start doing reuse more. Going that extra mile to add reused materials into a project might seem like a lot of effort for little gain, but the added effects on solidifying the reuse market, gaining experience, and showcasing results cannot be underestimated. It is just to start reusing!

Discussion

This thesis intended to find out how landscape architects could use their skills to increase our contribution to the environmental cause. That I ended up on reuse of materials is because of my interests, which again led me to Resirqel. But I did not start at reuse as the scope and used too much time narrowing the focus. That has given me less time to go deep into material-specific and methodologies, which makes parts of the thesis less impactful in my opinion. I do believe that plants, soil, and spatial reuse need each its focus, but I wish I could have opened up the door to those materials a bit more. This is anyway something I hope that someone else picks up and investigates properly. If by any chance you who reads this want to explore the topics, do not hesitate to contact me. I will gladly share my knowledge. Circular cities/communities are another important part of the puzzle for turning the human world circular. This is also a field for landscape architecture to flourish, but once again I had to leave it be until later. I could also have done less investigating in part 1, given that it is outside of my area of study. Still there are many things there which I excluded from the project.

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Norges miljø- og biovitenskapelige universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway