🏆 reviewed paper

Regeneration of Urban Sites with Circular Economy Principles

Matthias Haase, Mihaela Meslec

(Prof. Dr. Matthias Haase, ZHAW, Gruental, Waedenswil, Matthias.haase@zhaw.ch)
(Dipl.-Ing. Arch. Mihaela Meslec, ZHAW, Gruental, Waedenswil, mesl@zhaw.ch)

1 ABSTRACT

This research addresses the gap in effectively applying Circular Economy (CE) principles to urban regeneration, through the case study of Uetikon am See's redevelopment in Zürich. It introduces a Circular Economy in Real Estate (CERE) model to operationalize CE in urban planning, highlighting the challenge of translating CE concepts into actionable strategies. Focused on the "Chance Uetikon" project, the study demonstrates the need for strategic planning and stakeholder engagement to integrate circularity into the built environment effectively. By bridging theoretical principles with practical application, this research contributes to sustainable urban development, offering insights for achieving resilience and encourages closed-loop systems and circularity in spatial transformations.

Keywords: regeneration, economy, planning, city, sustainability

2 INTRODUCTION

A circular economy is an economic system that promotes the continuous circulation and sustainable use of resources and products at their highest value, while minimizing waste generation and environmental impact (EMF 2015). It is predicated on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. The concept of the circular economy represents a transformative approach to economic activity that aims to minimize waste, reduce resource depletion, and foster sustainable consumption and production (WEF 2014; EC 2012; EC 2014; EC 2020). It stands in stark contrast to the traditional linear economic model, which follows a "take-make-dispose" pattern, leading to resource scarcity, environmental degradation, and economic inefficiency (Kyrö 2020).

2.1 Brownfield recycling

As the circular economy begins with designing products and systems that are based on CE concepts and principles, it needs to consider a product or service (called here: a project) which encourages the development of closed-loop systems where flows are closed in the lifecycle perspective (Guerra et al. 2021).

On the other hand, urban regeneration emerges as a critical challenge and opportunity for the future urban development. This paradigm shift sees a reduction in new construction projects, which in turn, allocates more economic and spatial capital towards the revitalization of existing sites (Geisendorf 2017; Govindan et al. 2018). While considering the existing circular economy frameworks, a research gap has been identified in tools to transition urban areas and improve circularity at the city and regional scales.

Integrating brownfield redevelopment with circular economy principles is a promising approach to sustainable urban development, addressing both economic and environmental challenges by revitalizing underused urban areas through innovative, resource-efficient approaches. The following synthesis integrates findings from multiple studies to highlight the potential and challenges of such integration.

Arbab and Alborzi (2022) in their studies on sustainable regeneration of urban industrial heritage and redevelopment of urban brownfields, notably in the context of Tehran's Hakimiyeh neighborhood, provide a compelling basis for exploring the concept of recycling cities within the circular economy framework. These works underscore the significance of reimagining and repurposing abandoned industrial zones not merely as acts of preservation or aesthetic renewal but as integral components of a circular economy. By advocating for the sustainable regeneration of urban industrial heritage, these studies align with circular economy principles that emphasize minimizing waste, extending the life cycle of resources, and creating value through the restoration and adaptive reuse of existing urban fabrics. This approach not only addresses environmental challenges but also leverages historical and cultural assets to foster economic growth and social cohesion, illustrating a comprehensive method to recycling cities that harmonizes heritage conservation with circular economy objectives.

New Urban Ecosystem Services: The integration of bio-based land uses and Gentle Remediation Options (GROs) in brownfield redevelopment can significantly enhance urban ecosystem services, offering

sustainable alternatives for managing contamination risks and restoring contaminated soil (Chowdhury et al., 2020). Similarly, the incorporation of green infrastructure in brownfield areas can provide important urban ecosystem services to local residents, contributing to improved quality of life in cities (De Valck et al., 2019).

Economic and Environmental Benefits: Brownfield redevelopment projects that include green infrastructure not only address urban sustainability but also offer economic benefits (Dorsey, 2003). The integration of urban agriculture and stormwater management in urban planning further enhances ecosystem services and supports urban resilience in the circular economy (Deksissa et al., 2021).

Challenges and Solutions: Despite the potential benefits, the integration of brownfield redevelopment and circular economy principles faces several challenges, including site contamination, financial and regulatory barriers, and the need for interdisciplinary collaboration (Cappai et al., 2019). Overcoming these obstacles requires robust policy support, strategic planning, community engagement, and the adoption of green technologies.

Policy and Governance: Improved legal regulations and instruments enhance the market chances of fallow areas, facilitating circular land management and supporting sustainable urban development initiatives (Ferber, 2011).

In conclusion, integrating brownfield redevelopment with circular economy principles offers a sustainable pathway for urban development, capable of revitalizing underused areas while addressing environmental and economic challenges. Achieving this integration requires a coordinated effort among all stakeholders, supported by innovative solutions and robust policy frameworks. This approach not only facilitates environmental remediation and the conservation of green spaces but also promotes economic revitalization and community well-being.

2.2 Goal

The goal was to develop a method to integrate CE in urban regeneration projects. How can regeneration projects be based on CE concepts and principles, which role plays a product or service which encourages the development of closed-loop systems and where flows in the lifecycle perspective are closed.

Starting from the CE principles, circular economy projects should emphasize resource efficiency by reducing the extraction of finite resources, such as minerals and fossil fuels, and promoting the use of renewable resources. It should encourage the development of closed-loop systems where flows are continually cycled.

It must represent a holistic and transformative approach to economic and environmental sustainability, aiming to break away from the linear "take-make-dispose" model and create a regenerative, waste-reducing, and resource-efficient system. Where applicable, consider the principle of sufficiency (Refuse, Share), typically the most effective strategy for minimizing depletion and pollution (Cetin et al. 2021).

2.3 Method

The approach involves:

- Analyzing the synergy between CE practices and urban regeneration;
- Applying these concepts to the Uetikon am See redevelopment: detailed case study analysis;
- Development of a CE model for green urban regenation projects.

3 STUDY AREA

The regeneration of the CU site, a previously industrialised area by the Lake Zurich, is analysed as an approach to brownfield redevelopment through the lens of circular economy principles. The project leverages its lakeside context through a large lake side park which extends with a comprehensive network of mobility - public open spaces as its structural backbone. This site has transitioned from a restricted industrial zone into a vibrant, multi-use district under the "Chance Uetikon" initiative - a collaborative effort by the municipality of Uetikon am See and the canton of Zurich up until 2021. The masterplan, comprising for interconected hubs linked by the park, the network of open space and mobility as illustrated in Figure 1 and elaborated in Table 1, outlining a diverse mix of uses, including residential, commercial, services, education, recreation, leisure, and culture.

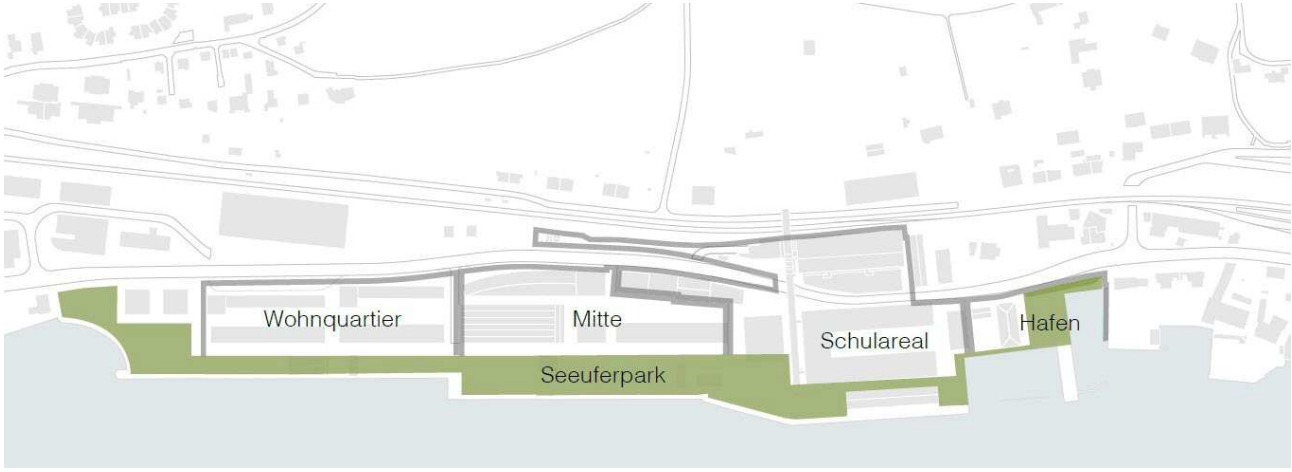

Fig. 1: Masterplan of Uetikon-am-See community with Residential Quarter (Wohnquariter), Community center/Mixed Use Area (Mitte), lakeside park (Seeuferpark), Cantonal School (Schulareal) and Harbour area (Hafen) (Masterplan Chance Uetikon, 2019)

Name	Picture	Description
1. Residential Quarter (Wohnquariter)		Ensures diversity through varying the apartments in terms of their location, standard of development, living space and type. Overall, on an area of 17300 sqm, 103 housing units and 85 condominuium were developed; Integrated CE priciples through ensuring diversity and embedding green spaces and natural elements for ecological benefits.
2. Community center / Mixed Use Area (Mitte)		Integrates CE principles in urban regeneration by repurposing historical architecture (“Düngerbau” building) and creating social cohesion through multifunctional spaces while preserving the local identity; “Düngerbau” is a central element of the development; through its public use, it is planned to become the social heart of Uetikon-am-See providing cultural events, small festivals, small business while conecting the old and new.
3. Lakeside park (Seeuferpark)		The lakeside park strongly contributes to a circular urban regeneration through Nature-based solutions It generates the ecosystem services and mitigates biodiversity loss at diferent scales; Increases the value of proximity residential and commercial developments.
4. Cantonal School (Schulareal)		In the east of the site, the Canton of Zurich is building a cantonal school with space for around 1,500 students and a vocational school with 500 students. An area that is coming to vibrant life.
5. Harbour area (Hafen)		The existing buildings are used by commercial or service businesses. In attractive locations, ground floors oriented towards the public are emerging. This area is envisioed as the new transport hub.

Table 1: Analysis of urban regeneration project (Masterplan Chance Uetikon, 2019)

4 RESULTS

The CU site's redevelopment into a new quarter at Uetikon-am-See give insights into how CE principles can be integrated into urban regeneration projects. The CU site's transformation into a mixed-use new quarter in Uetikon-am-See exemplifies the integration of CE principles into urban regeneration, offering a blueprint for future projects. The redevelopment is anchored by a strategic model centered around the lakeside park, which is part of a comprehensive network of public open spaces and infrastructure. This structural element enables four distinct mixed-use areas: a residential quarter, a community center/mixed-use area, a cantonal school, and a harbor area. Each of these hubs plays a pivotal role in fostering circular development by providing varied opportunities for the application of CE principles. The integration of CE principles across these mixed-use areas is crucial for achieving sustainability and resilience in urban environments. By emphasizing nature-based solutions, resource efficiency, waste reduction, and the preservation of natural

spaces, the project not only contributes to the social and environmental but also social and economic dimensions of sustainability. This case study contributes to the body of knowledge on successful CE management in urban regeneration, highlighting the importance of incorporating CE principles at every stage of development to create self-sustaining urban communities while following the elements highlighted below:

4.1 CE models

In each of the five projects several CE principles could be applied. In the residential quarter, the plan foresees demolition of the site and new construction of 188 living units. For the new construction of the residential area but also parts of the Cantonal school, the principle of Ressource Efficiency could be implemented. This includes an area efficient layout of the living units, applying the principle of Reduction by by minimizing the living area per unit. This approach must be carefully discussed with the property developer. Consequently, innovative renumeration models are needed for effective for sales marketing. Incorporating more green features in the residential area, but also in the lakeside park, makes the principle of regeneration feasable. However, one challenge remains as the land, formery a factory site is contaminated and unsuitable for trees and other vegetation.

The residential area should be developed with a specific focus on living concepts based on several generations. This provides a very good example to explore the principle Decelerate / Slow.

Evaluating the potential to reuse building components and/or materials of the exisiting buildings on a specific site exemplifies the principle of Circular Economy, specifically the Closing loop principle. By repurposing components and materials, we can close the loop, giving them new functions and uses.

Cooperation and Digitalization are two principles which most effectively can be integrated by cooperating with other stakeholders and by means of digital tools like digital twins. Implementing a digital building technology concept not only advances technology but also fosters efficient, sustainable schools. The collaboration with "Junge Tüftler" engages pupils to actively participate in energy management and emphasises the importance of a holistic educational experience. Building automation refers to the automatic control and regulation of functions within a building, including heating, air conditioning, ventilation, lighting, and shading (Junge Tuftler). As a key component of technical facility management, building automation aims to reduce energy and operating costs. It enables the automatic execution of functional sequences across different trades, based on predefined settings (parameters), and simplifies operation and monitoring.

This involves networking all sensors, actuators, control elements, consumers, and other technical units in the building. Processes can be integrated into scenarios, enabling intelligent and optimised interaction between the various components (Merz, 2016).

Building automation makes it possible to pursue and combine various objectives. These reach from reducing energy consumption through intelligent control; Demand-led control of heating, ventilation system or air conditioning; Flexible lighting control, Intelligent control of shading devices; Recording consumption data from heat meters, water meters, gas meters and electricity meters; Increased convenience, Load control based on consumption data recording; Increased safety through alarms in critical situations (Merz, 2016).

It is not only the resulting cost savings due to an energy-optimised building that are an incentive for a digitalised concept, but also the achievement of certification is a decisive reason for many building owners and users. With the help of nationally and internationally recognised certifications, sustainability aspects can be implemented in the real estate industry and the goal of sustainable properties can be achieved (Wagner, 2018).

The Düngerbau building, at the Chance Uetikon Areal, is envisioned a "Circular Community Hub” bringing together students, teachers, local residents, residents of the municipality of Uetikon, local businesses and associations. This hub aims to be a social connector within the community, offering to all stakeholders a space for various activities that enhance community life. (Suter and Jeanfavre 2023). This vision aspires to create an inclusive, flexible, and sustainable environment that fosters social ties within the community. The Circular Community Hub is a facilitator for collaboration, social innovation, and well-being for the community of CU Areal. The principle of Regeneration guides the community center`s development, repurposing an old storage building for new uses.

Lake water energy provides a sustainable option for thermal networks or areas. This is done by collecting lake water a few metres above the lakebed using a strainer, an extremely large sieve. In the centre, a heat exchanger extracts heat from the lake water, which then serves as an energy source for a heat pump. The heat pump increases the temperature to the required level, usually between 40 and 65 °C. This means that the heat obtained can be used in the connected buildings for both heating and hot water preparation. In contrast to many other energy sources, lake water not only offers advantages in heating mode, but can also be used for cooling in summer. Here, the lake water, which is around 4 °C cold all year round, is used directly for room cooling through freecooling (ewz 2023). This provides another example of urban regeneration by exploiting local (energy) resources.

To conclude, the CE principles in urban regeneration are consolidated below:

- Resource Efficiency and Reduction in Housing: Focus on area-efficient layouts and minimized living space in the development of living units to optimize resource use.
- Deceleration and Multi-Generational Living: Promotion of slow living concepts through multi-generational housing arrangements, enhancing social sustainability.
- Regeneration Through Nature-Based Solutions: Integration of green features in residential areas and parks to facilitate ecological regeneration, even on previously contaminated sites.
- Material Loop Closure: Assessment and reuse of building materials and components from existing structures to close material cycles and promote resource circularity.
- Participatory Planning and Digital Integration: Strengthening cooperation with stakeholders and employing digital tools, like digital twins, for sustainable urban development and participatory energy management.
- Creating a Circular Community Hub: Transformation of the Düngerbau building into a hub for community engagement, embodying circular principles through inclusive and flexible use spaces.
- Innovative Sustainable Energy Solutions: Adoption of lake water-based thermal networks for heating and cooling, leveraging local natural resources for sustainable energy in urban regeneration.

4.2 Methods and tools

The methods and tools that were explored in the case study are:

- Scenario planning
- System Separation and design for adaptability
- Asset tracking
- Circular label strategy
- Food waste reduction
- Grey energy accounting

4.2.1 Scenario planning

In the case of Chance Uetikon, BIM could could be exploited by decision makers from an early design phase as well as during the operation. A digital twin in an early design phase would allow for visualization of the project before the shovel hits the ground (Dye, 2023). Moreover, different scenarios (use cases) could potentially be compared to identify the biggest possible overlap. The bigger the over-lap is the less extensive the construction work will be for future alterations. Additionally, the digital twin could include relevant information for the maintenance of the building and can be used during the planning phase of future conversions. To successfully plan different scenarios stakeholder management is extremely important. The real estate owner must be willing to invest upfront whereas the architect and the BIM team must be able to think about different use types and create the biggest overlap of the different scenarios possible.

4.2.2 System Separation and design for adaptability

According to Brand (1994) a building consists of six different building layers with different lifespans (Brand 1994). Whereas the interior is considered to have a lifespan of under 3 years, the structure of the buildings

lasts up to 300 years. System separation as well as flexibility lead to better chances in reusing certain building layers. The Amt für Grundstücke und Gebäude des Kantons Bern (AGG) has created a guideline regarding the abovementioned issues. The aim of the guideline is to include the principles for separation as well as flexibility in all new developments as well as renovation. In order to achieve a higher flexibility, it defined the room height for new construction at 3.6 meters and the loading level of 3 kN (Amt für Grundstücke und Gebäude des Kantons Bern, 2013). The norming body ISO has created a document that defines principles, requirements as well as guidance regarding de-sign for disassembly (ISO, 2020). Such documentation will already be relevant in an early design phase as it gives the planning team more certainty regarding how to include these topics in the planning phase.

4.2.3 Asset tracking

Another important aspect of the circular concept on the area is to use assets more efficiently. Not far from the community centre is a school which is mainly in service during the day. As the Circular Com-munity Hub offers workshops and events in the evening, chairs, tables, whiteboards, cutlery, and so forth could be borrowed from there. To ensure that the location gets the desired amount of assets at the right time, a booking platform is relevant. However, the aim is to include that service as seemlessly as possible into the flow of the client. Systems such as Allthings (2022) allow to integrate needs of users along their customer journey, including the asset tracking and the booking of rooms as well as assets (Allthings Technologies AG, 2022).

4.2.4 Circular label strategy

Labels do help real estate owners in the communication with their stakeholders. Moreover, there are also studies, that argue that tenants are willing to pay a premium for sustainable buildings (Devine & Yönder, 2021). With the revision of their respective criteria, labels such as DGNB, SNBS, Minergie Eco will include the topic of circular economy in their scheme. Below, the most important criteria (in German) from DGNB are mentioned which could positively impact the assessment (Deutsche Gesellschaft für nachhaltiges Bauen - DGNB e. V, 2023).

4.2.5 Food waste reduction

The Düngerbau will be the central meeting point of the areal. As such, events will be hosted, and food will be offered. As a circular brownfield development, another focus will lie on the reduction of food waste. Technologies such as Artificial Intelligence can help to identify the sort of food waste which is generated. With it's plug and play solution, KITRO offers an overview of the food waste generated over time. These insights help to reduce the food waste over time by adjusting the supply.

4.2.6 Grey energy accounting

For the lake water use concept, the primary focus is on identifying the grey energy associated with the construction and operation of the lake water network, especially when compared to traditional methods like geothermal probes. This requires a thorogh calculation and analysis of the grey energy, which includes evaluating costs against those of geothermal probes. Such an analysis should be conducted through a life cycle assessment to accurately quantify grey energy and CO2 emissions.

4.3 Measuring circularity

Circularity is the core principle of the Circular Community Hub. The Circular Community Hub must have the ability to evolve with the needs of the stakeholders, both in the short and long term, while preserving limited resources. Additionally, the implemented strategies aim for economic, social, and environmental efficiency.

Aspects such as the dimensioning of the system, the achievable cooling and heating energy and the associated CO2 balance over the entire life cycle are to be considered in order to create a solid basis for decision-making. Another focus is on providing precise calculations to determine the required dimensions of the system and the achievable cooling and heating energy. The determination and calculation of the heating and cooling requirements can be carried out based on the requirements outlined in chapter 4.2. This helps to evaluate the efficiency and performance of the lake water network in comparison to other technologies. Com-prehensive monitoring could be implemented during the operation of the system. This involves the

continuous measurement of lake water and energy generation and their utilisation. This enables a real-time assessment of performance and contributes to the optimisation of opera-tion. The collection, measurement and evaluation of greenhouse gas emissions provide in-sights into the economic aspects and ecological effects over the entire life cycle of the lake water network.

The circularity of the measure should result in a value creation. To forster this it must be visible at three levels: at a social, economic, and environmental level. Additionally, for the value to be truly created for those three levels, a stakeholder centric approach must be taken. The value must be created for and with the stakeholders to be long-lasting (Tapaninaho & Heikkinen, 2022). Stakeholder centricity is at the heart of the Circular Community Hub, this is why the following types of value could be created.

4.3.1 Economic value

First, let's have a look at the most traditional value creation. Economic value creation can be observed for various stakeholders. The owners will get financial return on the buildings. Designers and planners, consultants, manufactures and facility management companies will get paid for their mandates. Additional jobs could be created thanks to the Circular Community Hub, such as kitchen chef or event managers for the scenario 2030, or care workers for scenario 2045. Hence, the Circular Community Hub could represent a local economic boost, which will make the local authorities and community more than happy.

The use of lake water is more economically and commercially viable if enough buildings or a neighbourhood can be connected. Thus, lake water utilisation projects often require local authority involvement and create an opportunity for citizens to actively participate in sustaina-ble developments. This raises awareness of environmental issues and the need for sustainable practices. Although the initial investment may be higher, such projects can lead to cost savings in the long term, especially if energy prices rise or environmental regulations are tightened (Impact Hub Lausanne, 2023).

Monitoring concepts are used to check the defined user requirements. With new software for technical monitoring, digitalisation makes it possible to optimise the settings and functionality of the system technology. With the help of monitoring, the functionality of different trades and systems becomes transparent. Potential for optimising the systems can be discovered and compliance with user requirements can be guaranteed. This ultimately leads to consistent, functional quality assurance and energy efficiency optimisation.

4.3.2 Social value

Then, social value creation might be the second most visible value creation of the Circular Community Hub project. A real community could be rise from the area which favours social cohesion. Additionally, community branding could contribute to the good reputation of the area. Cultural preservation of the history of the building but also of the new community's history can also be considered as social value creation. Finally, the flexible spaces of the Circular Community Hub could host educational workshop or health promotion initiatives as described in the various scenarios, which could contribute to the greater good.

A plan for digital labs for research on building technology in schools could include various elements to fulfil the needs of schools, teachers, and students. To integrate practical experience, a cooperation with the German organisation "Junge Tüftler" could be proposed. Thus, the teaching model for digital labs in schools in the field of building technology, in coop-eration with the organisation "Junge Tüftler", strives to provide a comprehensive educational experience.

4.3.3 Environmental value

Finally, the last value creation is about environmental value. The Circular Community Hub is designed to optimize the use of resources. Some materials will be reused, some reshaped and some even avoided thanks to scenario planning. Waste will be reduced or used as potential raw material to other projects. All these efforts contribute to the long-term sustainable viability of the Circular Community Hub and to reduce its environmental impact.

By using lake water as an energy source, the project can contribute to greater energy effi-ciency, as lake water can naturally store heat or cold. This leads to a more efficient use of energy compared to conventional systems. The project can also help to reduce greenhouse gas emissions by reducing the need for fossil fuels for heating and cooling systems (ewz, 2023). If implemented responsibly, the project contributes to the

protection of water resources by ensuring that the water quality of the lake is not compromised and that sustainable extrac-tion rates are maintained. This promotes technological innovation and contributes to the further development of sustainable technologies.

4.4 Business model specifications

Through the specification of circularity of the different measures towards CE, an added value is generated. When planning the urban regeneration, it became clear that design thinking and system thinking approach can help to develop business models for the regeneration of urban sites.

Ideally, a thorough stakeholder analysis can help to identify the stakeholders that are needed for the business model spcifications. Value will be created in the economic, social, as well as environmental pillar. Economic value will be created for different stakeholders such as real estate owners, planning teams and operator by activating an unused building. Social value will emerge by bringing together a community and offering events. Moreover, the identity of this location can be preserved. By reusing building materials and sharing assets on the areal, environmental benefits can be created.

The implementation of circular principles also requires a shift in business models. The most prominent business model are sharing platforms or products as a service, where light is for example rented instead of buying the infrastructure for light. Additionally, reused or recycled products can be used as the raw materials for the Düngerbau. In order to ensure the flexibility of the building, however, the physical connections between elements should gain special focus to ensure demountability.

5 DISCUSSION: DEVELOPMENT OF A CE MODEL FOR GREEN URBAN REGENATION PROJECTS

Based on the case study a method was developed and is presented that is based on four pillars:

- Determination of CE concept and alocation in the Circular Economy in Real Estate (CERE) model
- Choice of a method and a tool for the chosen CERE model
- Determination of data needed to measure the circularity, including stakeholders identifation
- Specification of business model by using Sustainable Business Model Innovation (SBMI) to specify all input needed.

Fig. 2: CERE model for urban sites

5.1 CE concepts

Based on an analysis of existing CE models, a new model tailored to the real estate lifecycle management was proposed [4]. Here, the principle should be allocated in the CERE model.

Principle	Description
Ressource Efficiency	Reducing Entropy and Optimizing operation
Regeneration	Improving the state of human and eco-logical systems through the use of renewable and healthy resources
Reduce	Restricting resource flows throughout the life cycle of buildings (Share, Reuse, Repair)
Decelerate/slow	Slowing down resource flows by intensifying use and extending useful life
Closing	Returning resources to the cycle at the end of their life
Cooperation	Fostering collaboration between supply chain actors
Digitalization	Efficient handling and systematic collection of information and data over the entire life cycle of a building to increase transparency, traceability and optimization of processes

Table 2: Basis of CE principles in CERE model [4]

Regeneration is one of the CE principles and is based on improving the state of human and ecological systems by using renewables and healthy resources.

5.2 Methods and tools

In practice, the circular economy encompasses a broad range of industries, from manufacturing and construction to fashion and electronics. It involves adopting innovative technologies, material recycling, reverse logistics, and sustainable procurement practices to close the loop on product lifecycles. This step involves choosing a method and a tool from real estate lifecycle which you would apply for your case. This step should be supported by giving the reasons for the choice and specification of the information need to use the tool and method. There are emerging tools and methods that can be explored. They differ in how to quantify the circularity of a proposed measure.

5.3 Measuring circularity

Beyond waste reduction, the circular economy seeks to regenerate natural systems. This includes promoting regenerative agriculture, reforestation, and sustainable land use practices to restore ecosystems and biodiversity. The urban developer should explain how he/she would measure the circularity of his/her project. It starts with listing the data needed to measure the circularity, which stakeholders are needed to involve, and which values are created in the project.

Table 3 shows emerging tools for measuring circularity. It will be interesting to explore further the relation between measures on the existing building stock and the materials, components, and buildings already in use and new constructions and their impact on the future life period of the urban site. In this sense, each urban development has two aspects to measure the circularity, a pre-use and post-use circularity. More work is needed to develop these methods further.

Tool	Developer	Description/Focus
Circularity score (SC)	RWTH Aachen University	Measures the circularity of materials and products, focusing on their lifecycle and reuse potential.
Concular Circularity Performance Index (CPX)	Concular	Evaluates the circular performance of building materials, emphasizing sustainable resource usage.
DGNB Circularity Index (DGNB CI)	German Sustainable Building Council (DGNB)	Assesses buildings for their circularity, including material recyclability and resource efficiency.
EPEA Circularity Passport Buildings (CP)	Environmental Protection Encouragement Agency (EPEA)	Certifies buildings on their circular design and construction, based on Cradle-to-Cradle principles.
IBO Disposal Indicator (EI)	Austrian Institute for Healthy and Ecological Building (IBO)	Quantifies the environmental impact of building materials at the end of life, promoting recycling.
Madaster Circularity Indicator (MCI)	Madaster	Tracks the circularity of building materials to improve waste management and recycling strategies
Urban Mining Index (UMI)	Bauhaus-Universität Weimar	Analyzes buildings as material reservoirs for future use, supporting the urban mining concept
Recycling Graph method	Schwede, D. and Störl, E. (2016)	Provides a method to calculate the potential for material recycling in construction projects
Circularity Index BBSR	Federal Institute for Research on Building, Urban Affairs and Spatial Development DE	Analyze the circularity of construction products in the German ÖKOBAUDAT database (Dräger et. Al. 2022)

Table 3: Emerging tools for measuring circularity

5.4 Sustainable Business Model Innovation (SBMI)

The circular economy is gaining global momentum, as various organizations, governments, and businesses actively pursuing circularity to tackle urgent environmental challenges, lower carbon emissions, and foster economic resilience in an increasingly resource-constrained world. The final step involves specifying the project`s business model. To achieve this, the SBMI framework can be utilized, requiring specific inputs.

These include defining the value creation process, identifying stakeholders and their roles in the project, and outlining the market opportunities for the business concept.

At the core of effective circular business innovation is design thinking, a methodology that emphasizes human needs, empathy, and collaboration. Design thinking encourages businesses to start with a deep understanding of user needs and aspirations, rather than relying solely on technical specifications or market trends. This empathy-driven approach helps businesses identify opportunities to create products and services that are not only sustainable but also valuable to their customers. Design Thinking is a human-centered approach to problem-solving that emphasizes empathy, creativity, and iteration. It involves understanding the needs and desires of users, brainstorming solutions, prototyping ideas, and getting feedback from users (Schön 1997). Design thinking also promotes a collaborative process, bringing together diverse stakeholders, including designers, engineers, marketers, and customers, to co-create innovative solutions. This cross-functional collaboration fosters a shared understanding of the problem and enables the development of solutions that address both environmental and human needs (Lawson 1997).

Once a sustainable business innovation has been identified and a CE concept has emerged, lean innovation provides a framework for rapidly prototyping, testing, and iterating on product or service ideas. This iterative approach helps businesses avoid costly mistakes in the later stages of development and ensures that their circular solutions meet the needs of both users and the environment.

The Lean Innovation Model was developed in 2014 with the aim to become a reference for a successful, coherent, and integrated implementation of lean thinking in innovation and product development. It considers, both the technical aspect that should be considered in lean product development process itself, as well as the ‘soft’ aspect which is indispensable for a successful implementation (LIM 2014).

6 CONCLUSION

This study contributes to the field by providing a practical application of CE in urban regeneration. It innovatively combines CE principles with urban redevelopment, showcasing how traditional "brownfield" sites can be transformed into sustainable, vibrant communities. This approach represents a significant shift from the linear economic model, offering a replicable model for sustainable urban development driven by Nature-based solutions.

In view of the comprehensive analysis of sustainable concepts at Uetikon Cantonal School, the introduction of a regeneration concepts, the lake water use concept and the digital building technology concept are pioneering measures. These initiatives not only reflect the idea of a circular economy, but also mark significant steps towards a future-orientated urban regeneration approach.

The integration of a CE models demonstrates a conscious use of resources and a clear positioning against the linear economy. The proposed method and tools not only offer efficient planning options, but also emphasise the emotional value of sustainability for the identity and history of the environment.

Nevertheless, our findings underline the effectiveness of this CERE model of energy generation and utilisation in the context of sustainability and the circular economy.

The implementation of a CE concepts often goes beyond technological progress and creates efficient, sustainable urban sites. The collaboration with stakeholders to actively participate in CE planning management emphasises the importance of a holistic planning experience.

This study contributes to the field by providing a practical application of CE in urban regeneration. It innovatively combines CE principles with urban redevelopment, showcasing how traditional "brownfield" sites can be transformed into sustainable, vibrant communities. This approach represents a significant shift from the linear economic model, offering a replicable model for sustainable urban development driven by Nature-based solutions. This research stands out in the realm of urban redevelopment by redefining the transformation of traditional brownfield sites. It extends beyond conventional approaches, exploring novel possibilities for real estate products.

7 REFERENCES

Allthings Technologies AG, Allthings, Blog. https://allthings.me/de, 2022.
Amt für Grundstücke und Gebäude des Kantons Bern. (2013). Richtlinie Systemtrennung. In German. «Guideline system separation»

Arbab, P., & Alborzi, G. (2022). Toward developing a sustainable regeneration framework for urban industrial heritage. Journal of Cultural Heritage Management and Sustainable Development, 12(3), 263-274.
Arbab, P., & Alborzi, G. (2022). Application of the Principles and Considerations of Urban Brownfields Redevelopment: An Abandoned Industrial Zone in Hakimiyeh Neighborhood of Tehran. Geographical Urban Planning Research (GUPR), 10(2), 165-188
Austrian Institute for Healthy and Ecological Building (IBO). IBO Disposal Indicator. Retrieved from https://www.ibo.at/en/building-material-ecology/lifecycle-assessments/ei-disposal-indicator. (Year).
Bauhaus-Universität Weimar. Urban Mining Index. Retrieved from https://urban-mining-index.de/en/, 2021.
Brand, S., How buildings learn—What happens when they are built. Viking Press. 1994.
Cappai, F., Forgues, D., & Glaus, M. 'A Methodological Approach for Evaluating Brownfield Redevelopment Projects', Urban Science, 2019.
Çetin, S., De Wolf, C. et al.: Circular Digital Built Environment: An Emerging Framework. Sustainability, 13(11), 6348. 2021.
Chowdhury, S., Kain, J.-H., Adelfio, M., Volchko, Y., & Norrman, J. 'Greening the Browns: A Bio-Based Land Use Framework for Analysing the Potential of Urban Brownfields in an Urban Circular Economy', Sustainability, 2020.
Concular. Circularity Performance Index. Retrieved from https://concular.de/circularity-performance-index/, 2022.
De Valck, J., Beames, A., Liekens, I., Bettens, M., Seuntjens, P., & Broekx, S. 'Valuing urban ecosystem services in sustainable brownfield redevelopment', Ecosystem Services, 2019.
Deksissa, T., Trobman, H., Zendehdel, K., & Azam, H. 'Integrating Urban Agriculture and Stormwater Management in a Circular Economy to Enhance Ecosystem Services: Connecting the Dots', Sustainability, 2021.
Deutsche Gesellschaft für nachhaltiges Bauen - DGNB e. V. DGNB System: Version 2023 für Neubauten. DGNB GmbH. https://www.dgnb.de/de/zertifizierung/gebaeude/neubau/version-2023, 2023.
Dorsey, J. W. 'Brownfields and Greenfields: The Intersection of Sustainable Development and Environmental Stewardship', Environmental Practice, 2003.
Dräger, P., Letmathe, P., Reinhart, L. et al. Measuring circularity: evaluation of the circularity of construction products using the ÖKOBAUDAT database. Environ Sci Eur 34, 13 (2022).
Dye, J., Top 10 Benefits of BIM in Construction. Autodesk Construction Cloud. https://construction.autodesk.com/resources/autodesk-bim-360/the-top-10-benefits-of-bim-in-construction/. 2023.
Ellen MacArthur Foundation. Growth Within: A Circular Economy Vision for a Competitive Europe; Ellen MacArthur Foundation: London, UK, 2015.
Environmental Protection Encouragement Agency (EPEA). Circularity Passport Buildings. Retrieved from https://epea.com/fileadmin/user_upload/5.0_News/C2C_Booklet_EPEA_PART_II_Gebaeude.pdf.
European Commission. Circular Economy Action Plan; European Commission: Brussels, Belgium, 2020.
European Commission. Communication to the European Parliament, the Council, the European Economic and Social Committee of the Regions. In Towards a Circular Economy: A Zero Waste Program for Europe; Document COM (2014) 398 Final; European Commission: Brussels, Belgium, 2014.
European Commission. Manifesto for a Resource-Efficient Europe; European Commission Memo 12/989; European Commission: Brussels, Belgium, 2012.
Ewz, Elektrizitätswerk der Stadt Zürich. from https://www.ewz.ch/de/geschaeftskunden/immobilien/referenzen-projekte/seewasserverbunde-zuerichsee.html. In German. 2023.
Ferber, U. 'Circular flow land use management', International Conference Virtual City and Territory, 2011.
Geisendorf, S.; Pietrulla, F. The circular economy and circular economic concepts: A literature analysis and redefinition. Thunderbird Int. Bus. Rev., 60, 771–782. 2017.
German Sustainable Building Council (DGNB). DGNB Circularity Index. Retrieved from https://www.dgnb.de/en/nachhaltiges-bauen/zirkulaeres-bauen/building-resource-passport, 2023.
Govindan, K., & Hasanagic, M., A systematic review on drivers, barriers, and practices towards circular economy: A supply chain perspective. International Journal of Production Research, 56(1–2), 278–311, 2018
Guerra, B. C., Shahi, S., Mollaei, A., Skaf, N., Weber, O., Leite, F., & Haas, C., Circular economy applications in the construction industry: A global scan of trends and opportunities. Journal of Cleaner Production, 324, 129125. 2021.
Impact Hub Lausanne, Home. Impact Hub Lausanne. https://lausanne.impacthub.net/. 2023.
ISO 20887:2020. ISO. https://www.iso.org/standard/69370.html. 2020.
Junge Tüftler. (2023). Retrieved from https://junge-tueftler.de/wir. 2023.
KITRO, Wie funktioniert KITRO? Unsere Lösung. https://www.kitro.ch/product, in German. 2023.
Kyrö, R. K., Share, Preserve, Adapt, Rethink – a focused framework for circular economy. IOP Conference Series: Earth and Environmental Science, 588(4), 042034. 2020.
Lawson, B., How Designers think, Routledge. 1997.
LIM, Lean Innovation Model, https://lean-analytics.org/lean-innovation-model/, 2014.
Madaster. Madaster Circularity Indicator. Retrieved from https://madaster.com/inspiration/madaster-circularity-indicator/.
"Masterplan." Chance Uetikon. https://www.chance-uetikon.ch/planungsrecht/masterplan/. 209.
Merz, H., Gebäudeautomation Kommunikationssysteme mit EIB/KNX, LON und BACnet. München, Germany: Carl Hanser. 2016.
RWTH Aachen University. Circularity Score. Retrieved from https://www.rb.rwth-aachen.de/cms/rb/forschung/forschungsprojekte/~yekba/circularity-score/.
Schön, D. The reflective practicioner. How Professionals Think In Action, Basic Books.1997.
Schwede, D. and Störl, E. 'Methode zur analyse der Rezyklierbarkeit von Baukonstruktionen', Bautechnik, 94(1), pp. 1–9, 2016.
Suter, M. and Jeanfavre, E. Circular Community Hub @ Chance Uetikon, Semester work in module Circular Economy Management of the MSc programme REFM at ZHAW. 2023.
Tapaninaho, R., & Heikkinen, A., Value creation in circular economy business for sustainability: A stakeholder relationship perspective. Wiley Online Library. https://onlineli-brary.wiley.com/doi/abs/10.1002/bse.3002. 2022.
Wagner, H. G., Facility Management: Handbuch für Studium und Praxis. München, Germany: Verlag Franz Vahlen. 2018.
World Economic Forum, Towards the circular economy: accelerating the scale-up across global supply chains. http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf, 2014.