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Urban Circularity in Time: Rethinking Quality of Life through Circular Communities

Barbara Goličnik Marušić, Damjan Marušić

(Dr. Barbara Goličnik Marušić, Urban Planning Institute of the Republic of Slovenia, Trnovski pristan 2, 1000 Ljubljana, Slovenia, barbarag@uirs.si; DIPSTOR d.o.o., Čevljarska ulica 29, 6000 Koper, Slovenia, barbara@dipstor.si)
(Dr. Damjan Marušić, DIPSTOR d.o.o. and Zavod DIPSTOR evolucija, Čevljarska ulica 29, 6000 Koper, Slovenia, damjan.marusic@dipstor.si)

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1 ABSTRACT

This paper proposes an integrated framework that connects circular communities, spatial planning, and time quality assessment (TQA) to support sustainable urban development. Circular communities, comprising material suppliers, producers, service providers, and users, aim to close resource loops and strengthen socio-ecological resilience. Yet, the translation of circular principles into durable, liveable urban environments remains a key challenge.

We introduce the Time–Space–Flow Integration Method, which links the temporal rhythms of daily life with material, energy, and social cycles to guide spatial planning. In this approach, time quality is redefined beyond efficiency or free time to include temporal proximity, synchronization, autonomy, continuity, and regenerative capacities. Circular communities are thus conceptualized as temporal-spatial systems, where short, medium, and long cycles of resources, services, and culture must be harmonized to optimize daily life.

To operationalize this framework, we propose the Circular Community Time–Quality Index (CCTQI), which evaluates urban areas based on daily access to essentials, local closure of resource loops, temporal flexibility of spaces, and intergenerational continuity. Coupled with spatial planning principles, 15–30 minute life radius, multi-layered mixed-use nodes, local metabolism zones, polycentric structures, and temporal flexibility of space, this approach enables the design and assessment of circular communities that are both resource-efficient and experientially rich.

By merging circularity with time quality metrics into Time–Circular Community Spatial Model (TCCSM), the paper argues that a sustainable society is grounded not only in circular systems but in spatial structures that protect and regenerate human time, providing planners with a measurable, actionable framework to shape inclusive, resilient, and high-quality urban life.

Keywords: urban sustainability, quality of living environments, circular community, circular spatial planning, time quality assessment

2 INTRODUCTION

Urban areas are facing unprecedented challenges related to sustainability, resource scarcity, and declining quality of life. Rapid urbanization, coupled with growing consumption, has intensified pressure on ecological systems and urban infrastructures, making traditional planning approaches increasingly inadequate. In response, the circular economy has emerged as a transformative framework for rethinking urban resource management. Circular principles such as reuse, repair, material recovery, and localized production promise to reduce waste, increase efficiency, and enhance socio-ecological resilience. However, translating these principles into functional, liveable urban environments remains a persistent challenge (Geissdoerfer et al., 2025).

Circular communities, understood as integrated systems of material suppliers, producers, service providers, distributors, and users, offer a pathway to operationalize circularity at the urban scale. These communities aim to close resource loops while fostering local innovation, social cohesion, and economic vitality (Marušić and Goličnik Marušić, 2025). Yet, most research has focused on technological solutions or isolated pilot projects, leaving critical gaps in understanding how circular communities influence daily life, temporal experience, and spatial structures. In particular, the interaction between circular resource flows and the lived experience of time in urban settings remains underexplored.

In this paper, circular communities are not conceptualized as self-sufficient or isolated neighbourhood units. Rather, they are understood as networked configurations of circular economy stakeholders operating within and across spatial scales. These configurations rely on collaboration between local actors – producers,

service providers, users, and secondary material processors – while remaining embedded in broader urban, regional, and global systems of exchange. The objective is not territorial autonomy, but the spatial coordination of circular functions so that value-retention processes become accessible, repeatable, and time-efficient within everyday urban life.

This paper addresses this gap by asking: how can time quality assessment inform spatial planning to enable networked circular economy configurations without implying spatial self-sufficiency? We hypothesize that sustainable societies are not solely grounded in circular resource systems but also depend on spatial-temporal structures that protect and regenerate human time. In other words, circular communities function optimally only when the spatial design of cities supports daily life rhythms alongside resource flows.

To address this, we propose an integrated framework that combines the Time–Space–Flow Integration Method, the Time–Circular Community Spatial Model (TCCSM), and a practical assessment tool – the Circular Community Time–Quality Index (CCTQI). Together, these components provide planners and policymakers with a measurable, actionable approach to design, evaluate, and optimize circular communities that are both resource-efficient and experientially rich.

3 THEORETICAL BACKGROUND

3.1 Circular Communities

Circular communities are conceptualized here as networked circular economy configurations composed of producers, service providers, distributors, secondary material processors, developers, and users connected through value-retention processes. These configurations do not imply territorially closed or self-sufficient neighbourhoods. Instead, they represent spatially coordinated stakeholder networks that enable reuse, repair, refurbishment, material recovery, and regenerative practices to operate efficiently within everyday urban contexts while remaining connected to wider regional and global systems.

Despite these benefits, a key challenge remains as most circular community initiatives exist as temporary experiments or isolated interventions, which rarely translate into durable, spatially integrated forms. Without careful planning, circular flows may be physically fragmented or temporally misaligned with daily life rhythms, limiting their potential to improve overall quality of life.

3.2 Time Quality Assessment (TQA)

Time Quality Assessment (TQA) is a framework that evaluates quality of life through the lens of time use, linking urban form to daily routines and lived experiences (Goličnik Marušić and Marušić, 2017). Unlike traditional measures of efficiency or free time, TQA considers time balance, financial balance, and the time quality coefficient (KTQ), capturing both the quantitative and qualitative aspects of daily activities. Applied to urban contexts, TQA enables planners to assess whether residents can comfortably access essential services, participate in community life, and engage in restorative and meaningful activities.

Integrating TQA with circular community planning provides a unique opportunity: It allows assessment of not only whether resources are efficiently cycled but also how these flows affect residents' temporal experience. In other words, TQA bridges the gap between ecological sustainability and human-centered urban design.

3.3 Spatial Planning and Circularity

Traditional urban planning often emphasizes distance, function, or zoning, which can inadvertently disrupt circular flows (Surekha et al., 2025) and misalign with residents' daily rhythms or routines. Time-aware spatial planning, by contrast, considers how spatial arrangements influence the temporal experience of residents. By synchronizing short, medium, and long resource cycles with daily life patterns, planners can ensure that circular practices, such as localized production, repair services, and material recovery, are both operationally effective and experientially accessible.

In this context, a planning model that explicitly integrates time, circular flows, and spatial form is essential. Such a model provides a blueprint for creating circular communities that are not only resource-efficient but also resilient, inclusive, and supportive of human time. This foundation sets the stage for our Time–Space–Flow Integration Method and the Time–Circular Community Spatial Model (TCCSM), which operationalize these principles.

4 CONCEPTUAL FRAMEWORK: TIME–SPACE–FLOW INTEGRATION

Circular communities operate at the intersection of temporal rhythms, resource flows, and spatial structures. The core assumption of the Time–Space–Flow Integration Method is that circular communities function optimally when daily life cycles align with material, energy, and social flows. Misalignment between temporal rhythms and resource cycles can undermine both the efficiency of circular systems and the quality of life of residents. This framework provides a bridge between time quality assessment, spatial planning, and circular community principles, offering a structured approach to design and evaluation.

Central to this approach is a redefinition or upgrade of time quality as introduced by Marušić and Goličnik Marušić (2017). Beyond conventional measures of efficiency or free time, time quality in circular communities (Marušić and Goličnik Marušić, 2025) encompasses five key dimensions (temporal proximity, synchronization, temporal autonomy, continuity, regenerative time). Temporal proximity reflects the time required to access essential services, ensuring that daily needs do not impose excessive burdens. Synchronization refers to the alignment of work, care, mobility, and production cycles, facilitating smooth daily routines. Temporal autonomy captures the ability of residents to choose and control their rhythms of life and most directly correspond to time quality coefficient (KTQ) as defined by Marušić and Goličnik Marušić (e.g. 2014, 2017), while continuity reflects the stability of time arrangements across generations. Finally, regenerative time considers the provision of sufficient time for rest, learning, community engagement, and environmental care. This multidimensional perspective highlights that even well-functioning circular flows cannot compensate for poor temporal-spatial planning.

As grounded in 3.1, in this paper, the term circular community refers to a functional configuration within the circular economy, comprising interconnected actors and value-retention processes rather than a residential or social community. To become operative through spatial planning, such circular economy configurations require a spatial interpretation that makes their functions accessible, repeatable, and efficient in everyday urban life (e.g. Verga and Khan, 2022). Time quality assessment is introduced as a translation tool that links circular economy functions to spatial planning decisions by examining how circular activities consume, save, or redistribute time. From this perspective, circular communities can be interpreted as temporal-spatial systems defined by operational rhythms. Certain circular functions, such as access to services, repair, and mobility, require daily spatial accessibility; others, such as learning, housing adaptation, or local exchange, operate on periodic schedules; while structural circular functions, such as material recovery, infrastructure renewal, and ecological processes, depend on long-term spatial anchoring. These temporal distinctions do not redefine circular communities as social entities but rather identify the spatial requirements necessary for circular economy processes to function efficiently. Spatial planning plays a key role in minimizing temporal and spatial friction between these functions, ensuring that circular economy strategies contribute to reduced time consumption, compact spatial organization, and improved time quality in cities.

Understanding circular communities as circular economy configurations highlights that their successful implementation depends not only on closing material loops, but also on the spatial conditions under which circular functions become accessible and repeatable in everyday life. The Time–Space–Flow Integration framework demonstrates that circular economy processes operate through recurring temporal rhythms and require spatial proximity to minimize friction in daily routines. Time quality assessment provides a means to evaluate these requirements by examining how circular functions affect time use, accessibility, and flexibility.

Building on this insight, the following section translates the temporal and functional logic of circular communities into spatial planning principles. These principles do not prescribe social forms of living, but identify spatial structures that enable circular economy processes to function efficiently while contributing positively to time quality.

5 SPATIAL PLANNING PRINCIPLES FOR CIRCULAR COMMUNITIES

Translating the conceptual framework into actionable strategies requires spatial planning principles that spatially interpret circular economy functions through a time quality lens. These principles do not redefine circular communities as residential entities but rather identify spatial conditions under which circular economy processes can operate efficiently while contributing positively to daily time use.

The first principle is the 15–30 minute life radius, which ensures that essential circular economy-related functions, including food provision, healthcare, education, work, repair, and care services, are accessible within daily time budgets. Unlike traditional distance-based zoning, time-based zoning prioritizes temporal proximity, reducing travel time, coordination effort, and dependence on distant systems, thereby supporting recurring circular activities. Second, multi-layered mixed-use nodes integrate living, production, learning, and care functions within shared urban spaces. This principle supports the co-location of circular economy actors and services, enabling value-retention strategies to function across day–night and weekday–weekend rhythms without spatial segregation. Such spatial overlap reduces friction between circular processes and everyday routines. Third, local metabolism zones spatially anchor resource flows, energy, food, water, and materials, within identifiable urban units. Making these flows visible supports the operational requirements of circular economy systems and enables time-efficient interaction with circular services. Visibility of metabolic processes strengthens engagement while reducing the spatial and temporal distance between users and circular functions. Fourth, temporal flexibility of space allows urban areas to accommodate different circular economy functions at different times. Examples include educational facilities functioning as repair or community hubs outside school hours, parking areas temporarily repurposed for markets or logistics, and workplaces adapted for learning or care activities. Such flexibility increases utilization efficiency and improves time quality without additional land consumption or construction. Finally, polycentric spatial structures distribute circular economy nodes across the urban fabric, creating semi-autonomous yet interconnected centres. This configuration shortens access times to circular services, supports redundancy and resilience in circular flows, and enables repeated local interaction. Reduced spatial and temporal distance between actors involved in circular processes may create conditions that facilitate social interaction and collaboration; however, such outcomes depend on institutional, cultural, and governance factors beyond spatial configuration alone.

6 PLANNING MODEL: TIME–CIRCULAR COMMUNITY SPATIAL MODEL (TCCSM)

The Time–Circular Community Spatial Model (TCCSM) operationalizes the integration of time, circular economy processes, and spatial structure for planning purposes. Its core premise is that circular economy configurations function efficiently when daily time use, spatial form, and resource flows are aligned, reducing temporal and spatial friction in recurring circular activities. The model consists of three interrelated layers, circular flows, spatial structure, and time quality, connected through feedback loops that support adaptive planning and continuous evaluation.

The spatial structure layer translates circular economy functions into planning-relevant spatial arrangements. It is organized around circular nodes differentiated by operational time scale, reflecting the frequency with which circular functions must be accessible. Daily nodes (0–24 hours) accommodate high-frequency functions such as essential services, mobility, repair access, and care. Weekly nodes (approximately 7 days) support periodic functions including local markets, repair and refurbishment services, and learning activities. Seasonal nodes (monthly or longer cycles) host lower-frequency but structurally critical functions such as agriculture, ecological management, material recovery, and cultural activities. These nodes are embedded within reachable time radii to ensure that circular economy processes remain accessible to users and actors without excessive time expenditure.

To support these spatial configurations, the model proposes indicative spatial ratios that guide land-use allocation and building typologies. These ratios are not prescriptive standards but planning benchmarks intended to ensure sufficient spatial capacity for circular economy functions to operate efficiently while maintaining time quality. They are grounded in the need to reduce spatial fragmentation, support recurring circular activities, and enable adaptability over time rather than prescribing fixed design outcomes: mixed-use land (e.g. $\geq 60\%$) enables functional overlap and reduces travel distances; local production and service spaces (e.g. $\geq 15\%$) provide room for repair, reuse, and small-scale manufacturing; public and shared spaces (e.g. $\geq 25\%$) support accessibility, coordination, and visibility of circular activities; and adaptable buildings (e.g. $\geq 40\%$) allow spaces to accommodate changing functions over time.

The time quality layer captures the lived temporal effects of spatialized circular economy processes, focusing on temporal proximity, synchronization of activities, autonomy in daily scheduling, continuity of access, and the availability of regenerative time. The circular flow layer monitors material, energy, water, food, and waste streams to ensure that value-retention loops are physically closed, locally anchored, and visible.

Feedback loops between the three layers enable planners to evaluate how spatial arrangements influence both circular performance and time quality, and to adjust planning strategies as circular economy practices and usage patterns evolve.

7 ASSESSMENT FRAMEWORK: CIRCULAR COMMUNITY TIME–QUALITY INDEX (CCTQI)

The Circular Community Time–Quality Index (CCTQI) operationalizes the Time–Circular Community Spatial Model (TCCSM) by providing a structured set of indicators that evaluate the performance of each model layer. Rather than functioning as a standalone assessment tool, the CCTQI is designed as the monitoring and feedback mechanism of the planning model, enabling planners to assess whether spatial configurations effectively support circular economy processes while maintaining or improving time quality.

7.1 Time Quality Indicators (Time Layer)

Indicators in this category assess how spatialized circular economy functions affect daily time use and lived experience. They reflect the core dimensions of time quality identified in the conceptual framework, including temporal proximity, synchronization, autonomy, continuity, and regenerative time. Key indicators include average daily access time to essential circular services, the share of daily time devoted to mobility, the proportion of spaces supporting multi-time use, and the availability of time for rest, learning, and community participation. Together, these metrics evaluate whether spatial arrangements reduce time pressure and enable coherent daily routines.

7.2 Spatial Structure Indicators (Spatial Layer)

Spatial structure indicators evaluate whether planning principles and spatial configurations align with the operational requirements of circular economy functions. These indicators capture the degree of functional mix, density and distribution of circular nodes, accessibility within defined time radii, and the adaptability of buildings and public spaces. By measuring spatial overlap, polycentric balance, and continuity of public networks, this indicator set assesses whether spatial structures minimize temporal and spatial friction between circular activities.

7.3 Circular Flow Indicators (Flow Layer)

Circular flow indicators measure the physical performance of circular economy processes within the spatial system. They track the degree to which material, energy, water, food, and waste flows are locally closed, reused, or regenerated. These indicators ensure that value-retention strategies are not only planned but materially effective, providing a quantitative basis for evaluating whether circular loops are functioning as intended and whether spatial anchoring supports their visibility and efficiency.

7.4 Composite Evaluation and Feedback Loops

To enable integrated evaluation and comparison across planning scenarios, individual indicator scores are aggregated into a composite Circular Community Performance Score. Weighting reflects the centrality of time quality and spatial structure in enabling circular economy processes, while maintaining the importance of material flow performance. Results from the CCTQI feed back into the TCCSM layers, informing adjustments to spatial design, allocation ratios, and circular infrastructure. This feedback mechanism supports adaptive planning and continuous improvement over time.

8 DISCUSSION

This paper set out to explore how circular economy configurations, conceptualized as circular communities, can be interpreted and operationalized through spatial planning using time quality assessment. The proposed Time-Space-Flow Integration framework, together with the Time–Circular Community Spatial Model (TCCSM) and the Circular Community Time–Quality Index (CCTQI), demonstrates that circular economy strategies are not spatially neutral. Their effectiveness depends on how circular functions are embedded within urban space and how they interact with daily time use.

The key contribution of the framework lies in its ability to translate circular economy logic into spatial planning-relevant thinking. By introducing time quality as an evaluative lens, the paper reveals how circular economy functions consume, save, or redistribute time, and how spatial planning can reduce temporal and

spatial friction in recurring circular activities. This perspective helps explain why circular initiatives often remain experimental or isolated when implemented within spatial structures inherited from linear urban systems.

The planning principles and the TCCSM provide planners with a structured way to design and assess spatial conditions that support circular economy processes. The alignment of operational rhythms, spatial accessibility, and value-retention flows shows that improvements in time quality are not ancillary benefits, but integral outcomes of well-functioning circular systems. At the same time, the CCTQI enables adaptive governance by linking planning decisions to measurable impacts on both circular performance and daily life.

Several limitations should be acknowledged. The proposed indicators and reference values are illustrative and require contextual adaptation and empirical validation. Data availability, especially for time-use and local flow measurements, may constrain application in some contexts. Furthermore, the framework does not prescribe institutional arrangements or governance mechanisms, which will be critical for implementation. These limitations point toward the need for applied case studies and longitudinal analysis. The framework does not assume deterministic relationships between spatial proximity and social cohesion. While spatial configuration can enable interaction, actual social outcomes depend on governance structures, institutional arrangements, and socio-cultural contexts. Future empirical research is required to test the strength and variability of these relationships across different urban settings.

8.1 Distinction from the 15-Minute City Model

The proposed framework differs fundamentally from the 15-minute city model, although both engage with questions of accessibility and proximity. The 15-minute city emphasizes minimizing travel time to essential services in order to enhance urban comfort and reduce mobility-related emissions. Its primary logic is spatial proximity.

By contrast, the Time–Circular Community Spatial Model (TCCSM) is organized around circular economy processes and their operational rhythms. Proximity within a 15–30 minute radius is treated as an enabling condition for certain high-frequency circular functions, not as a normative requirement for neighbourhood self-sufficiency. The model does not assume that all services or production activities must meet local critical mass thresholds within each spatial unit. Instead, it differentiates circular functions according to temporal frequency (daily, weekly, seasonal) and locates them across a polycentric and networked structure.

In this sense, the framework addresses one of the common critiques of proximity-based planning models: that different urban services require different scales of operation and critical mass. The TCCSM explicitly incorporates multi-scalar organization, allowing certain circular processes to operate locally while others function at district, metropolitan, or regional levels. The aim is coordinated circularity, not territorial closure.

9 CONCLUSION

This paper proposes an integrated framework that connects circular economy configurations, spatial planning, and time quality assessment to support sustainable urban development. By interpreting circular communities as functional circular economy systems and translating their operational requirements into spatial planning terms, the study demonstrates that circularity becomes effective only when spatial structures support daily accessibility, proximity, and adaptability.

The Time–Circular Community Spatial Model (TCCSM) and the Circular Community Time–Quality Index (CCTQI) together provide planners with a coherent model for design, assessment, and feedback. The central argument is that sustainable urban development depends not only on closing material loops, but also on protecting and regenerating human time through spatial structures that minimize friction and enable recurring circular activities.

Importantly, the framework does not advocate self-sufficient neighbourhoods or spatial isolation. Instead, it advances a multi-scalar, networked interpretation of circular economy implementation, where local accessibility is combined with regional coordination and differentiated critical mass requirements. By distinguishing between daily, periodic, and structural circular functions, the model accommodates the varying spatial scales necessary for viable urban services and production systems.

Future research should focus on empirical application of the framework in different urban contexts, including urban regeneration and new development, and on refining indicator sets using real-world data. By bridging

circular economy theory and spatial planning practice through time quality assessment, the approach presented here offers a practical pathway toward urban environments that are resource-efficient, time-conscious, and resilient.

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