# URBAN DENSITY AND CIRCULAR PRODUCTION: A SPATIAL ANALYSIS OF MAKER NETWORKS

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**Angelidou Margarita**
*Assistant Professor, Aristotle University of Thessaloniki, Schools of Spatial Planning and Development, Aristotle University Campus, Thessaloniki, Greece*
*mangel@plandevel.auth.gr*

**Roma-Athanasiadou Elli**
*Project Manager, Q-Plan International Advisors, El. Venizelou 11, Thessaloniki, Greece*
*roma@qplan-intl.gr*

**Tsolakis C. Apostolos**
*Project Manager, Q-Plan International Advisors, El. Venizelou 11, Thessaloniki, Greece*
*tsolakis@qplan-intl.gr*

***Abstract***
*This paper's goal is to analyse the potential of distributed urban production to lead to regenerative and circular city development in Thessaloniki, by engaging urban and spatial analysis tools, and by building upon the results of the EU Horizon2020 Pop-Machina project (Grant Agreement n. 821479). Pop-Machina grasps the opportunity to nurture the bottom-up development of maker communities and supports them to create new, circular and marketable products collaboratively. This is expected to stimulate urban innovation, reshape the urban productive system, and result in new job creation and the enhancement of the urban regeneration potential of the city. To this end, this paper (i) provides an overview of the regulatory and strategic context in which the city operates; and (ii) applies an innovative methodology to identify the characteristics of its urban maker ecosystem and the urban assets that may be leveraged as sources of strength for a more circular and regenerative urban production ecosystem. The results of this spatially based investigation of the cultural, socio-economic, regulatory, and technological characteristics of the maker community ecosystem of Thessaloniki provides insights for local, national and EU-level policy recommendations towards optimising distributed urban production for a circular and regenerative development.*

***Key words:*** *urban regeneration, circular economy, maker movement, urban industry, urban ecosystem*

## 1. INTRODUCTION

The design of production systems for urban development and vice-versa have long been a subject of interest in urban policy, analysis and planning, as well as sociology and the study of human relationships. Among the hundreds of examples, it is difficult to miss striking instances like Tony Garnier's "Industrial City" (1917) or Le Corbusier's plans for cities and buildings that function like machines in the 1920s (Frampton, 2020). As production evolves along with technological change and new social, economic and environmental developments take place in cities, its organisation in a contemporary context remains a challenge for policymakers and city planners. Perennial issues include the optimal spatial locations, functions and relationships among those places and the urban production network, i.e., their place in the

urban fabric; the nature and degree of intervention of urban policies to regulate the development of new economic relations and increase the regenerative capacity of the city; and the role of the extend-ed (formal and informal) network of stakeholders in this web of relationships.

Such questions are sought to be answered through the Pop-Machina project, funded through the European Commission's Horizon 2020 programme (Grant Agreement n. 821479) ("Pop-Machina Collaborative Production for the Circular Economy; a Community Approach.," n.d.). Pop-Machina seeks to promote circular collaborative production in urban areas, driven by communities that operate based on trust-driven relationships in a spatially distributed way. Collaboration within these communities is facilitated by means of cutting-edge technologies (factory-of-the-future, blockchain), with the ultimate goal of developing and demonstrating innovative distributed urban production models for urban regeneration, circular cities and new job creation. The cities that participate in this research include Thessaloniki and Piraeus (GR), Leuven (BE), Santander (ES), Venlo (NL), Kaunas (LT) and Istanbul (TR). On this basis, the Pop-Machina cities and the project as a whole aspire to boost dialogue around social innovation and create new policy and planning models for circular urban regeneration in Europe.

This paper presents and builds upon the results of Pop-Machina with a specific focus on the pilot city of Thessaloniki, Greece. More specifically, it investigates the regeneration and circularity potential of the municipality of Thessaloniki's distributed urban production and how it could be optimised. The findings can help urban policymakers and urban planners to design and support distributed urban production systems in a way that promotes sustainable, circular urban development, and enhances the regenerative capacities of the city.

## 2. LITERATURE REVIEW

Production has always been seen as a key driver of urban development and a determinant of the urban form. Traditionally, urban production has been referred to as the production of physical products in urbanised environments, and it is shaped by its physical and policy context. Indeed, dispersed production spaces within the city are a frequent phenomenon. These light production spaces are usually small studios, labs and factories in buildings dispersed throughout the city, also in mixed-use vertical configurations (Rappaport, 2017). They may exist informally or not. Their operation is manifested within networks of specialised, small-sized manufacturing companies that benefit from their proximity, knowledge exchange and economies of scope (Lane and Rappaport, 2020), while different forms of local production systems can be identified (Srai et al., 2020). Examining the distributed urban production in a city can provide insights into the potential contribution of the local maker ecosystem in sustainability (Tsui et al., 2021).

Recent developments enabled by technology, combined with a global realisation of the ongoing climate crisis, have shifted thinking about urban production towards two new directions: circularity and urban regeneration.

The first one is the direction of circularity. It involves promoting forms of urban production contributing to a circular urban economy, reducing carbon footprint of productive activities and fostering sustainability. Circular economy principles involve closed-loop systems, utilizing processes like reuse and recycling (Tsui et al., 2021). As urban production companies become smaller, cleaner and less of a nuisance to their urban environment, they can thrive anywhere in the urban fabric, not just industrial zones (Lane and Rappaport, 2020). Despite the potential, however, small-scale urban production has up to date had a limited impact on the circular economy due to challenges such as the availability of industrial land within an urban setting, the scaling up production (Ferm and Jones, 2016; Tsui et al., 2021),

the absence of permitted small-scale production activities in the cities' land use plans and other factors. It is important to note that for distributed urban production to be able to contribute to the city's circular economy, it should be sourced from the local supply chains and the local secondary raw materials. Also, the circular businesses should be able to stay inside the city in case they manage to scale up and not have to move outside due to increased space needs which means increased costs, as rents inside the city are higher (Tsui et al., 2021).

Circular development can produce adaptable urban systems that can evolve based on the city's changing needs and is managed through processes that support active communities that self-organise and are willing to learn and share knowledge. It is also a costly process that demands a lot of changes in planning procedures, new infrastructures and changes in social practices (Williams, 2023). The key challenges that need to be faced to allow for circular development lie in political and economic factors as transforming urban systems in the current neoliberal economic system heavily relies on the market, so in this context, it needs to become able to compete with the existing systems (Williams, 2023). Spatial planning can also play a pivotal role, regulating the influence of the market and providing tools which can help circular development to flourish. Such tools could be strategies (spatial plans), capacity building tools (collaborative planning/ co-design processes) and regulatory tools (planning conditions and permissions that will enable circular practices and experiments) (Williams, 2023).

The second one is the direction of urban regeneration - a city planning strategy closely tied to the direction of circularity, covering many aspects of city life: physical, social and environmental-, in the sense of promoting organizational forms of urban production with a potential to bring life back to shrinking cities, underutilized urban assets (brownfield areas, buildings, infrastructures), promote re-urbanisation in more sustainable forms, bring nature back into the city, and create new jobs and forge new community relationships, as well (Ferm and Jones, 2016; Manika and Anastasiou, n.d.). Urban regeneration tends to limit urban sprawl and peri-urbanisation by enhancing local (re)development, particularly to reduce the environmental footprint of the city. It also encourages new economic and sustainable development, and develops solidarity at the scale of the district, aiming at more social inclusion and wealth distribution (Allwinkle and Cruickshank, 2011; Evans and Jones, 2008; Guy et al., 2002; Meegan and Mitchell, 2001). There is a tendency in European cities and municipalities to reuse brownfields from former industrial areas to create mixed-use neighbourhoods, combining residential and commercial uses. At the same time, the fact that there is a shift towards neoliberalism globally has caused many privatisations of such areas, formerly owned by the state, limiting the cities' abilities to reuse them. Furthermore, the proliferation of urban production in cities is often inhibited due to outdated land-use regulations (Tsui et al., 2021).

Until recently, the interest of planners and policymakers concerning post-industrial sites within the urban fabric was focused on how to best transform those derelict areas into new residential or mixed-used ones, ensuring that they will become liveable places, with constant human activity and poles of urban regeneration within their broader area of influence. Thus far, this has been only partly achieved, and we know some of the basic ingredients of successful urban regeneration, but several aspects -especially the social one- remain underdeveloped (Colantonio and Dixon, 2011). Regenerating the city through urban production brings to the centre of the city's operation the means of production and the creative community, creating a fertile environment for planning practices such as placemaking. It also creates a framework of increased urban resilience, since local supply chains are utilized in the place of the global ones, providing more independence (Tsui et al., 2021).

Moreover, the role of technology is undeniably tied closely to the recent transformations in production. On one hand, technology and automation bring new challenges to production concerning societal and economic relations: the loss of traditional manufacturing jobs is

leading to income polarisation and the displacement of urban functions and urban populations (Angelidou, 2014). On the other hand, however, recent technologies have created new methods for collaborative working and community building around production, also supporting the development of new working relationships and roles within the community. The collaborative and multidisciplinary Research and Development (R&D) required for urban production has thus been challenging the traditional hierarchical structures that governed production until recently, concurrently important changes in the governance structures of maker communities have also been taking place. As a response, urban production has undergone a transformation, giving rise to innovative spaces like makerspaces, fab labs, and vertical factories, often nestled within densely populated urban areas. (Rappaport, 2017). These makerspaces and fab labs have a pivotal role in empowering the maker movement, by providing a space for makers to experiment with new ideas, test, and develop their skills. Important is also the existence of acceleration programs many of which are especially focused on circularity ("Accelerator Circular Economy," 2023; "CircularStart," 2023; The circulars, 2023), which sometimes are deployed through makerspaces as well ("Pop-Machina Circular Maker Accelerator," 2023). These accelerators usually follow an educational curriculum combined with mentoring services, they help their participants access business networks and provide opportunities for interaction with investors (Avnimelech and Rechter, 2019), thus providing a way to the market for circular projects which could potentially be the leverages of circular urban production and make a difference regarding the reuse of materials.

Based on the writings of Diez (Diez, 2018), the proliferation of makerspaces and fab labs in cities, along with the digitalisation of fabrication are gradually driving the emergence of a new model of urban development, in which cities essentially produce everything they consume: the Fab City. A 'Fab City' is essentially '*a city where citizens once again become manufacturers and take responsibility for their own needs, reclaiming technologies collaboratively and contributing to the control of various flows (materials, energy, etc.) which shape urban ecological situations'* (Rumpala, 2021). In a Fab City, digital information (like designs, knowledge, resources and skills) travels globally, while physical objects (buildings, infrastructures, materials) remain local (Tsui et al., 2021). Fab Cities are essentially an enhanced version of the smart city model, in which the digital and physical worlds come together to create systems of enhanced urban innovation (Diez, 2018; Rumpala, 2021).

What remains understudied, however, are ways to accommodate the new industrial forms of urban production that have made their appearance since the 2010s in models such as, for example, designs for comprehensive production districts with open space systems or designs for positive energy districts based on industrial symbiosis. As Lane and Rappaport put it, today 'mixing production with other daily activities of the city is the ultimate mixed-used design challenge' (Lane and Rappaport, 2020). The biggest planning challenge is thus the city planning challenge, in the sense of policy and regulation of urban production. Questions such as '*How to define this new form of light manufacturing in planning regulation? How to determine the mix of functions allowed in these areas? How to evaluate the contribution of these areas to sustainable urban development?*' arise. One more important challenge concerning urban production is the urban design challenge: '*How to support the connectivity of urban production spaces with their broader urban area while maintaining their distinct character, brand and identity? How to protect them from commercial gentrification? How to design streets that allow for goods and freight transportation, while also encouraging pedestrian mobility and open interaction?*'

Considering the recent developments, as well as the opportunities and challenges that come along with them, there is an emerging need to reconsider urban policy-making and urban planning in light of the new forms of urban production, adopting a circular and regenerative city mindset.

In the context of reconsidering urban policy-making and planning, the way the citizens are involved in planning should also be reconsidered. The need for public participation in planning becomes evident when considering the plethora of ineffective plans and designs that have been implemented from the top-down, the need for representation and consent in planning, creating a fruitful environment where the citizens can trust the state, as well as the need for citizens equipped with the tools, knowledge and confidence to actively pursue the changes they envision in the municipal and urban realm (UN-Habitat, 2018). Targeting participatory procedures and showing the path of active citizenship could also act adjunctively to empowering the local bottom-up movements (such as the maker movement) and making way for their needs to be taken into account in designing the public space.

Focusing on the Greek reality, the tendencies in urban and regional planning in a country that is still recovering from the recent financial crisis, have been heavily dictated by the 2nd memorandum: "Memorandum of Understanding on Specific Economic Policy Conditionality". With that, Greece undertook the obligation to review and revise the general law on spatial and urban planning, to provide flexibility in the utilization of real estate for private investments and to speed up the preparation procedures for spatial plans, pointing to attracting foreign direct investments through the privatization of large as-sets of public property (Giannakourou and Kaukalas, 2014; Papageorgiou, 2017). It is interesting to note that the reform of spatial planning as a memorandum obligation is a practice occurring in other countries of the European south as well, almost at the same time, resulting in the development of an informal spatial planning policy of the European south (Tulumello et al., 2020). As a result of these policies, spatial planning in Southern European countries became a field for the development of political conflicts and bottom-up initiatives to reclaim public space (Madanipour et al., 2014), since citizens saw the public space being disputed and felt the need to fight for it (Athanassiou, 2017).

## 3. MATERIALS AND METHODS

Urban production in cities has significant connotations for urban design, planning and policy. However, these relationships have been insufficiently researched up to today (Lane and Rappaport, 2020). The aim of this paper is thus to explore how an integrated analysis of urban production systems can be implemented in a real case of a city environment (Thessaloniki, Greece), and based on this experience, develop actionable recommendations about how such an analysis can inform future urban planning and policy in Thessaloniki and cities with similar characteristics.

Given the complex economic, societal, technological and environmental dimensions of dispersed urban production, an integrated analysis of urban production systems can be implemented only through a multi-disciplinary approach. Further, engaging with a research topic that hasn't been thoroughly explored calls for an exploratory research design, following the principles of research theory (Cresswell, 2014; Eisenhardt, 1989; Yin, 2003). Thus, the research design of the present paper aims, (i) to be exploratory and qualitative so that it covers the not yet built theory base of the topic explored (Cresswell, 2014) and (ii) to approach an immature, due to lack of previous research, concept and build new theoretical constructs (Morse, 1991). Moreover, case study analysis is an effective approach to gaining a contextual understanding of a particular phenomenon and has been used in studies of circular cities before (Marin and De Meulder, 2018; Prendeville et al., 2018).

Addressing these requirements, this paper follows a case study approach that analyses Thessaloniki's urban production system to (i) identify patterns and characteristics of urban production that could drive urban regeneration and circularity and (ii) come up with

theoretical constructs that can provide a solid base for using this analysis method in other cities and future studies.

The research design includes three stages. Stage 1 (see Section 2) presents the literature review performed to identify emerging trends in urban production from an urban development and planning point of view. The current literature, focused on published research sources regarding urban production and manufacturing, circularity and urban regeneration was identified and reviewed. The literature review maps the state-of-play with regards to urban production and the transitions it has undergone during the recent years due to the role of technology, as well as its contribution to the city's circularity and its relation to urban regeneration.

Stage 2 (see Section 4) includes the case study analysis, during which the analysis of Thessaloniki's urban production system was implemented, including the identification of the scales of analysis and the methods used within each scale. The overall approach was inspired by a higher-level analysis designed and implemented for the city of Thessaloniki (amongst others) in the context of the European Commission Horizon2020 project Pop-Machina (GA 821479) (Elwakil et al., 2021, 2020). For the present research paper, however, the entire urban analysis framework was redeveloped, and all data for Thessaloniki was collected from the anew with significantly greater depth and granularity concerning urban policies and spatial data related to urban production. The case study analysis was performed across two axes: spatial and across scales, analytically described in the following two paragraphs.

The spatial analysis takes inspiration from the typological analysis introduced by Pop-Machina (Elwakil et al., 2021). Pop-Machina identified types of circular maker facilities, i.e., urban production-related spaces, places, facilities and infrastructures that can be found in urbanized environments and with a potential to become part of an urban maker eco-system. Based on Pop-Machina, the five primary types are defined as follows (Meegan and Mitchell, 2001):

- 'Reuse' is typically found in busy city areas with pedestrian access and entails second-hand items (e.g., thrift stores, charity shops or second-hand furniture shops).
- 'Repair' is typically found in busy city areas with pedestrian access/ side streets and does not require expert skills, it can be found in home-based environments (e.g., Repair cafes, small pop-up workshops for clothing/tailors, electronics, car garages, etc.).
- 'Craft' is found in accessible, yet not highly public/social areas and attracts craftspeople, skilled or interested in learning a skill (e.g., Woodwork workshop, ceramics workshop, metal workshop, jewellery, pottery, traditional crafts etc.).
- 'Fabricate' is often connected to a larger learning/design institution and the people engaging have expertise in digital fabrication machinery, often found in design/engineering schools (e.g., Fablabs, Educational digital fabrication workshops etc.).
- 'Distribute' is often found at the periphery of cities, accessed by roads (not pedestrians). The people engaging with it are often connected to city municipal work and it entails warehouse spaces, vehicles for collection, parking space, composter, shelving for inventory (e.g., Materials bank/storage warehouse, thrift shop warehouse, Salvage yards, Recycling warehouse available for people to obtain materials from).

Given that these types of facilities come to exist under various urban conditions in different contexts, they are used as the basis for city-wide mapping and analysis. The typological analysis provides a cross-sectional reading of a city's maker metabolism across a range of scales, connecting local makers' experience with city-wide data mapping. The information was collected through a search on online map platforms (i.e., Google Maps) and repositories (i.e., CORINE). The tool used to accumulate the information gathered and to present the results in the form of maps is QGIS.

Regarding the scales of analysis, in relevant studies multiple scales are addressed, as '*literature has predominantly focused on micro-level interventions'*, but the analysis also has '*origins in industrial ecology... a primarily macro-level activity*' (Prendeville et al., 2018). Thus, in the identification process of the scales and methods of analysis, three main physical scales were selected, in terms of "reading" the city's urban production system and related policies:

- Strategic scale (Meso/Macro): policy & strategic projects for planning and governance. It includes policies and plans providing a long-term framework of reference regarding visionary agendas that set out the goals for a desirable future and shape the decision environment, as well as the EU, national, regional and local planning policies and plans. The information here derived through desk research, accumulating respective policies and plans at the EU, national and local levels.
- Urban Area scale (Meso): urban functions, accessibility at municipal/urban unit level. It examines the framework including urban plans & regulations on urban & land use at a municipal level, the procedures including citizen participation in planning, the municipal actions towards projects of hyper-local significance within the city, the existing land uses and connections. The information was collected through desk research, accumulating the respective plans and local policies, as well through mapping the important city's characteristics (i.e., use land uses, transportation routes, blue and green networks).
- Building and urban design scale (Nano/Micro): building use, building characteristics, urban design for regeneration, and local maker culture. The information required for this level of analysis was gathered by means of desk research, accumulating urban regeneration plans, local public space design plans, and other types of plans falling within the urban design category.

Stage 3 (see Section 5) - Refinement and interpretation of the findings: Conclusions were drawn regarding Thessaloniki's urban production potential and needs. Urban policy and planning recommendations towards circular and regenerative development are presented focusing on the case of Thessaloniki. Last, but not least, an integrated method for the analysis of urban production systems is described, expanding on urban policy recommendations per scale that could be applied in other cities with similar characteristics.

## 4. RESULTS: THE CASE STUDY OF THESSALONIKI, GREECE

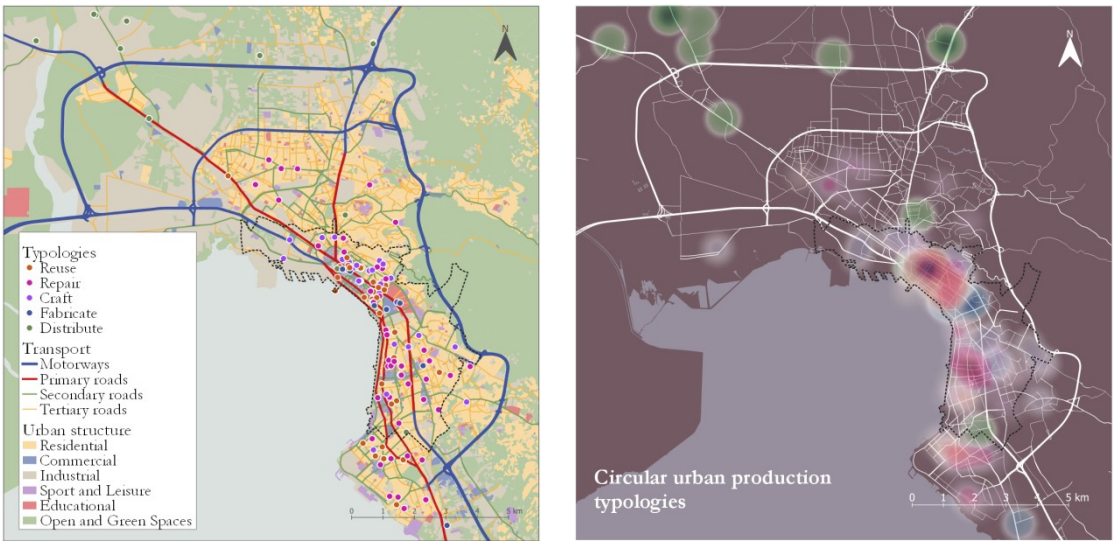
This section will describe the state of play of distributed urban production for urban regeneration and circularity in the municipality of Thessaloniki. Our research considers different contexts and includes both open-source data and local expertise to offer a balance of qualitative and quantitative approaches.

### *4.1 Overview and Spatial Analyis*

Thessaloniki, with a population of approximately 1 million spread across 8 municipalities, including the municipality of Thessaloniki, has seen its urban development shaped by historical migratory crises and fragmented planning until the 1970s (Christodoulou, 2015; Giannakou, 2008; Karadimou Gerolympou, 2008). This led to the creation of degraded neighbourhoods lacking infrastructure and facing environmental and traffic issues. Despite this, the city's urban evolution fostered a resilient mixture of commercial and craft activities on neighbourhood level, facilitating social interaction and affordable housing (Christodoulou, 2015, 2008; Karadimou Gerolympou, 2008). However, since the economic crisis of 2010, there has been a decline in trade and craft activities, resulting in abandoned areas and brownfields, particularly in the eastern part of the city (Andrikopoulou et al., 2015; Giannakou and Kaukalas, 1999; Municipality of Thessaloniki, 2016)

The Spatial Analysis, focuses, as described in section 3, on the distribution of circular maker activities in the municipality of Thessaloniki, revealing a widespread presence of "Reuse, Repair, Make, Fabricate, and Distribute" activities (Figure 1a & b). These activities are concentrated around the city centre and smaller trade centres. Specifically:

- "Reuse" typology, such as second-hand stores and antique shops, are prevalent in commercial zones and the city centre, particularly in key commercial centres like Thessaloniki and Kalamaria. Gounari street, known for its alternative young crowd and student population, hosts numerous clothing second-hand stores and Bit Bazaar in the city centre constitutes a trademark antique shop neighbourhood;
- "Repair" businesses are dispersed throughout residential areas, catering to clothing, shoe, and electronics repairs, often operating as small neighbourhood businesses. Social activist initiatives (squats with a social agenda) also provide repair services for free or with voluntary contributions;
- the "Craft" typology, including NGOs, small businesses and bottom-up citizen initiatives offering crafting spaces and lessons, is concentrated in the city centre and scattered in residential areas;
- the "Fabricate" typology includes fabrication labs, situated near educational institutions, indicating synergies with a younger audience;
- "Distribute" activities such as recycling centres and warehouses, are primarily located on the outskirts near industrial zones and motorways, facilitating material transfer.

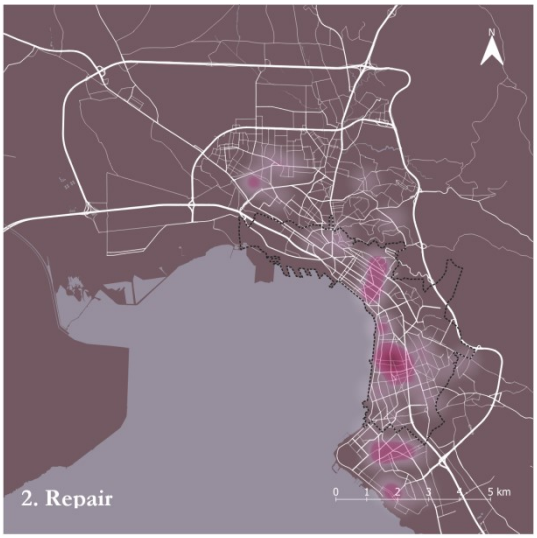



(a) (b)

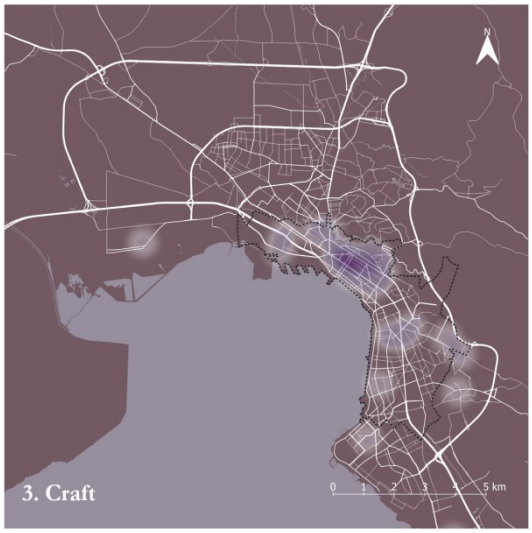
**Figure 1.** (a) Urban structure & transport (authors' elaboration based on ("CORINE Land Cover 2018," 2018; "Google maps," 2023; "Urban Atlas 2018," 2018)); (b) Circular urban production typologies aggregated heat map (authors' elaboration based on ("CORINE Land Cover 2018," 2018; "Google maps," 2023; "Urban Atlas 2018," 2018))

Very few of the sample typologies appear in the north of the city which suggests that they cluster more around the city's trade centres and more intensely around the three main primary roads in the city centre. The maker movement-related initiatives seem to include (i) small businesses, (ii) creative economy activities, that seem to occur predominantly through bottom-up initiatives and are currently not receiving explicit support from top-down policy (Karachalis, 2015), (iii) NGOs with environmental and circular agendas, as well as (iv) some top-down initiatives.


(a)




(b)




(c)


(d)


(e)

**Figure 2.** Circular urban production Typologies heat maps (authors' elaboration based on ("CORINE Land Cover 2018," 2018; "Google maps," 2023; "Urban Atlas 2018," 2018)) (a) Reuse; (b) Repair; (c) Craft; (d) Fabricate; (e) Distribute.

### *4.2 Analysis at Strategic Scale (Meso/Macro)*

At a global level, commitments towards more sustainable cities and industries, which entail circular, regenerative and production aspects, are included in the United Nations (UN) "*2030 Agenda for Sustainable Development*" and its 17 Sustainable Development Goals (SDGs), and more specifically in SDG 9 "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" and SDG 11. "Make cities and human settlements inclusive, safe, resilient and sustainable" (United Nations, 2015). Moreover, the UN have enclosed their vision for sustainable urban development in the "New Urban Agenda", including provisions for urban regeneration (United Nations, 2017).

Echoing global efforts, the European Union (EU) has embraced the SDGs and positioned them as central to Europe's recovery from the COVID-19 crisis. The "European Green Deal" serves as a cornerstone of these efforts (European Commission, n.d.), with initiatives such as the "Circular Economy Action Plan" (CEAP) taking centre stage. The CEAP aims to foster less waste and enhance product sustainability, while also promoting circularity at regional, city, and individual levels (European Commission, 2018). Furthermore, initiatives like the "New European Bauhaus" seek to promote sustainable living and enhance the environmental, functional, and inclusion aspects of the built environment (European Union, n.d.), while the "Circular Cities and Regions Initiative (CCRI)" facilitates knowledge exchange and networking among European circular cities stakeholders (CCRI, 2023). Additionally, the EU's "Urban Agenda for the EU" aims to stimulate growth, livability, and innovation in European cities, while addressing social challenges (European Commission, 2016). Action Plans developed under the Urban Agenda for the EU cover various topics, including the circular economy, sustainable land use, and cultural heritage, providing guidance for circular resource management, brownfield redevelopment, and enhancing city resilience (European Commission, 2020, 2018). Moreover, the "Territorial Agenda 2030" recognizes the need to promote circular value chains in urban areas to create more resilient economies (Territorial Agenda 2030, a future for all places, 2020), while the "New Leipzig Charter" provides a framework for sustainable urban governance, underscoring the importance of public participation in urban development processes (eu2020.de, 2020).

At a national level, Greece has launched the "*New Action Plan for Circular Economy*" in 2021, outlining 71 actions to foster a more sustainable and competitive economy. Recognizing the pivotal role cities can play in promoting circular policies, the action plan includes actions to empower citizens to engage in local reuse and repair activities, as well as promote sustainable consumption practices. Specific guidelines for urban regeneration planning are outlined in Law 2508/1997, which addresses sustainable residential development and provides criteria for identifying areas eligible for regeneration initiatives. However, while this law lays the groundwork for urban regeneration, it was created before the concept of circular economy became common and lacks provisions related to material reuse and other aspects pertinent to circular cities. Moreover, the implementation of circularity and regeneration initiatives is supported through the *Partnership Agreement for the Development Framework (PA),* which allocates financial resources from European Funds to various economic sectors and regions across Greece (Metropolitan Thessaloniki, 2017). The PA was embodied in the programme "Metropolitan Thessaloniki " (Metropolitan Thessaloniki, 2017) for the metropolitan area of Thessaloniki (see next paragraph), with financial support during the years 2014-2020 (also renewed for the years 2021 – 2027, as the new PA is currently being elaborated, prioritising smarter, greener, more connected and more social directions ("New PA 2021-2027," 2022)).

Moving toward the meso scale, Thessaloniki's urban fabric is divided into 8 different municipalities comprising a metropolitan area, which creates the need for a central and holistic planning and development approach. However, the "*Master Plan of Thessaloniki*" addressing strategic planning at the metropolitan level, was never institutionalized or

implemented, perpetuating a non-constructive situation. On a brighter side, the programme "*Metropolitan Thessaloniki*" in coordination with the 8 municipalities and the Central Macedonia Region's administration is updating and implementing an integrated plan for the regeneration and sustainable development of the metropolitan area while promoting a culture of participatory planning on a municipality level to pursue five priority axes for Thessaloniki to be:

1. Competitive and innovative (including also the aspect of circular entrepreneurship),
2. Coherent and participatory (focusing on public infrastructure that enhances inclusion of underserved communities),
3. Green and attractive (focusing on regeneration of urban public spaces and reusing unused buildings),
4. Resilient to climate change (including a holistic approach for urban mobility in the metropolitan area and promoting recycling and reuse), and
5. Effective (including promoting metropolitan plans) (Metropolitan Thessaloniki, 2017, n.d.).

Focusing on the municipality of Thessaloniki, it seems to take into account the EU directives and funding opportunities and has made some bold moves regarding strategic plans, such as the "Resilient Thessaloniki Plan" (which, even though it is a municipality initiative, aims for a holistic approach regarding the metropolitan area), and the "Digital Strategy 2017-2030", focusing on ways to enhance the city's resilience and to give citizens better tools to shape and use digital services (Metropolitan Development Agency of Thessaloniki S.A. and Municipality of Thessaloniki, 2016; Municipality of Thessaloniki, 2017). It also participates actively in the EU Mission for 100 climate-neutral and smart cities by 2030 ("Becoming a resilient city: what can we learn from the Greek city Thessaloniki?," n.d.), and in relevant international Research and Innovation projects besides Pop-Machina (e.g., UP2030: Urban Planning and design ready for 2030), which will provide it with new insights regarding urban planning needs and potentials in the city. Typically, however, initiatives like these, while providing a very important strategic orientation and having a transformative potential, cease to operate once funding is completed.

### *4.3 Analysis at Urban Area Scale (Meso)*

Urban policy and planning in Greece primarily operate at the municipal level, with recent reforms reflected in three institutional spatial planning laws: 4269/2014, 4447/2016, and 4759/2020. These laws permit land use mixing while emphasizing the avoidance of land use conflicts. Mixed uses are distributed both horizontally across the urban fabric and vertically within buildings. However, public engagement mechanisms in these planning frameworks are limited, as they only provision public consultation procedures at the last stages of plan development but lack institutional tools for participatory planning. While interested parties can submit proposals or opinions during these consultations, there are no legal obligations for supervising authorities to provide documented replies, potentially resulting in ineffective engagement (Seitanidis, 2023). Some participatory planning institutions are provisioned through the national local government governance framework, but related provisions have never been really used (e.g., Neighbourhood Town Planning Committee / L.1337/1983), are either no longer in force (e.g., Local and Municipal/Regional Referendums / L. 3463/200) or have a simple advisory role (e.g. Community Residents' Assembly / L.3852/2010, L.4555/2018) and Municipal Consultation Committee / L.3852/2010, L.4555/2018). Their application has been limited or ineffective due to bureaucratic formalities, lack of clear direction, and advisory roles without legal consequences for municipal authorities (Ministry of the Interior, 2017).

Consequently, urban planning and policy in Greece, including in Thessaloniki, have been criticized for their inflexibility, rigidity, and lack of vision, exacerbated by frequent legislative changes and a lack of clarity (Angelidou, 2018). Currently, urban area scale provisions for the city of Thessaloniki are mostly dictated by the municipality's General Urban Plan, which was revised in 2015 and approved by the local government in 2019 but remains to be approved and posted in the Government Gazette, before being deemed as in force ("Θεσσαλονίκη: Το νέο Γενικό Πολεοδομικό Σχέδιο, τέσσερα χρόνια στο ΥΠΕΝ, περιμένει να πάρει έγκριση [Thessaloniki: The New Urban Plan, 4 Years at the Ministry of Environment, Waiting for Approval].," 2023). This means that the old General Urban Plan of 1993 - a very outdated plan of 30 years- is still in force across the area covered by the Municipality of Thessaloniki. This old plan ignores completely the newer developments related to urban production and the organization of the city's productive economy, its placement in the current spatial structure, as well as its relationship with the circular economy.

Analysis of Figure 2 reveals that the primary commercial centre is situated in the city centre, with smaller commercial hubs in peripheral neighbourhoods. Bottom-up initiatives and non-profit organizations with environmental and circular agendas are predominantly concentrated in the city centre (mapping exercise of section 4.1). Initiatives focused on public space regeneration aim to enhance public spaces and create areas with broader community impact, sometimes extending beyond municipal limits. Specialized urban plans, such as the Nea Paralia Urban Plan, contribute to enhancing public spaces, transforming place identities, and fostering better citizen-public space relationships, thereby regenerating the city. Regarding transportation, Thessaloniki can be accessed via a ring road with motorway qualities, while internal mobility relies on primary roads along the coastline and secondary roads for vertical connections (Figure 1a). Public transport infrastructure faces challenges, with only city buses available, offering relatively low-quality service (Tsavdari et al., 2022). However, connectivity among key areas such as the university and small-scale industries is considered adequate. An underground metro line is expected to start operating soon ("Πρόοδος Βασικού Έργου Θεσσαλονίκης [Project progress – Thessaloniki].," 2023)

### *4.4 Analysis at Building & Urban Design Scale (Nano/Micro)*

At the neighbourhood level, public spaces in Thessaloniki tend to be narrow and constrained, posing challenges for goods transportation, pedestrian mobility, and social interaction. Nevertheless, the municipality is actively pursuing innovative urban design and regeneration projects aimed at enhancing public spaces both in the city centre and peripheral neighbourhood centres. Projects include improvements to Stock market Square, the Dock, Ayia Sofia street, neighbourhood parks, and the expansion of the bike lane network.

In fostering a local circular maker community and culture, the municipality has undertaken initiatives to raise awareness and engage citizens in circular issues. This includes organizing five Recycling Festivals and a Circular Economy Festival over the past decade. Efforts also extend to providing municipal spaces connected to the maker movement, such as the "Neighbourhood rooms" and the "SKG Makers" makerspace developed within the framework of Pop-Machina ("SKG MAKERS," n.d.; "The Neighborhood Room, Municipality of Thessaloniki," 2019). However, there is a lack of sustainability measures for these spaces post-funding, and neighbouring municipalities have yet to adopt similar initiatives.

At the initiative level, private sector groups organize large-scale flea markets annually or semi-annually ("Flea Market στη Θεσσαλονίκη [Flea Market in Thessaloniki]," n.d.), alongside flea markets organized by the Aristotle University and its volunteering groups ("Θεσσαλονίκη: Flea Market στο ΑΠΘ 8-9 Δεκεμβρίου [Thessaloniki: Flea Market in AUTh 8-9 December].," n.d.). Additionally, smaller-scale bazaars are organized by individuals,

groups, and the SKG Makers community/makerspace, while a multitude of initiatives provide DIY seminars. The local maker or circular initiatives and stakeholders often do not fully integrate both circularity and maker elements. They also predominantly identify as part of academic, research, industry, or civil society communities rather than as entrepreneurs or city authorities. Their visions focus on social cohesion, sustainability, and urban development, with strategies centred on knowledge sharing and networking rather than production and innovation (Metta and Bachus, 2020).

Individually, makers and maker teams in Thessaloniki are familiar with the maker movement but may not consistently incorporate both circularity and making elements, indicating potential immaturity in the circular maker community. However, the establishment of SKG Makers makerspace (and the Pop-Machina Circular Maker Accelerator) has played significant role in providing a common space for local makers, facilitating knowledge exchange, skills enhancement, and capacity building within the community.

## 5. CONCLUSIONS FROM THE CASE STUDY

Thessaloniki's fragmented urban policies and plans hinder the city's ability to adopt cohesive directions. The slow land use planning procedures result in outdated land use plans. Furthermore, current planning directions don't enable the citizens' involvement in planning procedures. Those findings indicate a non-flexible policy environment which doesn't encourage participatory planning.

Despite these challenges, the Municipality of Thessaloniki has taken pioneering steps towards a resilient, digital future and supported the maker movement by establishing "neighbourhood rooms" and the "SKG Makers" makerspace. However, the sustainability of these initiatives depends on securing further funding.

The metropolitan area's focus on becoming smarter, greener, more connected and social, holds promise, as projects funded by the "Metropolitan Thessaloniki" program are expected to contribute significantly to city regeneration and infrastructure development in line with circular agendas.

Thessaloniki exhibits a trend of social craftwork, with repair stores, second-hand shops, and antique stores dominating the landscape. However, the city lacks a focus on production-focused craftwork, with limited fabrication spaces and capacity. Most circular urban production typologies are concentrated in the city centre and two other local centres in the southeast (Analipsi and Kalamaria). The areas presenting increased potential to become part of the local maker ecosystem are mainly the commercial centres.

The study's findings offer insights into the city's metabolism and can inform urban planning and design decisions to embed circular and regenerative measures effectively. Recommendations include identifying sites with potential for the local maker ecosystem and supporting them with connectivity and mixed land uses. The city's commercial centres are in the spotlight of the urban maker ecosystem and need to be supported in terms of connectivity, with built infrastructure, with multimodal and combined means of transport. Mixed land uses enabling circular urban production need to be allowed.

In addition, the findings of our paper contribute to the development of recommendations for specific types of maker activities and maker infrastructure that should be developed, resonant with the city's making profile and needs identified in specific neighbourhoods:, Emphasis should be placed on enabling and scaling up repair and reuse stores while empowering crafts(wo)men to engage in circular maker activities, so that more craft and fabrication typologies appear, supporting the city's shift into a production-focused craftwork. More specifically, the city should try to nurture circular bottom-up initiatives of the Reuse and Repair typologies. Furthermore, regarding the Craft and Fabricate typology, the municipality

should ensure the sustainability of existing makerspaces and more should be created across the metropolitan area. An informative system on material flows should be created to support the "Distribute" typology, providing makers with essential information on material sources.

Last, but not least, this paper proposes changes that need to be made across scales to open new pathways for the maker movement's contribution to urban circularity and regeneration (Elwakil et al., 2021). Apart from opting for a holistic approach in the metropolitan area's planning and including circular and regeneration directions in the municipalities' strategic planning, it is crucial to create procedures and/or institutions that enable the citizens' participation in planning and adopt a placemaking approach. The participation tools need to be adopted on a macro scale level, so that they can be applied in all scales, and should be non-bureaucratic, topic-focused, and have more than an advisory role. Municipal makerspaces can serve as catalysts, providing start-up makers with affordable and accessible working spaces. Encouraging new circular businesses can create closed loops, boost circular procedures, and contribute to vibrant neighbourhoods, necessitating additional municipal infrastructures for regeneration.

## 6. DISCUSSION

### *6.1 Opportunities for Urban Policy and Planning toward Circular and Regenerative Development*

Howard Davis in 'Working Cities: Architecture, Place and Production' writes, '*Current, conventional wisdom is that many Western cities are no longer places of industry, but have evolved to house "service economies" and "knowledge economies*",' but he asserts '*that industry remains important to cities, that it can continue to define the culture of cities, that people who work with their hands deserve respect, and that efforts to bring more industry back to cities should be supported'* (Davis, 2019).

Manufacturing modes have significantly influenced urbanization since the industrial revolution, (Davis, 2019), suggesting that empowering distributed urban production could shape the urban fabric and regenerate cities while integrating circularity principles. Combining circular approaches with the makers' movement empowerment could lead to environmental and social reforms through large-scale reorganization of manufacturing processes and bottom-up reclamation of urban production processes (Elwakil et al., 2020).

The existing legislation or incentives in place, that regulate urban development and urban production can depict the setting in which the maker ecosystem is hosted and the challenges it is facing. At the same time, the identification of the patterns of the circular urban production typologies provides an overview of how this function is perceived in the socio-cultural context of the city, how it is structured and what traction and potential it has (Elwakil et al., 2020). These findings offer insights into the specific factors that need to align to create a more suitable environment for the city's transition into a circular and regenerative development.

The policy suggestions that could be implemented horizontally, to induce the empowerment of the maker ecosystem in every city for circularity and regeneration, should include recommendations in the three scales that have been examined in this paper. These recommendations should cover the continuity of planning, the inclusion of circular economy agendas and the empowerment of citizen participation in planning procedures.

Examining the Strategic scale, the needs that come up, which will help the circular and regenerative development include the institutionalization of strategic plans at the metropolitan level, to ensure a holistic planning approach. The strategic plans should provide circular and regeneration directions and indicate specific actions to be adopted, incentives to attract circular production activities, as well as provisions such as cross-municipal waste management synergies.

Furthermore, examining the different scales of participation (which exist in literature), it becomes apparent that the Greek institutional participatory (spatial) planning ranks at the lowest levels (Arnstein, 1969; Stathakopoulos, 1988). This means that the strategic plans need to introduce participatory planning procedures and tools on a macro-scale level, ordering its incorporation in the (more focused) urban and regional plans (on meso, micro and nano level). This will give voice to active citizens, offering the opportunity of focusing on the topics of circularity, making and regeneration.

On the Urban Area scale, both providing the fertile environment for existing circular businesses to up-scale, while staying in the city, and creating opportunities that will cause more circular businesses to arise could help increase the impact of distributed urban production. Increasing the urban production businesses and initiatives, indicates that the cities need to create new infrastructures to accommodate those uses, update their land-use regulations, empower their local communities and explore more needs towards this direction, since the approach is relatively unexplored (Tsui et al., 2021). This fact indicates a challenging new direction, as well as an opportunity for a city-scale experiment towards circularity. Spatial planning, on this scale, could create the tools that can lead to circular development, by transforming the urban provision system and thus providing a hospitable environment for circular activities (Williams, 2023). Moreover, activating the "Neighbourhood Town Planning Committees" could be a first step in providing a tool for the citizens to influence their municipality's strategies.

On the Building and Urban design scale, integrating maker-related land uses provisions into urban plans can encourage the emergence of circular urban production businesses. Cities can leverage the Typology analysis to identify trends and promote circularity effectively. Moreover, promoting regeneration projects that preserve local identity and enhance the public-private space dialogue can foster vibrant neighbourhoods, community bonding and the feeling of belonging and ownership of the public space. Finally, establishing municipal makerspaces and FabLabs can empower the circular maker community, offering equipment, training, and fostering community cohesion.

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