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Globally responsible urban and economic development: Municipal Approaches to Circular Economy

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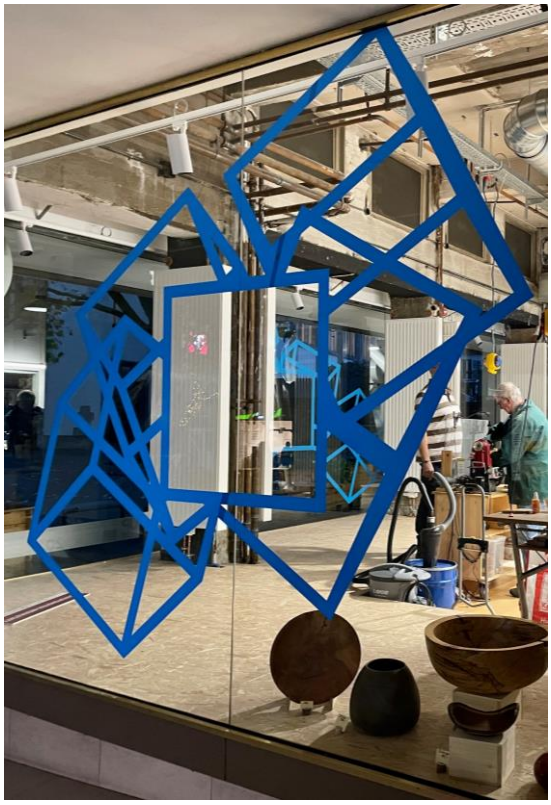
Highlights



- There is increasing research and discussion about *circularity* and the *circular economy*. However, global implementation is declining.
- At the municipal level, there are various approaches to implement a circular economy: from *Circular* to *Zero Waste* to *Fab Cities*.
- The differences among the three approaches lie in their spatial distribution, goals, admission criteria, and monitoring.
- While *Circular Cities* and *Zero Waste Cities* already have binding monitoring approaches in place, these are still lacking for *Fab Cities*.
- The ERDF project "FAB.Region Bergisches Städtedreieck" is driving transformation processes towards a co-creative, sustainable circular economy as Germany's first Fab Region.

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Keywords:

Circular Economy; *Fab City*; *Circular City*; *Zero Waste City*; Economic development; Municipality

1 Introduction

Earth Overshoot Day was reached this year on August 1, 2024 – one day earlier than last year. This means that by that date humanity had already exceeded the planet's biocapacity for the entire year. By May 2, 2024, Germany had exhausted its resource budget for the entire year 2024. These figures are calculated annually by the Global Footprint Network (2024). To align planetary boundaries with human needs, resource consumption (including energy, housing, transportation, food, textiles, and leisure) must be drastically reduced. In recent years, the concept of circular economy (see also Szabó-Müller & Angstmann, 2023) has gained importance worldwide – both in scientific publications and in political strategies (Kirchherr, Reike & Hekkert, 2017). As early as 2012, the German Federal Government launched the German Resource Efficiency Program (ProgRess), which has been updated three times until 2023, among other things to promote the circular economy. The German Sustainability Strategy includes the circular economy in the context of the Sustainable Development Goals (SDGs 8, 9, and 12) as one of six transformation areas to decouple economic growth from resource consumption and ensure that consumption and production take place within planetary boundaries (The Federal Government, 2021). Despite this, the actual circularity of the global economic system continues to decline, from 9.1 % in 2018 to 7.2 % in 2023 (Circle Economy Foundation, 2024).

The previously dominant linear economy of production, use, and disposal is partly responsible for several socio-ecological crises, such as climate change, species extinction, resource scarcity, and pollution (Kranert, 2017). To reverse this trend and transition from a linear to a circular economy in Germany, there are now a number of European and German funding programs for businesses, local authorities, research institutions, and the civil society: for example, the European Regional Development Fund (ERDF), the German Federal Ministry of Education and Research (BMBF), the German Federal Ministry for Housing, Urban Development and Building (BMWSB), and the German Federal Ministry for Economic Affairs and Climate (BMWK). From these and beyond, municipal and regional networks and strategies have developed: from the *Netzwerk Ressourceneffizenz (NeRess)* (transl.: Resource Efficiency Network), which primarily addresses the economy, to *Global Sustainable Municipalities,* which implement the principles of the doughnut economy, to *Circular Cities* and *Zero Waste Cities,* which will be discussed in more detail later in this article. Since 2014, Barcelona has been the first *Fab City* in the global Fab City Network, which now includes not only cities, but also regions, islands, and entire countries, with the ambitious goal of producing almost everything they consume by 2054. With the ERDF project “FAB.Region Bergisches Städtedreieck”, the cities of Wuppertal, Remscheid and Solingen want to become Germany's first Fab Region in 2024, alongside the German Fab Cities of Hamburg and Augsburg. A regional ap-

proach seems desirable because not all products we use nowadays can be manufactured and processed at the municipal level. In this article, we look at what a sustainable circular economy is, what municipal concepts there are (*Circular Cities, Zero Waste Cities, Fab Cities*), and what goals and measures they pursue.

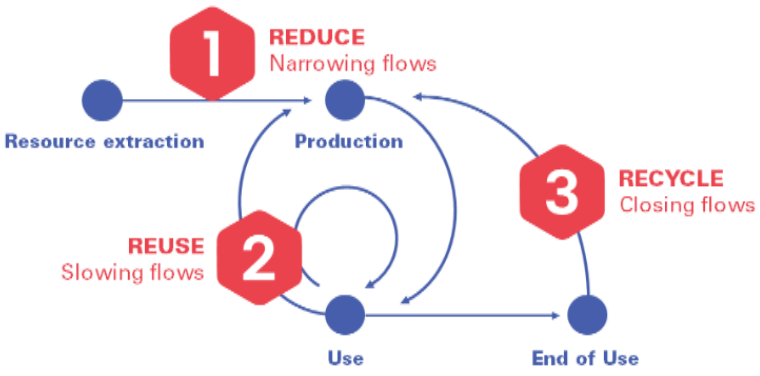
2 Circular Economy: understanding, legal framework and the scope for municipal action

In this article, we intentionally utilize the term "circular economy" (CE; zirkuläre Wirtschaft). In German, the term "Kreislaufwirtschaft" is frequently employed as a synonym, though in Germany it is associated with the Waste Act, which has been designated the "Kreislaufwirtschaftsgesetz" since 1994 (see Affolderbach & Schulz, 2024). Therefore, the term "Kreislaufwirtschaft" is associated more with recycling and *end-of-life* solutions rather than a comprehensive transformation of the economic system using additional R-strategies, which will be explained in more detail in the following chapter.

2.1 Understanding the circular economy

The circular economy can be classified within the concepts of industrial ecology and industrial metabolism (Ayres & Ayres, 1996). Life Cycle Assessments (LCA) serve as a database to determine the material and energy requirements of a product throughout the entire production and recycling process (Affolderbach & Schulz, 2024). The goal of CE is to use as few new resources as possible and to generate no waste through closed material and substance cycles (Affolderbach & Schulz, 2024). The overarching three R-strategies "Reduce, Reuse, Recycle", which can also be further differentiated into 10 R-strategies, describe different approaches to implementing a CE (Potting et al., 2017). Figure 1 shows where in the life cycle of a product the R-strategies are applied.

Figure 1: R-strategies along the product life cycle (own illustration)



The R-strategies are hierarchically related to each other, as they have different sustainability impacts (Potting et al., 2017).

1. ***Reduce***: Reduction has the strongest sustainability impact because it is directly aimed at minimizing resource consumption and waste generation. By reducing consumption and producing more efficiently, fewer raw materials are needed, significantly reducing environmental impact and footprint. Therefore, reduction should always be considered as the first step. As example serves optimizing packaging by using less material and eliminating unnecessary layers of packaging.

2. ***Reuse***: Reuse ranks second because it reduces the need for new products and raw materials by using existing goods for as long as possible. Reuse extends the lifespan of products and avoids the expenditure of energy and resources that would be required to produce new products. The sustainability impact is high, but lower than that of reduction as resources are still needed for maintenance and logistics. For example, beverages are offered in reusable glass bottles instead of disposable plastic bottles.

3. ***Recycle***: Recycling has the lowest sustainability impact among the three strategies, but it is still essential. It provides a way to return materials to the production cycle at the end of their life, thereby reducing the need for primary raw materials. However, recycling is more energy and resource intensive than reduction and reuse as the process itself consumes resources and not all materials can be fully recycled. For example, the separate collection and recycling of waste paper reduces both the demand for virgin fiber and the amount of paper waste that is incinerated or landfilled.

Overall, the three strategies should be viewed as complementary measures in a circular economy, working together to use resources efficiently and minimize waste. *Reduce* is the most effective approach, followed by *Reuse* and finally *Recycling*.

To design material and product life cycles in a circular manner, different levels, actors and perspectives must be addressed and connected simultaneously. On the production or supply side, this includes individual companies with their business models and products and extends also to regional ecosystems and global supply chains (Affolderbach & Schulz, 2024). By-products and waste materials from one industry can serve as resources for another. Supportive networks and collaborations are needed to drive transformation vertically along supply chains and horizontally across different industries (Korhonen et al., 2018). An understanding of economic ecosystems is important to consider the complex interrelationships and synergy potentials between businesses, politics, science and civil society actors (Aarikka-Stenroos et al., 2021). In this way, material flows, product life cycles and business activities can be jointly optimized and coordinated across different industries (Affolderbach & Schulz, 2024).

In addition to production, consumption, i.e. the demand side, is also crucial for the circular economy (Affolderbach & Schulz, 2024). Aligning resource consumption with planetary boundaries requires not only resource efficiency and consistency, but also an absolute reduction in resource consumption through sufficient lifestyles. Therefore, issues of overconsumption and wastage must also be discussed in wealthy countries – such as Germany.

The circular economy offers significant potential for sustainable regional development by aligning economic growth with the protection of global ecosystems and the compliance with human rights through the global responsibility of companies (Aarikka-Stenroos et al., 2021; Velenturf & Purnell, 2021; Korhonen et al., 2018). However, the actual sustainability impact of CE activities varies depending on the prioritization and implementation of circular economy strategies. The broad and inconsistent definition of circular economy in economy, politics, and science can lead to greenwashing and dilution of its sustainability potential (Korhonen et al., 2018; Velenturf & Purnell, 2021). Furthermore, savings in one area can lead to increased consumption in another (rebound effects) (Braun & Schulz, 2023). It is also not universally true that local or regional products are always more sustainable than globally traded ones, as resource savings in transport may be offset by higher consumption in production (Braun & Schulz, 2023). Therefore, an indicator and monitoring system is essential to make the implementation status and progress of a regional circular economy visible and to develop appropriate funding and support measures (Elia, Gnoni & Tornese, 2017). Since a sustainable circular economy is still a relatively new goal in economic and regional development, systematic data on circular production, resource use, or consumption within a municipality or region are still lacking. Therefore, an important first step in establishing and measuring progress of the circular economy in urban, regional or economic development is the development of relevant indicators and the collection and gathering of corresponding data.

2.2 Legal framework

The transition to a circular economy has been legally anchored for several years. Since 2015, the EU has adopted several waste-related regulations under the *Circular Economy Action Plan* as part of the European Green Deal. EU regulations apply directly to all EU member states upon entry into force, while EU directives must first be transposed into national law. The main EU regulations promoting a circular economy are listed in Table 1.

Table 1: EU regulations for a circular economy (own illustration)

Regulation	Introduction	Description
EU Corporate Sustainability Due Diligence Directive (CSDDD)	CSDDD was adopted by the Council on April 24, 2024	CSDDD obliges companies to comply with human rights and environmental due diligence obligations and to implement a climate plan. It is incumbent upon companies to maintain vigilance over both the upstream supply chain, encompassing activities such as raw material extraction and production, and, to a limited extent, the downstream supply chain, which includes transportation to end customers.
EU Taxonomy Regulation	in force since January 01, 2022	It provides an EU-wide system for classifying sustainable economic activities. An activity complies with the taxonomy if it makes a significant contribution to at least one of the defined environmental objectives and does not significantly harm any of them. This ensures that investments are made in projects that contribute to the circular economy by promoting sustainable and resource-efficient practices.
Ecodesign for Sustainable Products Regulation (ESPR)	came into force on July 18, 2024.	It does not impose requirements on the products themselves. It only provides criteria for new product regulations, which will be issued in the form of subordinate product-specific regulations, and sets criteria that cover the entire life cycle, including material efficiency, durability, reparability, reuse, and carbon and environmental footprints.
EU Directive on the "right to repair"	came into force on July 1, 2024. The member states are required to integrate the regulation into their respective national legal systems by July 21, 2026.	The Directive requires manufacturers to repair their products at reasonable prices and within a reasonable time after the legal warranty period. Consumers are given access to spare parts and repair information, and incentives such as vouchers and subsidies for repairs are created. This applies to – Household washing machines and dryers, (EU) 2019/2023 – Domestic dishwashers, (EU) 2019/2022 – Refrigerators, (EU) 2019/2021 – Electronic displays (e.g. monitors, televisions), (EU) 2019/2021 – Welding equipment, (EU) 2019/1784 – Vacuum cleaners, (EU) No 666/2013 – Servers and data storage products, (EU) No 2019/424 – Smartphones, mobile phones, cordless phones, tablets, (EU) 2023/1670 – Domestic clothes dryers, (EU) 2023/2533 – Batteries for light-duty vehicles, (EU) 2023/1542 (EVZ, 2024)

These legal frameworks support the implementation of circular economy principles and help align economic development with environmental and social goals. However, the increasing focus on sustainability and circularity in EU legislation also poses risks. Rising *compliance costs* and operational adjustments place a disproportionate burden on small and medium-sized enterprises, potentially leading to further market concentration. Additionally, there is a risk that companies may shift their production to less regulated markets outside Europe and maintain their unsustainable, linear business models there.

2.3 The municipality as a space for action

Municipalities play a critical role in the transition to a sustainable and circular economy. As centers of economic activity, cities have a high throughput of resources in terms of *inputs* (resources) and *outputs* (waste and emissions), overloading global ecosystems. Cities are responsible for about 75 % of global resource consumption, 60-80 % of global greenhouse gas emissions, and about 50 % of global waste generation (UNEP, 2019; ICLEI, 2020). Therefore, transforming cities towards a circular economy is essential to reduce environmental impacts and ensure global sustainable development. Following the motto "think globally, act locally", decisions and actions at the municipal level should always be aligned with the goal of global sustainable development. In addition, many areas of a circular economy, such as waste management, energy supply, transport and housing, are already mandatory for municipalities as part of public services. Many approaches are in place, but they need to be adapted and linked more closely in the spirit of circularity.

A holistic transformation towards a sustainable circular economy requires not only individual economic actors, but also their relationships with each other and with other social organizations. According to Hill (2020, p. 214), five groups of actors within the "penta-helix" are crucial at the local level and need to be linked in a circular economy "ecosystem": capital, businesses, knowledge, civil society and administration/politics. With this circular economy ecosystem perspective, the interrelationships of system components and actors can be considered and context-specific coordination mechanisms for shaping a municipal circular economy can be developed (Aarikka-Stenroos et al., 2021). The agency of an individual actor depends on its role and position within the ecosystem, which may vary depending on the material flow under consideration (ibid.). Interdependencies among ecosystem actors arise from kinship, physical connections, resource specificity, shared institutional logics, value propositions and purposes, and cognitive affiliation or technological complementarity (ibid.). Physical, spatial, technological, economic, and cognitive interactions can enhance or diminish an actor's agency (ibid.). Central actors function from their position as the "hub" or "orchestrator" of an ecosystem with special shaping capabilities. The ecosystem perspective also allows for a view of functional-spatial relationships that are crucial for a circular economy. Affolderbach & Schulz (2024) identify the following aspects as important for a circular economy:

- A material flow management system that controls material and product flows at an inter-company level, promotes new cooperation and supply relationships, and works across industries.

- The creation of new markets for new/alternative product components and services, e.g., in the areas of manufacturing logistics, production technology, as well as in cooperation with maintenance and repair services.

- The need for new infrastructures, e.g., for the storage of reusable building materials or to promote industrial symbioses through so-called eco-industrial parks.

A circular economy can have several economic impacts at the local level, such as on labor markets, investments, and value creation. It promotes the creation of skilled jobs in the craft sector and requires public and private investment in infrastructure, research and education. Circular approaches often lead to a re-regionalization of production systems and supply chains (Affolderbach & Schulz, 2024).

3 Municipal approaches for implementing a circular economy

To implement a circular economy at the municipal level, various concepts have emerged, each following its own approach and forming supra-regional or even global city networks. Below, we present three concepts: *Circular Cities*, *Zero Waste Cities*, and *Fab Cities*, compare their main features and approaches, and provide implementation examples.

3.1 Circular Cities

The *Circular Cities Network* currently includes 83 European cities (as of August 2024) that have signed the 2020 *Circular Cities Declaration* (CCD, 2024). The network is coordinated by ICLEI (*Local Governments for Sustainability in Europe*) and aims to support local governments in implementing the European Green Deal. To this end, ICLEI, together with other network partners, supports *Circular Cities* with networking and information events, individual advisory services and financial resources.

The *Circular Cities Declaration* (CCD) defines a *Circular City* as follows:

> "A *Circular City* is one that promotes the transition from a linear to a circular economy in an integrated way across all its functions in collaboration with citizens, businesses and the research community. This means in practice fostering business models and behaviour which decouple resource use from economic activity by maintaining the value and utility of products, components, materials and nutrients for as long as possible, in order to close material loops and minimise harmful resource use and waste generation".

By signing the *CCD*, cities commit to applying the available levers in a coherent way across the organization, based on ten criteria (see Table 2, p. 11). These commitments do not include quantifiable metrics, allowing *Circular Cities* flexibility in implementation. However, *ICLEI* will review the submitted reports to ensure that cities meet the criteria and maintain a certain standard of quality. The two *Circular*

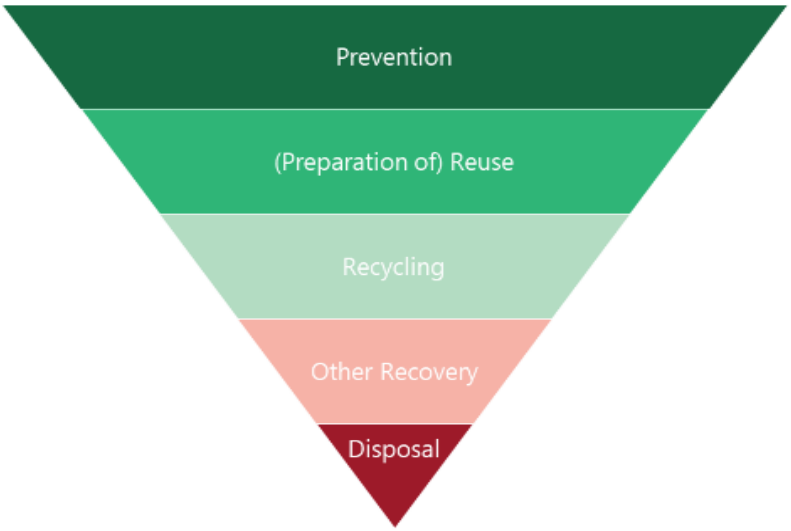
Cities Declaration Reports published so far, from 2022 and 2024, make the progress of *Circular Cities* publicly available on the website.

3.2 Zero Waste Cities

Zero Waste Cities exist all over the world. For European *Zero Waste Cities*, the non-profit environmental organization *Zero Waste Europe* (ZWE), founded in 2013, serves as the umbrella organization (ZWE, 2024a). It organizes campaigns, events, and publications, and has developed a unified certification system for *Zero Waste Cities* in collaboration with the *Mission Zero Academy*. Currently, there are over 450 European *Zero Waste Cities*, including many small and medium-sized municipalities (ZWE, 2024b). Since the certification process was only introduced in 2021, the number of certified municipalities is significantly lower: as of August 2024, there are nine certified *Zero Waste Cities* and twenty candidate cities that have begun the certification process.

The *Zero Waste* approach is based on the waste hierarchy (Figure 2), with waste prevention at the top (UBA, 2022). In this context, "zero waste" is more accurately understood as "zero wastage" (Koop, 2022). The goal is to significantly reduce waste in a municipality and to engage as many stakeholders as possible, including civil society. To achieve this, different *Zero Waste Cities* implement a variety of measures, depending on the specific conditions of the municipality.

Figure 2: Waste hierarchy based on EU Directive 2008/98/EC



The certification process consists of five steps:

1. **Expression of Interest:** Submitted by the municipality to the members of *Zero Waste Europe* (ZWE) and *Mission Zero Academy*.

2. **Commitment:** The municipality attains the status of a *Zero Waste Candidate City* and must develop and present its own certification roadmap according to **the required criteria** (see Table 2, p. 11) (MiZA, 2024).

3. **Implementation:** The municipality has a maximum of two years to complete the certification assessment and submit evidence for formal review to become certified.

4. **Certification:** After a successful third-party evaluation focused on performance levels and impacts based on the certification criteria, the candidate community becomes a certified *Zero Waste City*.

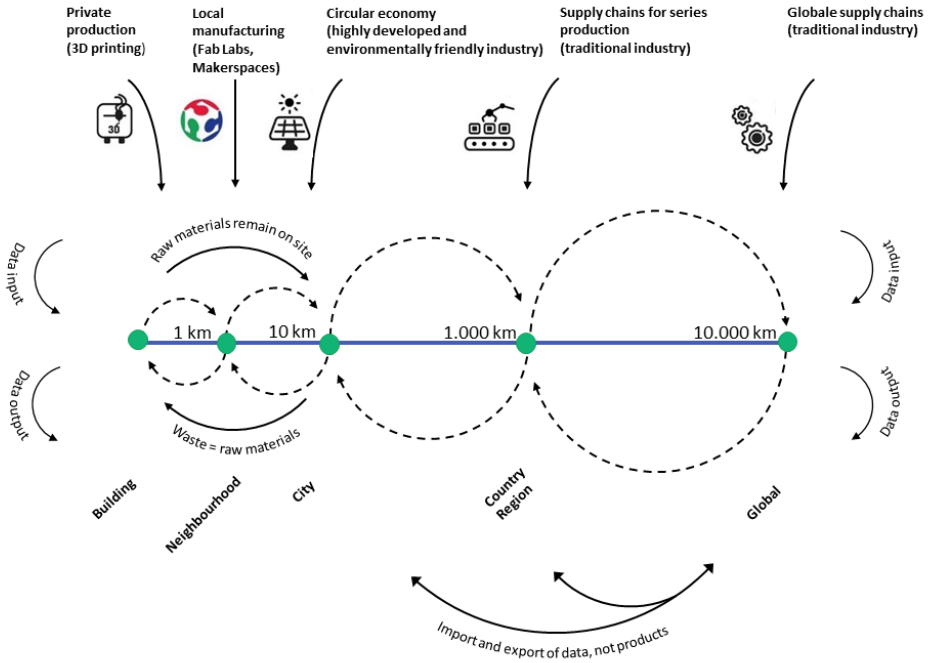
5. **Annual Improvements:** Once certified, the community must make annual improvements to monitor and improve results. A reassessment takes place every three years to confirm certification status. There is an opportunity to advance within a 5-star system.

3.3 Fab Cities

As the world's first *Fab City*, Barcelona called on other cities, regions, islands and countries to join the Fab City Initiative in 2014. Supported by the IAAC, *MIT's Center for Bits and Atoms* (CBA), and the *Fab Foundation*, the initiative aims to achieve the ambitious goal of producing (almost) everything they consume within their respective municipality by 2054 – Barcelona's mayor mentioned at least 50 % in 2014 (Diez, 2016; Fab City Global Initiative, 2024).

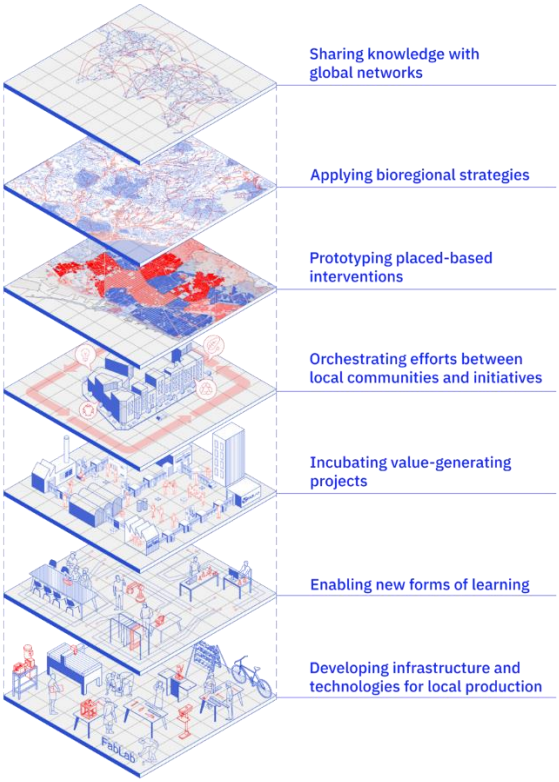
In 2016, Thomas Diez published the *Fab City White Paper* (Diez, 2016), which outlines the initiative's goal of developing a new socio-economic model based on a radical local *Circular Economy*. With the motto “from PITO (*products in, trash out*) to DIDO” (*data in, data out*), *Fab Cities* aim to replace the linear production and value creation model currently dominant in the Global North with open source-principles and decentralized, local production. By creating as closed material loops as possible, the material inputs or outputs of a city (or a region, island, or country) are to be minimized, while simultaneously strengthening the close immaterial exchange of knowledge and data among members of the *Fab City Network*.

Figure 3: Rescaling global production networks (own illustration according to Diez, 2016, 5)



Based on this, the *Fab City Full Stack* (see Figure 4) was developed in 2022 as a strategic framework that combines local specifics with global conditions. The *Fab City Full Stack* envisions coordinated action across seven levels: from small-scale, decentralized production in *Fab Labs* to global networking within the *Fab City Global Initiative*. This multi-scalar, ecosystemic approach aims to achieve the most comprehensive and long-term urban transformation possible.

Figure 4: Seven layers of the Fab City Full Stack (Fab City Foundation, 2022a)



The two central components of *Fab Cities* are the digital operating system, which provides open source data worldwide for production development for the *Fab City* community, and the *Fab Labs*, where the production of physical goods takes place at the local level (Jennewein & Seidel, 2022). Diez (2016) describes the latter more comprehensively with the term "*manufacturing infrastructure*". A typical FabLab is equipped with a 3D printer, CNC milling machines, and laser cutters, although fab labs can also specialize in specific fields. For example, there are textile, plastics, food and bio labs.

Every year, new local authorities join the Fab City Network according to the criteria listed in Table 2. The Bergisch City Triangle (consisting of the three cities Wuppertal, Remscheid and Solingen, in German Bergisches Städtedreieck) region is set to become the first German Fab Region within the Fab City Network. By doing so, the local authorities commit to making efforts and providing resources to achieve the goal of material self-sufficiency by 2054, to implement circular economy strategies for relocalizing production, and to promote the technological competence of citizens (Fab City Foundation, 2022b).

Currently, there is no monitoring and evaluation of the implemented projects. Additionally, questions arise about what happens after project funding ends, especially for those projects that were included as Fab Cities but do not continue activities post-project. Meanwhile, these local authorities still appear on the network's

homepage and are considered active members, even though no visible activities are taking place.

3.4 Comparing the approaches

The three concepts presented – *Circular Cities*, *Zero Waste Cities*, and *Fab Cities* – all aim to implement the transition to a circular economy at the municipal level. Table 2 provides an overview of the relevant features of the three municipal concepts.

Table 2: Comparing Circular Cities, Zero Waste Cities and Fab Cities (own compilation)

	Circular Cities	**Zero Waste Cities**	**Fab Cities**
Level of implementation	Cities and metropolitan regions	Municipalities (both large cities and small municipalities)	Cities, regions, islands, countries
Spatial distribution	Europe	Global	Global
Organizing institution	ICLEI - Local Governments for Sustainability (global association of cities, municipalities and counties for environmental protection and sustainable development)	Zero Waste Europe (non-profit environmental organisation for European municipalities)	Fab City Global Initiative as a subsidiary of the Fab Foundation (a foundation for the dissemination and support of Fab Labs & global knowledge exchange)
Year of foundation	2020	2013	2014
Number of members (As of: August 2024)	83	9 certified, 20 in certification process, more than 400 other not-certified	38 cities, 11 regions, 2 countries, 1 island
Examples from Germany	Aachen, Berlin, Frankfurt am Main, Freiburg im Breisgau, Haar	Kiel (certified), Leipzig und München (in the certification process)	Hamburg, Augsburg, Bergisches Städtedreieck (in preparation)
Selection of international examples	Amsterdam, Brügge, Glasgow, Kopenhagen, …	Bled, Borovnica, Gorje & Vrhnika, Slovenien; Capannori, Italien; Torreles de Llobregat, Spanien (certified)	Amsterdam, Barcelona, Ljubljana, Montreal, Oulu, Paris, São Paulo, Seoul, Shenzen…
Cities that implement multiple concepts	*Circular* and *Fab*: Amsterdam*, Paris*, Ljubljana, Oulu *the *Circular City* approach is implemented at metropolitan region level, while the Fab City approach is implemented at municipal level		
Objective	Holistic transformation to a circular economy; implementation of the European Green Deal at municipal level	Focus on waste prevention and reduction based on waste hierarchy	Material self-sufficiency of the municipality etc. by 2054 through a combination of globally networked digital infrastructure and local production
Admission criteria	10 criteria: 1. definition of clear goals & strategies for a CE	4 criteria: 1. public statement	3 criteria: 1. letter of commitment

	2. sensitization of administration, citizens & companies 3. involvement of local interest groups to promote circular business models 4. anchoring CE principles in urban planning, infrastructure & asset management procedures 5. use public procurement to promote CE products & services 6. economic incentives and tax measures 7. promotion of a CE-supportive legal framework for secondary materials, repair, reuse & sharing programs 8. cooperation with national and European level 9. monitoring system 10. reporting to ICLEI	2. declaration of commitment with quantitative waste reduction targets per inhabitant and year with the long-term goal of generating only 10% of the previous total amount of waste 3. gradual reduction of waste incineration 4. measures to increase awareness of *zero waste*	signed by public authority, 2. one-minute audition video, 3. *"Pledge"* at the *Fab City Summit*
Monitoring	Yes, via reporting obligation to ICLEI and biennial overall report on *Circular Cities*	Yes, via annual reporting obligation to *Zero Waste Europe* or *Mission Zero Academy*	Not yet

The differences between the three concepts mainly lie in their spatial distribution or reach, goals, admission criteria, and monitoring.

While *Circular Cities* and *Zero Waste Cities* are implemented only at the municipal level, the *Fab City* approach is pursued at the regional or even national level. *Zero Waste Cities* and *Fab Cities* are widespread around the world, while *Circular Cities* have only been implemented in European cities. The *Zero Waste Cities* approach is followed by the largest number of municipalities, including many small municipalities, although a large proportion of these municipalities are not certified. *Circular cities* are also widely implemented, including European capitals such as Tirana, Prague, Helsinki, Berlin, Budapest, Oslo and Ljubljana, as well as the metropolitan regions of Paris and Copenhagen. The smallest number of cities have joined the *Fab Cities* initiative. Four cities are implementing both *Circular Cities* and *Fab Cities* approaches: Amsterdam, Ljubljana, Oulu and Paris. Examples of applications for each of the three concepts can be found in German municipalities.

The *Circular Cities* initiative has already developed a very comprehensive approach to achieving its goals, addressing both production and consumption systems together, involving a wide range of municipal actors, and considering financial, economic and legal frameworks. However, it is the *Zero Waste Cities* approach that has the greatest potential to save resources, as its goal of reduction and prevention, as

described in Chapter 2, has the greatest impact on sustainability. In addition, the more specific approach of *Zero Waste Cities* allows for consistent monitoring based on measurable targets, making the progress of a city's transformation to a CE more transparent. Therefore, *Zero Waste Cities* are required to collect and evaluate waste-related data. This makes success concrete and measurable, and the data must be submitted annually for review. *Circular Cities* are also required to develop a monitoring system for their circularity and report the results to ICLEI annually. Only *Fab Cities* currently have no mandatory monitoring or reporting. To make *Fab City* activities measurable and evaluable, a *Fab City Index* is being developed (Boeing, 2024). However, suitable metrics and data are currently lacking.

According to existing literature, *Fab Cities* have the potential to make a significant contribution to the sustainable transformation of value chains by strengthening local production (Krenz et al., 2024; Jennewein & Seidel, 2022). Krenz et al. (2024) see opportunities for narrowing value chains by recycling raw materials, avoiding overproduction, reducing transportation, and involving regional actors. They propose combining production at the point of need, the inclusion and use of local resources in production processes (machines, actors, materials), and a focus on local needs to fully exploit the potential. However, it is noted that local production is not inherently sustainable and not all products can be produced locally. Often, locally produced goods and small-scale production are more expensive. For a sustainable production policy, such products would need to be affordable for all social groups (Jennewein & Seidel, 2022). In addition, it is unclear whether a complete shift away from mass production, with its efficiency benefits and economies of scale, makes sense, while the global consequences are unpredictable. It may be that wealthier countries in particular would benefit from local production, as they have the necessary technical and skills resources.

Despite these challenges, Fab Cities have the potential to transform the current system into a more environmentally friendly and socially just one, provided there is sufficient coordination of action at the global level (Krenz et al., 2024).

4 Outlook: FAB.Region Bergisches Städtedreieck

The "FAB.Region Bergisches Städtedreieck" project (https://www.fab-bergisch.org/) aims to become Germany's first Fab Region. The Fab City approach will be extended to the region to better consider the regional ecosystem with its existing market relations and networks. The three-year project is funded by the European Regional Development Fund (ERDF) through the European Union and the state of North Rhine-Westphalia. Since January 1, 2024, the Institute for Work and Technology (IAT) has been working in a consortium with the Bergische Struktur- und Wirtschaftsförderungsgesellschaft (regional economic development agency), the Wuppertal Institute for Climate, Environment and Energy, the Collaborating

Centre on Sustainable Production and Consumption (CSCP), the University of Wuppertal, and three innovation labs: "Gut Einern" in Wuppertal, "Gläserne Werkstatt" (operated by the Solingen City Development Corporation) in Solingen, and "Gründerschmiede" in Remscheid. Together with regional actors from business, civil society and academia, the project aims to drive the transformation of the Bergische City Triangle towards a co-creative, sustainable circular economy.

The Bergische City Triangle has a total population of over 630,000 and is a major industrial region in western Germany. Historically shaped by metal processing, mechanical engineering, and the textile industry, the Bergische City Triangle remains a central economic hub in North Rhine-Westphalia. Today, the region faces the challenge of modernizing its traditional economic structure and making it more sustainable without the possibility of providing new space for companies. The transition to a circular economy, in which resources are used and reused efficiently, is a central goal. This transformation is supported by various initiatives and projects that promote both innovation and cooperation between companies, research institutions and public bodies. For example, there are joint institutions such as the Bergische Struktur- und Wirtschaftsförderungsgesellschaft and the Neue Effizienz gGmbH as the "Bergische Gesellschaft für Ressourceneffizienz mbH", as well as the Circular Valley Initiative, which connects regional companies with international start-ups to promote a circular economy.

Based on these existing networks and approaches, the *Fab Region* project is oriented towards the regional challenges and needs of economic actors. The project develops co-creative learning formats to raise awareness and activate stakeholders along the entire supply chain towards a circular economy. The three innovation labs serve as complementary test pilots, each addressing different industries and target groups – from producers to consumers.

The Institute for Work and Technology (IAT), together with the Wuppertal Institute, is responsible for the scientific support of the *Fab Region*. Based on a comprehensive ecosystem analysis, the institutes develop a strategic action plan for a sustainable circular economy, which forms the framework for the project. Using scenario analysis, they will identify options for regional actors under different macroeconomic and global conditions. Finally, a catalogue of measures with measurable goals will be developed to ensure the long-term implementation of the project objectives. The researchers place special emphasis on the environmental impact and sustainability potential of the *Fab Region* approach. Through a global exchange between Fab Cities, regions, islands and countries, the knowledge gained in the project will be shared and discussed with the *Fab Community*. In this way, the project can contribute to the development of stricter admission criteria and the introduction of monitoring systems to ensure sustainability benefits within the *Fab City* network.

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