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# Towards solutions and infrastructure for circular neighbourhoods in rural areas

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**Abstract.** Recently, there has been an increase in circular cities and research on the concrete meaning of circularity at the city mesolevel. However, circular solutions or requirements for rural areas are often overlooked. This can be explained by the dominant deterritorialized and sectoral approach in circularity research, policy, and practice, which isolates places, people, and practices. The point of departure of our study is that circular cities can only thrive if their related rural areas are healthy, as they are interdependent. Within this context, we develop a framework that contributes to the conceptualisation of circular neighbourhoods and infrastructure in rural areas. We use a literature review to build on the findings of circularity research in Japan, Belgium, Finland, and Norway, and distil predefined categories for deductive analysis. We validate the deductive analysis by a further inductive analysis of the literature. Our review focuses on how the existing built environment (buildings, roads, and other infrastructure) can increase the vitality of rural areas to enable rural circularity practices (RCPs). In addition, we propose new directions for future research on circular neighbourhoods in rural areas, preferably in symbiosis with circular cities.

## 1. Introduction

Circularity has recently become an emerging concept in sustainability practice, science, and policy [1]. The concept, although contested, can be designed and analysed at different scales, from the individual business to the regional or global scale [2]. One of the growing branches within the circularity discourse is research on circular cities, which includes various imaginations and perspectives, implementation strategies, resource governance, and the role of local governments and other stakeholders [3-5]. Within this context, there is a need to consider the role of space as a resource that can hinder or enable urban circularity practices [6,7]. Space can be interpreted in different ways. Drawing on a concept from sustainability transitions and socio-technical system studies [8,9], space can refer to six different aspects. Firstly, space, or location, refers to the proximity of infrastructure or a neighbourhood to another place, and to related logistical challenges and opportunities. Secondly, space can refer to the influence of a landscape where actors or specific places have more advantages than others, which relates to the third aspect, the uneven distribution of benefits and how a space can reinforce these injustices. A fourth aspect is the choice of scale on which to study a phenomenon or idea such as circularity, because of the implications regarding justice, while a fifth interpretation relates to increasing awareness that concepts such as circularity are multiscalar in nature. The final



aspect relates to the potential of a space for change, but also the potential for technological and cultural lock-ins and path dependencies related to debt [8].

In this review, we focus on the development of circularity in rural or non-urban areas, and focus specifically on rural circularity practices (RCP). Circular requirements and solutions in rural areas are often overlooked in circularity research and circular-city studies. The role of space in shaping and hindering circular transitions can be explained by the dominant deterritorialized and sectoral approach in circularity research, policy, and practice. Only recently, as research on urban circularity practices (UCPs) and circular cities has increased, have various researchers connected theories of well-established urban planning and regional studies to the discourse on circularity [10,11]. These spatial studies have focused primarily on cities, as cities offer fertile grounds for new initiatives and the relabelling (or rebranding) of older practices as circular practices. However, we argue that this focus on urban circularity is not sustainable enough. Marin et al. [12] indicate the importance of context in circular cities regarding the flow and stock of wood in Leuven and its hinterlands and show that cities cannot be studied as an isolated place. Although some urban planners have attempted to develop self-sufficient circular cities (for example, see Masdar [13]), case studies illustrate that places cannot be viewed in isolation, but rather as embedded in bigger socio-ecological and socio-technical systems [14]. Inspired by research on the co-creation of shadow ecologies of sustainable practices, we focus on RCPs to investigate whether rural areas pay a price for the development of UCPs [15].

Very few researchers have investigated the following question: “*what if the focus was shifted away from a sector based analysis and towards an analysis of the rural territory as a whole, would the circular economy model still be a valid instrument for defining sustainability pathways?*” [16]. Within this context, our study is based on the premise that circular cities can only thrive if the rural areas they depend on are also thriving or vital, as both dependent on each other. Vitality, in this context, refers to the capacity of a place to absorb shocks and transform as a result of a shock and even become better, which is the difference with resilience [17]. The term acknowledges that places are continuously changing and adapting to new realities and needs. Our study engages specifically with the view that a place is a living entity, which embraces plurality, change, and relationality, and where diversity is inherently accepted [18]. The refusal of seeing the world in isolated fragments is aligned with the previously mentioned idea of contextualising and territorializing circular economies [10-13].

A number of studies in rural sociology point towards positive indicators of transformation. Within this context, our study is guided by Mitchell [19], who draws on decades of experience visiting rural areas in Canada and observing how rural areas were affected by creative destruction, leading to monadic rural landscapes with a sole functionality (e.g. secondary production), user type, and identity, while others underwent creative enhancement and became multifunctional landscapes. Arguably, multifunctionality and a diversity of users, among other, can be considered proxies for rural vitality. Simultaneously, to investigate whether RCPs increased vitality, there is a need for appropriate categories, indicators, and definitions for vitality as well as for (rural) circularity. Specifically, these indicators/categories of circular rural areas should comply with the needs and visions of different users as well as have similar characteristics to current and emerging identities. Although we could not find satisfactory indicators/categories in relevant literature, based on our observations of RCP in Japan, Belgium, Norway, and Finland, we argue that vital circular rural areas are multifunctional. Furthermore, circular rural areas are not confined to primary economic activities (e.g. forests, grains) and manufacturing sites for linear practices, or shadow places for circularity elsewhere. Vital RCPs harness different types of users, including producers. For example, a local labour pool with the necessary crafts and skills for various rural circularity practices (RCP) with different functions, well-connected through formal and informal networks, often as a community of practice, through physical and/or digital infrastructure, as well as social events and spaces. A vital RCP implies relationality, diversity, and fluidity. Notably, this view challenges categorisations of rural versus urban places in scientific and grey literature, as well as statistical data collections [20].

The urban-rural spectrum can also be referred to as “peri-urban areas” [20, 21]. Often, rural areas are defined as being opposite to urban areas, which are mostly defined on population or population

density data [21]. However, much has been written about the lack of divide between urban and rural (e.g., Brenner and Schmid [22]). Massey [23], for example, refers to spaces as being in constant flux and that rural spaces are a combination of localities, particularities, or small stories of interactions with a common enemy, such as depopulation or environmental degradation. When studying circularity in rural areas or RCPs, one could argue that these practices emerged against similar problems, where solutions can serve as indicators for success. One of the problems of RCPs may be distance and the associated environmental and economic costs. Rural areas do not have the advantage of high population density and the associated benefits of networking, resource sharing, or agglomeration effects [10]. However, rural areas have the advantage of proximity to renewable resources and nature-based solutions. Within this context, it is important to not fall into the trap of dualism. In some countries such as Belgium (and especially Flanders), rural areas are interwoven with the urban fabric, because of infrastructure development. In Norway, distance has shaped the built environment and related environmental awareness. Therefore, it is important to test circular concepts against concrete circular solutions for rural (or peri-urban) neighbourhoods and how these are envisioned by local policy makers and examine the territory in which they (do not) thrive. The initiatives related to RCPs are also important for circular cities to acknowledge the crucial role of related rural areas.

In summary, our study focuses on possible circular solutions in rural areas and their contribution to vitality. In addition, we focus on the related preconditions (tensions, synergies, barriers, opportunities), with a particular focus on infrastructure, the built environment, as well as off-grid and nature-based solutions (NBS). Off-grid and NBS are key for adapting and mitigating the costs of infrastructure. Thus, our primary objective was to develop a framework that contributes to the conceptualisation of circular neighbourhoods and infrastructure in rural areas, while acknowledging the need for (re)territorialising circular economy.

## 2. Materials and Method

### 2.1. Case studies

Rather than providing an in-depth evaluation of the transformation of certain rural areas towards circularity, we develop a conceptual framework that can be applied to a larger area. The identification of predefined categories was the result of previous and ongoing research by the first author on circularity and rural revitalisation, in Japan, Belgium, Finland, and Norway. The diversity of cases offers us a systems perspective on the following question: to what extent do RCPs contribute to vitality, and what are the related preconditions? Within this context, a number of themes arose, including cultural heritage and identity as well as governance (examples of strategic participatory citizen projects), which underline the importance of location. In our previous research different media were analysed inductively, including policy documents, news media, policy briefs, webinars, and meetings. In addition, the first author drew on reflections from lived experiences of rural circularity practices. Although predefined categories help to identify gaps in empirical studies, there is also a risk of information being missed. Against this background, the second author performed a more deductive literature study.

### 2.2. From integrative literature review to conceptual framework

With the aim of developing a conceptual framework, we used an integrative literature review to investigate the actual meaning of circularity or RCP for rural areas. This methodology provides a transparent and reproducible process of selection, analysis, and reporting. The process is integrative, as it aims to create a preliminary concept [24]. However, the choice of the search terms is essential for the collection of relevant articles. Within this context, our first inclusion criterion was rural (or peri-urban) areas. A further requirement included areas of interests, namely neighbourhoods, infrastructure, other built environments, as well as nature-based solutions (referring to the regenerative principle of circularity). We used the following search terms: “circular economy” (or “circularity”), “rural” (or “peri-urban”), and “infrastructure” (or “built environment”, “construction”, “road”, “nature-based solutions”, or “neighbourhood”). Data were obtained through the Scopus database. The first search

was done in January 2022 and the last search was conducted at the end of February 2022. A first selection was done using the title, abstract, frequency of keywords in the text (such as “circular economy”) and several inclusion and exclusion criteria, which resulted in 12 studies that met our requirements.

Notably, an exclusion criterion was the use of circular economy to legitimise a research method, for example, related to the life cycle assessments of waste management practices. Other exclusion criteria were related to studies that focused on bio-based waste-to-energy applications. Studies where waste was converted into other applications, such as fertiliser (e.g., Gonçalves et al. [25]), were included. Although certain book chapters and literature reviews were excluded, they were read to obtain further insights and for validation purposes. Inclusion criteria included studies in English and studies published after 2012. The low number of studies (11 were published in 2021 and 2022) signalled that RCPs are an understudied topic, and invited us to be more creative in our data collection for an integrative literature review [24].

Via Google Scholar, with the same inclusion and exclusion criteria, we found 10 additional papers. In total, we analysed 22 papers. The analysis by the first author included predefined categories, while the second author read the papers without predefined categories, through reflexive thematic analysis [26]) based on the material, rather than on predefined categories. We established the following guiding questions beforehand: Which local assets (e.g., natural resources) and solutions (e.g., nature-based-solutions, off-grid solutions) are interesting from a vitality perspective? What are the success factors? Notably, we also investigated the possible phasing out of old structures (path dependencies) to upscale and accelerate the transition towards circularity [27].

### 3. Results and Discussion

#### 3.1. Rural Circularity Practices: Ongoing practices and opportunities

Although the list of circularity practices is non-exhaustive, our selection addresses frequently mentioned problems and challenges in rural areas, such as depopulation, hollowing infrastructure, underused buildings, as well as the distance from or lack of access to basic services. From our literature review, we obtained the following RCP solutions:

**Locally available material resources.** 18 of the 22 selected studies addressed the use of locally available material resources, such as wood or hydropower, primarily situated in the agricultural and forestry sectors (e.g., Gonçalves [25]).

**Off-grid solutions and short supply chains.** These concrete solutions lead to closed loop cycles, reducing environmental costs related to transport. It is preferable if these loops close locally, rather than on a global scale. A well-known circularity practice is industrial symbiosis, where, in ideal situations, a 100 % closed loop is achieved. The famous example of Kalundborg was initiated in a rural area. Various studies also look at opportunities for industrial symbiosis by matching potentials and using the factor of proximity [28, 29]. Various studies mentioned the role of local suppliers or short supply chains initiatives and policies [16].

**Nature-based solutions.** These concrete solutions are associated with the principle of regenerative design. This includes the observation of life cycles of soil and minerals, water, fire and ash [31]. These solutions also include the management of resources and pollution. More concretely, nature-based solutions refer to biophilic designs and living buildings, which are in harmony with natural cycles and elements. It is easier to establish nature-based solutions in less populated rural areas, as there is space for various cycles and elements [32].

**Cultural heritage and identity.** Various RCP solutions that embody the idea of reviving past or almost lost practices, or searching for alternative options, are often driven by identity and/or new business models. Some studies see cultural heritage buildings as rural attractions, which can lead to more tourism and income, and increased employment through the rehabilitation, maintenance, and repurposing of underused buildings [16, 33, 34]. These practices embody the idea of slowing down and extending the lifetime of existing buildings and infrastructure. In addition, the practices encompass living heritage and the related skills and knowledge [35]. Mbah and Franz [36] refer to

“intangible heritage”, such as beliefs in sacred forests or ritual spaces that are connected vitality and to the regenerative design principle of circularity.

**Repurposing underused infrastructure, buildings, and spaces.** This solution is connected with the previous solutions, especially as many built heritage sites are often underused [16, 33, 35, 36], and the infrastructure could be repurposed and rehabilitated. Various studies mention initiatives of local banks or platforms of abandoned or underused spaces, with the aim of bringing them back into society [16, 35]. One interesting application is the relocation of buildings from shrinking rural areas to thriving cities or other rural areas [37]. However, this application does not lead to more vitality, nor addresses the root of rural challenges, but is a solution for a specific symptom.

**Sharing resources and (public) spaces and infrastructure.** This solution is often linked with underused spaces.

**Other practices.** Although we identified various other RCPs, these were not present in the selected studies. Frugal or sober and simple, lean practices as well the protection or recovery of soils are underexplored research areas.

### 3.2. Challenges for circular rural area infrastructure

Our study focuses on the role of local infrastructure in circularity. Circularity is often a logistical challenge, such as the efficient and safe transport of good quality materials from A to B at a certain time. In rural areas, there is a focus on resources that follow cycles. For example, agricultural waste ash is produced in a scattered and seasonal manner, requires complex infrastructure and logistics, and specific infrastructure to make it economically viable [33]. As existing infrastructure often includes path dependencies and lock-ins, it affects how liveable, maintainable, improvable, suitable, and usable a RCP can be [38]. The spatial layout of infrastructure and location of buildings can make or break the success of RCPs, as both help “manage the water cycle, seasonal food cycles, the carbon cycles, as well as inorganic material cycles” [30]. However, GIS can help identify optimal locations for hubs, storage spaces, treatment and remanufacturing plants, or other spaces needed for circularity, as shown by Laasasenaho et al. [39] for biogas plants. Noteworthy, although we use the label circularity in this study, bio-energy should not be considered as a circular economy. An unintended effect of the improvement of infrastructure that connects rural and urban areas occurs when rural areas are in close proximity to urban areas. Wealthier people can settle in these peri-urban areas, which increases the value of the land, and leads to expulsion of less wealthy people who lived there, and the development of informal and other unpaid economies that contribute to circularity, as in the case in China [41].

### 3.3. Success factors for improved vitality and circularity

The following list presents promising factors that can enable the development of RCPs. Noteworthy, only a few studies looked at physical ( $n = 4$ ) and digital ( $n = 3$ ) infrastructure, while more studies focused on social structures ( $n = 13$ ).

**Governance, planning, and stakeholder engagement.** Decentralised governance was mentioned by three papers as a success factor for RCPs, especially the increased authority to make decisions, which are more tailored to the local needs, conditions, and assets [30,36,42]. A further step is local governance with participatory processes with citizens or strategic, inclusive stakeholder management. Ten studies also examined and proposed reconfiguration of the social and legal relations and roles between different stakeholders [e.g. 43, 47]. This can, however, be a messy and uncomfortable process, as circularity challenges the same categorisations that are inherent to the linear economy model [43]. Stakeholder engagement and personal networks were often mentioned as being key elements in establishing complex combined practices such as industrial symbiosis [29] or collective agricultural projects [25].

**Community of practice.** A community of practice (CoP) is a group of people who “share a concern or a passion for something they do and learn how to do it better as they interact regularly” [44]. Two studies explicitly acknowledge this concept [38,45], for example in the Do-it-yourself (DIY) community where vehicles are remanufactured [45]. Two more studies highlighted CoP, but did not

explicitly label it as such [35,38]. Noteworthy, one study analysed development at the community scale and not at administrative border scale [24]. Lastly, CoP can occur through the unconscious or deliberate choice for inconvenience and slowness; it is through the continuous process of maintenance, rebuilding, and working actively that CoP allows for the transfer of knowledge to further generations or other people [38]. However, in this scenario, the politics of speed can create an uneven distribution of benefits, where people who work and live at a faster pace receive more government support in capitocentric societies than people who work and live at a slower pace.

***Diverse labour pool and cultural mind-set.*** From our review, a number of studies contained the codes “vocational training”, “living heritage”, and “DIY”. In addition, we found reference to “cultural mind-set”, for example, “frugality” or “sober living”, “slow living”, “slow working”, and “sufficient living”. Although these are positive aspects, their effect on community poverty and disadvantage should also be critically examined [46]. Furthermore, there is a need for trust, cooperation, and an entrepreneurial mind-set for the development of RCPs (e.g. industrial symbiosis) [29].

***Digitalisation.*** Even before COVID-19, there was already a trend in various countries towards moving back to rural areas, because of the economic crisis and the search for a slower lifestyle. Various researchers proposed how Information and Communication Technology-related jobs, which are not place-bound, can lead to more job and income creation as well as diversification in rural areas [42]. Within this context, digitalisation can reduce transport and travelling costs [42]. However, a number of studies also share the concern that digitalisation can increase extraction and other symptoms of the linear economy [16].

***Other success factors and preconditions.*** A number of studies focused on areas that have experienced armed conflict (e.g., Mbah and Franz [36]) that hindered development. Lastly, another red thread, which is also valid for urban circularity, is the focus on the specific context. Almost all studies focused on specific situations, which implies caution toward replicability, but emphasises the importance of the socio-technical context, as well as local practices resources such as locally available materials, infrastructure, labour pool, and suppliers. However, this should not be romanticized and it is important to acknowledge the “form or degree of external support (material, construction method, labour)” [38].

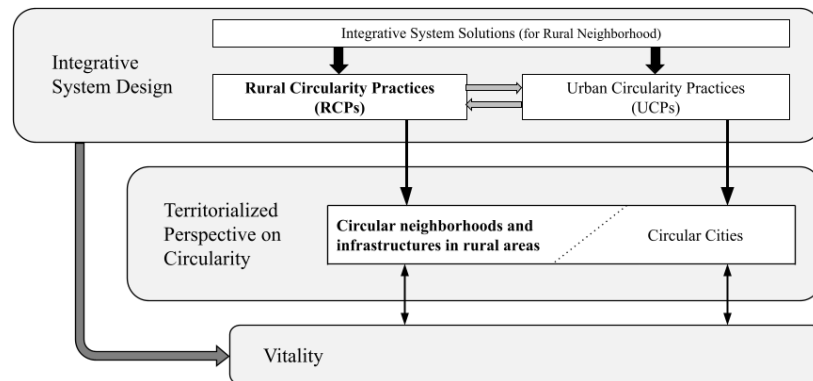
#### **4. Discussion: proposing the conceptual framework**

We found only 22 studies which addressed rural circularity, and even less so in a holistic manner. We expect more developments in this area, with, for example, descriptive case studies of shadow ecologies in rural areas related to UCPs that strengthen or weaken the link between urban and rural circularity and vitality. As argued before, (social) circularity and vitality share a number of characteristics, namely the acknowledgment of fluidity, diversity, and relationality. Unsurprisingly, the results of our analysis primarily highlight success factors related to both circularity and vitality, as these share common contexts, principles, preconditions, or, a common enemy [23]. Noteworthy, circularity does not always lead to more vitality and vice versa. The relationship can rather be described as certain success factors/preconditions can lead to a synergy of circularity and vitality. More empirical evidence and statistical analysis are required for future research on this relationship.

However, the results from our literature review provide some basic building blocks for a conceptual framework (Fig. 1). One of the first steps of future research on rural circularity practices is determining the system boundaries for monitoring and measuring. In metabolic studies, administrative units are often viewed as systems but, we argue that they should rather be viewed as communities (of practice), taking into account the complexities between spaces (e.g. [35, 42, 45]), such as valleys and watersheds (e.g. [46]), or resources sheds [47]. To investigate whether these solutions increase vitality and circularity, we suggest using a number of key themes that can be applied to broader areas.

We suggest that future research focus on the definition of performance indicators. In addition, although beyond the scope of our study, it would be interesting to examine the relationship between vitality and circularity in rural areas and in urban areas. As we challenge the urban-rural binary, we also encourage future research to investigate the relationship between RCPs and rural vitality on urban

vitality and vice versa. Possible research areas include “interpreting cities as a network of village-scale communities” [30] investigating concepts such as the 15 min city in Paris, France, and studying optimal location planning concepts in various Japanese cities.



**Figure 1.** The conceptual framework

## 5. Conclusion

In this review, we investigated whether RCPs lead to more vitality in rural areas. Our findings indicate that circularity and vitality are more affected by certain preconditions that emerge primarily as a reaction to a common enemy or crises, such as natural degradation and under management/underuse of the built environment and infrastructure. This highlights the power in designing integrative systems rather than solutions that focus on an individual effect. Our curated list of practices can guide local planners in interventions and investments that create synergies in both vitality and circularity.

Our study included diverse cases of neighbourhoods and local infrastructure (both physical and digital) in rural areas, and pinpointed often that the presence and access to physical infrastructure (e.g. roads, bridges) are not necessarily needed for more vitality and/or circularity. Some case studies, with a strong CoP, showed that the lack of physical infrastructure was not a hindrance, but a fertile ground for innovative local solutions. Some local governments struggle with the maintenance of deteriorating physical structures, which requires resources and costs, while in some cases, it is possible to passively or actively restore these spaces. Rather than investing in more and better physical infrastructures, we recommend prioritising the maintenance of infrastructure and rather investing in human resources, skills and mind-sets, or identifying supportive financial mechanisms. This implies not only phasing out physical infrastructure and path dependencies, but also social and cultural structures and mental lock-ins, which believe that physical structures provide the ultimate solution for rural (re)vitalisation and circularity. Noteworthy, communication and information transfer (skills and problem solving knowledge) are key in increasing vitality and circularity of rural areas. Therefore, we encourage future research on RCPs to investigate the role of local digital infrastructure, as well the impacts, which can be positive (e.g., networking) and negative impacts (e.g., the generation of e-waste and increased energy consumption).

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