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PART I

GOVERNING CIRCULAR ECONOMY: PLACE-SPECIFIC BARRIERS THAT HAMPER THE CLOSE OF THE LOOP

Guest Editor: Viktor Varjú*

FOREWORD

In the past decade, the concept of 'circular economy' (CE) has been gaining importance on various levels. CE has plenty of definitions, however, based on Kirchherr and colleagues' (2017) systematic analysis it can be argued that most often circular economy is depicted as the set of activities reduce, reuse and recycle. Kirchherr *et al.* (2017) has indicated that the necessity of a systemic shift in order to achieve CE is often not highlighted (Kirchherr *et al.*, 2017).

According to Reike *et al.* (2018), the first CE article was recorded in 2007, while an exponential increase could be detected since 2015. However, the concept dates back much further, though framed differently, and CE can be divided into three phases (Blomsma and Brennan, 2017; Reike *et al.*, 2018). Alongside environmental movements in the 1970s, the focus was on the 'output side', on the pollution, and less attention was paid to prevention. From the 1990s, the second phase had a stronger integration among preventive and output measures, while the third phase in the last decade "is phrased as a way out of 'resource trap'" (Reike *et al.*, 2018, p. 249).

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On the meta-governing level, the urgency of closing materials loops is a new phenomenon, UNEP (2011) or OECD (2011) promoted the resource efficiency via their reports. Consortia of global actors (e.g. Ellen MacArthur Foundation[1]) play also a significant role in the field, and in 2015 the EU introduced its first Circular Economy Action Plan[2] and adopted a new one (COM/2020/98) in March 2020. Additionally, there are many initiatives to implement a CE, where the main actors are legislative and governmental bodies, NGOs, and consultancy firms (cf. Kalmykova *et al*., 2018), from global, national, and local/regional levels (Milligan and O'Keeffe, 2019), each yielding specific responsibilities and territorial limitations/scopes.

There are several lenses through which the aim of CE can be viewed, placing the emphasis on different part. CE is usually presented with a goal to achieve a transition towards a circular economy with a focus on closing material flow loops, aiming for 'zero waste', generating new business models based on waste as a precious resource, and deeply transforming the society's approach to consumption and disposal of goods and materials. With other emphases, CE "is expected to promote economic growth by creating new businesses and job opportunities, saving materials' cost, dampening price volatility, improving security of supply while at the same time reducing environmental pressures and impacts" (Kalmykova *et al*., 2018, p. 190). Whatever ambitions one considers, those tend to be moderated when confronted with the multiple governance, economic, legal, socio-spatial, socio-cultural, sociological, and behavioural barriers (Dąbrowski, 2019). A resource-efficient Europe can only be achieved with 'a policy mix that optimises synergies and addresses trade-offs between different areas and policies' (EC, 2011). Thus, local authorities, citizens, and other stakeholders need a collaborative and science-informed decision environment for developing proper resource management scenarios and assessing their impacts on the environment, the society, and the economy. Hence, circular economy transition needs to work with and in complex systems (Remøy *et al*., 2019).

Sustainability transitions – beyond traditional planning and development – require broader engagement, empowerment, and breakthrough strategies. The optimised management of a transition (that is often cited as 'transition management' in subject literature) combines frontrunners from policy, science, business, and the society (Wittmayer and Loorbach, 2016). It can ensure that (eco)innovation (that is a key aspect of the concept) serves the transition from linear towards circular economy. As Ghisellini and colleagues (2016) have indicated – based on their research seeking successful experiences – a key aspect of the transition towards CE comes from the involvement of all actors of a society and their capacity for creating collaboration and knowledge exchange (Ghisellini *et al*., 2016). Actu-

[1] https://www.ellenmacarthurfoundation.org/ [accessed on: 18.08.2020]

[2] https://ec.europa.eu/environment/circular-economy/first_circular_economy_action_plan.html [accessed on: 15.06.2020]

ally solutions and eco-innovations "require broadly carried «bottom-up» initiatives and innovations that can connect and interact with governance structures and «top-down» policies on higher levels," (Loorbach and Shiroyama, 2016, p. 9).

This thematic issue partly presents studies and cases from *Hamburg* (Germany), *Łódź* (Poland), *Pécs* (Hungary), *Naples* (Italy), *Ghent* (Belgium), and *Amsterdam* (the Netherlands). These studies were conducted under the umbrella of the EU Horizon 2020 research project of REPAiR – REsource Management in Peri-urban Areas: Going Beyond Urban Metabolism.

> The core objective of REPAiR is to provide local and regional authorities with an innovative transdisciplinary open source geodesign decision support environment (GDSE) developed and implemented in living labs in six metropolitan areas. The GDSE allows creating integrated, place-based eco-innovative spatial development strategies aiming at a quantitative reduction of waste flows in the strategic interface of peri-urban areas. These strategies will promote the use of waste as a resource, thus support the on-going initiatives of the European Commission towards establishing a strong circular economy.[3]

For research purposes, REPAiR used a common solid methodology. The scale of research was urban regions and their peri-urban areas with the classical problems of excessive use of resources and waste production, that is usually accompanied by fragmented (sometimes confrontative) local governments and planning systems within the peri-urban regions (and among the case studies) (Obersteg *et al*., 2019). Furthermore, their spatial configurations offered a range of possibilities to establish laboratories to co-explore and co-design solutions for the peri-urban regions.

In order to examine governance challenges, a different scale of governance (i.e. multi-level governance), cross-sectoral governance (the involvement of different divisions of the public sector, relating to CE) and 'quadruple helix' governance (that focus on the participation actors from the public, the private sector, science, and the civil society) have been considered. To allow a comparison between the cases, the analytical framework of PESTEL (Political, Economic, Social, Technological, Environmental, and Legal) had been used (Fozer *et al.*, 2017; Obersteg *et al.*, 2019; Song *et al.*, 2017).

For applying the above described framework and for conducting empirical research, apart from document analyses, semi-structured interviews with key stakeholders from waste management sector, local and regional authorities, and representatives of the private sector were conducted using a snowball sampling method, which led to the identification of additional stakeholders in the field of CE (Obersteg *et al.*, 2019). The identified stakeholders (from the four spheres mentioned above) – outside the interviews – were invited for a series of meetings following the living laboratory format. This *Peri-Urban Living Laboratories*

[3] http://h2020repair.eu/ [accessed on: 1.09.2020]

(PULLs) enabled a co-exploration of challenges and a co-creation of new solutions in order to push peri-urban regions towards CE (Amenta *et al.*, 2019).

All the studies in these six case-study peri-urban regions followed the same methodological framework (described above) tailoring the implementations to their case specific circumstances, however, each of them faced different challenges towards circular transitions. The Łódź case – at the beginning of the path towards circularity – offers an overview of the new socio-geographical challenges and the changing flows due to a new waste management regulation (enforced in 2013). *Berutti* and *Palestino* analysed 'wastelands' in Naples' urban region and the *Land of Fire*. As in CE, usually flows are investigated, therefore, the analysis of 'wastescapes' is unique in this field. The authors have argued that after a long bad period 'wastescapes' can offer potential to rehabilitate spaces and a governance model. The Pécs case, similarly, shows waste as a resource potential and emphasised the drawback of the recent Hungarian centralisation processes and their impacts. Governance is also a critical issue in the case of Ghent, but in a contrary manner. Reflecting to the need for strong and wide collaboration, the case study shows a strategic long-term thinking towards the transition. The Hamburg Altona case indicates that the involvement of local stakeholders (in the format of a living lab) can force place-based solutions in response to CE-related local challenges, however, there is a need for an embeddedness in (local) governance and spatial planning systems. Amsterdam appears a frontrunner in the transitional process towards circularity, however, the Metropolitan Area is also facing barriers in different phases of governance needed for an extensive cross-sectoral and cross-boundary partnership with a "visionary and proactive leadership at the regional level, integrating CE policy with spatial strategies".

In order to get a broad picture on the transition towards circular economy, other papers have been invited to present the state and challenges on the way towards circular economy. The paper on Visegrád countries (Hungary, Poland, Slovakia, and Czechia) provides an overview of the eastern, while the article presenting citizen involvements (in Copenhagen, Genoa, Hamburg, and Lisbon) shows an insight from the western part of Europe on the way of circularity transition. The latter comparative case reflects the importance of a broader engagement with citizens, while *Szabó and Pomázi* – via different indicators – have shown the performance of Visegrád countries that are lagging behind the EU average.

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CIRCLING THE SQUARE: GOVERNANCE OF THE CIRCULAR ECONOMY TRANSITION IN THE AMSTERDAM METROPOLITAN AREA

Abstract. Circular economy (CE), the new 'buzzword' in urban and regional studies and policy debates, is about shifting from a linear production process towards a circular one in which the generation of waste is minimised, materials circulate in 'closed loops', and waste is not considered a burden but rather a resource that brings new economic opportunities. However, while there is a consensus on the need to facilitate a transition towards a circular economy, the governing of this endeavour remains extremely challenging because making a circular economy work requires cutting across sectoral, scalar, and administrative boundaries. Drawing on the sustainability transitions literature and the case of the Amsterdam Metropolitan Area, arguably one of the frontrunners on the strive towards a circular built environment and economy, the paper seeks to identify and understand barriers for CE transition at a regional scale. The findings underscore the multi-faceted nature of the challenge and offer lessons for the governance of emerging regional circular spatial-economic policies.
Key words: circular economy, transitions, urban regions, governance, sustainability, planning.

1. INTRODUCTION

In an increasingly urbanised world, cities are crucial for enacting sustainability transitions and human development within global boundaries (Frantzeskaki *et al.*, 2017; Wolfram and Frantzeskaki, 2016). With the advent of Circular Economy (CE) as a 'new sustainability paradigm' (Geissdoerfer *et al.*, 2017), there has emerged the need to shed more light on the role of cities – vital economic, social and political hubs – in a shift towards circularity.

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CE is most often understood as a socio-economic regime in which value-creation mechanisms would be decoupled from the consumption of finite resources by avoiding waste, closing material loops, and facilitating ecological restoration and regeneration of the damage to the eco-systems done by the predominant linear industrial processes underpinning the current capitalist economy (Ellen McArthur Foundation, 2015; Geissdoerfer *et al.*, 2017). While in a 'linear' economy products are manufactured, then sold, used, and disposed of, and finally, hopefully their parts are recycled, in a circular model the focus is on maintaining the value of the materials used in products through maintenance, repair, reuse, remanufacturing, etc.

The ascent in significance of the CE concept in business, policy and academic circles has been nothing short of spectacular. It prompted new policies and strategies at all scales and levels of government, from the European level (European Commission, 2015; Domenech and Bahn-Walkowiak, 2019), national (e.g. in the Netherlands, see Dutch Ministry of Infrastructure and the Environment & Ministry of Economic Affairs, 2016), to regional (e.g. Provincie Noord-Holland, 2017) and local (e.g. Circle Economy, 2016). Cities across the world put CE on their policy agendas and develop strategies to shift away from the linear mode of production and consumption (Obersteg *et al.*, 2019; Williams, 2019; Turcu and Gillie, 2020; Prendeville *et al.*, 2018, Petit-boix and Leipold, 2018). The concept has also spawned a rapidly growing body of literature from across various disciplines, from environmental economics, industrial ecology to urban studies (for an overview of the emerging perspectives on CE in research, see Merli *et al.*, 2018 and Winans *et al.*, 2017). Thus, 'circular' has become the new 'sustainable' (see Geissdoerfer *et al.*, 2017).

While we are merely at the beginning of a transition towards CE (Ghisellini *et al.*, 2017), it is already clear that this transition requires vast resources, involvement of a large variety of actors, and it depends on the ability to foster collaboration and exchange of knowledge. According to Ellen MacArthur Foundation "a transition to the circular economy […] would involve considerable costs, such as R&D and asset investments, stranded investments, subsidy payments to promote market penetration of new products, and public expenditure for digital infrastructure" (2015, p. 15). More specifically, a shift towards circular models of production and consumption would require that all actors engaged in the flow of a particular material flow were engaged in the process and revised their business models, ways of working, behavioural patterns, and expectations towards products. Crucially, new governance arrangements are also needed to revise and connect the strategic agendas of territorial authorities, businesses, and civil society actors to facilitate the transition. Governance is thus one of the pillars of this shift (Ellen MacArthur Foundation, 2015, p. 15).

Even though there is a consensus that cities need to 'go circular', there is a gap in knowledge on how cities can actually facilitate a transition towards CE (Fratini *et al.*, 2019). The literature on circular economy tends to focus either on the technical aspects of closing the material loops or on the business models related to it,

at the expense of a consideration for the social and environmental dimensions. While this may be "be more attractive for policy makers and private business", it can be "problematic for the transition to a more sustainable economic system because attention and resources are diverted from more comprehensive and holistic approaches" (Geissdoerfer *et al.*, 2017, p. 766). Fischer and Pascucci argued that "the main challenge is to understand how to facilitate this transition when constrained by an institutional system that is aligned with the status quo of a linear economy" (2017, p. 18). In a similar vein, Fratini *et al*. stressed that "developing and implementing circular economy strategies in cities calls for new governance systems and/or changes in the existing governance arrangements" (2019, p. 987). However, to enable a shift towards a circular economy in a particular territorial context, one needs to understand the context-bound barriers for it, explore what needs to change, and where problems lie.

Addressing this lacuna is urgent because "the concept of the CE in itself is over-hyped, scarcely investigated and therefore ill-defined, [...] so far dominated by a business-focused narrative for competitive advantage, raising questions about the placement of the CE within a broader urban sustainability agenda" (Prendeville *et al.*, 2018, p. 172). The current applications of the CE paradigm in urban strategies and initiatives tend to neglect the questions of land use, geographical scale, and the complexity of urban systems (Williams, 2019) and local territorial conditions (ESPON, 2019), which all have a bearing on multi-actor cooperation across scales and sectors that CE requires (Obersteg *et al.*, 2019).

There is also a gap in knowledge regarding the role of social contexts, including social identities and institutions, in CE transitions in cities (Fratini *et al.*, 2019; Moreau *et al.*, 2017; Korhonen *et al.*, 2018). Research to date highlights institutional barriers for a CE transition and the need for new rules governing interactions between the multitude of actors involved (Ghisellini *et al.*, 2017; Fischer and Pascucci, 2017). Against this background, the fact of understanding the institutional context for a CE transition is an urgent research gap to bridge, especially considering the political tensions that the spatiality of cities and their transition agendas entail (Marin and De Meulder, 2018).

Finally, while most studies on urban transitions towards CE focus on cities, there is insufficient attention paid to its regional dimension and the operationalisation of a CE at the scale of an urban region (Obersteg *et al.*, 2019; OECD, 2019). Such a regional perspective is much needed in the wake of the growing role of urban regions as the scale at which urban (sustainability) policies are developed and implemented, albeit often without sufficient resources and capacity (Turcu and Gillie, 2020). A regional lens to study a CE transition is also helpful due to the regional dimension of metabolic flows, which go beyond the administrative boundaries of cities, connecting actors and activities across wider regional spaces (Geldermans *et al.*, 2018). In summary, without a clear understanding of those issues one risks taking ill-informed decisions on how to best promote a CE and

lead to a situation where the concept might "lose credibility and become reduced to buzzwords or greenwashing" (Prendeville *et al.*, 2018, p. 188).

This paper responds to the abovementioned knowledge gaps by exploring the scope for transitions towards a CE in the Amsterdam Metropolitan Area (AMA), often (self-)styled as a global leader in circularity. Building on transition management literature, the paper aims at identifying the barriers that prevent the implementation of the necessary elements for governing a CE transition in that urban region.

2. TRANSITION GOVERNANCE AND MANAGEMENT

2.1. Transition governance

Given the complex nature of governing a CE transition in urban regions (Obersteg *et al.*, 2019) and cities, and the many barriers that need to be overcome to depart from the prevailing linear economy, it can be fruitful to apply a governance approach that aims to address the tension between "the open-ended and uncertain process of sustainability transitions and the ambition for governing such a process" (Frantzeskaki *et al.*, 2012, p. 21). Examples include adaptive governance (Olsson *et al.*, 2006), reflexive governance (Voß *et al.*, 2006; Grin *et al.*, 2010), or transition governance (Loorbach, 2007; Frantzeskaki *et al.*, 2012). What these governance notions have in common is that they perceive reality as being "multiscalar, complex, nonlinear, uncertain, normative, dynamic, complex and path dependent" (Wittmayer and Loorbach, 2016, p. 14). Such notions resonate with the complex nature of governing a CE as a major sustainability transition (De Jesus and Mendonca, 2018; Bode *et al.*, 2019; Obersteg *et al.*, 2019). Additionally, these governance theories have evolved in more specific approaches like transition management (Rotmans *et al.*, 2001; Loorbach, 2007), offering potential pathways to manage sustainable change in various ways.

2.2. Transition management

Therefore, in relation to our specific CE case, we chose to use the transition management approach for two reasons: (1) to understand what can be done to transition from one situation to another, thereby overcoming barriers and challenges; and (2) to develop possible policy recommendations for CE transitions.

Yet what are transitions and what is transition management? A transition, according to Rotmans *et al.* (2001, p. 16), can be defined as a "gradual, continuous process of change where the structural character of a society (or a complex sub-system of society) transforms". "The 'transition management' approach has

made substantial contributions in questions related to the governance of large-scale societal transformations" (Farla *et al.*, 2012, pp. 991–992) and has played a pivotal role in Dutch policies aimed at decreasing persistent environmental and societal problems (Rotmans, 2003; Elzen *et al.*, 2004; Loorbach, 2007; Farla *et al.*, 2010). The central idea behind transition management is that societal, environmental and economic changes requires the identification of a multitude of barriers that prohibit or hamper change, and to do so in a holistic integrated manner by looking at various governance levels and the links between them. Governing sustainability transitions starts with understanding how "strategies, resources and capabilities of individuals, firms and other organisations impact the overall system and trigger transformation processes, and how these changes at the system level feed-back into the observed strategies at the actor level" (Farla *et al.*, 2012, p. 992).

Importantly, the transition management approach does not hold "a silver bullet solution for actually realising ambitious sustainability objectives" (Nevens and Roorda, 2014, p. 120). It requires translation and adaptation to specific transition challenges and questions in the urban contexts (Nevens *et al.*, 2013; Wittmayer *et al.*, 2014b), and political regimes (see Wittmayer and Loorbach, 2016). One can also question the extent to which "governance towards desired outcomes can be deliberately managed, despite their multi-level, multi-actor character" (Jackson, 2014, p. 524). To this, Meadowcroft (2009, p. 484) responded that "although transitions cannot be controlled in any absolute sense, they can be influenced (encouraged, re-oriented, or sped up) through deliberate intervention."

2.3. Transition management framework

In order to effectively govern the various barriers towards a CE in urban regions, applying the transition management framework to a specific institutional context can be particularly useful (see Fig. 1). Transition management provides "an action impetus and more intangible outcomes in terms of practising collaborative governance and system thinking (Nevens and Roorda, 2014), and it holds promises with regard to creating space for alternative ideas, practices, and social relationships (Wittmayer *et al.*, 2014a; Roorda *et al.*, 2014)" (Wittmayer and Loorbach, 2016, p. 24).

This transition framework distinguishes four transition levels and corresponding transition governance activities (see Loorbach 2007; 2010) as follows (see Wittmayer and Loorbach, 2016, p. 19):

– Transition Arenas with strategic-level activities: activities aimed at the long term through which the future is collectively debated, imagined, and formulated in policies, visions and norms;

– Transition Agendas with tactical-level activities: activities aimed at the mid-term, aiming for change in established structures, institutions, regulations, and physical or financial infrastructures;

– Transition Experiments with operational-level activities: activities aimed at the short term, involving experiments and actions through which alternative ideas, practices, and social relations are explored, tested, and showcased;

– Transition Monitoring and Evaluation with reflexive-level activities: activities geared towards learning about the present state and system dynamics, possible future states, and the path from present to future, including (collective) learning from ongoing transition activities.

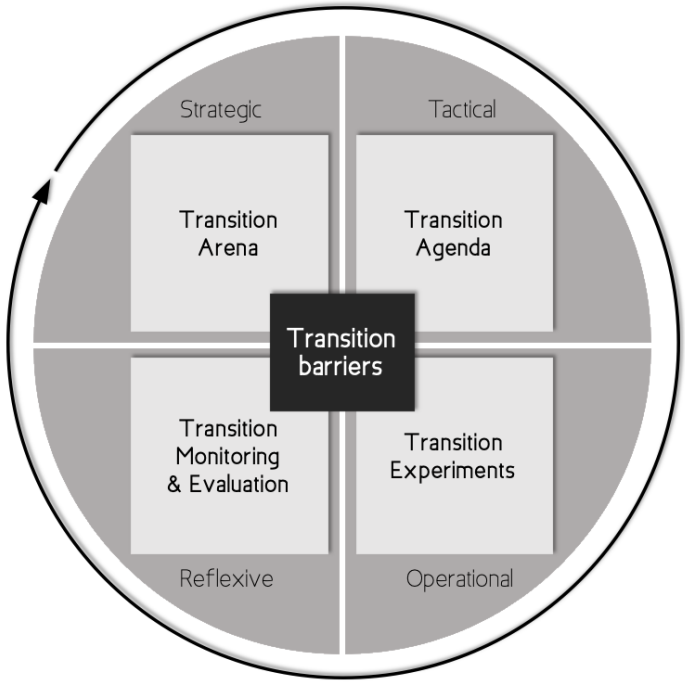

Fig. 1. Conceptual framework: barriers for managing transition towards CE

Source: adapted from Wittmayer and Loorbach, 2016.

This framework has been applied in other studies about sustainable urban transitions (Frantzeskaki *et al.*, 2014). For transitions to happen, change and activities are required to take place at all of these levels, despite the different time horizons. Moreover, activities at one level affect governance activities at other levels, so interdependence is a key feature for transition management. As De Jesus and Mendonca (2018, p. 75) argued, we need to "develop a thorough understanding of the factors that foster and hinder the transition to a CE", by us defined as transition barriers that might occur at various transition management levels. Therefore, we will use this framework to map and relate the barriers and activities towards CE, using the AMA as a case.

3. METHODOLOGY

3.1. Research methods

This exploratory research is based on a set of three qualitative research methods, enabling the gathering of rich empirical material and a triangulation of insights from each of the methods used. First, we analysed the key policy documents, such as analyses, reports, visions and strategies elaborated by public authorities at the national, regional and local levels. This provided the necessary background knowledge and allowed us to orient interview questions to extract additional information from key stakeholders.

Second, we conducted 12 interviews with a selection of public and private circular economy stakeholders in the AMA and at the national level. The interviewee selection strategy entailed ensuring variation of kinds of actors, operating in different sectors and scales, in order to be able to contrast the different perspectives and paint a nuanced picture of the barriers for a CE transition. In particular, interviews were conducted with sustainability managers of the key economic actors and producers of waste in the region (Schiphol Airport, Greenport Aalsmeer, Flora Holland, Tata Steel, and the Port of Amsterdam), governmental organisations (Municipality of Amsterdam, Municipality of Haarlemmermeer, Ministry of Infrastructure and the Environment), grassroots organisations (Buiksloterham, Amsterdam), construction industry companies (Amvest, Delta Development Group), and major waste management companies (Afval Energie Bedrijf, van Gansewinkel). Interviews were semi-structured and focused on the stakeholders' understanding of a CE and its respective objectives, main challenges and potentials in achieving these objectives, the conflicts and collaborations between stakeholders, and knowledge needs. The interviews were recorded, transcribed and coded for the purpose of analysis.

Third, data was gathered through participatory observation in a series of four workshops as part of the REPAiR[1] living lab in Amsterdam bringing together a plethora of CE stakeholders, from academia, regional and local governments, to industry and civil society. The living labs workshops were intended to enable a co-creation of knowledge with stakeholders on the diagnosis of CE potential and challenges, design and testing of a participatory tool called GDSE[2] and on the design of eco-innovative solutions and strategies for CE in the AMA (see Amenta *et al.*, 2019; Arciniegas *et al.*, 2019).

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[1] *REsource management in Peri-urban AReas*

[2] *Geodesign Decision Support Environment*

3.2. Selection of case study

In a nutshell, the choice of Amsterdam region as a case study is relevant and justified because of its leading position in its transition towards a CE and the plethora of circular initiatives already taking place there. Additionally, these pioneering activities take place in a wider context where a CE is becoming a top policy priority. The Dutch government aims to shift the national economy towards one based on the principles of the CE by 2050 (Ministry of Infrastructure and Environment and Ministry of Economic Affairs, 2016). Finally, the national government has formulated specific CE policies focusing on specific sectors, for instance construction (Rijkswaterstaat and Ministry of Infrastructure and Environment, 2015).

That said, it is important to understand that the Dutch government administration is democratically institutionalised at the national, provincial and municipal territorial levels. All formal policy-making and legitimised democratic decision-making takes place at these three administrative levels, including spatial-economic and resource management issues. Nonetheless, in terms of spatial planning the Dutch state has a strong tradition of coordination between these administrative levels. At the regional and metropolitan levels, formal government bodies with financial means and decision powers are absent. Hence, at this regional scale more informal regional-metropolitan governance networks and local public-private project-oriented actor constellations are active. They influence formal policy-making, implementation and the co-governance of the built environment.

This situation is also recognisable in the AMA. The metropolitan region spans across the boundaries of two provinces and encompasses the city of Amsterdam and 32 municipalities. It is at the heart of the national circularity effort. The region brands itself as 'worldwide frontrunner in circularity'[3], the city of Amsterdam presents itself as a 'circular hotspot'[4], while the Port of Amsterdam sees itself as 'the perfect hub for circular economy'.[5] Behind the branding, there are also concrete policies implemented by cities located in the AMA, including Amsterdam, Haarlem, Haarlemmermeer, and more. In parallel, various private actors, from waste management companies to construction companies, develop circular development initiatives and formulate their own circularity ambitions, while a large variety of small and medium businesses and start-ups join the CE push (see Prendeville *et al.*, 2018). Despite this wealth of initiatives, the region remains at the beginning of the transition towards a CE. As reported in previous research, in Amsterdam "the focus is mostly on innovative solutions/products for supporting the making of urban circularities" (Fratini *et al.*, 2019, p. 982), whereas much less attention

[3] https://hollandcircularhotspot.nl/cities/metropole-region-amsterdam/ [accessed on: 18.06.2020].

[4] https://www.iamsterdam.com/en/business/news-and-insights/circular-economy/amsterdam-a-circular-hotspot [accessed on: 18.06.2020].

[5] https://www.portofamsterdam.com/en/business/settlement/port-amsterdam-perfect-hub-circular-economy [accessed on: 18.06.2020].

is paid to the management of the transition towards a CE and in particular to the development of cooperation across sectoral, scalar and administrative boundaries. Our analysis aims to shed light on these matters.

Fig. 2. Amsterdam Metropolitan Area and the focus area for the research

Note: on the map on the left, thin lines represent provincial boundaries, while the thick line corresponds to the boundaries of the AMA; on the maps in the middle and on the right, thin lines represent municipal boundaries, while the thick line indicates the focus area of the study.

Source: own work by REPAiR team TU Delft.

3.3. Analytical framework

In order to structure the analysis of CE challenges in the AMA we used a PESTEL-O model as proposed by Obersteg *et al.* (2019). It is based on the PESTEL framework (e.g. Song *et al.*, 2017) , often used in strategic planning. The acronym stands for Political, Economic, Social, Technological, Environmental, and Legal factors that affect how organisations work. The framework enables a comprehensive overview of (often interrelated and interdependent) challenges. Following Obersteg *et al.* (2019) we add the organisational factor ('O'), reflecting the importance of governance challenges for a CE identified in literature.

4. CIRCULAR ECONOMY TRANSITIONS IN THE AMA

This section describes the status quo of the transition towards a CE in the AMA, by relating the various identified governance challenges to the various transition management levels. The analysis is based on qualitative data retrieved from interviews

Table 1. CE governance challenges and positioning within the transition management levels

		Transition management			
PESTEL-O	*Governance challenges*	*Arenas*	*Agendas*	*Experiments*	*Learning*
Political	Lack of consistency in municipal sustainability policies	x			
	Lack of regional CE policy formulation and coordination	x			
	Lack of CE policy spanning across administrative boundaries	x			
	Domination of Amsterdam	x			
Economic/ financial	Banks reluctant in financing CE ventures			x	
	Limited awareness of successful CE business models in resource management and planning projects			x	
	No tax disincentives for companies and households producing waste		x	x	
	Competition for waste as a resource		x		
	Extreme pressure on land development favours rapid linear redevelopment at the expense of CE solutions			x	
Social/ behavioral	Consumer readiness to pay premiums for circular products			x	
	Fence-sitting and reliance on business leaders to make the CE transition			x	
	Limited awareness of CE among producers			x	
Technological	n/a				
Environmental	Presence of polluted or noise-restricted peri-urban wastescapes in port and airport areas			x	
Legal	Construction tender procedures not adapting CE principles and respondent to CE processes		x	x	
	Unclear legislation on waste ownership		x		
	Misalignment new planning law CE goals and provincial and municipal plan CE applications		x		
	Building regulations too rigid to accommodate circular innovations		x	x	
Organisational	Lack of regional CE platforms, networks and leaderschip	x			x
	Risk-avoiding attitude towards CE initiatives in municipalities		x		
	Silo-mentality within governments and business regarding CE	x	x	x	
	Knowledge fragmentation within and asymmetry between organisations	x	x		x
	Dominance of big players in waste management				x
	Secrecy about resource flows in production process				x

Source: own work based on Obersteg *et al.*, 2019; Dąbrowski *et al.*, 2019; Arlati *et al.*, 2017; Remøy *et al.*, 2018.

with key stakeholders, workshops, document reviews, scientific papers (Obersteg *et al.*, 2019), and conference presentations (Dąbrowski *et al.*, 2019). By doing so, we provide insight into how the AMA region shapes the transition towards CE, enabling a discussion about the extent to which these efforts and activities are assumed effective from a transition management perspective in addressing identified governance challenges. Table 1 illustrates AMA's main CE governance challenges and the transition management levels at which these challenges occur. The remainder of this section discusses the transition barriers observed in more detail.

4.1. Transition arenas

Concerning transition arenas, i.e. long-term-oriented strategic circular activities, the AMA can indeed be considered an early adopter among European urban regions, even though the municipalities lead the strategic efforts on CE. As already mentioned, several municipalities, especially the larger ones (the Municipality of Amsterdam, 2016; the Municipality of Haarlem, 2017; the Municipality of Haarlemmermeer, 2015) put forward visions, policies or action agendas for the development of CE and formulated circular city policies, intended to guide public and private decision-making towards that goal.

That said, the stakeholders have highlighted a number of political and organisational barriers for the implementation of these strategic activities. Some of those stem from internal issues within local governments and other organisations. Namely, stakeholders stressed the lack of consistency in municipal sustainability policies, now being supplemented by CE activities. They also indicated a risk-avoiding attitude towards CE initiatives among municipal decision-makers and a silo mentality within governments and large business (such as the Royal Schiphol Group managing Amsterdam's airport). This results in CE strategies being of interest or limited to some departments and not mainstreamed across the wider organisation.

Other barriers reported impact the relations between governmental and private organisations. First of those was mistrust between the municipalities involved in the AMA, particularly between the smaller municipalities and Amsterdam, which tends to be perceived as the dominant player in the region. At the same time, it was striking that none of the provinces involved in the AMA (North-Holland, Flevoland, and Utrecht) played a strong role in the CE arena, despite their important roles in spatial planning and many policy fields. This was partly due to the political clout of Amsterdam in the region contrasting with that of the provinces' territories spanning far beyond the AMA. But also the stakeholders simply did not deem the province as a relevant level of government for CE policy. Against this background, stakeholders tended to complain about a lack of inspirational and effective leadership in the region that could connect CE stakeholders effectively

and trigger commitment to a long-term strategy for CE. On the organisational front, our interviewees and workshop participants also highlighted a lack of regional policy platforms for formulating and coordinating longer term CE policy goals, with the time horizon of existing policies being limited to the medium term (AMA, 2018a). Moreover, stakeholders underscored knowledge fragmentation and knowledge asymmetry between organisations, both municipalities and companies, which skewed the playing field towards those organisations that had started developing knowledge on CE earlier. This was further aggravated by secrecy and a lack of platforms for data sharing on resource flows in production and demolition processes, hindering development of CE policies and strategies.

4.2. Transition agendas

Concerning transition agendas, the province of North-Holland (see Circle Economy, 2017; Provincie Noord-Holland, 2017), and the region of Amsterdam and its municipalities, especially Amsterdam, have put forward numerous tactical actions to stimulate the stride towards a CE. Examples included the establishment of a development plan for circular economy in the 2025 perspective (AMA, 2018a), the definition of actions along three tracks: circular procurement (harmonising tender procedures among municipalities to reach 50% of circular procurement by 2025), workgroups to facilitate closing loops in specific material flows, and a set of actions to kickstart CE (cooperation on waste management, facilitating access to data on materials, etc.). Interestingly, the leadership on the implementation of the plan was entrusted to sustainability councillors of Haarlemmermeer and Lelystad, which could partly contribute to addressing the lack of regional leadership problem mentioned above (AMA, 2018a). That was done to facilitate the implementation of the plan, the 2016–2020 spatial economic agenda for the AMA (AMA, 2018b) and to emphasise CE goals. What is more, the city of Amsterdam together with the AMA commissioned a study into the current circular jobs and skills' base across the region (Circle Economy, 2016), while a study by Metabolic (2017) mapped the circular potential of Amsterdam's neighbourhoods. Both studies have taken stock of the region's potential and provided a knowledge base of municipal and regional CE policies, but also for developers, construction companies, and waste companies willing to invest in circular activities. In parallel, the municipality of Amsterdam has issued a roadmap towards circular tendering (the Municipality of Amsterdam, 2017), recognising that the purchasing power of a municipality can be a catalyst for promoting circular land use and construction. Thus, CE conditions for building projects are now attached to land sales in Amsterdam, however, the approach is also promoted across the region with efforts to harmonise procurement rules (AMA, 2018a).

Despite this flurry of tactical activities to promote CE, stakeholders again underscored many economic, political, legal, and organisational barriers. First, even

though efforts were undertaken to promote circular tendering, stakeholders stressed that this practice remained a relative novelty and companies in the construction sector were not yet prepared to offer competitive circular products and services. Second, more fundamentally, the existing tax system, as stakeholders frequently argued, did not disincentivise production of waste. Should waste generation be taxed, companies would have a strong incentive to change their ways of production towards more circular ones. Third, stakeholders recognised that should CE become mainstream, waste would no longer be seen as a burden but as a valuable resource for which companies would compete and keep it to themselves to reap the profits from activities towards maintaining or upgrading its value. In other words, individual agendas rather than collective ones are likely to become a challenge in the near future. Concerning legal barriers, stakeholders also recognised that the recently revised Dutch spatial planning law (Dutch: *Omgevingswet*) adopted CE as a goal, which could be an opportunity to push for circular urban development. However, the law has fallen short of providing clear rules for implementing that goal in spatial development plans at provincial or municipal levels. At the same time, building decree regulations (Dutch: *Bouwbesluit*) have remained too rigid to accommodate circular innovations in building technology and area development. This limits the possibility for imposing circular building features as a precondition for receiving a construction permit. Finally, the same organisational barriers as those affecting strategic level activities, namely fragmentation and knowledge asymmetries as well as silo mentality within organisations, were mentioned by stakeholders as hindering the deployment of tactical actions for CE.

4.3. Transition experiments

Transition experiments in the AMA region are operational activities which aim to facilitate changes at the relatively short term, focussing on experiments and actions through which alternative ideas and social relations are practised. One example in which the Amsterdam municipality and local builders experiment with circular visioning, tendering and construction is the circular urban redevelopment area of Buiksloterham. This CE initiative has been supported by a vision document Circular Buiksloterham (Gladek, *et al.*, 2015) that has been signed by many different organisations, including the city of Amsterdam, housing associations, the water board, and home builder groups. Moreover, CE tendering procedures also have been applied here as an act of a CE policy implementation. This site, being earmarked as an Urban Living Lab (Steen and Van Bueren, 2017) in which the development and testing of CE initiatives, products and policies plays a vital role, has been crucial for its experimental character in Amsterdam North. Lessons from this CE experiment indicate a wide variety of challenges, e.g. high CE ambitions being weakened by requirements motivated by the status quo (Steen and

Van Bueren, 2017). Many other CE spatial and urban experiments and initiatives across the AMA region are emerging as documented, for instance, in the Resource Atlas (Dutch: *Grondstoffen Atlas*) from RoyalHaskoningDHV *et al.* (2018).

Despite these extensive efforts, it has become clear from our interviews and workshops that such transition experiments face various barriers. Stakeholders have indicated that there is a lack of best practices of spatial CE initiatives, a fact which hampers a further development and financing of CE ventures. Also, knowledge on implementing CE initiatives seems rather fragmented, insufficient and/or unbalanced within and between organisations to effectively support a broader governance of CE transitions. Moreover, a lack of urgency in the demand for CE is evident, and it was marked as a 'root' challenge by some, as it is cheaper to produce in a linear manner, because reusing is more expensive, which for instance is the case of circular building materials and systems. Moreover, due to the prevailing extreme pressure on land development (for housing mainly), planning and development actors opt for risk reducing speedy business-as-usual development, in which CE solutions are often side-lined. At the same time, flexible land use rules are needed, as restrictions in zoning plans do not accept a re-use of wastescapes as construction around Schiphol airport for instance. In brief, financial, legal and organisational barriers observed in operational experiments often show a direct interdependence with (insufficient or incomplete) transition paths at the tactical levels, therefore hindering the effective management of transitions in more concrete CE projects.

4.4. Transition learning

A crucial final step in governing the transition towards a CE is (collective) learning. Transition learning consists of monitoring, evaluation, and reflexive activities aimed at understanding the present state and the dynamics in a system and the possible pathways from present to future situations. In the AMA, there are promising CE initiatives, and a few focus on learning. There is the AMS Institute which promotes circularity in urban regions as a central part of their research activities and various events and educational programmes[6]. In addition, AMS collects, develops and shares urban data for the scientific and professional community. Other learning platforms include Cirkelstad[7], which promotes CE themes nationwide, including policy, purchase, design, construction, and demolition for the building industry and cities. Recently, Cirkelstad has started organising various so-called Master Tracks including Circular urban development, circular housing, circular schools, and circular tendering[8]. Also, Madaster

[6] https://www.ams-institute.org/urban-challenges/circularity-urban-regions/ [accessed on: 08.10.2020]
[7] https://www.cirkelstad.nl/ [accessed on: 08.10.2020]
[8] https://www.cirkelstad.nl/opleidingen/ [accessed on: 08.10.2020]

plays an important role in the monitoring of the transition towards a CE as their online platform registers and stores data on the products, components, and materials being used in buildings, aimed at creating material or building passports. Thus, building industry actors would be able to determine the financial and circular value of buildings, and the opportunities for demounting and reusing building resources. Lastly, there are a number of funded research projects and programmes led by universities (of applied sciences) in which public and private organisations participate, through which personal, organisational and collective learning takes place.

Nonetheless, the data from our interviews and workshops has revealed that despite these learning activities several organisational barriers persist. The main barrier for this level of the transition towards CE is the lack of free and widespread availability and accessibility of data. For instance, information on the origins and characteristics of materials within CE building products or the resource and waste flows at the regional level is unavailable. In addition, such knowledge is fragmented within different organisations and platforms, and the data is not always managed accurately, which prevents collective learning. One major lacuna is the absence of systems and tools that monitor the progress in CE development in a region. In essence, a regional CE platform that links the diverging data and knowledge is missing. Also, the dominance of big players in the waste management sector and the secrecy about resource flows in production processes prohibit more collective transition learning processes. There is a need for data that enables municipalities, businesses and other organisations to assess and evaluate CE progress, and to steer upon that process with, e.g. guidelines and key performance indicators (KPIs). In more detail, the workshop participants have expressed the need for different CE assessment criteria, and a change from economic indicators to social and environmental values, the assessment of the value of sharing, and an evaluation of behavioural change triggered by a CE project and policies, as well as an overall assessment on the governance of the AMA in terms of how well its setup performs in CE policy implementation in order to propose reforms if and where needed. Finally, there is a need for awareness-building campaigns and more collective mainstream learning about a CE, embedded in and supported by regional innovation, education and economic policies.

5. CONCLUSIONS AND RECOMMENDATIONS

Governing a transition towards a CE in an urban region remains a great challenge, even for a frontrunner in this field like the AMA. This is not only because the governance challenges are multi-scalar, multi-sectoral, and multi-actor in nature

(Obersteg *et al.*, 2019), but also because these changes towards a CE need to take place simultaneously at and between different transition management levels (Wittmayer and Loorbach, 2016). In essence, transitioning towards a CE requires changes in the institutional cultures within a plethora of organisations involved in closing material loops, steering the transition, and dealing with its socio-economic, legal, technological, and spatial implications. Our paper illustrates that effective CE transition governance requires a consideration for the four transition levels of the framework in an integral way. All of them are interrelated, interdependent and needed to change the practices on the ground. For instance, transition experiments in circular construction are hampered by existing building legislations addressed at the transition agendas' level. Therefore, simultaneous action at all transition levels is needed to assist in the transition from local experiments by frontrunners to a regime change.

This paper contributes to the literature, first, by applying the transition management framework to a CE (Ernst *et al.*, 2016; Frantzeskaki *et al.*, 2017). We posit that – even more so than in other sustainability transitions – governing CE transitions requires working across sectors of the industry and institutions at various scales. Our findings also suggest that governance on a regional scale matters, because of the spatial implications of resource flows that span across the boundaries of municipalities. Second, we confirm that there are tensions and complexity in CE endeavours (see Marin and De Meulder, 2018), which indeed require new governance approaches. Our contribution here is, specifically, the identification and classification of the barriers for implementing the transition management framework on a regional scale. By doing this, we also enhance our understanding of institutional and governance challenges in CE (see e.g. Fratini *et al.*, 2019), often neglected at the risk of undermining a transition.

In the AMA, we generally have observed uncoordinated attempts to govern the transition towards a CE, due to the variety of institutions involved and the various unconnected CE-related initiatives occurring at different transition levels. Therefore, even though the AMA is a self-styled frontrunner in CE, we can conclude that the transition towards a CE is unfolding and ongoing, in some aspects advancing rapidly (e.g. the proliferation of strategic and experimental activities), but overall it is still at an early stage and, critically, remains uncoordinated across the levels of transition management.

Several implications for policy emerge from this research and the AMA as empirical case study. First, in line with previous research, we confirm that the regional scale is particularly important for governing a transition towards CE, due to the regional geography of material flows ignoring municipal boundaries (see Geldermans *et al.*, 2018) and the diversity of actors that need to be involved (see Obersteg *et al.*, 2019). The AMA case illustrates the complexity of

this regional challenge and the need for an extensive cross-sectoral, cross-scale and cross-boundary partnership to establish shared strategic, tactical and operational goals and means. To galvanise and steer such a partnership one needs an inclusive, visionary and proactive leadership at the regional level, integrating CE policy with spatial strategies. Such leadership cannot be relegated 'by default' to the largest municipality in the region. In the Dutch context, it can be argued that CE transition adds a new argument in favour of either strengthening (that is formalising, strengthening elected authorities and financially equipping) the currently ill-defined regional level of government, or rebalancing and consolidating inter-municipal cooperation within the existing system of territorial jurisdictions. Nonetheless, institutionalising a separate regional administrative government level with democratic decision-making powers and financial means is far from likely in the Netherlands, since it requires a constitutional change. Therefore, we advocate for stronger CE and spatial policy coordination between the formal national, provincial and municipal governments, informal regional, and metropolitan networks, and the key private sector actors involved. Second, our study has revealed that many practitioners advance within their own specific CE initiatives but encounter barriers that are beyond their sphere of influence. We recommend thus to interrelate the four elements of the transition management framework to put in place a more integral and holistic approach to the shift towards a CE. Third, in order to build awareness and catalyse transition it may be worthwhile to aim for 'quick wins with big impacts' by focusing on transition in a specific metabolic flow. For instance, construction and demolition material flows are a good place to start as construction is the biggest consumer of resources and simultaneously it is hugely important for AMA's economy and its urban expansion.

To conclude, we should mention the limitations of the research. Firstly, the empirical research included a study of only one region also illustrating a snapshot in time, which makes it difficult to generalise findings and conclusions. Therefore, future research should focus on cross-regional or cross-country comparisons of barriers for CE transition to draw more generalisable lessons and enable a transfer of knowledge between regions. Secondly, CE in the built environment, its governance and relation to spatial planning is a rapidly evolving field. This paper presents a snapshot of the governance of an emerging sustainability transition. Future research should adopt a more dynamic perspective on how the connections between the levels of transition develop over time.

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WASTELANDS AS AN OPPORTUNITY FOR MANAGING NAPLES' SUSTAINABLE TRANSITION

Abstract. Circular economy offers new visions of how diversely urban spaces could be inhabited and managed. While the generation and management of waste is being treated through innovative practices, disused industrial, rural, and infrastructural areas are resistant to becoming included in a closed-loop cycle. They, in fact, establish wastelands that need to be completely re-imagined as a precondition for the transition. The fact of shifting the definition of a 'neglected area' into a 'wasteland', in line with the metaphor of urban metabolism, could be of tactical importance for generating alternative policies and practices. In exploring how the transition impacts Naples' urban region, the paper argues that turning wastelands into resources has the double potential of rehabilitating spaces and challenging the governance model in use, overcoming barriers in multiple sectors.
Key words: wastescape regeneration, multilevel governance, waste circularity, transition management.

1. INTRODUCTION

Circular economy, one of the pillars of sustainable transitions promoted by the EU, suggests new visions of how people should live in urban space and, consequently, how it should be managed. The roots of such mostly conceptual visions are strongly dependent on the powerful metaphor of urban metabolism. It helps not only in the imaging and organising of strategies for the transition process, but also in situating them and completely rethinking the governance model consistent with urban metabolism itself. The metabolisation of such transitions demands deep changes in the dominant practices, policies and ways of thinking, which will in turn call for new knowledge on the part of ordinary people, and different research frameworks and responsibilities on the part of scholars and institutions, respectively.

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The Horizon 2020 research REPAiR, "Resource Management in Peri-urban Areas: Going Beyond Urban Metabolism", promotes the reuse of waste as a resource. In this framework, peri-urban areas have to be reinterpreted as those "transition spaces with some degree of intermingling of urban and rural uses" which characterise urban regions of European cities (Wandl and Magoni, 2017, p. 1).

As for the methodology, the transition management has been adopted in order to examine how to reduce waste flows in peri-urban areas, beginning from the pilot cases of Naples and Amsterdam[1].

According to the metaphor of urban metabolism, considered as a device to address the transition, urban regions have been interpreted as complex ecosystems. Consistent with this conceptual framework, one of the first steps of the REPAiR strategy consists of deliberately turning a definition of a 'neglected area' into a 'wasteland', in order to emphasise the shift from the socio-technical regime of the linear economy, where the adjective neglected refers to the end of the Fordist domain, to the socio-technical regime of the circular economy, where the manner of regulating the metabolism of waste is crucial. Since this shift has been generating alternative narratives and different public discourses and images, we have been exploring policy instruments and practices that fit the new vision.

According to the new narrative, waste flows in peri-urban areas have to be tightly related to the entanglement between solid waste and wastelands. The latter should be considered as ruins germinated from the shrinkage or even disappearance of past land uses such as industrial, rural, infrastructural and so on, with the consequent degradation into wastelands.

In the urban region between Naples, Caserta and Salerno, waste has often been stock-piled or even concealed in peri-urban areas with the effect of transforming abandoned or soon to be abandoned open spaces and land into wastelands. The urban region has been nicknamed the "Land of Fires" since 2003, due to the malpractice by organised crime of burning waste stocked illicitly. In particular, the Land of Fires is the consequence of a previous fifteen-year-old regional waste emergency (Cantoni, 2016). Due to the weak territorial control on the part of institutions, the instances of arson, combined with the effects of the waste management crisis, and other endemic problems affecting the region since the 1960s, such as poverty, low schooling, unregulation (De Leo and Palestino, 2017) and nepotism (di Gennaro, 2014; Corona and Sciarrone, 2012), not only

[1] The academic partners of REPAiR (Grant Agreement no. 688920), together with the *Joint Research Center* of the EU, and several public institutions and public/private companies in the field of waste management, consist of universities and research institutes from Delft (the Netherlands), Naples (Italy), Hamburg (Germany), Łódź (Poland), Pécs (Hungary), and Ghent (Belgium). The Naples REPAiR team is composed of researchers from the Department of Architecture of the Federico II University and officials from the Campania Regional Authority, while the mayor of Naples is in the user board. See: http://h2020repair.eu/.

caused toxic conflagration (Musmeci *et al.*, 2016), but even the overproduction of urban informality.

The resulting wastelands include: stretches of agricultural land housing unauthorised buildings; portions of abandoned heritage sites; polluted sites under designated state tutorship; housing or productive facilities confiscated by the state from criminal organisations, etc. (Berruti and Palestino, 2018; Berruti, 2018). This is why, following the socio-ecological disaster of the 'Land of Fires', the regional plan of the Caserta Province termed an area of approx. 5000 ha of critical land with accumulations of waste as negated land (Provincia di Caserta, 2012).

As a consequence, the quality of life is low and inhabitants do not trust the institutions, and even struggle against them in order to defend their right to urban environments (Berruti and Palestino, 2020; Kaika and Swyngedouwn, 2011).

Moreover, when many wastelands compound the effect of bringing waste to the foreground of cities, the result is the proliferation of wastescapes (Geldermans *et al*., 2017; Amenta and van Timmeren, 2018). Such wastescapes even spill over the administrative borders of individual municipalities, thus involving different communities and institutions and requiring complex multilevel governance. They need, therefore, to be completely re-imagined, re-framed and re-organised, a fact which is a precondition for their sustainable transition.

This is why one of the most important challenges for REPAiR-Naples is the promotion of a common understanding of how to include not only waste and waste flows, but also wastelands, in a closed-loop production cycle.

In exploring how the transition toward sustainability is affecting social actors, decision models, and formal and informal practices in the urban region of Naples, the paper focuses on how turning wastelands into resources has the double potential of rehabilitating urban spaces and challenging the governance model in use. In so doing the framework of transition management offers an inspiring methodology for planning how to reduce, recycle and regenerate waste and wastelands in peri-urban Naples.

2. THE TRANSITION TOWARDS SUSTAINABILITY

The framing of environmental problems triggers complex societal challenges that require socio-technical transitions and modify the workings of territorial systems. Contemporary transitions towards sustainability can be considered as specific processes of long-term, multilevel and multiphase change that happen in complex and adaptive systems such as cities and urban regions. As a consequence, sustainable transitions work as multi-actor processes involving firms, industries, policy makers, and politicians, but also consumers, civil society, and researchers. It is

important to underline that, while focused on the environment, transitions towards sustainability are closely related to collective goods (Geels, 2011).

Being an open-ended process aimed at reframing problems through social learning and experimenting, the transition management approach can be successfully adapted both for supporting policies and engaging actors in order to find innovative solutions. As a matter of fact, its recent urban turn (Wittmayer and Loorbach, 2016) has provided site-specific applications in domains such as energy, water, mobility, and climate change, since the challenges in applying circular economy are frequently located in cities, towns, and neighbourhoods. Furthermore, these applications of transition management describe governance processes where frontrunners among policy-makers, scientists, business, and the society are asked to share their understanding of complex challenges. Thus, they help researchers analyse urban sustainability, supporting shared visions and strategies extensively, and experiment with social innovations (Loorbach, 2010; Wittmayer and Loorbach, 2016).

It is important to add that the transition management is conceived as a kind of selective participative setting that works as an iterative cycle of mutual learning. Thanks to *ad hoc* networks of pivot stakeholders coming from different backgrounds, it develops a plural discourse which is aimed at guiding sustainable transitions. Given the cyclical nature of the transition management framework, strategic level activities are followed by tactical and operational phases, while the cycle itself is closed by means of the resulting appropriate reflexive measures.

The aim of the strategic activities is to direct the public discourse and the related narrative through long-term visions. It is necessary to create an arena of frontrunners with different backgrounds during this stage in order to imagine a future perspective, together with transition pathways.

Tactical activities have to be built in the mid and the long terms, dividing the public discourse into steps, preparing the transition agenda, and analysing gaps between different scenarios. Consistent with this 'agenda setting' stage, tactics to explore and specific pathways can be further developed by means of negotiation and collaboration among actors. Operational activities, working in the short term, are oriented towards sharing those specific needs coming from practice, projects, and experiments. This stage is based on "activating" communities and anchoring ideas from below. Reflexive activities offer the basis for monitoring the previous three levels, where the focus is on how to support and enable societal learning processes.

When all four levels are embedded in urban contexts, the related actions are fulfilled through experimentation at the so-called Urban Transition Labs, which are inspired by the Living Labs approach. Living Labs are defined as "user-centered, open innovation ecosystems based on a systematic user co-creation approach in public-private-people partnership, integrating research and innovation processes in real life communities and settings" (ENoLL, 2013; Concilio, 2016). In Living

Labs, the innovation process is ensured by co-creation activities (Steen and van Bueren, 2017) enacted by the presence of several stakeholders at the same time in the same place, working to identify challenges and co-design feasible solutions and strategies. The involvement in the process of different stakeholders is crucial for the delivery of a successful result.

3. FOSTERING WASTESCAPE REGENERATION IN PERI-URBAN NAPLES

The focus area of REPAiR Naples includes eleven municipalities, going from the eastern city to the town of Acerra, making up a peri-urban area of 519,425 inhabitants and 164.6 square kilometres where different wastelands and waste flows intersect. We chose this vast area and a smaller sample area, mainly due to the following reasons: it is an area strongly affected by the fifteen-year-old regional waste emergency and socio-ecological disaster known as the Land of Fires (Armiero, 2014; Palestino, 2015), the high percentage and variety of wastelands, and its location within the administrative boundaries of the regional waste management system.

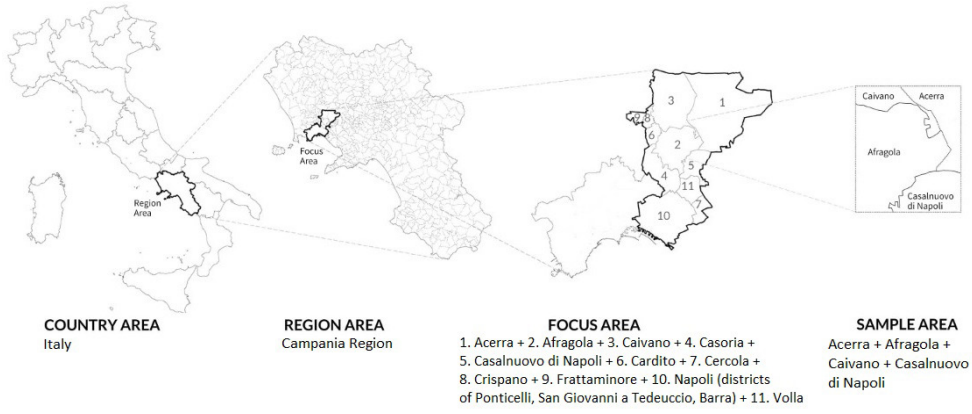

Fig. 1. Naples' Focus and sample area in the REPAiR Project
Source: Geldermans *et al.*, 2018, fig. 2, p. 24

In line with the transition management model, we organised the research by means of an 'orienting phase' where the strategy of looking at waste as a resource was defined. In this perspective, redefining the abandonment of places provided the agenda for regenerating them with a new perspective, and using the provided funding. Thus, a focus on wastescapes has supported a vision which was strong enough to allow the

introduction of circular economy principles both through designing new measures and policies, and involving distrustful citizens in taking care of peri-urban spaces. At the beginning, the arena of the frontrunners was composed by the research team from the Department of Architecture, Federico II University of Naples, several officials of the Campania Region belonging to the Departments of Environment, Planning and Agriculture, and selected user-board members from the City of Naples. Citizens as representatives of local associations and movements were added later.

The agenda setting was supported by interviews with politicians and officials aimed at analysing the governance of waste in the focus area and by institutional meetings where shared knowledge on the working of the waste management system and the related challenges was collected. Representatives of regional, metropolitan and municipal governments and policy makers, waste management administrators, local company representatives all joined those meetings. In directing them, the research team worked hard to set the agenda, starting from the outcomes of this stage. Later, with the organisation of peri-urban living labs (PULLs) the activating stage began. Apart from institutional actors and companies, social organisations and active citizens were also involved in the experiments of innovation.

PULLs have mainly focused on wastescapes and eco-innovative solutions. First, participants identified critical wastescapes in the focus area, located them on the map, and collectively updated the map and its legend[2]. Next, they framed solutions for wastescapes. Participants were organised into three worktables, each focused on a territorial project to be fulfilled together with the aim of discovering the proper eco-innovative solutions to the investigated wastescapes. Later, proposals coming from previous workshops were analysed and each territorial project was transformed into action (Amenta *et al.*, 2019). The current possibility of funding the proposed actions was explored, as well as actors' commitment to support them.

The operational activities included the co-designing of actions aimed at solving problems of abandonment related to wastescapes, and the attribution of specific responsibilities to the actors involved in Living Labs. At this stage, some negotiations between public administrators and inhabitants were conducted by the REPAiR team in order to reveal previous conflicts or solve those which emerged during their interactions.

Actions proposed during Living Labs provided the base for drawing eco-innovative solutions, also by means of improvements made by the research team, through the involvement of public sector officials and companies, carrying out part of the reflexive activities. This step was mainly aimed at transforming them from site-specific to generally transferable, and indicating aspects of innovation.

The activation phase was planned as the result of a further learning process in which collaborative decisions should be taken by means of a geo-design planning support system that was currently under investigation by the research team.

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[2] For information on maps of critical landscapes in the focus area, see Geldermans *et al*. (2018).

4. OVERCOMING THE GAP TOWARDS A SUSTAINABLE TRANSITION

As indicated by the transition management process applied to the metabolism of waste in Naples, the first important step towards a transition consisted of overcoming the current provisional nature of the waste management system, through a partial enforcement of the regional law on waste management (R.L. no. 14/2016). On the one hand, though the Campania Region has made circular economy a leading principle in the law on the waste management, the same principle seems to be neglected in policy implementation processes. On the other hand, municipalities are interested in maintaining benefits and relationships coming from the waste management system developed during the environmental emergency, often relying on companies selected through political nepotism. In so doing, the fact of preserving the waste management existing status quo ends up responding to decision-makers and organised crime stakes, even if for different reasons. The former for ensuring the pre-existing policy networks, the latter for defending the self-activating arrangement in politics and the economy in which organised crime is involved. Moreover, the Metropolitan City of Naples, which might have exerted a connective role in the transition stage, was erroneously excluded from the waste management.

Intra-institutional difficulties in overcoming sectorial policies, together with the lack of shared knowledge about waste management among institutions and among citizens also contribute to hindering the application of circular economy principles (Obersteg *et al.*, 2019). In addition, social attitudes also play a role, through suspicions about the quality of waste, and the consequential stigmatisation and distrust that prevent innovation in policies and the development of new economies. For instance, companies managing composting plants do not use organic waste coming from Campania because of its supposed (and often actual) poor quality; local communities fight against any proposal concerning waste coming from a higher level of administration, even if they are concerned about the location of a new composting plant that could be effective in resolving the organic waste management system at a local scale[3].

As for wastescapes, there are some interesting experiences of recovery and re-appropriation in the metropolitan area of Naples that require but do not receive the appropriate support from institutions. In addition to governance aspects, the capability of including wastescapes regeneration in an overall vision covering peri-urban areas and defining their potentialities has to be enhanced.

[3] Actually, in the region, a high percentage of organic waste is displaced in Northern Italy's plants. The lack of composting plants carries the risk of creating a new emergency concerning organic waste.

5. CONCLUSIONS

In the metropolitan area of Naples, circular economy currently works mainly as a rhetorical argument that is still hard to apply through policies, mainly due to ineffective sectorial planning and to difficulties in making urban metabolism work. Therefore, clear suggestions appear for how to enhance circular policies and regenerate circular landscapes.

First, PULLs function as useful environments for driving all the actors involved in the process to co-design site specific policies, while unravelling past conflicts and issues. Second, people and companies are a reliable source of creative actions and entrepreneurial initiatives on wastelands and waste flows. Third, public officials have to overcome sectorial and departmental barriers within the bureaucratic apparatus in order to apply their theoretical arguments on circular economy to real and effective policies, while seizing the innovations coming from local contexts. As a consequence, we recommend the adoption of a multilevel and cross-sectorial governance as the right way for designing and implementing circular policies.

As for wastelands, the transition management approach revealed itself useful for designing eco-innovative strategies and solutions and for rethinking new uses and practices for their regeneration. Such regeneration implies, on the one hand, that wastelands have to be treated as complex groupings of people and places, and, on the other, that, since landscapes do not follow administrative borders, a synergy between institutions is needed to create bridges between different actors and centres of responsibility. Innovations always require the courage to enact change, in multiple sectors (legal, political, economic, social, environmental, and technological) and overcoming barriers. Among these innovations we would stress the need for governance of wastescapes regeneration that has to be designed and implemented in order to effectively re-introduce wastescapes into urban metabolism.

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A MULTI-STAKEHOLDER AND INTERDISCIPLINARY APPROACH TO WASTE MANAGEMENT AND CIRCULAR ECONOMY: THE CASE OF FLANDERS AND GHENT, BELGIUM

Abstract. In 2016, the Flemish Government adopted the transversal policy paper "Vision 2050, a long term strategy for Flanders". It has set the ambition for Flanders for 2050 and has paved the way for a transition to a Circular Economy. It provided new objectives and confirmed the ambition to further reduce the total amount of (residual) waste by closing the loop and reducing the use of primary resources. More than before, prevention and reuse have been an integral part of materials management. The impact of waste behaviour needs to be measured against environmental and social priorities. In this context, the REPAiR project developed a multi-stakeholder and interdisciplinary methodology. Building on this methodology, this paper explores how governance in Flanders and Ghent has been affected by this transition and draws lessons to address these challenges.

Key words: Resources and waste management, circular economy, organic waste, Flanders, Ghent, Living Lab, Eco-innovative solutions.

1. INTRODUCTION

As European cities are heavily dependent on land and resources beyond their borders to sustain their e.g. consumption patterns and energy demands, etc. (Unmüßig *et al.*, 2015), the transition from a linear economy towards a circular model is nowadays a concern of the European Commission (EC, 2015). There has been an attempt to push this transformation by stimulating circular economy (CE) strategies in Europe, whereby the Circular Economy Package is set up.

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Notwithstanding a supportive environment and favourable government policy for circular economy, either at local, regional or European levels, and an increasing number of initiatives that consider the entire value chain, including prevention and the reuse of waste, many initiatives remain small scale and locally embedded. There is an important gap to bridge between local civic initiatives on the one hand and commercial waste producers and the waste treatment industry on the other. This hampers the potential for up-scaling locally embedded initiatives.

In this context, the REPAiR-project[1] examines whether an interdisciplinary and multi-stakeholder approach, supported by a spatial, waste flow and life cycle analysis, based on environmental, economic, and social indicators, can help entities to overcome some of these challenges, and further decision-making to make the transition to a circular economy.

A prominent example of the transition from conventional waste management to an integrated resources' policy is the Flemish case. Although Flanders is a relatively small region in Belgium with approximately 6.5 million inhabitants, it is a particularly interesting case because it is one of the best performing regions in terms of household waste reduction and recycling in Europe (De Jaeger *et al.*, 2011). Flanders has the exclusive authority to develop its environmental policy and waste/resources management. This includes the development of international relations and foreign policy on waste/resources, all within the broader European legislation. However, there are challenges to go beyond proper waste management towards a real circularity. While offering overview of those, this article is structured as follows: after theoretical insights and a short presentation of the method and materials, the paper gives an overview of the recent status quo of the case study area. Afterwards, the process and the results of a co-creation work in the living lab format are presented. Finally, the conclusion indicates what aspects are missing for a real circular transition.

2. THEORETICAL INSIGHTS

The concept of a Living Laboratory appeared in Europe around 2000. Since then, the idea has become widespread in planning processes across the world bringing together stakeholders from different positions with different knowledge backgrounds, providing them with a methodology for co-creating innovation (Lepik *et al.*, 2010; Steen and van Bueren, 2017; Dąbrowski *et al.*, 2019).

[1] http://h2020repair.eu – More details about the REPAiR project can also be found in the Foreword of this Special Issue, by Viktor Varjú.

Living Labs (LL) are defined as physical and virtual environments in which public-private-people partnerships experiment with an iterative method to develop innovations that include the involvement of end-users (Pallot *et al.*, 2010). In Living Labs, different areas of expertise from diverse partners are needed for a correct development of activities, to meet the needs of the stakeholders by innovation. LLs are instruments that can be used to improve the innovation capabilities and competitiveness of territories.

Within REPAiR, Eco-Innovative Solutions (EIS's) are defined as creative and smart ideas aimed to innovate and improve a specific and fixed process in relation to the management of waste as a resource and Wastescapes (cfr. Amenta *et al.*, 2018). EIS's may include an implementation of new materials or processes in existing economic activities or adding new activities in value chains; a proposal of a modification to existing policies and governance or new policy/governance developments; or the development of spatial design proposals. These decisions will potentially lead to a modification of existing flows, the development of new material flows and processes and/or changing the physical design of areas, and will generate a change in the behaviour of stakeholders and inhabitants in an area.

Apart from innovation, thanks to the LL approach, policymakers can face the many socio-economic challenges of their territories, increasing social inclusion (Innovation Alcotra, 2013; cf. Russo *et al.*, 2017). Additionally, the user–centre design of Living Labs has the co-creative potentialities (that is also defined in the REPAiR[2] project), the awareness of users, and real-life settings (Dell'Era and Landoni, 2014).

The term **waste hierarchy** is often mentioned in connection with sustainable resources' management and circular flows[3]. In Europe, the concept of waste hierarchy was first introduced by a Dutch politician Ad Lansink in 1979 (Parto *et al.*, 2007). The waste hierarchy framework aims to dematerialise the economy as much as possible to approach circularity. It describes the order and priority of actions to be taken. The most recent revision in the European Union was implemented in the Waste Framework Directive 2008/98/EC which sets 1) the basic concepts such as end-of-waste criteria, Extended Producer Responsibility and the waste management hierarchy, and 2) definitions, e.g. by-product, waste, recycling, and recovery, all related to waste management. However, according to Van Ewijk and Stegemann (2016) and Gharfalkar *et al.* (2015), the waste hierarchy in its current form is an insufficient foundation for a waste and resources policy to achieve absolute reductions in material throughput. Resources and waste management must be combined to establish a fully circular economy. With the aim to dematerialise, the reduction of primary inputs is given priority over the reduction of secondary inputs but ultimately both are limited by the end goal. Apparently, there is a need for more efficient resources' management.

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[2] http://h2020repair.eu/

[3] An insight about the concept of circular economy can be found in the Foreword of this special issue by Viktor Varjú.

3. METHODS AND MATERIALS

REPAiR implements LLs for six European peri-urban areas or cities, one of which is Ghent-Destelbergen. The REPAiR team designed a scheme for implementing the so-called Peri-Urban Living Labs (PULLs), focusing on the important steps of the REPAiR format of an LL: co-exploration, co-design, co-production, co-decision, and co-governance (Amenta *et al.*, 2019). The format was applied in the follow-up cases of the REPAiR project (including Ghent) tailoring it to the local context. This paper covers the first three steps of the Ghent Living Lab.

The PULL in Ghent-Destelbergen counted four workshops, bringing together a good and balanced representation of different stakeholders concerned: the waste management sector, both operational and legal, public and private, covering different governance levels (city, region), academic partners, all with a good knowledge of the focus area. Citizens were involved indirectly, through a representation of participatory civil society organisations such as '*Gent en garde*'[4].

The main objectives of the PULL Ghent-Destelbergen were: 1) delineation and exploration of the area under study, 2) identification of key waste streams and priorities, and 3) co-creation of Eco-innovative solutions and strategies. The aim was to improve the recent situation in the Ghent area towards achieving circularity, and the PULL was used as a tool to achieve that. The objective of this article is to demonstrate how this was done in Ghent-Destelbergen.

The need to further reduce the amount of residual waste – one of the key objectives of the Flemish implementation plan for household waste (Flemish Government, 2016) – is a generally accepted objective, as confirmed by several stakeholders interviewed during the REPAiR project (cf. Obersteg *et al.*, 2017). However, opinions differ considerably regarding the method on how to realize this objective depending on the approach and insights of individual stakeholders. According to some, excessive emphasis was put on separate waste collection and valuations of selective waste flows, especially those which offered opportunities to develop an interesting and viable business case. While there has been an increasing interest in opportunities to valuate waste flows, less emphasis has been placed on prevention and the reuse of waste. Increasing emphasis on these goals will require cooperation and collaboration among a wide range of (different) stakeholders.

[4] *Gent en Garde* is an initiative of the City of Ghent making its citizens and visitors aware of the climate impact of food. *Gent en Garde* offers citizens, organisations and companies a participation platform in which they can find like-minded people, recognise shared interests, share their expertise with the outside world, and lift initiatives to the next level.

4. THE CASE STUDY REGION

4.1. Flanders' legal framework: an interplay of regional and local actors

Since 1981 OVAM, the Public Waste Agency of Flanders, has maintained Flanders' waste, soil and materials policy. With the adoption of the first **Waste Decree** in 1986, several instruments have gradually been used to move waste management up in the waste hierarchy, promoting prevention and resource recovery. Measures such as obligatory source-separated waste collection in urban and rural areas, subsidies for reuse centres, pay-as-you-throw schemes, producer responsibility, landfill and incineration taxes as well as selective bans and quotas on waste production per person have contributed to making Flanders' one of the most waste sensitive areas in Europe.

The **Material Decree** and its Implementation Order have paved the way for the transition from a waste to a materials or resources policy. The Material Decree assumed a complete view of the material chain. It determined the responsibilities of different actors in the entire life cycles of materials: from designers, through producers, distributors, consumers, waste companies to the government.

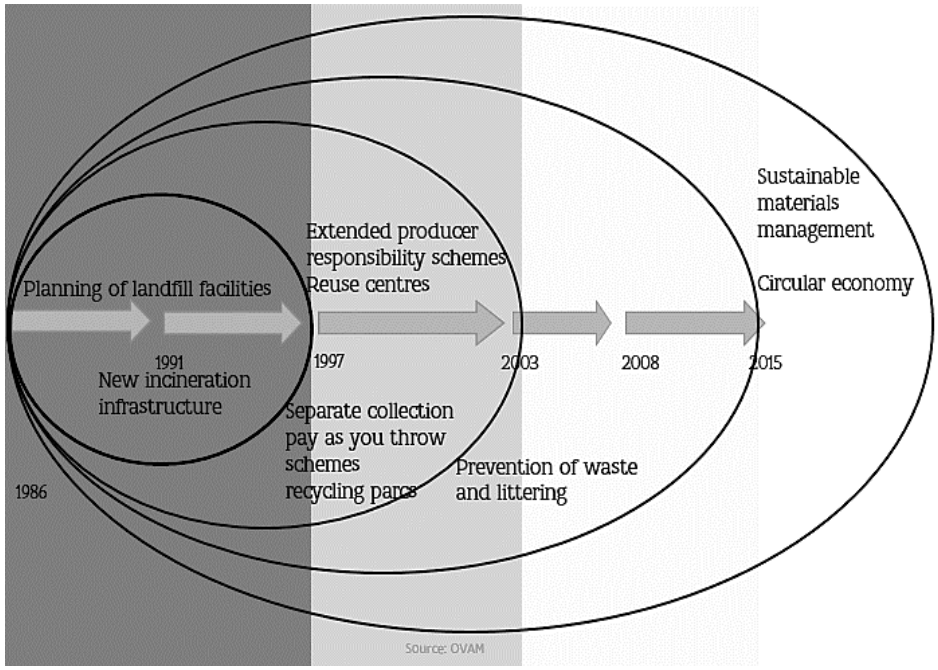

Fig. 1. Overview of waste management measures in Flanders
Source: OVAM.

The Implementation Plans complete the legal framework at the regional level, setting priorities, targets and general strategies to organise waste management over several years. These Implementation Plans are the result of intense consultations with different stakeholders involved in waste and resources management: federations of municipalities, of inter-municipal organisation for waste management, of waste collectors and treatment centres, and reuse centres. The current plan contains the main policy measures, targets and actions to further decrease the quantity of residual waste from households by 2022.

In 2016, the Flemish Government adopted the transversal policy paper "Vision 2050, a long term strategy for Flanders". This paper has set the ambition for Flanders for 2050 and paved the way for the transition to a Circular Economy, integrating materials, water, energy, land and food. It has opened opportunities for a broad multi-stakeholder and multi-disciplinary approach.

At the local level, municipalities such as Ghent and Destelbergen have the legal responsibility to collect and treat household waste. Local authorities are responsible for an organised network of door-to-door collection or a bring-in system such as central collection points and recycling parks.

More than before the current Implementation Plan considers the differences between municipalities. While the plan still determines the waste fractions that each local authority is required to collect and its minimal frequency, it provides more flexibility as to the method of collection. While setting the residual waste targets, it adopts a tailor-made approach taking several socio-economic characteristics into account[5].

Most municipalities in Flanders delegate their authority for the collection and treatment of household waste to inter-municipal organisations. Today, Flanders counts 26 inter-municipal waste management organisations, each focussing on their geographical sector. This allows municipalities to organise their waste management jointly, take advantage of an economy of scale and rely on experts in an ever more complex and specialised sector. The long periods of the delegation agreements (initial up to 30 years) make negotiations about their revision a challenging exercise.

4.2. Waste generation/secondary resources production: facts and figures for Flanders

Through the combined efforts of local and regional authorities and waste and resource managers, the total amount of household waste generated in Flanders yearly has continued to decrease. In 2018, on average 470 kg of household waste was collected per inhabitant in Flanders, which is a reduction by 53 kg compared to 2013. Apart from the challenge to prevent waste from being generated, another goal is equally impor-

[5] The Belfius-index, used for this purpose, is based on 150 variables, clustered around 5 dimensions: the presence of facilities in a municipality, the living standard of the population, rural vs. urban area, the age pyramid, and economic activity. The typology was last updated in 2018 and it identifies 16 different types of municipalities, covering 9 different targets for residual household waste.

tant: to treat waste according to the highest levels on the waste hierarchy. Therefore, the collection needs to be organised in an intelligent way (Friege, 2017).

Waste in Flanders is collected per many different fractions which contain types of waste with similar properties. From the 470 kg/inhabitant total, about 146 kg is residual waste and the rest is selectively collected. Green waste (21%), paper and cardboard (19%), building waste (16%) and Vegetables, Fruit and Garden (VFG) (11%) waste are the biggest parts. The most common treatments are recycling (44%), incineration with energy recuperation (30%), and composting/anaerobic digestion (22%) (weight percentages). More details on the composition and shares of the separately collected waste streams that undergo specific treatment pathways are visualised in Fig. 2.

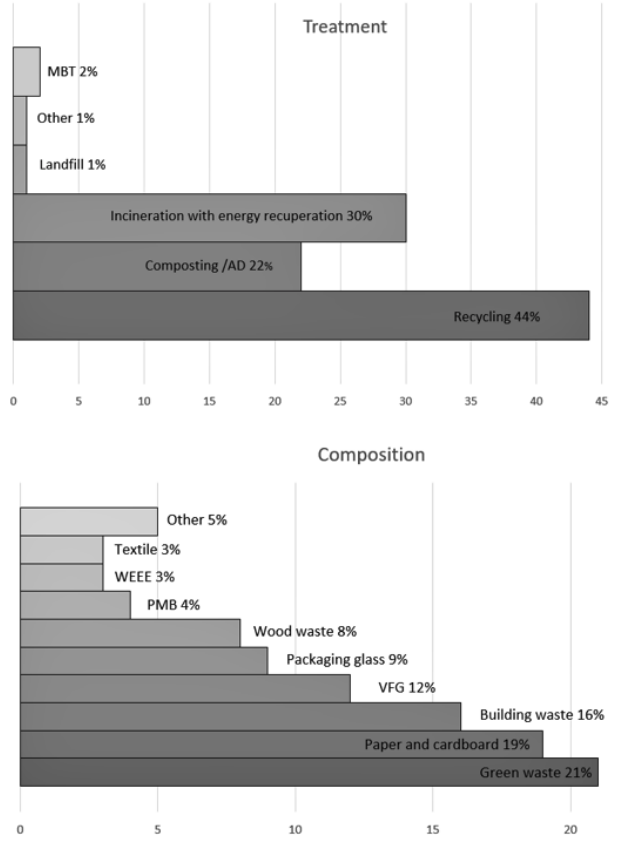

Fig. 2. Treatment and composition of separately collected household waste flows

VFG = Vegetables, Fruit and Garden, WEEE = Wasted Electric and Electronic equipment, PMB = Plastics, Metals and Beverage cartons, AD = Anaerobic digestion, MBT = Mechanical biological Treatment

Source: own work based on Statistiek Vlaanderen, 2018; VMM, 2018.

The continuing progress in Flanders' waste and resources management is based on its multi-stakeholder approach and cooperation between different partners in the sector and at different governance levels. Empowerment of different actors in combination with a tailor-made approach have resulted in the optimisation of the waste collection and treatment schemes, and a far-reaching waste reduction.

4.3. The status quo of the case study area: Ghent-Destelbergen

The Ghent-Destelbergen area is identified as the focus-area within the REPAiR Project (Fig. 3). It covers two municipalities, each legally responsible for the implementation of their municipal waste policies. Both municipalities delegate their authority for the collection and treatment of waste to the IVAGO inter-municipal organisation.

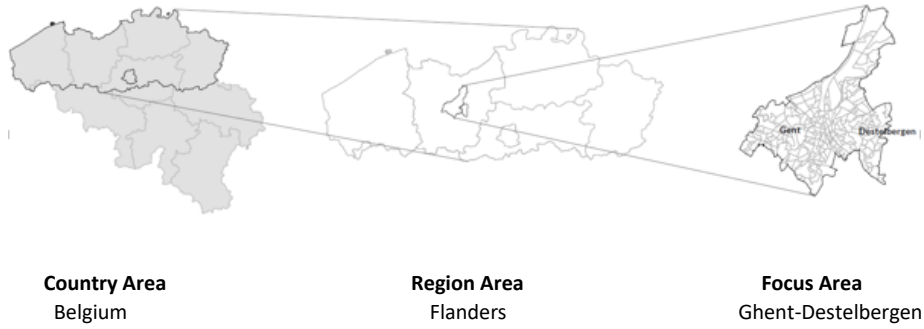

Fig. 3. Case study area as considered in REPAiR: country, region, focus area Ghent-Destelbergen
Source: own work in the REPAiR project.

With a population of 259,083 Ghent is Belgium's 3rd largest city. Its neighbouring municipality Destelbergen has a population of 18,051. Both areas are characterised by a high population density, with considerable difference between the densely populated inner city and more remote areas. Destelbergen is particularly eager to safeguard its 'open space'. However, due to its proximity to Ghent, Destelbergen is very much affected by the demographic evolution, mobility, and urban development in Ghent.

The urban fabric of the area is determined by its rich historical and industrial past, with its peek in the Middle Ages and during the Industrial Revolution. The historic city centre of Ghent features narrow streets and waterways. Beyond its medieval walls, factories were built along canals, waterways and railways and compact worker neighbourhoods appeared. In the 1960s and 70s, large infrastructure investments took place to attract new industrial activities and connect the city

with the hinterland (Van den Berghe, 2018). At the same time several neighbouring municipalities, absorbed by the growing city, formally merged with Ghent.

These spatial developments, the transport infrastructure, as well as housing are important factors to consider in waste management. Compact living forms and smaller housing constitute challenges for residents regarding storing different waste fractions indoors over long periods. The road infrastructure in the dense urban areas challenges the door-to-door waste collection. The efforts to reduce car traffic in the centre of the town and to stimulate the use of bicycles and public transport challenge the accessibility of existing recycling parks, mainly designed for delivery by car. The demographic evolution is another key factor. While Ghent has a better balanced age pyramid than Destelbergen, both face a growing number of small(er) households. On top of the considerable residential student population (over 30,000), Ghent needs to consider more than 1 million overnight stays in the touristic sector.

5. RESULTS AND DISCUSSION

The transition to a circular economy challenges us to go beyond the mere optimisation of existing waste and resource management schemes. The REPAiR project has created the opportunity to test a multi-stakeholder and interdisciplinary approach, involving waste management experts, urban planners, experts in Life Cycle Analysis (LCA), citizens and decision-makers. Based on the methodology developed in the project, and supported by the Geo-design Decision Support Environment (GDSE), participants in the LL developed Eco-Innovative Solutions and Strategies to make the transition to a circular economy by closing material loops and reducing the use of primary resources.

5.1. Identification of VFG as the key waste flow

In line with the EU target for recycling 65% of municipal waste by 2030, the PULL workshops in Ghent-Destelbergen focussed on bio and residual wastes from households. Since bio waste still represents a considerable fraction of the residual waste from households, increasing the separate collection of bio waste (and more specific vegetable, fruit and garden waste) contributes to the Flemish policy objective to further reduce the amount of residual household waste.

IVAGO handles the collection of household (residual and VFG) waste in the entire case study area. However, it applies different schemes for collection due to the different waste policies of both municipalities with different targets for the maximum amounts of residual waste per inhabitant, different collection rates, and

different collection containers[6]. The spatial development of the area is another determining factor. The narrow streets in the centre, combined with intense traffic, limit the opportunities for kerbside collection using containers or underground collection points in the more densely populated areas.

In the territory of Ghent, IVAGO has two zones: the Z-zone (Dutch: Zakken, bags-zone), situated in the inner city centre, and the C-zone (Container-zone) in the more peri-urban and rural areas. In the Z-zone, residual waste is collected in garbage bags, which customers buy at a fixed price. In this zone, residual waste is collected once a week. Households within this zone can request a bin, enabling them to separate VFG voluntarily, in which case they collect it in kerbside green containers. In the C-zone, citizens dispose their waste for door-to-door collection in containers, a grey container for residual waste and a green container for VFG waste. Both are collected once every two weeks. The same applies to Destelbergen. In building blocks with more than 10 housing units, residents use garbage bags for their residual waste. They can opt for separate collection of their VFG-waste using small individual bins, left for kerbside collection.

In practice, only a limited number of households maintain their VFG-waste for separate collection. This results in the collection of 9,970 tonnes each year, 65% provided by the C-zone, 24% by the Z-zone, and 11% by Destelbergen (personal communication, IVAGO). Much VFG-waste still ends up in the residual waste bin. A sampling of household residual waste in the focus area revealed its composition: on average, 19.7% VFG, 20% other organic waste and 60.3% non-organic residuals were found (OWS, 2017a,b). Compared to other municipalities in the Flemish region, the result is average (Flemish government, 2016).

After collection, all separate collected VFG are first stored in the north of Ghent at a storage facility of SUEZ, a French environmental services company. From there, trucks take all the VFG to IVVO[7] in Ypres for anaerobic digestion and composting. Residual household waste goes to the incinerator of IVAGO in Ghent.

5.2. EIS from the PULL Ghent-Destelbergen

The existing VFG and residual household waste flows and current collection and treatment processes in the case study area were the starting points for exploring the eco-innovative solutions contributing to the transition towards a circular economy.

[6] Ghent is considered a 'large regional city' with a maximum amount of residual waste per inhabitant of 193 kg. Destelbergen is a 'residential zone with higher income' and a maximum figure set at 122 kg.
[7] The inter-municipal organisation IVVO is an association of 12 municipalities and aims to collect and treat household waste, as well as organic industrial waste.

During the PULL Ghent-Destelbergen, participants identified challenges, prioritised objectives, and developed EIS. In total, 20 EIS (cf. Taelman *et al.*, 2019a) were developed addressing 6 objectives with the highest priorities (Table 1).

Table 1. Top priority goals identified by the PULL participants

1. Prevent, reduce and reuse food surpluses
2. Favour highest possible value creation/retention of organic material
3. Increase participation in separate collection of organic waste
4. Create opportunities for innovative CE-initiatives
5. Legislation enabling a combined collection of kitchen and food waste with VFG waste fraction
6. Efficient collection system for organic waste

Source: own work.

While prioritising objectives and discussing EIS and strategies, participants in the PULL looked beyond traditional waste management. They easily made a connection to other policy domains such as environment, mobility, local economic production, and the quality of life in the city. Prevention of waste generation was high on the agenda. Some of the EISs focussing on the development of tools to help schools and households prevent food waste often applied to behavioural aspects. While it proved difficult to validate these aspects in a sustainability analysis (Taelman *et al.*, 2019b) due to their intrinsic quantification complexity, they were considered important by the stakeholders and as such documented in the GDSE. The same applied to some of the EIS creating a favourable environment to accelerate the transition to a circular economy or to increasing social cohesion in the city.

Some of the objectives and EIS identified during the PULL were very much in line with the ongoing debates at city or regional level. As such, they confirmed the urgency of the ongoing debates or brought new insights to the discussion. For example, the legal aspects in the collection of kitchen waste (objective 5) have been addressed since, owing to a revision of the sorting rules for VFG-waste at the Flemish level.

5.3. Evaluating the process of the applied Living Lab

The result of the REPAiR methodology very much depends on the definition of the case study area and the participation of the stakeholders. For Ghent, the case study area was determined by the working area of the inter-municipal or-

ganisation IVAGO. This facilitated the collection of data, it was in line with the concept of peri-urban areas as determined by REPAiR, but it did not thoroughly address the issue of scale: should we have looked at Ghent within a broader region? While it is difficult to judge whether that would have affected the outcome, there is no doubt that it would have altered the process, involving more municipalities and several waste-treatment companies.

During the PULL workshops it proved challenging to involve stakeholders from Destelbergen. While there was an openness on their side to participate, the intensive consultation process was considered a major obstacle. This indicates the challenging and different realities of large cities and their often smaller, peri-urban neighbouring municipalities. Major cities such as Ghent have more means and are often more proactive to engage in new insights. Representatives of different departments of the city of Ghent (e.g. environment, urban planning, waste management, and food waste prevention) participated in the PULL workshop. In Destelbergen, most of these issues are handled by one (smaller) department. The urgency to make the transition from a linear to a circular economy could create an opportunity to get smaller municipalities on board, but this is not yet a reality.

6. CHALLENGES AND RECOMMENDATIONS FOR THE FUTURE

In the past decades, Flanders has made a successful journey from waste to resource management. Today, it prepares for the transition to a circular economy. The REPAiR methodology prove its potential to support the decision-making in this transition and strengthen ongoing processes.

The GDSE paves the way for a transparent and documented decision-making process. The involvement of the different stakeholders in the co-exploration, co-design and co-production process creates a strong common understanding of the challenges and a solid base for support for future solutions and decisions. Linking the REPAiR process to the existing multi-governance and participatory approach already practised both by OVAM (resources management) and the city of Ghent (e.g. environment, urban planning), offered a real added value, both in terms of content and of the process.

The EISs developed during the process covered aspects related to several phases in the value chain, from prevention, through reuse and recycling, collection and valorisation. They also applied to a broad spectrum of social issue going beyond mere resource management. The Eco-innovative strategies, combining several EIS, illustrate a more circular economy approach, addressing systemic challenges and going beyond a mere optimisation of existing practises.

The co-creative and interdisciplinary approach of the REPAiR-project, bringing together researchers, waste management practitioners, urban planners, decision-makers and students, clearly lifts the differences between the individual approach of each stakeholder, at different stages of the value chain. The LCA analysis proved to be a valuable tool in balancing efforts to implement EIS, against environmental, social and economic gains.

However, the REPAiR approach also has its challenges. The transparency of the multi-disciplinary and multi-level approach will need to be maintained in the drafting process when EISs and strategies are translated into legislation and policy. An acquired insight might be reconsidered when new stakeholders and considerations enter the discussion. The need to maintain a degree of uniformity and respect for the principle of equality at the regional level might interfere with some of the expectation and EIS, motivated by the local context. The review of regulations often requires a delicate balance between different levels of decision-making. Hence, the need to carefully consider the scope of the case study area from the start.

Financial implications are a determining factor in each debate on waste/resource management and circular economy. While the fact of reaching a circular economy might have a positive impact on the environment, it also comes at a cost. The benefits, from the recuperation of valuable materials, do not necessarily flow back directly to municipalities and their residents. Since this imbalanced cost-benefits model is one of the real political challenges for the transition to a circular economy, it is worth considering how this could be integrated into the REPAiR approach.

Regulations should equally provide support to balance the environmental impact against economical costs and social burdens to decide which are the most desirable options (Van Ewijk and Stegemann, 2016; Lavrysen, 2017). Although it is extremely relevant to cover the three pillars, lessons learned from applying the sustainability framework to European urban waste management systems (both status quo and EIS) show the huge primary data requirement due to its comprehensiveness, incurring substantial time-consumption and effort, far beyond a classic Life Cycle Analysis (LCA) that usually involves a more limited number of impact categories to be addressed. Although the confidentiality of information will remain an issue, it must be clear that we have to make the data and methods used within the project as much as possible available for the wider public, preferably distributed on an open-source basis, because transparency and reproducibility are key ingredients of excellent science, facilitating the sustainability assessment to other cities or regions in the world.

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MAKING CITIES CIRCULAR: EXPERIENCES FROM THE LIVING LAB HAMBURG-ALTONA

Abstract. The article argues that to reach circular economy goals urban regions need to identify and understand the challenges and opportunities originating from the differences in spatial settings, and to develop place-based solutions by adequately involving (local) stakeholders. Based on the case study that was conducted in Hamburg within the Horizon2020 project REPAiR, spatial specificities in five different urban areas shall be analysed and strategies that were developed in a co-creative process shall be explored. The results show that the spatial organisation of CE strategies depends on urban structures and stakeholders' interest and needs to be embedded in the (local) governance setting and a spatial planning system.

Key words: circular economy, urban regions, Multi-level governance, living labs, urban metabolism.

1. INTRODUCTION

This paper is mainly based on the results from the Horizon2020-funded REPAiR project. It aimed at supporting the transition of urban regions from a linear to a circular economy by specifically addressing questions related to the spatial organisation of possible circular economy concepts. This refers to recent studies in the field, such as the 'circular city' (Williams, 2019), that have drawn attention to the spatial implications brought by actions focussed on reaching circularity at the urban scale.

The paper aims is to analyse and indicate the differentiated requirements of the implementation of circular economy schemes and solutions in different types of urban neighbourhoods. The analysis was conducted in the REPAiR case study in the district of Altona in Hamburg. The thematic focus lies in the organisation of

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activities to achieve circular economy solutions that are linked to waste management (i.e. production, transport, consumption, and treatment).

The article investigates the main requirements that need to be addressed to develop, and preferably implement, CE schemes and solutions. These are namely changes in the governance structure and stakeholder constellation, and the subsequent modification of the urban tissue at the strategic level. After contextualising the working conceptual terms (Section 2), we shall present the case of Hamburg (Section 4) based on the methodological framework that is described in Section 3. This framework shall allow us to analyse and highlight the differences in the characteristics of the urban pattern of five areas representing different urban typologies in the district of Hamburg-Altona (Section 5). Here, the relationships between spatial configurations of the five neighbourhoods, the stakeholders' activities and the application of CE principles are explored. The conclusions on these relations shall be discussed in the final Section 6.

2. LINKING CIRCULAR ECONOMY AND URBAN METABOLISM WITH URBAN GOVERNANCE: SPACE MATTERS

At the base of the REPAiR project there is the exploration of innovative solutions for a shift towards a more circular economy (CE) in six European urban regions: Amsterdam, Naples, Ghent, Pécs, Łódź, and Hamburg (REPAiR, 2017a).

CE is a rather new paradigm that has been accepted and embraced at the level of the European Union, which currently demands for an inclusive and just transition towards circularity (EC, 2019). This concept is rooted in the broader concept of sustainability (EC, 2011) and, specifically, it draws upon the concept of Urban Metabolism (UM), which aims at describing cities as open systems which exchange flows with the environment (Kennedy, Pincetl and Bunje, 2011). While UM is mainly a descriptive paradigm, CE offers a conceptual framework for managing flows (Ghisellini, Cialani, and Ulgiati, 2016). This framework was translated into policy recommendations among others by the Ellen MacArthur Foundation (EMF) and largely adopted by the European Union in the EU action plan for the Circular Economy 2015 (EC, 2015; Obersteg *et al.*, 2019).

CE has mostly ignored one element, i.e. the accounting of the effects on the (urban) space of projects aimed at pursuing a shift towards circularity (Williams, 2019; Obersteg *et al.*, 2019). Further, scholars have argued that the spatial dimension cannot be underestimated when handling flows in cities, since every undertaken action implies inevitably a change on the land(use) (Girardet, 2015; Prendeville, Cherim and Bocken, 2018; Williams, 2019). In the current debate, it has been argued that urban planning as a discipline that studies the development of cities should incorporate CE perspectives (Petit-Boix and Leipold, 2018; Prendeville *et al.*, 2018; Obersteg *et al.*, 2019) and that

urban regions are "the most suitable scale to act for the concretization and spatialization of CE actions (Milligan and O'Keeffe, 2019)" (Obersteg *et al.*, 2019).

REPAiR positions itself inside this debate. Its ambition is to investigate the conditions which enable a shift towards circularity in urban regions. This approach includes the involvement of all relevant stakeholders in the activities concerning a specific material flow, the analysis of the urban pattern of five different neighbourhoods in Altona District, and the understanding of the implications of possible CE actions in such areas given a determined governance setting.

We assume that this shift can be pursued throughout a process (the analytical framework proposed in Section 3) that needs to be governed (Obersteg *et al.*, 2019). As governance is a rather blurry concept (Bressers and Kuks, 2003; Björk and Johansson, 2001; Rhodes, 1996), we shall define it here as multi-level, cross-sectoral and multi-actor or quadruple helix governance (Obersteg *et al.*, 2019). This approach has enabled us to "encompass a diversity of governing modes (e.g. Bulkeley and Kern, 2006; Nilsson, Eklund and Tyskeng, 2009) and multi-level interdependence (e.g. Hooghe and Marks, 2001; Newig and Fritsch, 2009)" to understand the transition (REPAiR, 2017b, p. 9).

Against this background, this article investigates the following theses: (1) to reach CE goals in urban regions it is necessary to identify and understand the challenges and opportunities in different spatial settings, (2) based on this understanding it is necessary to develop place-based solutions, and (3) the analysis process and the development of solutions need to be conducted adequately involving (local) stakeholders.

3. METHODOLOGICAL MIX: LIVING LAB APPROACH AND MATERIAL FLOW ANALYSIS

The REPAiR project approach to address CE-related issues in urban regions is built on a mix of methods that are grounded in natural science, social science, and economics: the analysis of material and energy flows provides background information as support for a series of five Living Lab (LL) workshops held in 2018 and 2019 and several smaller meetings, which enabled the real inclusion of local stakeholders' knowledge in the project results (Evans *et al.*, n.d; REPAiR, 2017a) organised in the following four main steps: (a) identification of the geographical boundaries and the governance framework setting, (b) definition of main problems in the case study area, (c) declination of the problems and objectives, and (d) design of solutions (not further elaborated in this paper). This framework was then adapted to face the specificity of the Hamburg context. Interviews were conducted with key stakeholders from the fields of urban planning and waste management which helped identify additional actors to be involved in further steps of the process (Reed *et al.*, 2009).

As a result, the local public authority and the public waste management company shared the interest to consider five different urban typologies: (1) a large housing estate at the urban fringe (Osdorfer Born), (2) a densely built-up urban area (Ottensen), (3) a new urban development area (Mitte-Altona), (4) a single-housing area at the urban periphery (Rissen), and (5) a single-housing area with second homes and weekend visitors (Blankenese). These five "sample areas"[1] were investigated through an extensive spatial analysis to deepen the understanding of land use, socio-economic, and physical structures, as delineated in REPAiR (2018a). A Material Flow Analysis (MFA) conducted by the public waste management company provided the basic information on the waste behaviours in the five areas (U.E.C., 2017). Further, the governance analysis investigated the constellation of stakeholders in place and their responsibilities, tools and decision-making processes in use. The collected information provided a clear picture of the examined area and formed the base for discussion with the local stakeholders through the aforementioned four steps in the LL. Within this process, a university project was conducted to further analyse the areas and to collect first ideas for solutions, the latter were further discussed in the workshops with the local stakeholders.

Fig. 1. The five sample areas in the district of Hamburg-Altona (REPAiR, 2020)

Source: own work.

[1] NB: The "sample areas" have artificial boundaries developed within the REPAiR project, they borrow the name of the quarters that encompass them. As an example, the name Ottensen refers to the sample area located within the Ottensen quarter.

4. SPATIAL PLANNING, ENVIRONMENTAL AND WASTE MANAGEMENT IN THE CITY OF HAMBURG AND THE DISTRICT OF ALTONA

The circular city concept is closely linked to the policy fields of spatial planning and environmental management. The Free and Hanseatic City of Hamburg as a city-state[2] itself is responsible for legislating on planning and environmental issues including waste management. The Ministry of Urban Development and Housing (Behörde für Stadtentwicklung und Wohnen – BSW) manages planning policies and processes. The preparatory land-use plan (Flächennutzungsplan) is the most important and superordinate planning document; it covers spatial planning for the whole city (REPAiR, 2017b, p. 27). This document describes the current land-use and the planned new development areas to fulfil the foreseeable needs of the city (Pahl-Weber and Henckel, 2008). The plan is updated to record new city developments (BSW, 2020a). On a more concrete planning level, legally binding land-use plans (Bebauungspläne) are drafted for specific sections of the municipal territory: this "sets out the legally binding stipulations for urban structure [...] concerning property" (Pahl-Weber and Henckel, 2008, p. 47). In Hamburg, these plans are developed mostly by the planning departments of the districts, e.g. Altona. Additionally, for larger new development areas often spatial concepts, like master plans, are established: these are not legally binding but rather they coordinate the various sectoral plans, providing common goals and inputs for further developments (Pahl-Weber and Henckel, 2008; REPAiR, 2017a). This was the case in the Mitte Altona development project (see Section 5).

Hamburg's Ministry of Environment and Energy (Behörde für Umwelt und Energie – BUE) is responsible for administrative and legislative duties regarding environmental issues, including waste management. It develops the waste management plan (Abfallwirtschaftsplan) and controls Hamburg's public waste management company Stadtreinigung (BUE, 2017). As stipulated in a law (Stadtreinigungsgesetz SRG, 1994), Stadtreinigung (SRH) manages the collection of household waste, street cleaning, winter services, and public toilets; at the same time, it manages twelve recycling stations throughout the city. The household waste fractions that are collected by SRH are residual waste and bio waste. The first fraction is incinerated to generate heat and electricity for the city, the latter is brought to a composting facility for obtaining biogas and compost (SRH, 2019). Packaging and paper fractions belong to the so-called dual system and are managed by the subsidiary company WERT GmBH (BUE, 2017). A major aim of the waste management plan is to connect as many private households as possible to the four-tons system (residual, bio,

[2] Hamburg is one of 16 federal states in Germany and more specifically one of three so-called city-states (besides Berlin and Bremen). As a city-state Hamburg is a federal state and at the same time it incorporates competences and duties of a municipality. Parts of the municipal competences and duties are transferred to its seven districts. Each district has its elected council (Bezirksversammlung) and administration (Bezirksamt).

packaging, paper) to enhance recyclables rates. However, not every unit has all four bins, especially in areas with a dense building structure (cf. Section 5).

On the level of the Altona district administration, the department for urban and landscape planning is responsible for drafting binding land-use plans, in accordance with the preparatory land-use plan (BSU, 2011, p. 3; BSU, 2013). This department also steered the development of the Altona climate action plan that includes objectives, strategies and measures for climate mitigation in Altona. The plan was developed in a participatory process. Two of the plan's major topics are sustainable consumption and improved waste behaviour (Bezirk Altona, 2019a; Bezirk Altona, 2019b).

5. THE SAMPLE AREAS IN HAMBURG-ALTONA: SOCIO-ECONOMIC AND SPATIAL ANALYSIS AND IDENTIFICATION OF SPECIFIC PROBLEMS, OBJECTIVES, AND SOLUTIONS

As mentioned in Section 3, during the case study area analysis, a list of general problems was established in reference to the entire district of Altona, which then was refined at the sample area level. The following Table 1 presents the list of problems for Altona with respect to CE principles.

Table 1. List of problems identified for the entire district of Altona in order of importance for the local stakeholders

Ranked General Problems
P1) 38% of biowaste is disposed of into the residual waste bin and incinerated instead of being used for biogas and composting.
P2) When planning buildings, waste management is hardly considered, as it is not required by law.
P3) Urban planning and waste management do not communicate and cooperate sufficiently.
P4) The residents do not include waste management in their routines.
P5) With the growing collection of biowaste, there is a risk that quality will be compromised by plastic pollution.
P6) The separation of bio-waste has a bad image with many citizens ("bio-waste stinks") and they prefer to throw it into the residual waste bins, although those also stink.
P7) The financial incentives given to citizens to separate their waste are not clear or not high enough.
P8) Some public containers are not placed in the optimal position for users.
P9) Social pressure on the residents of housing estates is not sufficient to force them to separate waste properly.
P10) Older people and people with disabilities do not have access to some of the public containers.
P11) At schools and kindergartens, children do not learn enough about waste problems.
P12) Garden waste from public green spaces is generally not passed on to the waste management company for compost and biogas production.

Source: own work based on REPAiR, 2018a.

Further, the sample areas of Osdorfer Born and Ottensen are presented in detail, while the characteristics of the other three areas are only mentioned as supporting the main argument. This choice reflects also the interest of the main stakeholders involved in the process, who are currently concentrating their efforts in these two areas. Therefore, after an analysis of the socio-economic and urban physical structure, there follows – based on the work with the local stakeholders – an overview of the identified problems, objectives and first ideas for solutions. Table 2 provides an overview of all five sample areas at the end of the section.

5.1. Osdorfer born: a large housing estate at the urban fringe

Located in the northern part of the Altona district bordering Schleswig-Holstein, Osdorfer Born was the first large housing estate project in the history of Hamburg, which nowadays offers 4,750 housing units for a total of 10,263 inhabitants (Statistik Nord, 2017). Built in the late-1960s, Osdorfer Born was the result of the housing boom program after the Second World War. It was meant to be a modern and liveable place, with access to a big park area. The planned connection to the metro system was not fulfilled as a consequence of the economic crisis in the 1970s, a fact that contributed to the poor accessibility of the neighbourhood that lingers until today (Schubert, 2005). As a result, a rather disadvantaged share of Hamburg's population lives in this area: according to the social monitoring of Hamburg, Osdorfer Born is considered a neighbourhood affected by multiple types of ailments (i.e. low income, high unemployment rate – see Table 2), as well as a considerably high share of foreign population (26.4% compared to 17.3% in the Altona district). Due to its characteristics, Osdorfer Born is considered to have a "very low status" (BSW, 2019b, p. 16) and, therefore, is defined as a possible funding area receiving support for urban regeneration[3]. In this context, the city has been funding neighbourhood management and projects with its framework integrated urban development program 'Rahmenprogramm Integrierte Stadtteilentwicklung' (BSW, 2019a). Additionally, the public and cooperative housing companies in the area have set up a neighbourhood management to enhance social inclusion and requalify the built and natural environment (Osdorfer Born, 2020).

Based on the analysis and the statements of stakeholders during the living lab process, 1) socio-economic related issues, and 2) spatial-related issues were identified. Among all socio-economic issues, the language barriers are the most often indicated problem in the area, one which causes difficulties in explaining correct waste behaviour and involving citizens in CE activities within the neighbour-

[3] Since 1999, the federal government of Germany has been supporting the stabilisation and upgrading of urban, economic and socially disadvantaged and structurally weak urban districts and neighborhoods with the Social City "Soziale Stadt" urban development program (BMI, 2019).

hood. Lower levels of education and income also contribute to an often-limited awareness on environmental related issues (and waste behaviour consequently).

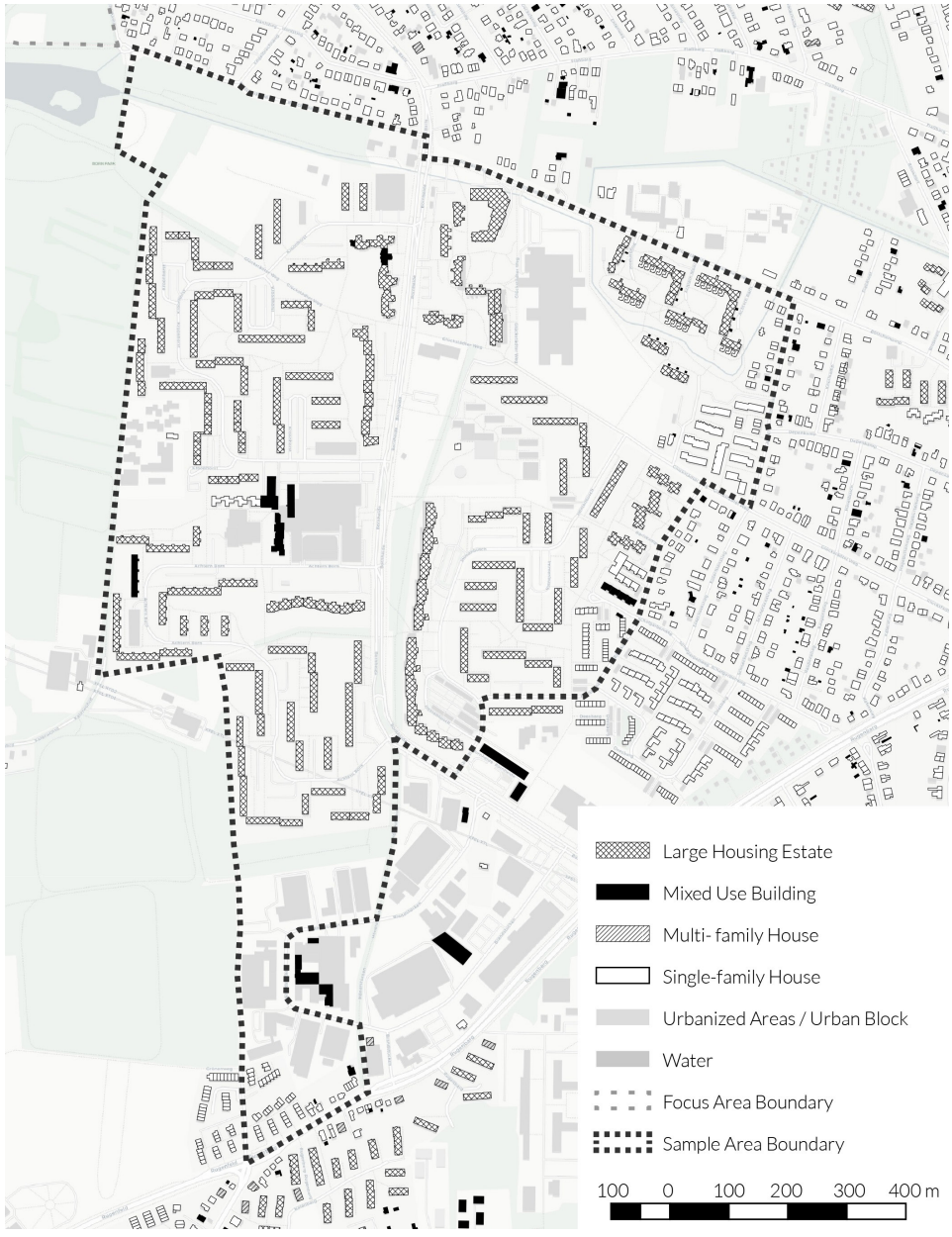

Fig. 2. Residential building types in the sample area Osdorfer Born

Source: own work based on RERAiR, 2020.

Concerning the spatial-related issues, the stakeholders stated that the anonymity of high rise buildings and the longer distances from the flats to the waste collection points on the street level lead to worse waste separation and generate littering in public spaces, especially concerning bulky waste. Moreover, the apartments' usually small kitchens do not allow residents to have all four bins for waste separation (Bauverein der Elbgemeinden, 2020). Finally, some waste collection points are not adequately accessible, especially for the elderly and disabled persons.

Therefore, the objectives defined by the local stakeholders for this area were related to enhancing social inclusion, improving environmental awareness, and at the same time providing knowledge on waste and life cycle. As space for waste separation inside the flats is scarce, alternative solutions, which enable a different way of separation, were explored (e.g. community composting, innovative forms of waste collection, like cargo bikes). To achieve these objectives the stakeholders concluded that a strategy that involves different groups of citizens is necessary to co-create solutions. Furthermore, possible tangible benefits for the citizens, like lower costs for waste management and improved cleanliness and quality of spaces, were regarded as necessary elements to be communicated. The stakeholders decided to develop this strategy using the existing network of local institutions (like housing companies, sport and neighbourhood associations) in the area. The neighbourhood management together with SRH would organise the process of strategy development and project implementation involving the local institutions.

5.2. Ottensen: a densely built-up urban area

The Ottensen neighbourhood is part of the historic centre of the district of Altona, which historically was an independent city and today functions as a centre for retail and services for the whole district. Its built environment is characterised by a rather dense structure mainly with 19th century buildings and narrow streets. Due to this high density, there is a high competition for space, especially for public land. As a consequence, it is difficult to dedicate spaces, either private or public, to waste collection, e.g. for the placement of tons or containers inside and outside of the buildings. In some parts of Ottensen, due to this insufficiency, residual and packaging waste is still collected by means of waste collection bags that are placed by households on the sidewalk (Sackabfuhr).

This bag collection causes problems of littering, bad smell, and negatively influences the aesthetic image of the area. Furthermore, a separated collection of organic waste cannot be conducted using the bag system, as it might cause hygiene-related problems. Although SRH conducted pilot projects to build underfloor containers for separated waste collection on public ground, there are still many streets where bag collection persists.

The population of Ottensen has an income close to Altona's average and is comparably well educated and young. Environmental sensitivity is rather high which is mirrored by the presence of many socio-cultural centres, initiatives and shops with an pro-environmental focus (e.g. zero packaging). Furthermore, several community gardening projects are active in the neighbourhood.

Despite these favourable conditions, the waste analysis performed by SRH has shown that the separation behaviour in this area is not better than in other parts of Hamburg even in households that potentially have the four bin system and could, therefore, separate fractions.

Further, the lack of (public) space to implement an improved waste infrastructure (especially an underfloor system) also generates conflicts of land with other possible uses of (public) space, e.g. parking spaces for cars or bicycles, and charging stations for electric vehicles.

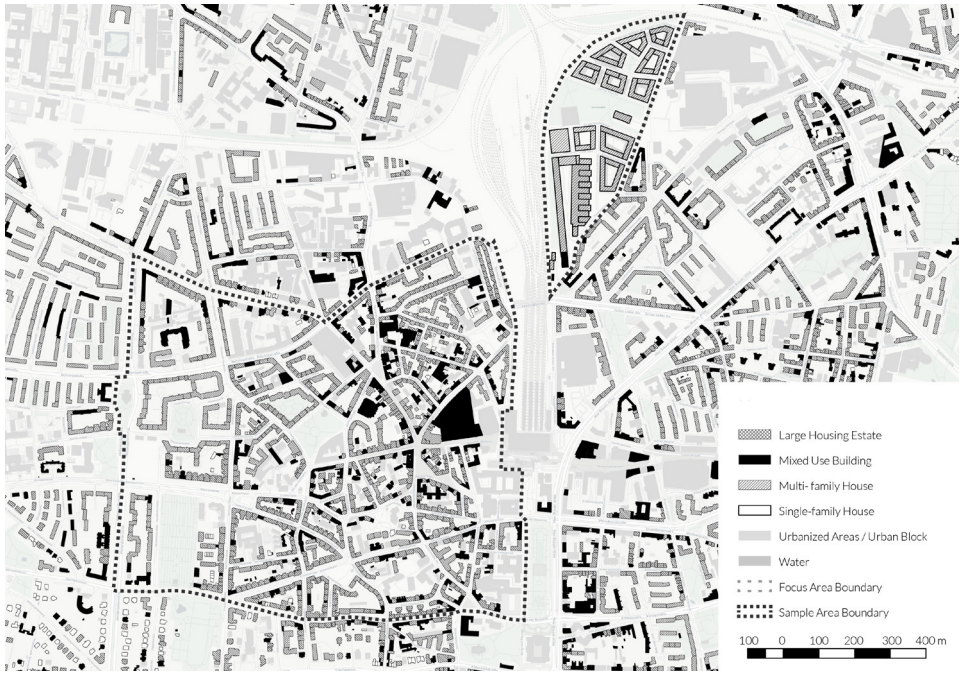

Fig. 3. Residential building types in the sample areas Ottensen and Mitte-Altona
Source: own work based on RERAiR, 2020.

The two main objectives for this area are described as follows. First, to reduce the bag collection and to improve the situation in the waste areas by implementing underfloor containers; to achieve this, creative solutions need to be developed. Second, to improve the waste separation and collection of bio waste in households that already have the four-bin system.

5.3. Mitte-Altona: a new urban development area

Mitte-Altona is the second largest urban development project in Hamburg after HafenCity. It is situated close to the historic centre of Altona Nord and Ottensen. The project is being developed on a disused railway freight station. Its master plan is composed of two areas: the first part will largely have been finished in 2020, while the second is planned to be completed in 2023 (Hamburgische Bürgerschaft, 2012a; Hamburgische Bürgerschaft, 2012b). Mainly apartment buildings are built in the area in order to face the need for new housing in Hamburg. The planning process started in 2007 comprising different steps, like a masterplan, a legally binding land-use plan, an urban design and architectural competitions, and participatory elements as foreseen by the German planning law. A part of the first development section was completed in 2018. The area can be considered as a future-oriented residential model with a mobility concept aiming to reduce car use and offer a planned mixture of social and free market housing. The residential buildings, which are predominant in the area, are characterised by a particularly high proportion of perimeter blocks with a common courtyard. The heights of the buildings follow the ones of the surrounding structure, while the density of the area is relatively high. The development of the second part of Mitte Altona area will start in 2026 (BSW, 2020b).

Despite the innovative planning with regard to the social mixture and mobility, the stakeholders indicated during interviews and workshops that the topic of waste management was not treated in an innovative way. Actually, the topic was rather neglected. Unlike in other newly planned areas, here no underfloor containers were implemented and even too little space was provided for waste bins to be well handled during collection days. This leads to conflicts with other uses of spaces, e.g. with car parking and the use of sidewalks and streets.

5.4. Rissen: a single-housing area at the urban periphery

This neighbourhood borders Schleswig Holstein, and is located around forty minutes by local train from the city centre of Altona. This area features a low density settlement with a high share of green areas, including big parks and vegetation on streets and backyards. Single-family houses are the main housing typology besides some four to five floor buildings in the centre of the neighbourhood close to the train station, where also local supplies are located. The low density of the built area offers sufficient space both inside and outside the properties for placing bins and containers for the waste separation. However, the waste separation analysis of SRH (U.E.C., 2017) has shown that the bio waste bins are mainly filled with garden waste, while kitchen waste is mostly disposed of in the residual waste bins and with it consequently incinerated. Therefore, a considerable amount of kitchen waste is lost for further treatment in the bio waste plant, where it would be anaero-

bically digested and then fermented to produce biogas and compost. The objective in Rissen is to improve the separation behaviour. As the infrastructure (four bin system) is already in place, solutions will have to focus on education, information and incentives (REPAiR, 2018a).

Fig. 4. Residential building types in the sample area Rissen
Source: own work based on RERAiR, 2020.

5.5. Blankenese: a single-housing area with second homes and weekend visitors

This neighbourhood features a hilly topography (around 70 metres of altitude) leading to the river Elbe (REPAiR, 2020). This area is famous for its nice paths on stairs (circa 5,000 steps) and small streets with single-family houses, many for weekend vacation. This means that the population here is not stable, and it varies considerably during the week.

Due to the topography, bins cannot be easily carried. Therefore, to a large extent, bags are used for residual, packaging and paper waste collection. In interviews and workshops this has been indicated as problematic, as it causes hygienic problems and makes the area less attractive for visitors. As in areas with bag collection, kitchen waste cannot be separately collected and has to be disposed of with residual waste. Like in Rissen, households with a bio waste bin mainly use it for garden waste. The main objective in Blankenese is to reduce bag collection. Solutions will have to tackle the lack of space and the topography.

Fig. 5. Residential building types in the sample area Blankenese
Source: own work based on RERAiR, 2020.

Table 2. Summary of the main spatial and socio-economic information for each sample area

INDICATORS	Osdorfer Born[a]	Ottensen	Altona-Nord	Blankenese	Rissen	Altona District
Population [n]	10,263	35,370	22,137	13,407	15,192	273,263*
Population density [inh/sq. km]	11,591	12,654	9,981	1,733	909	3,469*
Population over 65 years old [%]	18.0* (22.6)	13.4*	10.1*	27.2*	30.6*	18.0*

Table 2 (cont.)

INDICATORS	Osdorfer Born[a]	Ottensen	Altona-Nord	Blankenese	Rissen	Altona District
Foreign population [%]	26.4* (17.3)	13.1*	18.8*	8.3*	7.3*	16.1*
Population with migration background [%]	63.8* (39.2)	26.0*	36.0*	17.1*	16.9*	32.0*
Annual average income per taxpayer [€]	17,480 * (43,177)	40,830*	29,901*	117,139*	65,855*	48,620*
Unemployment rate (between 15 and 65 years old) [%]	11.8* (6.6)	4.4*	7.2*	1.9*	3.5*	5.9*

* These details were found in Statistik Nord (2017) related to the quarter level in the year 2016.
[a]For Osdorfer Born, the details at the neighbourhood level were found and are shown here compared to the quarter level (in parenthesis): according to the Hamburg Social Monitoring, Osdorfer Born functions as a "very low status" neighbourhood. Other details have been derived from the HCU Transparent geoportal and related to the year 2016. The comparison with the district of Altona is shown in the last column. These numbers have been calculated from the Datasets in the Transparent Geoportal Hamburg, GIS.

Source: own work, 2020.

6. DISCUSSION AND CONCLUSION

In the attempt to address the topic of circularity, the European Union is demanding a more inclusive and just transition by addressing all levels of governance. Our research concentrated on the local level and investigated the effects of CE activities on the socio-economic aspects and the consequences that affect the spatial organisation of the urban structure (as stated in Williams, 2019). Hence, the understanding of specific spatial conditions has proven important for the development of solutions that respond to local problems and meet stakeholders needs. As highlighted in Section 5, the mosaic of urban structures composing the five different areas raises unique problems specific for the local situation.

The analyses of the two most contrasting examples, i.e. Osdorfer Born and Ottensen, have shown that socio-economic and spatial aspects generate similar (but not equal) problems which require the development of a sound local strategy by involving stakeholders in place.

In Osdorfer Born, the current situation demands addressing societal challenges to overcome cultural and language barriers to reach a better waste separation at source. However, Osdorfer Born also faces problems in the built environment related to a lack or bad quality of space dedicated to waste-related activities. Additionally, spaces dedicated to waste collection and separation are not always well configured, ranging from a lack of understandable information to a suboptimal location.

In Ottensen, adequate physical waste infrastructures are present only in some parts of the area, with the Sackabfuhr (i.e. poor source separation) system currently being the most relevant practice. Additionally, even though the inhabitants of the neighbourhood have generally proven to be aware of environmental issues[4], this is not reflected in their waste separation behaviours (U.E.C. 2017).

The differences in the two areas demand distinctive strategies to achieve circularity at the local level. In Osdorfer Born, the involvement of institutionalised stakeholders (e.g. the neighbourhood management), who are already present in the area, could foster and guide the sensitisation campaign of the citizens through systematic engagement and rewarding or fining mechanisms. In Ottensen, a possible strategy should aim to create a network to connect those stakeholders who are already active in the neighbourhood (e.g. environmental and social associations) to foster local initiatives and projects.

In summary, it is argued that the strategic component to support locally tailored actions towards CE should consider the collection of a sufficient amount of data (qualitative and quantitative) to support the decisions by the stakeholders involved in the process. These should embrace a spectrum of both local (bottom-up) and institutionalised (top-down) stakeholders, as for the cases of Ottensen and Osdorfer Born. Furthermore, not only the vertical dimension, i.e. the levels of governance but also the integration between different sectors on a horizontal level plays a relevant role. Actually in Altona-Hamburg the Climate Action Plan (see Section 4) saw the participation of local (e.g. zero-packaging shops) and super-local stakeholders, such as the local waste management company and the municipality. In fact, the results have shown that in Hamburg there is a demand for a more decisive intervention of the public authorities to guide such a process, implying a narrower collaboration between the urban planning division and the waste management sector.

Reflecting on the methodology, the mix of data-based (Material Flow Analysis) and qualitative (stakeholder involvement in living labs) methods has proven to be useful for the research on circular economy and cities. Spatial, material-flow, governance and stakeholder analyses created the base for an informed discussion to address circularity in such local contexts.

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[4] As can be interpreted by the high voting results of the Green party in the latest Hamburg regional elections in February 2020 (Statistik Nord, 2020).

The involvement of local stakeholders has helped identify problems, understand peculiarities, and discover the challenges that prevent the achievement of circularity at the local level. Moreover, although the involvement process has been time and resource consuming, it could assure an innovative way of defining suitable solutions for specific problems and raising the chances for actual implementation.

The mixture of different stakeholders enabled various views as well as new insights for the participants themselves. The observation from different angles led to a richer and more balanced analysis of the problems and the exchange of a variety of arguments set the ground for the development of new strategies and solutions.

Nevertheless, the identification, the involvement and the mixture of stakeholders in a living lab is challenging and contains risks that could strongly affect the process and outcome. Therefore, the usage of the living lab method related to circular economy and city approaches should be further examined in research, although currently being highly recommended.

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LOCAL RESOURCE-BASED DEVELOPMENT POTENTIAL AS REFLECTED IN WASTE MANAGEMENT/CIRCULARITY TRANSITION: GOVERNANCE BARRIERS IN HUNGARY

Abstract. Waste as a local resource is a development opportunity for resource owners as waste may act as a foundation for bottom-up development at local levels. This paper presents the most important governance challenges that hamper a paradigmatic change in resource efficiency, a transition towards circular economy in the case of Pécs (Hungary). In recent years waste management infrastructure has evolved to provide resource potentials for recycling and reuse, this is a first step towards a (circularity) transition, however, the centralisation of power is hampering local transitions. The article concludes by arguing that in Pécs (Hungary), the transition towards a local resource-based development is impeded by a myriad of legal, institutional and administrative obstacles created by recent efforts towards institutionalisation.
Key words: waste management, governance, local resource-based development, sustainability transition, circular economy.

1. INTRODUCTION

Since 1992 (United Nations Conference on Environment and Development in Rio de Janeiro), the role of local level sustainability has been evident as "so many of the problems and solutions being addressed by the Agenda 21 have their roots in local activities" (UNCED 1992, Agenda 21, Chapter 28). Hence, the transition towards sustainability needs new approaches, instruments and frameworks in local development activities (Wittmayer and Loorbach, 2016).

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Waste is often stigmatised as merely something that needs to be disposed of. However, with the drive towards a circular economy (CE), the beneficial reuse of waste as a resource or as an input for other processes has been globally recognised as a paradigmatic change (Mason-Renton and Luginaah, 2018).

As Varjú (2020) in the foreword of this special issue of ESR&P describes in detail, CE as a concept has been gaining popularity. Sustainable resource management is a global and borderless phenomenon, and the actors who participate in resource governance are both governmental and non-governmental institutions, as well as agents from the global, national, regional, and local levels (Milligan and O'Keeffe, 2019), each having specific responsibilities and territorial limitations.

Sustainability transitions, beyond traditional planning and development, require broader engagement, empowerment, and breakthrough strategies. As Ghisellini *et al.* (2016) has indicated, a key aspect of the transition towards CE comes from the involvement of all actors of a society and from their capacity for creating collaboration and knowledge exchange (Ghisellini *et al*., 2016). From a former stakeholder survey in the REPAiR[1] project (Varjú *et al*., 2019) we know that the perceptions and interpretations of relevant stakeholders regarding sustainable resource management can be considered to be at an advanced level and have a good capacity for collaboration and learning. Although Pécs is a pioneer in waste management in Hungary, today the city is far from being at an advanced level in circular transition. Hence, the research questions here are what circumstances interrupted this promising process in Pécs, and what the main barriers that hamper the use of local resources for local development are.

Based on the investigation in the REPAiR project, this paper presents the possibilities for a transition to a CE in the case of Pécs (Hungary) partly based on the dimensions of the transition to sustainability shaped by Markard *et al.* (2012), using this as an analytical framework. Regarding waste as a potential resource, this paper elaborates on how power can become a barrier in the transformation of waste to a resource, and hamper local resource-based local development.

The article is organised as follows: the presentation of the analytical framework (second chapter) is followed by a brief introduction of the research method. The fourth chapter is divided into three parts. The first introduces the case study area of Pécs. The second part offers an overview of the sustainability issues of the city, and the third part describes the recent waste treatment situation in Pécs. The fifth chapter discusses the recent governance challenges and the role of power in the waste sector, which is then followed by concluding remarks.

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[1] REPAiR – REsource Management in Peri-urban AReas: Going Beyond Urban Metabolism, European Union's Horizon 2020 research and innovation programme under grant agreement No 688920. http://h2020repair.eu/

2. THE DIMENSIONS OF SUSTAINABILITY TRANSITION

There are numerous on-going discussions on the ideal territorial scale for development policy, and on the scale where local economic development (LED) can be performed. The main approach of LED concepts is that the local level has an important role within development processes through the interactions of local stakeholders and the mobilisation of internal resources (cf. the endogenous development concept Slee, 1994), while there is a potential for the involvement of external resources as well (Mezei, 2019). The local resource-based LED concept endeavours to use all local resources as efficiently as possible. One of the essential features of this local resource-based development approach is not the precondition of development, but its purpose: the intervention's focus on the interests of local actors and local resource owners of a territorial unit, and the interests of all other actors subordinate to it (Mezei and Varjú, 2018).

According to the resource-based approach, all the factors that constitute the set of opportunities and that, at the same time, provide value to developers and users are considered as resources (Mezei, 2018). Adaptive, bottom-up local development has at least three conditions: 1) Mobilisation of locally available community and private resources; 2) Possibility of room for manoeuvre at the local level; and 3) Adaptive use of local development tools (Mezei, 2018).

The efficiency of development policy depends not only on the economy of scale and macro-economic subsidies but also on governance capacities, its social embeddedness, complexity, and its open or closed, hierarchical or horizontal nature. Although local economic development is a multi-layered policy, local governments are the most important actors. The types, amounts and quality of the available resources, social capital, trust, economic development networks, and knowledge are all equally important factors for the success of local economic development (Mezei, 2006; Pálné, 2015).

In the classic approach, waste is both a consequence of human activities and the cause of problems for human health and for the environment (van Ewijk and Stegeman, 2020), however, recently, in the era of transition, it has been a potential local resource, as described in the EU Action Plan for the Circular Economy (EC, 2015), that can be used by adaptive local resource-based developers. In addition, by closing material flow loops, the new approach can generate new business models based on waste as a resource.

Moreno-Pires and Fidélis (2012, p. 609) have argued (citing Bomberg, 2004) that governance for sustainable development can be defined "as the set of institutionalised patterns for interpreting and pursuing sustainable development policies and goals." These new modes of governance give new roles to different governmental levels and actors, and need innovative forms of collaboration and stakeholder involvement. Today, transition management (cf. Loorbach, 2010) and transition governance in sustainability topics such as CE (cf. Heurkens and

Dąbrowski, 2020) are emerging. These approaches focus on the management and governance peculiarities of cities or regions, which (their space and scale) are also often neglected (Coenen *et al*., 2012), considering the activities from a strategic, tactical, operational, and reflexive levels (Wittmayer and Loorbach, 2016; Heurkens and Dąbrowski, 2020).

The notion of sustainability transition has been under discussion for 20–30 years and recently, as it being, in many cases, a goal oriented or 'purposive' process (Smith *et al*., 2005), it includes not only a fundamental transformation in the energy, water, and transportation sectors, but in resource management (towards circular economy) as well (Markard *et al*., 2012; Truffer and Coenen, 2012; Ghisellini *et al.*, 2016). Apart from the aforementioned Transition management, Strategic niche management, Multi-level perspective, and Technological innovation systems are often cited and discussed as concepts (a detailed overview can be found in Markard *et al*., 2012).

A sustainability transition as a socio-technical transition involves a broad range of actors and different dimensions: technological, material, organisational, institutional, political, economic, and socio-cultural (Markard *et al*., 2012). These dimensions are usually discussed in different theoretical approaches to management (mentioned above). As Markard and colleagues (2012) have argued, "there is a pressing need to improve the understanding of the politics and policies of sustainability transitions" (Markard *et al*., 2012, p. 962). Although politics (including not just the behaviour of a government but also of other actors) is a constant element of a socio-technical transition (Meadowcroft, 2011), it was somehow neglected in the past and has only recently become the focus of discussions (Markard *et al*., 2012).

This paper focusses on the aforementioned dimension of sustainability transition reflecting on most of the dimensions mentioned by Markad *et al*. (2012) and on how power and agencies have shaped the sustainability transition processes in Pécs (Hungary) and have finally obstructed the transformation of local resources as a basis for local resource-based development.

3. METHODS AND MATERIALS

The methods and materials in this study follow the methodology of the REPAiR project (Obersteg *et al*., 2017). The literature and document review and the analysis of the legal framework on circularity and resource efficiency in Hungary and Pécs were followed by the identification of relevant stakeholders (including actors in the waste management, NGO, and business sectors). Following the REPAiR project scheme, semi-structured interviews were conducted, during which we asked the interviewees to name additional stakeholders for interview (snowball method). These interviews, a total of ten, were conducted from August to November 2017.

The interview questions focused on the stakeholders' challenges of having to cope with the transition towards resource efficiency and the practices of resource management. In addition, the interview endeavoured to reveal the knowledge and institutional capacity of different actors with respect to a circular transition and focused on the role of governance and power (at the local and country levels), whether they hamper or facilitate this transition.

In order to gather more information from stakeholders, under the umbrella of Peri-Urban Living Lab (PULL)[2] (Russo *et al*., 2017), and as a starting event of the Pécs PULL, a workshop was organised (on 28th November 2017) for relevant local and regional stakeholders (including the city government leadership, experts from the regional green authority, and business actors starting initiatives in circularity). After a few plenary presentations about the recent situation of a sustainability transition in Pécs, the aim of the workshop was to identify the key challenges and objectives for Pécs (including for the local government, the local waste management company, private individuals, business actors) to progress towards a higher level of circularity. (The aim of a follow-up workshop (organised in January 2019) was to rank these challenges and objectives and group them according to three material flows: organic, plastic packaging, and residual waste streams. This workshop has also provided information for this paper.)

Further information was gained during the PULL workshop series organised between January 2019 and January 2020. The main aim of these seven workshops was to co-develop eco-innovative solutions reflecting the challenges identified beforehand. Additionally, beside the main focus, there was an opportunity to consult experts and get more empirical information about the then institutional changes and the role of power in and politicisation of the waste sector.

Based on the above materials, in the following sections a general overview and change over time will be described touching on the technological, material, economic, and socio-cultural dimensions. The fifth section focuses on the challenges of the organisational, institutional, and political dimensions of the circular transition in Pécs, Hungary.

4. THE CASE STUDY AREA OF PÉCS

4.1. Short overview of the geographical and socio-economic situation

Pécs, the seat of Baranya County in the South Transdanubian Region (Hungary), is situated 30 km from the Croatian border. This borderline location represented an unfavourable situation in terms of investments due to previous geopolitical

[2] See more details in the introductory article of this special issue.

processes in the 20th century (cf. Rácz, 2016; Varjú, 2016). The geographically diverse area of the Baranya county has more than 382,336 inhabitants (in 2018, based on KSH-TeIR database[3]).

Coal mining, the basis of Pécs' economy, began in the 18th century with a significant increase in the volume of coal excavation from the beginning of the 20th century. That led to the turning point of the transformation of the city to play a dominant role in the broader region (Faragó, 1997), which "greatly affected the city's traffic, its society, its built environment, general economic development, cultural and intellectual life" (Pirisi *et al*., 2009, p. 3). In the 20th century, mining continued to have an important role in the economic structure of the city with uranium mining, in addition to coal, also contributing to the socio-economic life of Pécs.

After the decline of this form of heavy industry in the 1980s, and the post-1990 industrial restructuring in Hungary (including Pécs), the closure of mines (at the end of the last millennium) had a significant impact on the employment and economy of the city, also leading to the emergence of large, and sometimes 'long-term', brownfield areas (Dannert and Pirisi, 2017). One of their attempt at regenerating them was triggered by the awarding of to the 2010 title of the European Capital of Culture, which provided a possibility to overcome the difficulties for the city of Pécs (Trócsányi, 2011).

The county is considered peripheral and disadvantaged in both social and income aspects (Pénzes, 2014), which is partly manifested in the low economic performance index of GDP/capita: 43% of the EU28, 63% of the Hungary average (2015) (Varjú *et al*., 2018). Pécs, the county's centre, has a disproportionate role in the employment and economic performance of the Baranya county (Varjú *et al*., 2018). In past decades, the city (with its population of 143,531[4]) became a *university city*, and now has around 25,000 students (Gyüre *et al*., 2013) including 4,500 from abroad, which has an important impact on the society, culture, and economy of the city.

4.2. Sustainability overview

The 'green thinking' of certain stakeholders in Pécs is rooted in the 1990s. As a first attempt, Biokom, the local waste management company, introduced separated collection of waste (paper, plastic, and glass), which was a pioneering step in Hungary in 1996. In the early 2000s, the introduction of the *Pécs Eco-City, Mecsek-Dráva Ecological Region Programme* (ECO-CITY–ECO-REGION) development concept aimed to seek effective solutions to the problems of environmental protection (partly originating from the collapse of the mining and the heavy industries) as a high priority of the county. A major aim of the programme

[3] http://www.teir.hu

[4] In 2018, based on KSH TeIR database.

was to mobilise the regional economic and social actors while developing an environmentally conscious market and social behaviour, and integrating the elements of sustainability into the regional and local spatial planning and development processes. To do so, the ECO-CITY–ECO-REGION programme used the ecological footprint as a background concept (Kiss, 2004).

Pécs does not have a (sectorial) plan for waste management, nor for CE (Hungary has no CE plan either). The city's goals for waste management are included in the Integrated City Development Strategy 2014–2020 (ITS, 2014), which contains only one relevant indicator: a higher rate of segregated municipal solid waste. Besides, the city of Pécs has initiated several circular focused *green city* actions. Among others, renewable energy and energy efficiency are very much highlighted in the strategy, both of which have some history, when the local power plant changed its fuel from coal to biomass in 2004.

Apart from the development of the Sustainable Energy Action Plan (SEAP) in 2014, management and other practical actions for stakeholders in the use of renewable energy and energy efficiency were proposed, a year before the city joined the Covenant of Mayors initiative aiming to reduce CO_2 emissions by at least 20% by 2020 (MANERGY, 2014).

Based on the SEAP, a 10 MWp photovoltaic power plant was built by the city and the local power plant on a brownfield site, a former ash deposit area. Furthermore, on the way towards circularity, a biogas plant on the local wastewater treatment area was also built. The combined cycle-power station provides electricity for the grid, while the thermal energy is used for heating the offices and other buildings of the wastewater treatment centre on site.

4.3. Waste treatment practice

By 2016, as a result of a large regional waste development project co-financed by the EU, a new, improved waste management system with new technologies had been established in Pécs and its agglomeration with the dominant contribution from BIOKOM, which played a decisive role in the planning and implementing phases.

Municipal waste subject to mixed collection and separately collected waste are organised as a basic service in Pécs and its agglomeration, maximising the yield of recycled materials while keeping financial sustainability. Hence potential secondary raw materials can be removed from the system at certain processing/refining points. The mechanical-biological treatment centre (in Kökény, a suburb settlement of Pécs) is responsible for processing mixed waste, which is followed by the biological treatment of its biodegradable fraction. Additionally, in the scope of the above investments, transfer stations were also established in the central settlements of the micro-regions (in the whole project region, not only in the Pécs agglomeration).

In the analysed area (the Pécs agglomeration of 41 settlements and the city itself), there are two types of segregated collection: collection islands, and door-to-door collection. In the agglomeration, at least one collection point serves each settlement, and, additionally, settlements with populations of 500 to 1,000 have an additional collection point. In major settlements, one additional collection site has been set up per 1,000 inhabitants. Although packaging waste (paper, cardboard, plastics, and glass) are collected, organic waste is excluded for the time being. Door-to-door segregated collection has been introduced in the districts of towns with detached houses and within a 20 km radius of settlements with more than 15,000 inhabitants. The placing of different capacity collection bins is being continuously monitored. In 2003, door-to-door green waste collection was introduced in the suburban districts of the city. The collected material is composted at the waste treatment site (in Kökény) with a capacity of 9,750 tonnes/year.

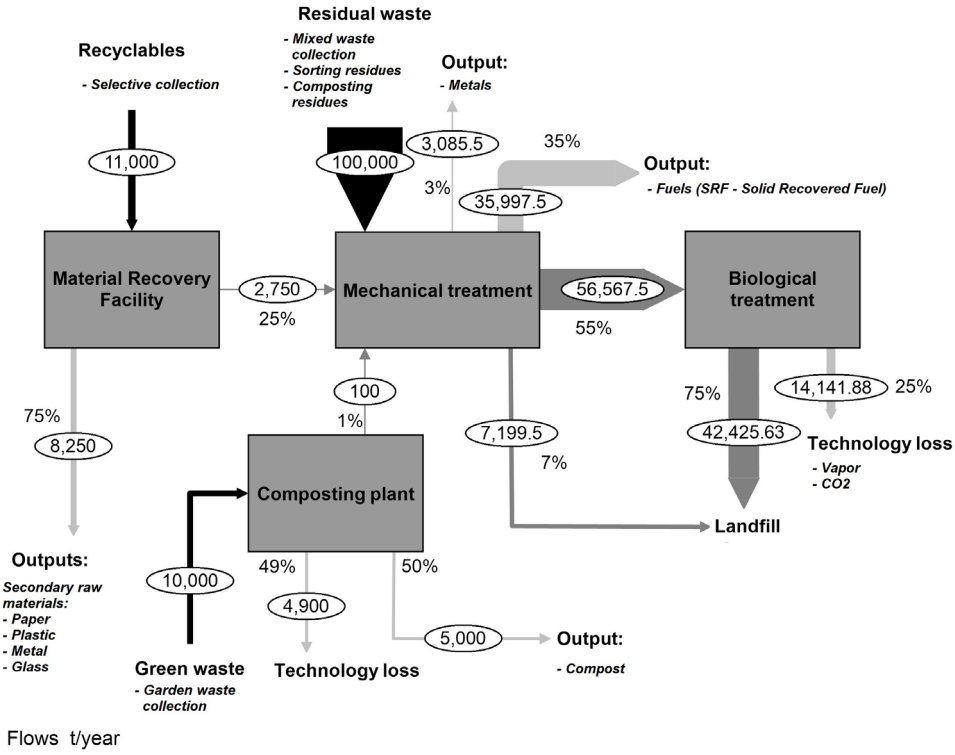

Fig. 1. Internal waste streams of the Pécs-Kökény site (2017)

Source: own work based on Biokom Nonprofit Ltd data.
Designed with STAN2Web open source software

Fig. 1 shows how the waste is treated at the waste treatment centre in Kökény in order to maximise the yield of recycled materials and to make the most valuable end product. One key flow there is green waste that is transferred into the composting plant.

– 45–50% of the mass of 9–10 thousand tonnes of incoming green waste is returned as ready-made compost, which is sold for soil improvement purposes. The remainder is released in the form of gases and vapours, except for 1–2% of foreign matter, which is transferred to the mechanical treatment unit after separation.

– The 10–12 thousand tonnes of dry packaging material collected separately is sorted at a manual sorting plant and segregated, if possible, into pure secondary raw materials by the conveyor belt workers. Paper, plastic and metal raw materials of various qualities are sold in bales, glass is sold in bulk. It is important to note that glass waste is not transferred onto the sorting belt in order to avoid personal injury. Sorting residue (approx. 22–25%) is taken to the mechanical treatment plant.

– Around 100,000 tonnes of residual waste from mixed collection is delivered to the mechanical treatment unit. The waste transferred from the composting plant and the manual sorting plant that can no longer be recovered is added to this quantity. Solid recovered fuel (SRF) is produced from the light fraction, accounting for 32–38% of the incoming waste mass.

– The organic fraction from the mechanical treatment plant is first stabilised. This technology is similar to composting, however, due to the collection method (mixed waste) legislation does not allow this material to be composted, only stabilised. The purpose of stabilisation is to decompose organic materials under controlled conditions, preferably aerobic, thus to ensure that CO_2 is produced instead of methane, which is a typical by-product of traditional landfills. As a result of biological treatment, one-fourth/one-fifth of the treated volume is removed in the form of gases and vapour and 75–80% is deposited (Varjú *et al*., 2018, p. 88).

5. GOVERNING AND/OR POLITICISING THE WASTE IN HUNGARY

As a pioneer in the introduction of European policies and principles, BIOKOM has become an internationally known and recognised waste management company, with potential for implementing a paradigmatic change in the field. The potential for reusing waste comes from the waste management infrastructure, however, there are other barriers to overcome, mainly from the side of governance, especially the processes of recent years.

Waste policy is managed to various ministries in Hungary as this policy affects the environmental, public service, and regional development sectors. According to the first post-socialist law on environment in 1995, local governments were made

responsible for the collection and treatment of locally generated waste (Municipal Solid Waste-MSW), a fact which had led to a fragmented waste management system due to the high number[5] of local governments in Hungary. Based on the European waste directive, the new Waste Act[6] was introduced in 2012, which included, among others, waste type definitions and it introduced a waste treatment hierarchy.

As an analysis of the legislation shows, the Hungarian National Waste Management Plan for 2014–2020[7] was introduced in 2013 (HNWMP 2013). The plan's target was to achieve 50% reuse of household waste. Segregated waste collection was also a priority. Another aim was to achieve a 28.95% selection rate of organic waste within MSW. The latter was defined by another important document, the Waste Management Public Service Plan for 2017 (OHKT 2017, p. 42). The Hungarian average in 2016 was very far from that (13.81%), however, the percentage in Pécs reached 18.9[8].

From 2013 the contractual freedom of local governments was restricted, as previously they had had the right to sign contracts with waste management public service providers. Since then only one integrated contract has been allowed for the collection and management, and the company has to be majority owned by the local government or a state owned company.

As it is clear from the results of the workshop relating to the ranking of the (circularity) challenges, since 2010 the strong centralisation process within the whole area of governmental and regional development (Nagyházi, 2015), accompanied by a degradation of the independent environmental management system (at all decision-making levels), has also affected waste management. The gaps in environmental governance have been also emphasised by the OECD[9].

NHKV Plc. (National Coordination of Waste Management and Asset Management Plc.), a new coordinative organisation (established in 2016), rescaled the entire waste management system. In 2016, the organisation accepted a new regional optimisation plan (HNWMP, 2016) for the provision of the public service of waste management.

The priorities of the new waste management plan 2016 are:

1) Upholding the reduced cost of the waste service (household tariff) 'achieved' by the government;
2) Ensuring a waste service of equal quality in every region;
3) Regional equalisation at the public service provision level;
4) Sustainable financing of the waste management public service (Varjú *et al*., 2018).

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[5] There are more than 3,250 settlements in Hungary with self-governmental rights.
[6] The Act CLXXXV of 2012 on wastes.
[7] HNWMP 2013: Hungarian National Waste Management Plan for 2014–2020. http://web.okir.hu/dokumentum/318/Orszagos_Hulladekgazdalkodasi_Terv_20142020.pdf [accessed on: 01.12.2017]
[8] https://www.teir.hu/
[9] https://www.oecd.org/hungary/hungary-2018-9789264298613-en.htm

The most important effect of the plan has been the (top-down) regionalisation (integration) (cf. Pissourios, 2014) of public waste management. Instead of the former 110 public service providers in 2016, the plan targeted the creation of 20–22 units.

As an analysis of the legislation and the empirical investigations during the PULL project show, since 2017 the selectively collected secondary raw materials from households and the recovered materials from the residual waste on waste treatment sites (including, for example, the new material generated from waste RDF – residue-derived fuels) have been owned by the new organisation instead of the local public service provider (materials collected from the private sector are still subject to market conditions). As a result, local governments with the responsibility for providing the waste service at the local level are unable to manage the local waste (and its potential as a resource) alone. This, in fact, hampers the spread of the circular concept, even at the local level. Hence, local actors have lost their economic interest in moving towards better segregated collection methods, and recovering and reusing secondary raw materials as they do not have the income from sales, while the fixed service price paid by households cannot force regular people to increase segregated collection and allows no room for manoeuvre by the local service provider (e.g. decreasing the price in the case of less residual waste in bins). However, companies using secondary raw materials as resources collected by local service providers are able to purchase them from the NHKV (via public procurement procedure), and are no longer dependent on the limits of the regional waste market.

In 2016, the city generated 48,400 tonnes of municipal solid waste, of which 37,300 tonnes came from households. At the same time, the average per capita waste generation was slightly worse than the national reference value. However, in contrast to national trends, due to a very early introduction of selective waste collection in the city, the proportion of selective waste to total weight has remained above the national average, increasing from 5% in 2006 to 18.9% in 2016. Thanks to the developments, the percentage of waste going to landfills in 2016 was only 51.74%[10].

Although the legislative background clearly defined the city's administrative area as the scope of the public waste management service, the city management recognised at an early stage the challenges of scale in the sector. The city management was able to do this with the help of consultants and experts from the by then non-existent mining industry, who were aware of the problem of managing industrial waste. Based on this team of experts, the first public service company owned by the city started to perform waste collection and treatment tasks in Pécs, and then in the surrounding area, based on the principles of economies of scale. This approach has also become a competitive advantage for Pécs. After the temporary privatisation of the public waste management company, at the beginning of the 2000s, BIOKOM Nonprofit Ltd, now re-acquired by the city, has been working to meet EU requirements as soon as possible, on a large-scale basis.

[10] http://www.ksh.hu (Hungarian Statistical Office)

A higher proportion of household segregated waste collection also contributes to improving the local availability of local resources and secondary raw materials, but at the moment legislation does not encourage households to participate in segregated waste collection. At the same time, key issues include the role of the population, and consumer attitudes and behaviour. Their development will not only provide municipal or corporate actors with opportunities to increase the amount of resources available locally, but it will also provide the public with a cleaner, safer, and livelier environment (as a local resource).

6. CONCLUSION

This paper has made an attempt to present the sustainability transition of the city of Pécs in the waste management sector in order to transform resource use towards a more efficient way and to use it locally. Using the (technological, material, organisational, institutional, political, economic, socio-cultural) dimensions of several transitional concepts it has been shown that in the past decades Pécs was a pioneer in waste management transition. However, in past years, taking into account the organisational, institutional, and political dimensions, this transition has been stalled.

The governance of a territory translates to the quality of democracy and public services, therefore, several attempts have been made to make changes in the governance of territories across Europe. Many of these changes were linked to the rescaling of government and its functions, shifting policy responsibilities or the regional development role (Hoffman, 2018) downwards to the local governments (Stead and Pálné Kovács, 2016). In Hungary, since 2010, rescaling has existed in the other direction, i.e. from the local to the central government, shifting the power and the potential of use of local resources to central actors. Due to the centralisation process more and more selectively collected secondary raw materials from households are becoming owned and redistributed by a centralised sectoral body, the NHKV, withdrawing the right of sale from local providers, though allowing the creation of a unified secondary market for these materials. This has resulted in the lack of the opportunity to use these materials locally. This has several negative effects including the increased impact of the transportation of potential resources and the failure to meet local interests in proper 'resource-focused' waste treatment. Hence, although, this reversed change in the competence of local governance does not hamper the transition of the waste sector completely, the potential to use local resources locally, an important aspect of circularity, does not exist.

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WASTE MATERIAL FLOW ANALYSIS IN THE ŁÓDŹ METROPOLITAN AREA

Abstract. The main sources of waste generation are: industry, municipal sector, and agriculture. Municipal waste is solid and liquid waste that arise in households, public utilities (trade, services, handicrafts) and municipal services (e.g. street cleaning and maintenance of green areas). The main aim of this paper are the analysis of the flow of municipal solid waste in Łódź Metropolitan Area, its composition, presentation of the process towards a more selective waste system, and the extraction of biodegradable waste from the MSW. The article is based on a report prepared within the Horizon 2020 project REPAiR "Resource Management in Peri-urban Areas: Going Beyond Urban Metabolism".
Key words: municipal solic waste, waste management, Łódź Metropolitan Area.

1. INTRODUCTION

Research on waste management in Poland had already commenced in the 1980s when researchers sought to reuse waste, employing the term "circular economy". Publications that were crucial in this field were released by the Institute of Geography and Spatial Organisation, Polish Academy of Sciences, i.a. works devoted to the issue of environmental protection (Leszczycki, 1974; Kamiński and Szyrmer, 1981a), waste flow models (Kamiński and Szyrmer, 1981b) or a waste-free economy (Cała, 1985). Currently, this term is commonly used in the context

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of waste management (e.g. Tundys, 2015; Szyja, 2016; Turoń and Golba, 2016; Pieńkowski and Kośmicki, 2016). International literature (e.g. Lacy and Rutqvist, 2015; Haas *et al.*, 2015; Singh and Ordoñez, 2016; Tisserant *et al.*, 2017; Malinauskaite *et al.*, 2017; Winans *et al.*, 2017, and numerous others) places great emphasis on circular economy. It is difficult to identify the creators to the concept of a circular economy, but its formulation dates back to the 1970s (Winans *et al.*, 2017). Although research on a waste-free economy was undertaken in Poland as early as in the 1980s, there are few publications which have dealt with its spatial aspect. Despite this, more and more publications emphasise the necessity of creating a circular economy, especially in the context of material flows within metropolitan areas (e.g. Vittiglio *et al.*, 2018).

New waste management regulations came into force in 2013, after the Waste Act (of 14 December 2012) had been introduced. The entire waste management system has been reorganised. According to the Act, municipal waste should be selectively collected and local government bodies are responsible for compliance with the principles introduced in the Act. Local government authorities are therefore responsible for managing the processes involved in local waste management; they also make the most important decisions as to the form and method of their implementation.

Waste is a by-product of human activity, introduced into the environment in quantities both large and small, including the primary product, but in which the time and place of creation is deemed unsuitable (Encyklopedia Powszechna, 1999). According to the Waste Act of 12 December 2012, waste is "any substance or object, the holder of which disposes, is going to dispose, or is obliged to dispose." Waste is, therefore, any material, raw material or final product which is not employed, has no designated purpose, and is not used for a specific purpose (Lipińska, 2016). Waste is then considered as any substance or object which the holder discards or intends to discard or is obligated to discard. Yet a producer of waste is understood as any person or organisation whose activity or existence results in the generation of waste (initial waste producers) and anyone who performs pre-treatment, mixing or other activities causing a change in the nature or composition of this waste.

Waste is classified on the basis of various criteria. Each classification is based on carefully set norms of a physical and chemical, biological, technological, and economic nature, such as: origin, state of matter, raw material criterion, chemical composition, toxicity, harmfulness to people and the environment, and suitability for further use. The general classification, which considers the origin of waste, its nature and its properties, divides waste into: municipal, industrial, liquid, and hazardous waste (Lipińska, 2016).

The main sources of waste generation are: the industry, the municipal sector, and agriculture. Industrial waste is generated in production processes (e.g. from the mining industry, as a result of wastewater treatment, or emissions of gases

into the atmosphere). Municipal waste is solid and liquid waste that emerges from households, public utilities (trade, services, handicrafts), and municipal services (e.g. street cleaning and maintenance of green areas). Hazardous waste is generated as a result of the direct or indirect impact of aggressive substances that can negatively affect living organisms. Hazardous waste may be toxic, harmful, carcinogenic, flammable, etc.

The main aim of this paper is to analyse the flow of municipal solid waste in the Łódź Metropolitan Area, its composition, and to present the process of moving towards a more selective waste system and extracting biodegradable waste from MSW. The article is based on a report prepared within the Horizon 2020 project REPAiR "Resource Management in Peri-urban Areas: Going Beyond Urban Metabolism" (Czapiewski *et al.*, 2018).

2. THE OVERALL SITUATION IN POLAND AND THE ŁÓDZKIE REGION

According to the Regulation of the Polish Minister for the Environment of 9 December 2014, the waste portfolio comprises 20 groups of waste, separated on the basis of the source of waste. The regulation specifies a waste portfolio which divides waste into groups, subgroups, and types.

Municipal waste is waste generated in households and retail, by enterprises, office buildings, and educational institutions, as well as healthcare institutions and public administration which is of a similar nature and composition to waste generated in households. However, it should be noted that in 2017 more than 85% of the total weight of municipal waste was generated by households.

The amount and morphological composition of municipal waste depends to a large extent on the place where it was formed, particularly on the social status and the related level of product consumption, but also on the time of the year. It should be noted that the amount of municipal waste collected per inhabitant annually is strongly correlated to the economic status of individual regions of the country. The Łódźkie region is not one of the most economically developed areas in Poland and this is visible in the weight of municipal waste collected *per capita* – in recent years the value for the region was 10% lower than the average for Poland (Fig. 1). Slightly higher values were observed in the Łódź suburban area, however, the highest amounts are definitely collected in the city itself.

The nature and the overall mass of waste generated is also strongly determined by the land use and the predominant type of area (urban vs. rural) in which the waste is produced, population density, type of housing (single or multi-family), the number of tourists, public facilities, as well as the type, size and number of commercial enterprises, small industries or services. For instance, the differences

between particular types of areas are especially noticeable in Poland when considering the "paper and cardboard" fraction – there is a gradual decline in the share of this fraction along the "big cities – small towns – rural areas" axis. By contrast, when considering "kitchen and garden waste", a continuous increase may be observed along the "big cities – small towns – rural areas" axis and for the "finest fraction – below 10 mm" the share increases in rural areas when compared to the amount observed in cities.

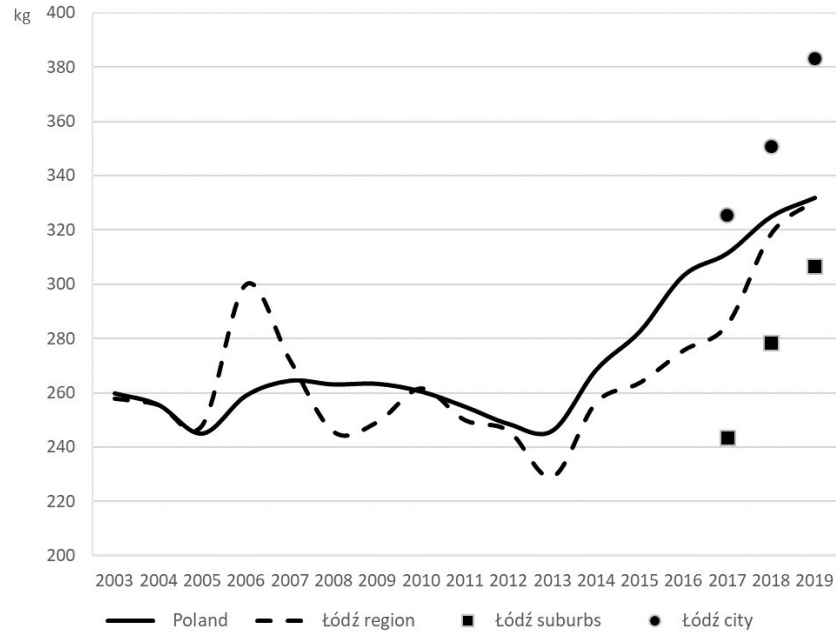

Fig. 1. Weight of municipal waste generated *per capita* in Poland, the Łódzkie region, Łódź suburban area and the city of Łódź in 2003–2019

Source: own work based on data from Statistics Poland.

The waste management system divides the Polish territory into 123 waste management regions within which modern facilities were to be established, i.e. Regional Municipal Waste Treatment Plants (RIPOK), whose construction has been assumed to produce an effective waste management system. Regional Municipal Waste Treatment Plants, in accordance with the principle of regionalisation, are responsible for accepting specific groups of waste from the region in which the waste is generated. In order to ensure a constant inflow of waste and following one of the basic principles of waste management, the so-called "Proximity principle" has been adopted highlighting the need to treat and/or dispose of waste in reasonable *proximity* to its point of generation. This means that waste is processed in the place where it is produced and,

if this is impossible, it is transferred to the nearest place where it can be processed, bearing in mind, however, that it is forbidden to transport it outside the region of origin. The Łódzkie Voivodeship is divided into four waste management regions.

After the introduction of the new Waste Management Act in 2013, a number of indicators of the society's approach towards waste have improved, and changes concerning the treatment of the waste collected have produced improvements (Fig. 2).

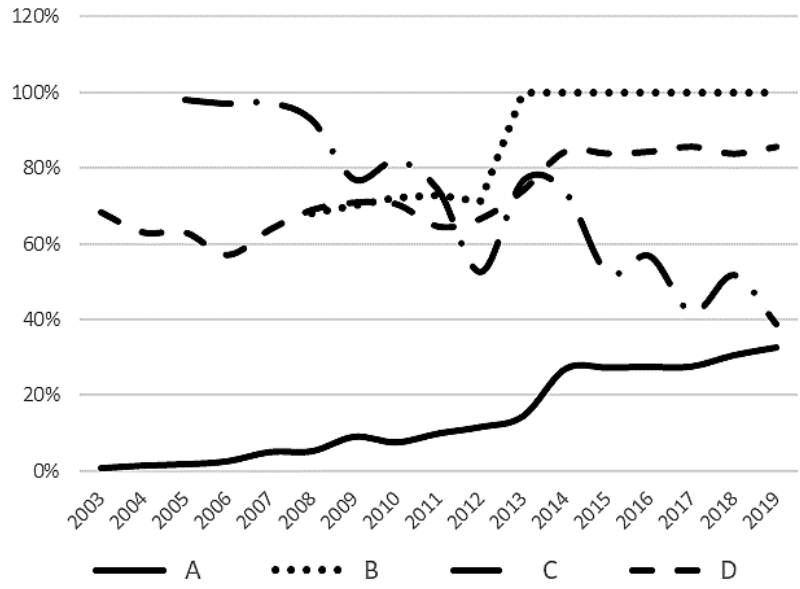

Fig. 2. Change in the values of selected indicators of waste management in the Łódzkie Voivodeship
A – Selectively collected waste in relation to the total waste
B – Percentage of population covered by municipal waste collection
C – Waste deposited in landfill compared to the total amount of mixed waste collected
D – Share of household waste in the total municipal waste

Source: own work based on data derived from Statistics Poland.

First of all, the change involving the taking over of responsibility for waste collection by local authorities has resulted in all residents being covered by compulsory municipal waste collection, although in 2012 the indicator for the entire Łódzkie Voivodeship was 75%. Concurrently, the number of illegal waste tips, i.e. places not intended for landfill, has decreased significantly (from 234 in 2008 to 136 in 2016) as has their area (130,000 sq. m in 2008 to 53,000 sq. m in 2016). At the same time, educational campaigns and financial incentives have led to a considerable increase in the share of collective selection of waste "at the source", i.e. in

households, from a few percent a decade ago to over 27% today. With the introduction of obligatory collection of household waste, its share in the total mass has increased from around 60% in the pre-implementation period (prior to 2013) to 85% today. Moreover, the methods for further collection of waste and processing of the municipal waste brought in have also changed significantly. As recently as 2007, almost all mixed municipal waste collected was deposited in landfills, whereas today this share has decreased to 40%. Yet it should be emphasised that the share of all municipal waste (not only mixed waste) utilised in landfills is distinctly higher in the Łódź region than the Polish average.

Municipal waste continues to be the key challenge in the field of waste management both in Poland, the Łódzkie region and in its conurbation – this has been indicated not only by various strategic documents, research or field studies, but also by participants in the PULL workshops conducted under the REPAiR project. Therefore, for the purpose of this analysis, Municipal Solid Waste will act as the basic type of waste examined.

3. DATA AND METHODS

In order to determine the material scope, i.e. the range of materials that will be subjected to the study, (waste) material(s) and their relevant possible applications have to be selected and defined. This selection is based on the interests of stakeholders, which in turn originate from local challenges and "personal" values, and are also required to ensure that there are traceable and justifiable reasons for the selection of the waste materials.

The table below summarises the structure of the waste collected in 2016 in the communes of the Łódź Metropolitan Area (ŁOM). An analysis of the data presented unambiguously proves that mixed municipal waste is the dominant category – up to 71.8% of the whole in weight terms. Packaging and biodegradable waste comprise a marginal share in this regard.

Considering data availability and the overall objectives of the REPAiR project, we decided to conduct a material flow analysis of biodegradable municipal waste in the Vegetable, Fruit and Garden (VFG waste) fraction. The study topic selected may serve as a good example in light of the need to solve issues resulting from the need to reduce the vast amount of waste collected in a non-selective manner. Biodegradable waste is entirely in line with the ideas of circular economy. Moreover, it is a crucial requirement that the mass of accumulated waste from households falling in this category (VFG waste) is sufficient to allow a statistical analysis of flows. As indicated above, one of the most important challenges which waste management in the Łódź Metropolitan Area (and Poland as a whole) faces is to offer more accurate information on the morphological composition of the generated waste.

Table 1. Structure of municipal solid waste collected in the Łódź Metropolitan area in 2016 per fractions

Waste subgroup		**Waste fraction**	
Packaging waste	11.2%	*of which:*	
150107 Glass packaging		150106 Mixed packaging waste	8.4%
		1.5%	
Municipal wastes including selectively collected fractions	88.1%	*of which:*	
		200301 Unsorted (mixed) municipal waste	71.8%
		2001xx Non-biodegradable municipal waste segregated and collected selectively	4.6%
		200201 Biodegradable waste (green waste from gardens and parks)	4.3%
		200108 Biodegradable kitchen waste	3.4%
		200307 Large-sized waste	2.4%
Waste from construction, renovation and dismantling of construction works and road infrastructure (including soil from contaminated areas)	0.7%		

Source: own work based on municipal reports.

Table 2. Details of the waste flow investigated.

Waste group	Municipal Solid Waste
Waste category	Biodegradable municipal waste within Vegetable, Fruit and Garden (VFG waste)
Waste fraction by category	200108 – Biodegradable kitchen waste 200201 – Biodegradable waste (waste from gardens and parks) 200302 – Waste from marketplaces
Actors/generators of waste involved	Households, local government, waste management companies
Steps involved in the supply chain	Production, wholesale, retail, consumption, waste treatment

Source: own work based on municipal reports.

As has previously been emphasised, the new regulations that came into force in 2013 have restructured all existing waste management practices. According to the Act, municipal waste ought to be collected selectively, and communal authorities (local government authorities) are responsible for compliance with the

principles adopted in the Act. Local authorities are therefore in charge of managing the processes related to local waste management; they also take the most important decisions regarding the forms and methods of their implementation. A system of containers for three categories of waste has been widely introduced: mixed waste, glass, and plastic/paper. However, depending on the commune, the number of segregated waste categories varies, ranging from three to six. Local authorities have established the categories into which waste is segregated.

Therefore, for the purpose of the analysis, the basic reference unit of area was the municipality (commune). We decided that all (28) such units within the Łódź Metropolitan Area should be considered – thus the entire region was examined. The analysis was made for the year 2016.

Every six months enterprises receiving municipal waste from property owners submit a report to the head of the commune, mayor or town president concerning the treatment of municipal waste they collect. By contrast, bodies responsible for operating points for selective collection of municipal waste submit annual reports on the treatment of the collected municipal waste to the head of the municipality, the mayor or the president of the city. The mayor or president is obliged to submit an annual report on the implementation of their tasks in the field of municipal waste management to the marshal of the voivodeship and the voivodeship inspector for environmental protection. Subsequently, the marshal of the voivodeship reports the fact of the completion of the assigned tasks to the government minister for the environment. On the basis of the reports submitted by the bodies receiving municipal waste from property owners, those who operate selective municipal waste collection points, and based on the annual report on implementation prepared by municipal waste management undertakings, the head of the commune, mayor or city president draw up analyses of the municipal waste management situation. This document is compiled annually to verify the technical and organisational capabilities of a commune in the field of municipal waste management. It is open for public examination.

4. WASTE PRODUCTION

Municipal waste is a crucial part of waste management. According to the Waste Act of 12 December 2012 municipal waste is "waste generated in households, excluding end-of-life vehicles, as well as wastes not containing hazardous waste originating from other waste generators, which due to their nature or composition are similar to waste generated in households". Municipal waste features numerous unfavourable characteristics that cause obstacles in its management. These include temporal variability in the quantity and quality of waste, heterogeneity of the morphological and chemical composition, possible sanitary and epidemiolog-

ical threats, the problem of the odour, the occurrence of dangerous substances in certain fractions (e.g. heavy metals), as well as the presence of hazardous waste (e.g. expired medicines, used batteries, chemicals).

In 2016, a total of 337,300 tonnes of municipal waste were collected from the Łódź Metropolitan Area. The largest amount of waste was collected from the Łódź commune (224,200 tonnes). This accounted for about 66.5% of the total mass of waste collected from the entire Łódź Metropolitan Area. The mass of municipal waste produced by individual communes depends, of course, on the number of inhabitants and population density.

The mass of municipal waste collected per inhabitant in the Łódź agglomeration varied throughout the communes (Fig. 3). The average weight of municipal waste collected per inhabitant in 2016 was 290 kg. The largest amount of municipal waste per capita was collected in the commune of Ksawerów (425 kg/person), Konstantynów Łódzki (422 kg/person) and Andrespol (401 kg/person). The communes of Łódź, Rzgów, Nowosolna, and Brzeziny (330–370 kg/person) also featured relatively large quantities of municipal waste collected per capita by weight. In other communes of the Łódź Metropolitan Area, the weight of municipal waste was significantly lower – below 260 kg/person.

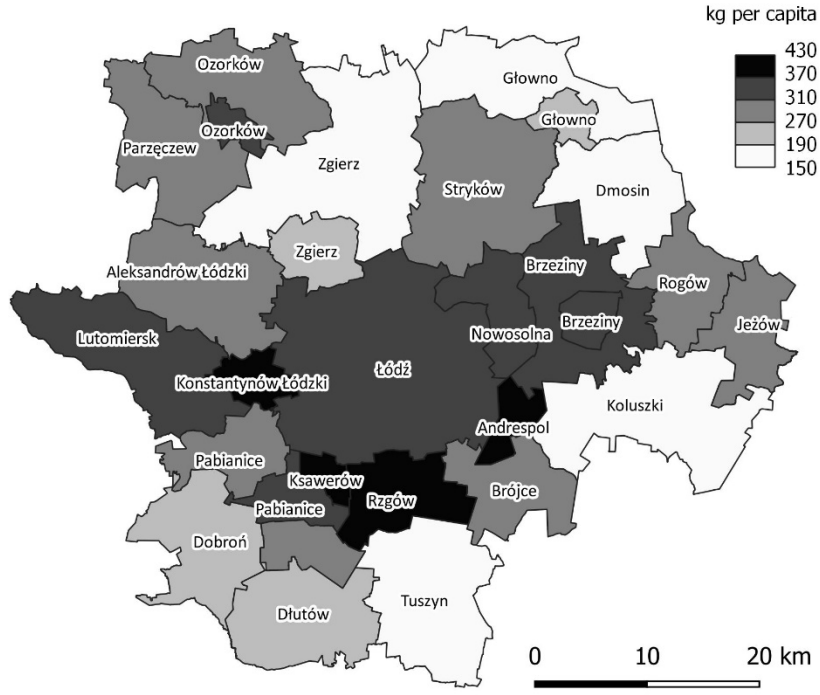

Fig. 3. Weight in tonnes of municipal waste collected per capita in communes of the ŁOM in 2016
Source: own work based on data from communal reports for 2016.

Non-biodegradable waste is waste that is not decomposed by microorganisms. In 2016, a total of 306,300 tonnes of such waste were collected in the Łódź Metropolitan area. Non-biodegradable waste accounted for approximately 90.8% of the total waste generated that was collected in the conurbation. The largest amount of non-biodegradable municipal waste was collected from the Łódź commune (204,200 tonnes) comprising 66.6% of the total non-biodegradable waste collected from the agglomeration. A considerable weight of non-biodegradable municipal waste was also collected from the urban communes of Pabianice (20,400 tonnes), and Zgierz (13,300 tonnes).

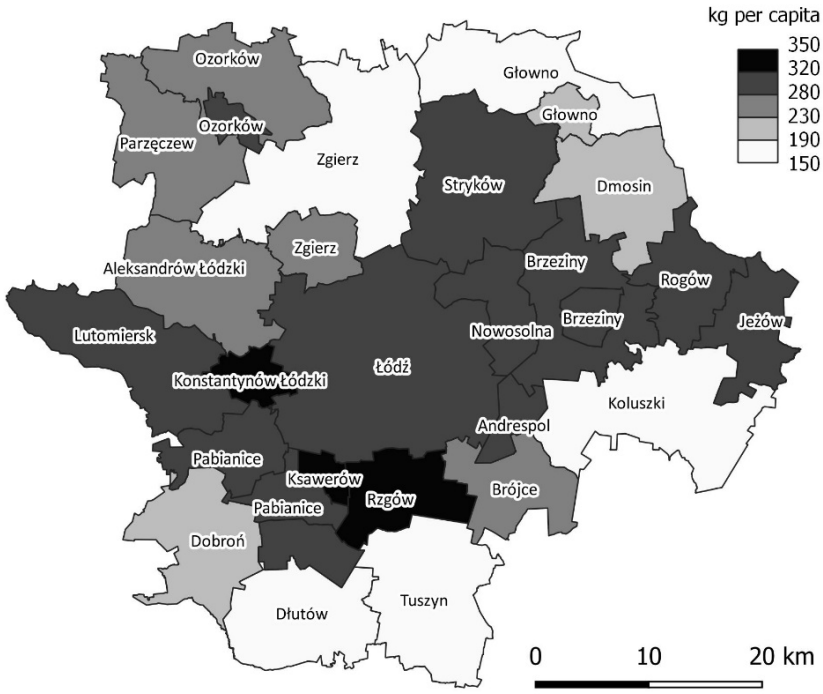

Fig. 4. Mass of non-biodegradable municipal waste per capita in the communes of the ŁOM in 2016
Source: own work based on data from communal reports for 2016.

The average weight of non-biodegradable municipal waste per capita was 260 kg. The largest amount of municipal non-biodegradable waste generated per inhabitant was collected from the urban communes of Konstantynów Łódzki (353 kg/person), Rzgów (332 kg/person), and Ksawerów (320 kg/person). The mass of non-biodegradable municipal waste collected from the communes of Lutomiersk, Pabianice, Stryków, Brzeziny, Łódź, Rogów, Andrespol, Brójce, Jeżów, Nowosolna, and Ozorków ranged from 280 to 310 kg/person. In other

communes in the metropolitan area, the average weight of non-biodegradable municipal waste per capita was in 2016 below 270 kg. The values for each commune are presented on Fig. 4. The largest quantity of non-biodegradable municipal waste collected comprised non-segregated municipal waste (waste code 200301), of which 242,3500 tonnes were collected in the Łódź Metropolitan area in 2016.

Biodegradable waste is a type of waste that undergoes aerobic or anaerobic decomposition, with the use of microorganisms. Biodegradable municipal waste includes:

- paper and cardboard (including packaging waste),
- clothing made of natural fibres,
- textiles made of natural fibres (including packaging waste),
- edible oils and fats,
- wood not containing hazardous substances (including packaging waste),
- biodegradable waste (including biodegradable kitchen waste),
- waste generated in marketplaces.

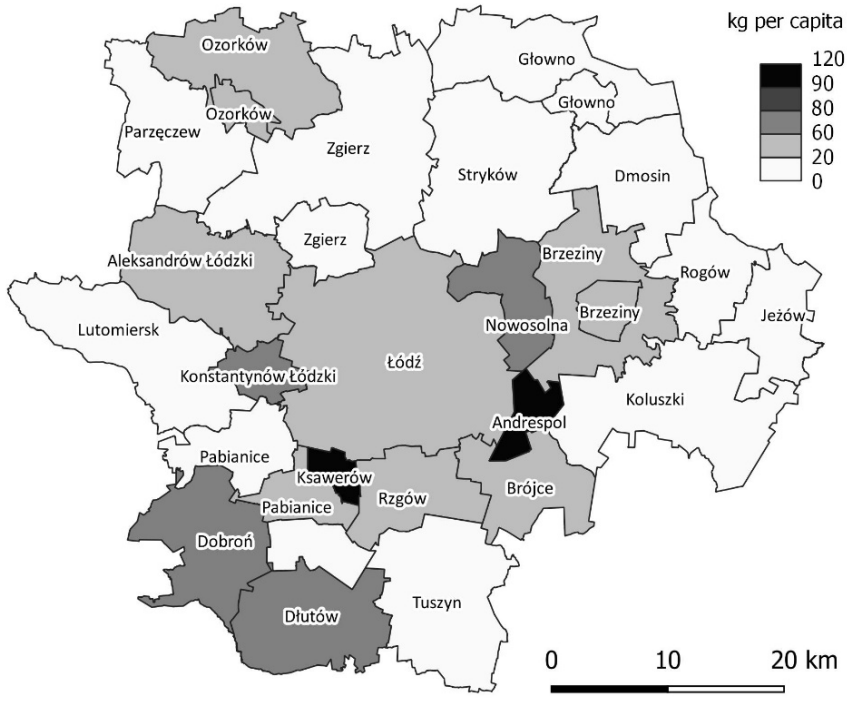

Fig. 5. Mass of biodegradable municipal waste per capita in the communes of the ŁOM in 2016
Source: own work based on data from communal reports for 2016.

In 2016, as many as 30,980 tonnes of biodegradable waste were collected from the Łódź Metropolitan Area. This accounted for 9.2% in weight terms of all municipal waste collected in the area. The largest quantity of biodegradable municipal waste was collected from the Łódź commune (20 tonnes). Approximately 2,100 tonnes were collected in the urban commune of Pabianice, 1,500 tonnes in Andrespol, and 1,200 tonnes in the Konstantynów Łódzki commune. The remaining communes collected less than 900 tonnes of biodegradable waste. The average weight of municipal biodegradable waste collected per capita in 2016 was 30 kg. The largest amount of municipal biodegradable waste per inhabitant was collected in the communes of Andrespol (112 kg/person), and Ksawerów (109 kg/person). The communes of Nowosolna (78 kg/person), Konstantynów Łódzki (69 kg/person), Dłutów (63 kg/person), and Dobroń (62 kg/person) also had relatively high masses of biodegradable waste per capita. In other communes in the Łódź Metropolitan Area, the mass of biodegradable municipal waste was below 42 kg per inhabitant. The spatial differentiation of these amounts are presented on Fig. 5.

5. WASTE FLOW

The generated municipal waste is collected from those who produce it by collecting companies appointed by the municipal authorities following a tendering process. Depending on the manner in which the waste is collected, a distinction is made between mixed municipal waste and selectively collected waste. The waste received is then directed to installations for municipal waste treatment where it undergoes recovery or disposal processes. In municipal waste treatment plants, the material undergoes a thermal or mechanical-biological transformation. Mixed municipal waste, which comprises the largest percentage of municipal waste received, is mainly channelled to an installation for mechanical and biological treatment of municipal waste. At that stage, the first process to which waste is subjected is separation of the waste material fractions (glass, paper, plastic, and metal), which are then sent to the sorting plant for separately collected waste (for cleaning purposes). The mechanical processing of mixed municipal waste consists of isolating specific fractions that can be used as a material or source of energy, as well as a fraction requiring additional biological processing. Fractions intended for further use include, i.a. paper, cardboard, ferrous metals, non-ferrous metals, plastic, and rubber. The mechanical treatment of mixed municipal waste involves the processing of waste for the purpose of preparing it for recovery, including the recycling or treatment of waste, after which stage there remains waste intended for disposal. Selectively collected waste (paper, glass, metals, plastics), as well as mixed municipal waste, is also directed to the mechanical and biological treatment

plant, where it passes through a cleaning process on waste segregation lines and is then recycled. Green and other biodegradable waste that is selectively collected is transferred to a composting plant. Hazardous waste selectively collected from property owners or collected at points for selective collection of municipal waste is transferred to installations where appropriate recovery and recycling processes are applied, adapted to the given type of waste.

In 2016, municipal waste from the Łódź Metropolitan area was collected by 82 plants located in 13 voivodeships in Poland. About 99% of the weight of municipal waste produced in the Łódź Metropolitan Area was collected by plants operating in the field of waste collection in the Łódzkie Voivodeship. The remaining 1% of the total weight of municipal waste produced in the agglomeration was collected by installations located outside of the voivodeship. The results of municipal waste flow analysis are presented on Fig. 6.

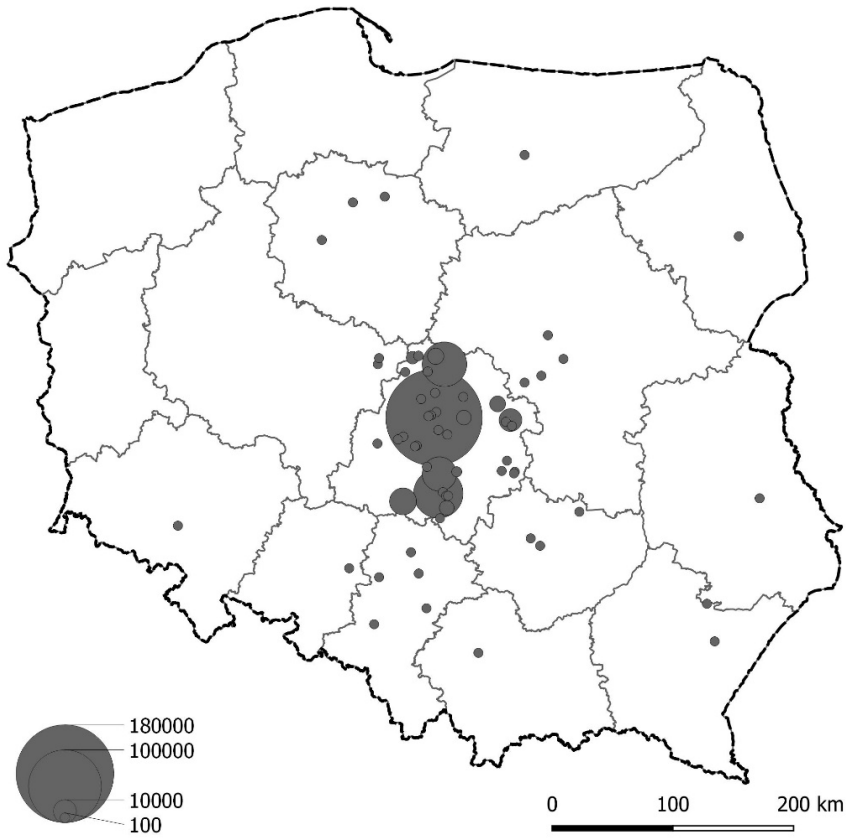

Fig. 6. Total weight of municipal waste collected from the ŁOM by individual installations in 2016
Source: own work based on data from communal reports for 2016.

Approximately 53% of municipal waste collected in the Łódź Metropolitan Area were collected by enterprises operating within the area. The largest quantity of municipal waste was collected by installations operating in the Łódź area, accounting for 51.5% of the total quantity of municipal waste collected from the metropolitan area. As much as 13.7% of the municipal waste from the Łódź Metropolitan Area was collected by enterprises based in Kamieńsk (Radomsko poviat, Łódzkie Voivodeship), 8.4% by an enterprise in Krzyżanówek (Kutno poviat, Łódzkie Voivodeship), 7.5% by an enterprise in Bełchatów (Bełchatów poviat, Łódzkie Voivodeship), 4.2% by an enterprise in Kutno (Kutno poviat, Łódzkie Voivodeship), 3.5% by an enterprise in Dylów (Pajęczno poviat, Łódzkie Voivodeship), 2.9% by an enterprise in Pukinin (Rawa poviat, Łódzkie Voivodeship), and 1.4% by an enterprise in Franki (Kutno poviat, Łódzkie Voivodeship). In total, approx. 6.9% of municipal waste from the Łódź Metropolitan Area was gathered by other enterprises.

In 2016, the municipal waste collected in the Łódź Metropolitan Area was treated by 80 plants located in 13 voivodeships. Approximately 99% of municipal waste was managed by plants operating in the Łódzkie Voivodeship, while the remaining 1% was managed by external installations. The management of such a large proportion of municipal waste collected in the Łódź Metropolitan Area by installations operating within the voivodeship has resulted from the provisions of the Waste Act of 14 December 2012. Pursuant to this legislation, waste is first processed at the place where it is generated. In situations where waste cannot be processed there, it is transferred to the nearest place where it can be processed. In 2016, more than half of the municipal waste by weight (53.3%) was received by installations operating within the area of the Łódź Metropolitan Area.

In 2016, non-biodegradable municipal waste was received by 70 plants. About 99% of the non-biodegradable municipal waste by weight were managed by plants operating in the Łódzkie Voivodeship. The amounts of non-biodegradable waste collected by plants from Łódź Metropolitan Area are presented on Fig. 7. The majority of this type of waste (54.8%) was feedstock for installations operating in the area of the Łódź Metropolitan Area. The largest quantity of non-biodegradable municipal waste was processed by installations operating in Łódź, which in 2016 managed to process 53.1% of this type of waste collected within the metropolitan area. Non-biodegradable waste is mainly treated by the R12 system, i.e. dismantling, sorting, crushing, compacting, granulation, drying, crushing, conditioning, repacking, separation, blending or mixing before submission to any of the processes listed in item R1-R11. Other processes are seldom used.

In 2016, biodegradable municipal waste was managed by 31 installations. About 99% of the biodegradable municipal waste were utilised by plants operating in the Łódzkie Voivodeship. About 38.3% of this type of waste were managed by installations operating in the Łódź Metropolitan Area. Biodegradable waste is

mainly treated by the R3 system, i.e. recycling of waste paper and board; reprocessing and recycling of plastic waste; composting of bio waste and green waste; and fermentation of biodegradable waste for biogas production (biogas plants). The amounts of treated biodegradable waste and ways of waste management are presented of figure below (Fig. 8).

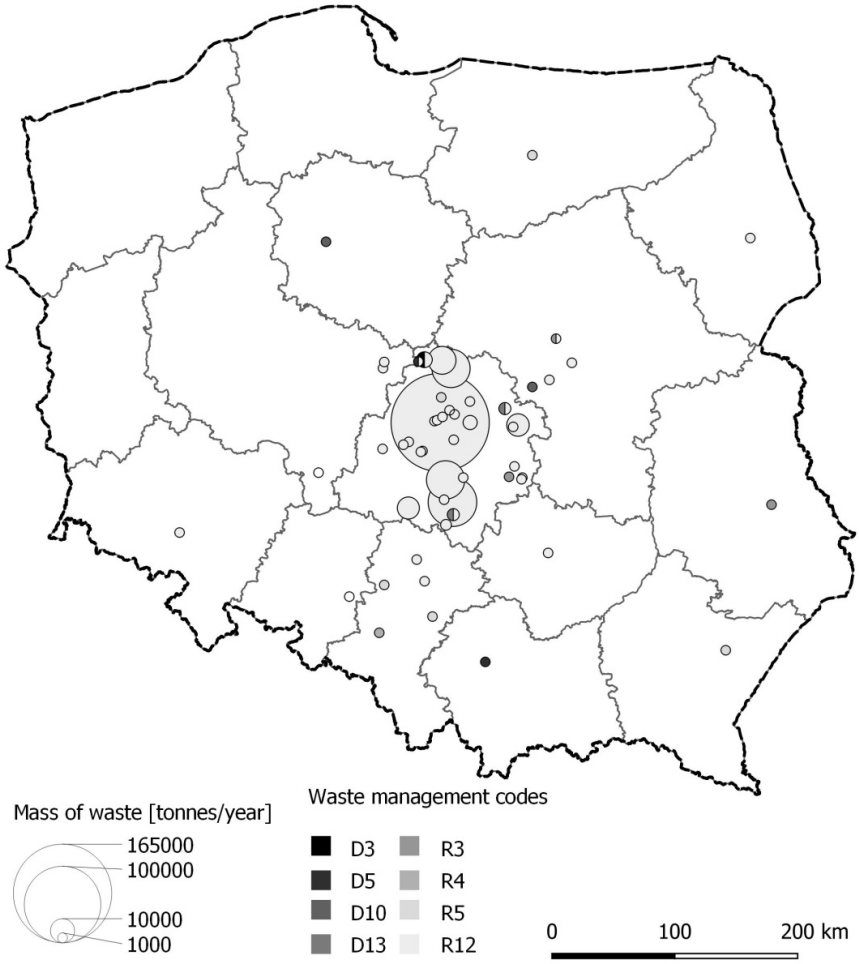

Fig. 7. Weight of non-biodegradable municipal waste collected from the Łódź Metropolitan Area treated by individual installations per the form of treatment

D3 – Deep injection, D5 – Engineered landfill, D10 – Incineration on land, D13 – Blending or mixing prior to submission to any of the operations numbered D1 to D12, R3 – Recycling/reclamation of organic substances, R4 – Recycling/reclamation of metals, R5 – Recycling/reclamation of inorganic substances, R12 – Exchange of waste for submission to any of the operations numbered R1 to R11

Source: own work based on data from communal reports for 2016.

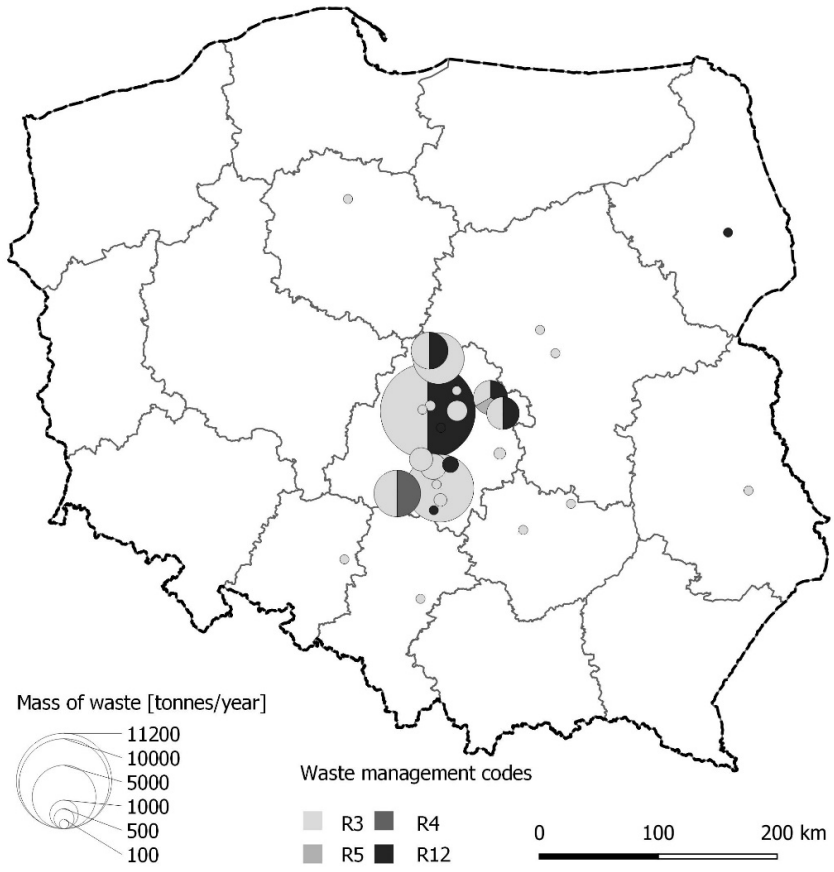

Fig. 8. Weight of biodegradable municipal waste collected from the Łódź Metropolitan Area treated by individual installations per the form of treatment

R3 – Recycling/reclamation of organic substances, R4 – Recycling/reclamation of metals, R5 – Recycling/reclamation of inorganic substances, R12 – Exchange of waste for submission to any of the operations numbered R1 to R11

Source: own work based on data from communal reports for 2016.

A detailed flow diagram of biodegradable waste in the communes of the Łódź Metropolitan Area is presented below. The following three categories of waste have been considered in the flow analysis of the Vegetable, Fruit and Garden (VFG) waste: 200108 (biodegradable kitchen and canteen waste; separately collected fractions as part of municipal solid waste), 200201 (biodegradable waste from garden and park wastes, including cemeteries), and 200302 (biowaste from markets). As over 70% of the waste collected in the Łódź Metropolitan Area in 2016 was classified as part of the mixed waste category, it was

decided to estimate this value based on national data and information obtained from communal reports on the implementation of tasks related to municipal waste management and concerning the weight of biodegradable waste collected from the municipal waste stream within the area of the commune in the accounting year, and transported to storage. As a result of these calculations, the total mass of VFG waste was estimated to be 76,570 tonnes, which comprises 22% of all municipal waste. It is worth indicating that in the above-mentioned study of Poland, the share of this type of waste varied from 20% to 37% depending on the type of municipality and the period examined, therefore the estimated value for the Łódź Metropolitan Area seems to be correct. The map below (Fig. 9) illustrates the VFG waste flows between communes in the Metropolitan Area and the treatment points – a very distinct geographical regionalisation is visible in terms of spatial proximity.

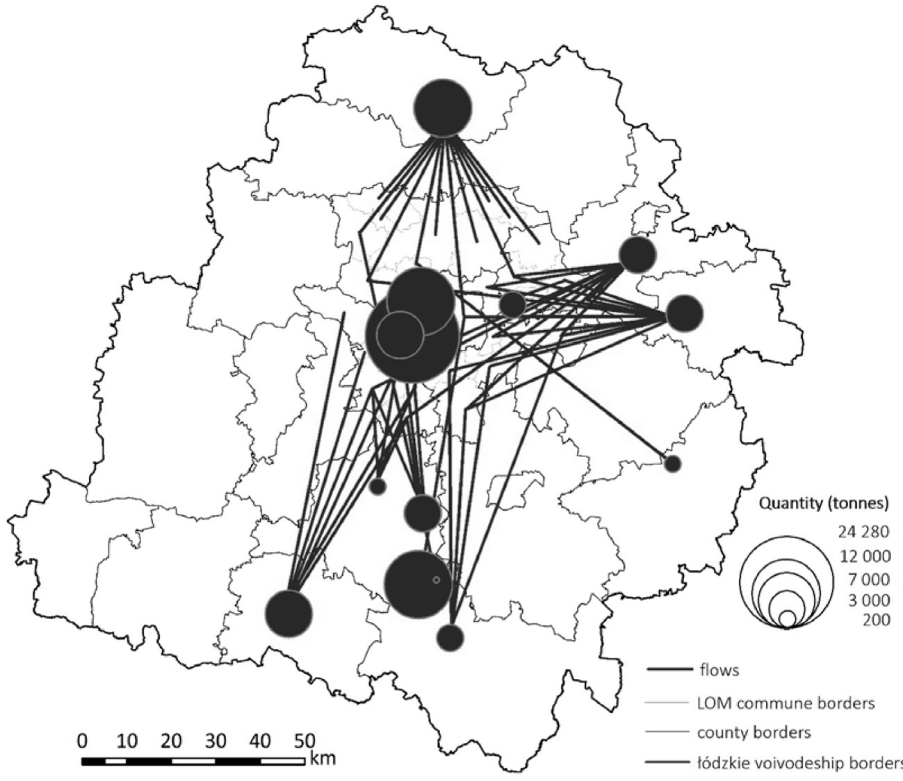

Fig. 9. VFG flows from communes in the Łódź Metropolitan Area in 2016
Source: own work based on data from communal reports for 2016.

6. CLOSING REMARKS

It is very difficult to determine the accuracy of the assessment of the current waste management system due to the relatively short period of applicability of the new rules which, from 2013 onwards, have transferred responsibility for this to local governments. The coming years will be decisive for the stabilisation of the waste collection and treatment system. A big responsibility lies with the legislative and executive authorities at the highest, state level that should, in a short time, verify the instruments used to achieve the effects of using waste for the production of new goods. An important role in this respect should apply to local government associations, which articulate the need for change and modernisation of the approach to waste management, including the creation of new legal regulations. However, achieving the success of the rules of circular economy will depend to a great extent on the strengthening of the ecological awareness of urban and rural residents who need to understand both social needs (collective responsibility) as well as individual needs based on the economic benefit of reusing waste in the production of new goods.

The amount of municipal waste generated should be determined following the changes in EU and national policies implemented through increasing pressure to prevent and limit waste generation, develop and promote "circular economy", as well as to raise environmental awareness in the society.

One should strive to reduce the amount of waste generated, increase public awareness of how to efficiently manage it, including food waste and other kinds of biodegradable waste. It is crucial to channel the functioning of waste management systems towards the hierarchy of waste handling methods and, above all, to diminish the share of mixed municipal waste in the entire waste collection stream. In addition, it is advisable to discontinue the storage of selectively biodegradable waste, cease the storing of mixed municipal waste without treatment, reduce the number of illegal municipal waste storage sites, and establish a monitoring system for municipal waste management. The last issue is of particular concern. It should be indicated that there are currently insufficient activities conducted by communal authorities associated with the monitoring of enterprises in the field of collection and management of waste from the area of a commune. Today's legal conditions preclude proper cooperation between the private and public sectors in the field of waste management systems.

Furthermore, the future of waste management also ought to be considered. It will be necessary to verify the existing and planned capacity of plants conducting the processes of mechanical waste treatment. The hierarchy for waste management methods and the objectives to be achieved by 2030 impose the need to significantly reduce the amount of waste deposited and to constrain storage to previously treated waste sites.

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CITIZEN INVOLVEMENT IN WASTE MANAGEMENT AND CIRCULAR ECONOMY IN CITIES: KEY ELEMENTS FOR PLANNING AND IMPLEMENTATION

Abstract. This paper identifies and explores key elements for planning and implementing citizen involvement in the area of waste management and circular economy in cities. The analysis has shown that institutions responsible for waste management regard strategic planning, inclusivity, transparency, continuity, and resources as particularly important for reaching the objectives of citizen involvement. However, not all of the four analysed cities have applied these elements to the same extent, due to e.g. a lack of a strategy for citizen involvement, or limited personal and financial resources.
Key words: circular economy, circular city, waste management, citizen involvement, collaborative governance.

1. INTRODUCTION

Citizens can be seen as major actors within the waste management of cities and related circular economy (Bernstad, 2014; Evison and Read, 2001; Sharp *et.al*, 2010). As promoted by the European Commission, circular economy aims at maintaining the value of products and materials for as long as possible (European Commission, 2020). Thereby, it is crucial to recycle materials from waste, in order 'to close the loop' (ibid.). The connection between citizens, waste management and circular economy lies in their roles as consumers and waste producers. Individual awareness while performing these two roles can lead to more responsible consumption and compliance with waste separation and collection schemes resulting in increased reuse and recycling.

Public and private institutions responsible for waste management at the city level involve citizens through activities ranging from information, communi-

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cation and consultation to participation (Smith, 1993; Rowe and Frewer, 2005) with the aim to promote pro-environmental behaviour and compliance with waste management schemes. However, behaviour patterns take time and effort to adjust (Csobod *et al*., 2009). There are various strategies to stimulate environmentally significant consumer behaviour, such as using information and education to change attitudes and beliefs, appealing to basic values, offering financial or other material incentives, or modifying institutional structures (Stern, 1999).

It is advantageous for institutions responsible for waste management to know how to plan and implement citizen involvement, in order to reach their objectives. Yet this knowledge is broadly dispersed among different thematic fields, like environmental communication, urban planning participation, education and behavioural change, etc.

2. COLLABORATIVE GOVERNANCE AND CITIZEN INVOLVEMENT

The paper draws on the research project FORCE (Cities Cooperating for Circular Economy), which is based on the concept of collaborative governance, where different public and non-public actors (including city authorities, private companies, waste management authorities, associations, and citizens) jointly develop and implement eco-innovative solutions for promoting circular economy in their cities.

Ansell and Gash defined collaborative governance as a "governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative, and which aims to make or implement public policy or manage public programs or assets" (Ansell and Gash, 2008, p. 544). This definition implies the identification of synergies and the development of consensus among public and non-public stakeholders of a process to amplify its effectiveness. Emerson, Nabatchi and Balogh have expand this definition as they described collaborative governance "as the processes and structures of public policy decision-making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres, in order to carry out a public purpose that could not otherwise be accomplished" (Emerson *et al.*, 2012, p. 2). The authors went beyond state-initiated actions and broadened the range of possible partnerships. Although these definitions differ slightly, they share the understanding that non-public stakeholders are not limited to private groups and institutions, but also include the civil society, whether in organised groups or as individuals.

Although the perspectives above include the civil society in the collaborative governance concept, they specify neither the method nor motivation for citizen

contribution. Regarding motivation, citizen participation was described by Cornwall as an essential ingredient to ensure efficient development of interventions and policies (Cornwall, 2006). As those are meant to regulate and serve civil society, the inclusion of peoples' perceptions in its design and implementation can be seen as an asset to produce efficient regulations. Still, according to Glass, the failure of many participatory programmes derives from the lack of structures and clearly defined objectives and inadequate mechanisms for participation to attend to such objectives (Glass, 1979). According to the collaborative governance regime framework of Emerson and Nabatchi, the structures and resources necessary to support engagement, including facilitation, leadership, and information, are an important element of collaborative governance (Emerson and Nabatchi, 2015). They also indicated 'shared motivation' (affective stance of individual participants to one another and to the process) as another relevant component.

Thus, collaborative governance explains the significance of involving citizens for achieving (in an effective manner) the objectives of waste management and circular economy in cities. The concept also suggests that authorities in charge of waste management have a higher chance of reaching their objectives if they share their motivations, if they have clearly defined objectives, well developed structures for citizen involvement, and resources available in order to reach the citizens and promote pro-environmental behaviour in the area of waste management and circular economy.

To examine these assumptions, this paper addresses the research question: what are the key elements for planning and implementing citizen involvement in the area of waste management and circular economy in cities? To support the investigation, the analysis is structured in three parts: (1) identifying and defining key elements for planning and implementing citizen involvement in the area of waste management and circular economy; (2) assessing how far those elements are regarded as important for reaching the objectives of citizen involvement by institutions responsible for waste management; and (3) determining if and how these key elements for citizen involvement are being applied in practice by the institutions responsible for waste management in the case of Copenhagen, Genoa, Hamburg, and Lisbon.

3. METHODOLOGY

The analysis within the FORCE research focused on four cities, i.e. Copenhagen, Genoa, Hamburg, and Lisbon, and aimed at evaluating the tools and instruments for citizen involvement applied in the project, as well as recommending good practices for civic involvement in municipal waste management and circular economy in European cities.

The analytical framework was derived from findings of studies in the area of citizen involvement, communication, evaluation, and waste management, which indicated key elements for planning and implementing citizen involvement. They were then adopted as criteria for evaluating each of the instruments and tools for citizen involvement applied in the four case cities. For each criterion, concise questions were formulated that had to be answered by experts that had an overview of the citizen involvement tools implemented in their cities. For answering a Likert Scale (Joshi *et al.*, 2015), a widely used approach for scaling responses from 1 (strongly disagree) to 5 (strongly agree), was applied that allowed us to measure the degrees of opinions and obtaining qualitative data for the analysis. The evaluation focused on the process rather than the outcomes of citizen involvement, as they could not be measured during the project's duration, and the mix of different measures made it difficult to evaluate the impacts of each individual tool and instrument.

Collaborative governance states that citizens should be engaged and not merely 'consulted', yet the scope of this study was extended to include more types of citizen involvement instruments and tools, so all activities of the four cities were included in the evaluation to explore to what extent waste management authorities actively engaged citizens in their activities. Thereby, for each citizen involvement instrument and tool its main aim was specified with regard to the categories: inform, consult, involve, collaborate, or empower. This spectrum of public participation was taken over from the International Association for Public Participation (similar to the "Ladder of Citizen Participation" outlined by Arnstein (1969), according to which the participation goals and their impact on decision-making could be allocated within these five categories (with the first having the lowest and the last step having the highest impact on decision-making). Although the spectrum focused on decision-making, as most of literature presented to this point, Butteriss has indicated that the meaning of 'citizen participation' may vary and its scope of action may also refer to other aims, such as capacity building and relationship development (Butteriss, 2016).

The evaluation was based on a subjective assessment. By answering the questions, the cities could evaluate how their citizen involvement tools performed in each of the five evaluation criteria and establish in what areas their activities could be improved in the future. At the same time, through the application of the evaluation framework, the cities tested the importance of the five criteria for planning and implementing citizen involvement in waste management and circular economy in cities. Moreover, we obtained an overview of all implemented citizen involvement tools and instruments and their main aims (inform, consult, involve, collaborate, empower).

Additionally, we conducted ten qualitative semi-structured interviews with key organisations in charge of waste management in the four case cities and with communication experts from their organisations, in order to collect further information on the importance of the selected evaluation criteria and critically assess

those. We also determined if and how these key elements for citizen involvement were being applied in practice by the institutions responsible for waste management and circular economy. The semi-structured interviews gave the interviewees an opportunity to fully express their views and highlight the aspects of citizen involvement they ranked as most relevant.

4. EMPIRICAL BASIS: COPENHAGEN, GENOA, HAMBURG, AND LISBON CASE-STUDIES

The division of competences regarding waste management among public and private actors differs among the four cities. In some cases the municipality has a stronger role in organising and implementing waste management, in others, public (or public-private) companies assume responsibility.

Waste management competences in the City of Copenhagen are characterised by the presence of public and private actors who share different responsibilities. Being the main actor in implementing the national waste management plans and targets, the municipality is in charge of treating all waste, and enterprises are responsible for recycling their recyclable waste (Copenhagen Cleantech Cluster, 2012).

The City of Genoa is responsible for organising the collection, transport, and management of undifferentiated waste and its disposal in landfills. At the operational level, the municipal company AMIU Genova SpA covers all services related to the management of the waste cycle: from separation, waste collection and waste treatment, up to management of disposal plants and pre-treatment plants for recyclable fractions, as well as other related activities (e.g. street cleaning) (Azienda Multiservizi e D'Igiene Urbana, 2018).

In the City of Hamburg, the responsibility for waste management is shared between the Ministry of Environment and Energy, responsible for all ministerial and administrative duties concerning waste management, and the local city-owned public waste management company Stadtreinigung Hamburg, which is responsible for the disposal of waste from households (Ministry of Environment and Energy, 2017). The framework is complemented by various schemes of extended producer responsibility.

In the City of Lisbon, the municipal waste management plan is developed by the municipality in close collaboration with a public-private company Valorsul S.A., which is responsible for turning the national legislation into an action plan for the region of Lisbon. Regarding the operational tasks, municipalities are in charge of collecting waste from households and small waste producers, while producers that exceed this amount are responsible for managing their own waste (European Environmental Agency, 2016).

5. RESULTS

A cross-analysis of the results from the four cities has shown that citizen involvement played a more or less important role, depending on the cities' objectives that they wanted to reach within the FORCE project. For example, one of the main objectives of the City of Genoa was to implement an urban laboratory for integrated wood management, which does not necessary require citizen involvement. On the other extreme there was the City of Copenhagen which aimed to establish three different collection schemes for household flexible plastic for which successful citizen involvement was crucial. Furthermore, although the cities implemented several different citizen involvement tools and instruments, most of them focused on informing citizens, and only to a small extend, through consultation or active involvement in joint development of project solutions.

Regarding the content of citizen involvement, it could be observed that the tools and instruments predominantly focused on improving sorting and the collection of waste, but not necessarily preventing its generation. This might be related to the obligations set in national legislations. In Denmark, for example, a city cannot finance activities related to waste prevention via the waste charge paid by households; waste prevention is mainly a national government matter.

Moreover, five key elements for successful planning and implementation of citizen involvement in the area of waste management and circular economy have been identified, which constitute the focus of this article. These include strategic planning, inclusivity, transparency, continuity, and resources. This section will be structured according to the objectives of the article. First, by introducing and defining each element, also on basis of theoretical considerations, then by assessing importance to those according to the interviewee opinions, and finally by identifying whether and how these elements have been present in the planning and implementing of citizen involvement in the four case cities.

5.1. Strategic planning

Strategic planning is understood as having a clear outline of a citizen involvement process (including an assessment of its scope, procedures and expected outputs) ready prior to its implementation (Rowe and Frewer, 2000; The Waste and Resources Action Programme [WRAP], 2010; Chakraborty and Stratton, 1993). The fact of having developed a strategic plan establishes trust among stakeholders, and increases the effectiveness and credibility of the process (Rowe and Frewer, 2000). It also minimises the chance of misunderstanding and conflict (ibid.).

The interviewees have agreed that having a strategy ready prior to implementation is vital for reaching the project's objectives. It helps to define the scope, the overall aim of the participatory process, and the objectives for each stage (e.g.

planning, implementation, etc.). The involvement of professional communication experts right from the beginning can improve the strategies and outputs. Stakeholder mapping (from strategic to operational level) is regarded as relevant. When developing a strategy for citizen involvement, a timeline and budget should be prepared, and feasible tools and instruments for implementation should be selected. It was recommended to decide how to monitor and evaluate the impact of the citizen involvement and how to make feedback loops possible to optimise a strategy during the implementation process. A strategy should also consider potential implementation risks and solutions.

The analysis has shown that three of the four cities had a strategy for citizen involvement prior to implementation, but the level of detail varied strongly between them. Also, differentiation could be made between a strategy at an institution/company level and a specific implementation plan on a project level. The role of stakeholder mapping was highlighted in the context of waste management strategy development, as it lists all subjects, names, and groups with whom a relationship needs to be built. It can also provide information which stakeholder groups need to be targeted, which are already involved, how they can be involved in the most constructive ways, etc. Even though all four cities have agreed that stakeholder mapping is fundamental, only three out of four cities had conducted it prior to implementation of citizen involvement activities. The fourth city targeted its citizens as a whole, without differentiating between the various citizen groups.

Several best practices were mentioned in this context. For example, the City of Genoa has provided a small budget for projects conducted by citizen associations and defined criteria for a competition in line with the city's strategic goals (e.g. increasing awareness in the area of waste collection). Another example included collaboration with local associations, community managers or local parish councils as intermediaries for conveying a message from the institutions responsible for waste management to the citizens. The intermediaries know how to reach the citizens in the fastest and most efficient way and they have the advantage that citizens usually know and trust them, which is not always the case with public authorities.

5.2. Inclusivity

Inclusivity is defined as ensuring a variety of perspectives through the involvement of various affected citizen groups (Rowe and Frewer, 2000; Webler, 1995; Mee and Clewes, 2004; Petts, 2001). For achieving true inclusivity, all affected communities should be involved (Rowe and Frewer, 2000). The greater the range of different interests and concerns in a decision-making process, the greater the chances of achieving acceptance of environmental and social decisions (Petts, 2001). Moreover, citizen involvement offers new perspectives to solutions pro-

posed by waste management authorities, making them more suitable for addressing citizens' needs. It is crucial to choose the right means of communication for ensuring that information will reach a large group of citizens (Webler, 1995). Moreover, in order to help choosing the language and channels for an awareness campaign, identifying the target group beforehand can be advantageous, since strategies can change depending on geographic and demographic variables (ibid.).

The interviewees have confirmed that inclusivity of various citizen groups is vital for reaching the objectives of citizen involvement. Therefore, the use of a variety of involvement tools and communication channels enables one to address a wide range of inhabitants. Ethnic minorities can be reached by providing information in several foreign languages and by local facilitators. The community of disabled people has very particular needs and should be involved through their representative associations.

The analysis showed that all four cities considered various population groups in their citizen involvement activities including children/pupils, adults, the elderly, and other relevant stakeholders like companies and associations. A variety of different channels for reaching different groups was used, inter alia printed booklets, newsletters and a call centre for the elderly, social media and apps for teenagers/young adults, or environmental education and recycling plant visits for children. Still, all the cities focused mostly on informing citizens and to a small extend on consultation or active involvement in developing project solutions. Regarding the content of citizen involvement, it could be observed that the tools and instruments predominantly focused on improving sorting and collecting waste, but not necessarily on prevention. This, however, might have been a result of the obligations set in national legislations. In Denmark, for example, waste prevention is a national government matter and, therefore, municipalities cannot finance such activities via a waste charge paid by households.

Several best practices were mentioned. In the City of Genoa, when the collection system in a neighbourhood was changed, the waste management company organised information activities in schools. Pupils then transferred the information to their families. Printed material (potential waste) was replaced by direct contact (information meetings). To encourage participation of the elderly in public meetings, the attendees were given free tickets to a garden exhibition, what resulted in high participation rates.

5.3. Transparency

Transparency is understood as clearly disclosing information, rules, plans, processes, and actions (Tranparency International, 2019). It also implies the provision of relevant, complete and clear information in citizen involvement (Rowe and Frewer, 2000). The fact of having a transparent and comprehensive communica-

tion approach can increase trust between users and providers of the waste management system (UN Habitat, 2010). The users of a waste management service (citizens) are more likely to cooperate if they understand why services are set up in a particular way and why it is important to separate the materials as requested by a service provider or municipality (ibid.). Furthermore, transparency is crucial to ensure trust among stakeholders, as well as credibility and legitimacy of the process (Transparency International, 2019; Rowe and Frewer, 2000).

The interviewees have confirmed that having transparent communication is vital for reaching the citizen involvement's objectives. They stressed that communication needs to be clear and easy to understand (simple vocabulary, inclusion of pictures/illustrations, use of vibrant colours, etc.). It was highlighted that positive messages can motivate and inspire the citizens better than negative communication. Citizen involvement activities should be stimulating and engaging. It is important to explain to citizens how waste needs to be separated, why this should be done, and what happens with it afterwards, so citizens can see that their efforts are meaningful. The fact of providing practical tips can help citizens learn how to improve their behaviour. Therefore, the gains for the individual, but also for the collective, should be highlighted. Convenience also plays a vital role – good waste infrastructure accessibility has a positive impact on participation rates. Finally, the interviewees mentioned that incentives, for example discounts on waste tax or on everyday shopping, further support the promotion of behavioural change.

The analysis has shown that elements for increasing the transparency of the process and information have been applied in all four cities. Information posters prepared by the cities were clear, easy to understand and visual, e.g. showing exemplary objects for the different types of waste. In some of the cases a description explaining how waste had to be separated, why this should be done, and what happened with it afterwards was provided.

Several best practices were mentioned. The City of Copenhagen placed containers for plastic bags and glass bottles with no refund in three retail shops right next to a PET bottle collection machine, so the citizens bringing PET bottles to the store could easily and correctly dispose of the plastic bag, as well as the no-refund bottles. An example for convenience associated with transparency is the CYCEL online platform ("reCYCle your Electronics", www.cycel.de) in Hamburg, which provides information needed to deal with broken electronic devices (repair guidelines, the addresses of repair cafes, donation possibilities, disposal guidelines, etc.).

5.4. Continuity

Continuity refers to the timeframe for the implementation of strategies and tools, implying the length and frequency of their application (Bickerstaff and Walker, 2001; Petts, 2001; Maibach, 1993; Sharp *et al*., 2010). Awareness campaigns with

durations limited to weeks or some months are not sufficient to promote a long-term behaviour change, a longer and lasting commitment is necessary (Rogers and Storey, 1987). Thus, continuity is essential for strategic planning of effective citizen involvement. Furthermore, diluting the information (with applicable practical suggestions) throughout a longer timeframe instead of delivering it all at once has a better result in terms of behaviour change (Sharp, Giorgi and Wilson, 2010). In the context of participatory involvement activities (e.g. workshops and public meetings), the timeframe is also crucial (Petts, 2001). It is relevant to waste management in various ways: from the total length of a programme, to the interval between communications and the time provided for such communication to take place (ibid.).

The interviewees stated that providing information over a longer period of time and on a regular basis could foster behaviour changes. Moreover, continuity of activities prevents people from losing interest in the topic and wasting the efforts and investments already made for involvement activities. A regular exchange enables trust building and strengthening of the relationship between a city or waste management company and other stakeholders and citizens. Furthermore, connecting the topic of waste with currently popular issues can make it more visible. Finally, the interviewees indicated that regular monitoring of the impacts, results and learnings is essential in order to make adjustments during a process.

The analysis has shown that citizen involvement activities in some cities happened on a more regular basis whereas it was more clustered in others. This could have been impacted by the degree of detail of the strategic plan for citizen involvement in the cities. One city that had no strategic plan for their citizen involvement activities clustered their actions (publicity campaign) and implemented them over a relatively short period.

Several good practices were mentioned. In order to achieve a behavioural change, Genoa's waste management company has a communication plan consisting of several phases of more intense communication shortly before Christmas and Easter, when people tend to consume more. The City of Hamburg has a couple of days in the year when citizens can contribute to cleaning their city. In 2017, the number of participants increased by 10,000 people (in comparison to 2016) with the result that waste collected by the waste company decreased.

5.5. Resources

Resources refer to the compatibility of time, staff and financial resources dedicated to a project and the reaching of its predefined goals (Rowe and Frewer, 2000). The goal to implement changes in a waste system generally implies changing peoples' habits (UN Habitat, 2010). The acceptance of new habits depends largely on the persons who are presenting the knowledge, how it is presented, the credibility of the communicator, and the conditions on which the knowledge is transferred

(Desa *et al*. 2011). Therefore, human resources (experts, local authorities, community representatives) are crucial to ensure the quality of the outcome of a public participation exercise (Rowe and Frewer, 2000). Mediation may also be needed in citizen involvement processes, not only to encourage stakeholder participation but also to settle antagonisms and seek productive discussions (Forrester, 2008). Furthermore, resources are necessary for implementing financial incentives like discounts on the waste tax or on everyday shopping that can promote environmental behaviour. The cost-effectiveness should also be considered when deciding about the resources dedicated for conducting for a certain participation exercise; the time and money dedicated to it should be coherent to the magnitude of the outcome expected (Rowe and Frewer, 2000).

The interviewees agreed that the involvement of skilled people (topic experts, local authorities, community representatives) in the planning and implementation of citizen involvement activities can ensure a higher quality of the process outcomes. People need to know the topic area so that stakeholders can ensure the credibility of communication and the provided information. In addition, expertise in participative processes (e.g. facilitation), suitable tools and formats (e.g. focus groups), and the skill of active listening are important. According to the interviewees, social media are one of the most cost-effective citizen involvement tools, even though not all age groups can be thus reached. Participatory processes are generally more expensive initially, but in the long run they become cheaper and more effective. Finally, they mentioned that education of waste management company employees who work on site (those who empty bins) should be kept in mind as they are often in contact with citizens and should be able to provide accurate responses to their questions.

The analysis showed that the expertise of the city administration or the people from a waste management company (personal resources) involved in the process, as well as the financial resources dedicated to citizen involvement impacted both the details of strategic planning and further activities. In some cases the experts managing the activities had knowledge in the area of communication and participation, as well as waste management, in others the experts had to reach out to the communication departments of their organisations during the preparation or implementation of citizen involvement activities. Experts combining knowledge in both fields had an advantage as they could plan the activities on their own, which was more time and resource-efficient. However, working in cross-sectoral teams can achieve comparable results if there are well thought through routines in place.

In this context, a household waste analysis was indicated as good practice. Once a year, Hamburg's waste management company conducts such an analysis based on samples in order to measure the amounts of waste being collected and the changes in separation behaviour. It was recommended to base evaluation criteria on a household waste analysis, which allows for assessing the cost-effectiveness of the applied citizen involvement tools.

6. CONCLUSION

The research presented in this paper provides further evidence on the key factors for successfully planning and implementing citizen involvement in waste management and circular economy in cities. Based on the concept of collaborative governance, which highlights the role of dialogue and collaboration between citizens and actors in charge of waste management for achieving the objectives in a more effective way, the empirical research provided valuable insights regarding the key elements to be considered.

As a result of the analysis, five factors were identified as relevant: strategic planning, inclusivity, transparency, continuity, and resources. All those factors were regarded by interviewed institutions responsible for waste management as being of key importance for conceptualising and implementing citizen involvement in the area of waste management and circular economy. However, as the analysis also showed, not all four case cities have applied these five factors to the same extent. The reasons for that include, e.g. a lack of a strategic plan for citizen involvement activities, as well as limited personal and financial resources. Nevertheless, the analysis allowed for a detailed description of each of the key elements for citizen involvement, including important aspects that should be considered, and it provided a number of good practices implemented.

Based on the analysis of the four cities, it could be observed that in the majority of cases citizen involvement in the context of waste management and circular economy focuses on informing citizens about how to behave and what to do with waste, rather than on a joint and collaborative development of solutions. This raises the question of how and to what extend institutions responsible for waste management could incorporate more citizen involvement formats that go beyond information and unidirectional communication.

There have been some limitations to the study discussed in this paper, and those should be pursued further. On the one hand, the evaluation of the citizen involvement tools and instruments focused more on the process than on the outcomes, and, on the other, it was based mainly on the perception of the interviewed experts, not on a quantitative analysis of waste data. Moreover, it would be beneficial to have a larger sample size. Additionally, further research would benefit from assessing the citizen involvement tools and instruments regarding their effectiveness to reach the goals set in strategic planning by the waste management authorities. More research is also needed in the area of behavioural change. In particular, it would be significant to investigate what aspects have the highest impact on making citizens that already are environmentally aware change their behaviour. Against the background of the findings in the case cities, we can only assume that information, incentives, and convenience play relevant roles.

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CIRCULAR ECONOMY POLICY-RELATED NATIONAL INITIATIVES IN VISEGRAD COUNTRIES

Abstract. The concept of circular economy (CE) has become popular in the last decade: both decision-makers and businesses are looking for alternative solutions replacing the present economic model. Official governmental documents have been selected for introducing Visegrad countries' (V4) initiatives and monitoring the progress toward a transition to a circular economy. Based on selected material flow and resource productivity (RP) indicators, the study compares the regional differences among Visegrad countries. The current performances of the V4 in the implementation of the circular economic model are below the EU average. Moreover, it is noticeable that the dynamics of the changes of each indicator is more positive than on average in the EU, however, only moderate relative decoupling of domestic material (DMC) from GDP has occurred. When comparing individual countries, the wide range of the policy measures taken by V4 countries to support the transition to a circular economy can be considered promising. Despite the different characteristics of Visegrad countries, they show similar performances that are rather close to each other and incrementally approach to the EU average.
Key words: circular economy, resource productivity, measuring progress, Visegrad countries.

1. INTRODUCTION

The intensity of material use is increasing globally despite the partial dematerialisation of the global economy based on the rationalisation of production and services and info-communication technology. In 2019, according to a recent report, only 8.6 per cent of the world's economy was circular, consuming 100 billion tonnes of materials a year for the first time (Circle Economy, 2020). This may increase up to 190 billion tons a year by 2060 provided that historical trends continue (International Resource Panel, 2019).

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The strategies and action plans adopted to implement a closed-loop product life cycle aim at supporting circular economy (CE) at each stage of the value chain, from production to consumption, from repair to production, including waste management and recycled raw materials.

To make CE widely used, significant changes need to take place along entire value chains, from product design to new business and market models, from new ways of turning waste into secondary materials to new forms of consumer behaviour. This means a complete transformation of the current linear economic system, as well as innovation not only in technology but also in organisation, society, financing methods, and regulation.

The transition toward a circular economy can create new economic and employment opportunities and brings significant environmental and social benefits through a more efficient use of resources. A group of developed countries, including the European Union (EU), play an important role in the development and implementation of the CE model. In the EU circular economy action plan, a circular economy is explained as an economy "where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised" (European Commission, 2015, p. 1).

The concept of circular economy has gained in appeal in the last decade among both academics and practitioners. It is much more tangible and manageable for businesses than sustainable development that is now more than thirty years old (United Nations, 1987) but it is still a widely disputed concept (Ghisellini *et al.*, 2016; Murray *et al.*, 2017). The latter is too 'fuzzy' to be operationally feasible, and thus, while widely used in both academia and policy discourse, it is considered by many to be increasingly losing its appeal and momentum. Moreover, Naudé (Naudé, 2011) called it a 'theoretical dream' rather than an 'implementable reality'. According to Engelman (Engelman, 2013), the spreading of the term 'sustainable development' ranges from 'environmentally better' to 'cool'. The concept of green economy (UNEP, 2011) and green growth (OECD, 2011) both aiming at sustainable development may also be conceptual frameworks that deserve attention for both enterprises and policy-makers but the concept of circular economy is the one that is the focus of attention today (Ellen MacArthur Foundation, 2014a, 2014b; Ernst & Young Accountants LLP, 2014). According to Kirchherr *et al.* (2017), there are 114 different definitions of circular economy in scientific literature.

Many countries have already demonstrated their commitments to enhancing their transitions towards a circular economy, which is often expressed in a national CE policy statement or as part of a broader environmental strategy. For example, to refer to a circular economy, OECD countries use various terms such as resource productivity and sustainable materials management[1] (OECD, 2019).

[1] Sustainable materials management (SMM) is a systemic approach to using and reusing materials more productively over their entire life cycles.

Resource productivity (RP) measures the direct use of the total amount of materials in an economy (counted as GDP over DMC). It shows how efficiently an economy uses material resources to create human well-being that is to create more (value) from less (material input). DMC derived from economy-wide material flow accounts provides an assessment of the absolute level of resource utilisation and refers to apparent consumption.

According to current experiences of OECD countries, "a key barrier to the implementation of a comprehensive and coherent circular economy policy mix can be the absence of an effective institutional framework. In order to develop and implement policies that support the move to a circular economy, countries should seek to build broad government support and inter-ministerial co-ordination for effective policies that address all stages of the materials life-cycle," (OECD, 2019, p. 27). CE strategies and/or policies require wide-range institutional co-operation involving all relevant players, including ministries for economic development, and ensuring that circular economy objectives are integrated across all environment-related policy areas (Flynn *et al.*, 2019; Sassanelli *et al.*, 2019; Grdić *et al.*, 2020; Momete, 2020).

In 2004, Visegrad countries (V4) consisting of the Czech Republic, Hungary, Poland, and Slovakia joined the EU and inherited the energy and material intensive economy from the former socialist regime. Since the early 1990s, these post-socialist countries have been striving to catch up with the development level of the European Union and boost competitiveness, which requires much more efficient use of natural resources.

The Visegrad Group is a regional configuration within the EU, where there are regular consultations at the top state and government level, ministerial level, and expert level. V4 countries mainly coordinate their positions on relevant EU regulations and policies. The main task of the annually rotating presidency is to manage intensive intergovernmental co-operation, develop common positions, organise political and expert meetings, and launch common projects. According to 2019 data, the countries of the Visegrad Group have a population of 63.8 million, which accounts for 12.4 per cent of the total population of the EU and they together generate 6 per cent of the GDP of the European Union.

The primary purpose of this article is to provide a comparative presentation of the main policy measures adopted individually by the four Central European countries participating in the Visegrad co-operation to move their current national "mainstream" (linear) economies towards circular economies.

The secondary goal is to compare the effectiveness of the state policy performances of V4 countries to each other and to other groups of EU Member States at the macro level using certain elements of the EU's set of key indicators for monitoring circular economy (European Commission, 2018c). The notion of CE involves not only the recycling of materials coming from nature to the socio-economic system but also the reduction of consumption itself; the indicators selected

for this analysis cover not only municipal waste generation and management but also resource productivity in Visegrad countries.

In Section 2 methodological issues and data sources used for comparison are described. Section 3 provides a brief overview of circular economy-related policies of the European Union, while Section 4 presents CE-related policy initiatives and relevant progress in Visegrad countries. In Section 5 some important results are presented and discussed together with brief conclusions.

2. METHODOLOGICAL ISSUES AND DATA SOURCES

To achieve the main objective of comparing V4 initiatives, we have carefully selected the relevant official documents dealing with CE-related issues elaborated and presented by V4 governments or their affiliated bodies. We studied only those policy documents which had been adopted (or waiting for final approval) by the Parliament or the government, and they could have been downloaded from any of the official websites or were available in hard copies. We excluded from our research plans not yet adopted and documents under discussion.

In general, the role of using indicators is very important in evaluating, monitoring, and developing the various policies and programmes aimed at the implementation of the circular economy concept. In the transition to a more circular economy, monitoring the key trends and patterns is a prerequisite to understanding how the different driving forces of a circular economy are evolving (European Commission, 2018c). In close cooperation with the European Environment Agency and consultations with Member States, the Commission has developed a monitoring framework for circular economy, designed to measure progress effectively based on reliable existing data (European Commission, 2018c). This monitoring framework consists of four broader themes (production and consumption, waste management, secondary raw materials, competitiveness, and innovation) and includes 10 key indicators and together with sub-indicators totals 21 indicators (Table 1). We have chosen one indicator as a sample from each group for further examination. The selection criteria were: (1) offer time series, and (2) be representative for a wider topic rather than focus on specific sub-issues. All the data used for country comparisons was taken from the Eurostat database[2] including CE-related tables[3]. All the data applies to the most recent year available.

[2] https://ec.europa.eu/eurostat/data/database [accessed on: 04.04.2020]

[3] https://ec.europa.eu/eurostat/web/circular-economy/indicators/main-tables [accessed on: 04.04.2020]

Table 1. Indicators for monitoring the EU's progress towards the circular economy (CEI)

	CE Indicator (CEI)	**Coverage-Time**
	Production and Consumption	
1	EU self-sufficient for raw material	
2	Green Public Procurement	
3	Waste generation	
3a	*Generation of municipal waste per capita (kg per capita)*	*>10 years (2000)*
3b	Generation of waste excluding major mineral waste per GDP unit (kg per thousand euro, chain-linked volumes (2010)	>10 years (2004)
3c	Generation of waste excluding major mineral waste per domestic material consumption (percentage)	>10 years (2004)
4	Food waste (million tons)	
	Waste Management	
5	Recycling rates	
5a	*Recycling rate of municipal waste (percentage)*	*>10 years (2000)*
5b	Recycling rate of all waste excluding major mineral waste (percentage)	5 to 10 (2010)
6	Recycling/recovery for specific waste streams	
6a	Recycling rate of overall packaging (percentage)	>10 years (2000)
6b	Recycling rate of plastic packaging (percentage)	>10 years (2000)
6c	Recycling rate of wooden packaging (percentage)	>10 years (2000)
6d	Recycling rate of e-waste (percentage)	5 to 10 (2010)
6e	Recycling of biowaste (kg per capita)	>10 years (2000)
6f	Recovery rate of construction and demolition waste (percentage)	5 to 10 (2010)
	Secondary Raw Materials	
7	Contribution of recycled material to raw materials demand	
7a	End-of-life recycling input rates (EOL-RIR) (percentage)	2016
7b	*Circular material use rate (percentage)*	*>10 years (2010)*
8	Trade in recyclable raw materials (tonnes)	>10 years (2004)
	Competitiveness and Innovation	
9	Private investments, jobs and gross value added related to CE sectors	
9a	Gross investments in tangible goods (percentage of GDP at current prices)	>10 years (2012)
9b	Persons employed (percentage of total employment)	>10 years (2012)
9c	Value added at factor cost (percentage of GDP at current prices)	>10 years (2012)
10	*Number of patents related to recycling and secondary raw materials*	*>10 years (2000)*

Note: indicators in italic are discussed in the article

Source: European Commission (2018c).

3. CIRCULAR ECONOMY-RELATED POLICIES OF THE EUROPEAN UNION

The implementation of a circular economy requires long-term commitment at all levels, from Member States, regions and cities to businesses and citizens, as well as not only at the EU level but also at the global level. The main ideas of the Roadmap to a Resource Efficient Europe (European Commission, 2011) were set out in more detail in the Seventh Environment Action Programme (2014–2020) (European Commission, 2014). (Fig. 1 and Fig. 2).

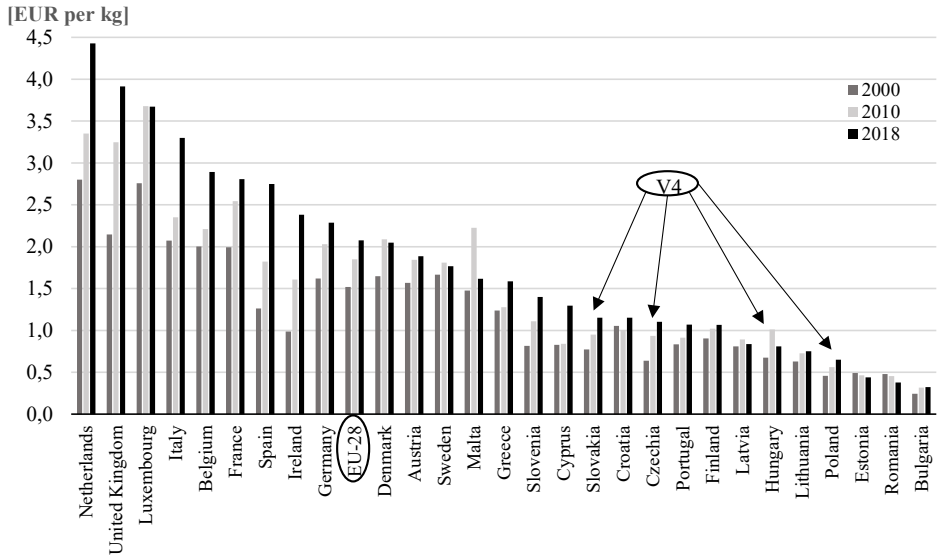

Fig. 1. Resource productivity in EU Member States, 2000–2018

Source: own work based on Eurostat data.

In 2015, the European Commission adopted the ambitious Closing the Loop – an EU Action Plan for Circular Economy (European Commission, 2015), which includes measures that will help push Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth, and create new jobs. The Action Plan incorporates a series of aspiring and focused measures covering the entire cycle from production and consumption to waste management including the market for secondary raw materials and a revised EU-level legislative proposal on waste (European Commission, 2015). The proposed actions expectedly promote the 'closing of the loop' of product lifecycles via recycling and re-use at a higher rate, while bringing benefits for both the environment and the economy (European Commission, 2015).

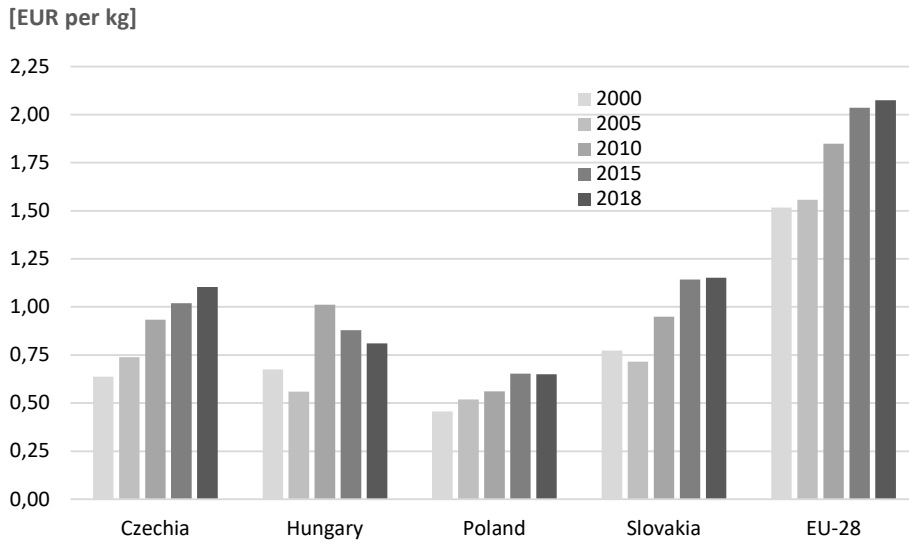

Fig. 2. Resource productivity in V4 countries
Source: own work based on Eurostat data.

The revised legislative framework directive on waste (European Commission, 2018b) entered into force in 2018. It defined clear targets for the reduction of waste and established an ambitious and credible long-term path for waste management and recycling (Table 2). Further key elements of the revised waste proposal include a binding landfill target to reduce landfill use to a maximum of 10 per cent of municipal waste by 2035; and separate collection obligations are strengthened and extended to hazardous household waste (by the end of 2022), bio-waste (by the end of 2023), and textiles (by the end of 2025) (European Commission, 2015).

Table 2. Targets of waste recycling rate for 2025 and 2030 at EU level

Type of waste	**By 2025**	**By 2030**
All packaging	65	70
Paper and cardboard	75	85
Ferrous metals	70	80
Glass	70	75
Aluminium	50	60
Plastic	50	55
Wood	25	30

Source: European Commission (2015).

A European Strategy for Plastics in a Circular Economy (European Commission, 2018a) adopted in 2018, the first-ever strategy on plastics, is a decisive part of the transition towards a more circular economy. The strategy aims at reducing the pressure on the environment coming from plastic pollution whilst fostering growth and innovation. Under the new plan, all plastic packaging waste on the EU market will be recyclable by 2030, the consumption of single-use plastics will be reduced, and the intentional use of microplastics will be restricted.

The European Green Deal published in late 2019 represents a new growth strategy aiming at transforming the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where in 2050 there are no net emissions of greenhouse gases and where economic growth is decoupled[4] from resource use (European Commission, 2019d).

In 2020, the European Commission adopted a new Circular Economy Action Plan (European Commission, 2020b) – one of the main building blocks of the European Green Deal. The new Action Plan covers initiatives regarding the whole product life cycle, such as targeted product design, fostering CE processes, promoting sustainable consumption, and keeping the circulation of materials inside the economy for as long as possible. A New Industrial Strategy for Europe emphasises that industry must play a leading role in the ecological transition by reducing its carbon and material footprint and embedding circularity across the economy (European Commission, 2020a).

Appropriate objectives and indicators have played a key role in the overall process of developing and implementing the abovementioned policies. In 2011 Eurostat compiled a milestone methodological guide (Eurostat, 2001) for measuring economy-wide material flow and resource productivity (Fig. 2), followed by additions and improvements in 2009 and 2018 (Eurostat, 2009; Eurostat, 2018).

Since 2013, the European Commission has been publishing the Resource Efficiency Scoreboard as part of the Europe 2020 indicators. The aim is to monitor the implementation of the Roadmap to a Resource Efficient Europe, to demonstrate the link between resources, and to involve stakeholders even more in the process of measuring social development beyond GDP.

4. CIRCULAR ECONOMY-RELATED POLICIES AND PROGRESS IN VISEGRAD COUNTRIES

In the last five years, V4 presidencies several times discussed the EU proposals on circular economy and waste management (Visegrad Group Presidency Programmes, 2018). The transition toward resource-efficient, low carbon and

[4] Decoupling occurs when the growth rate of environmental pressure is less than that of its economic driving force (e.g. GDP) over a given period.

circular economy represents a common challenge for all these countries. The Czech Presidency programme for 2019–2020 identified broad priority areas for enhanced co-operation. Concerning circular economy, the Czech Presidency programme focused on boosting the market for recyclables and secondary raw materials; promoting the efficient use of resources (Fig. 3) to prevent waste generation at all levels; increasing waste recycling rates and reuse (Fig. 4); radically reducing landfilling (Fig. 5); increasing the substitution of secondary for primary materials (Fig. 6); promoting eco-design of products; promoting technologies for effective use of primary raw materials and extraction, processing and use of secondary raw materials following the EU Action Plan for the Circular Economy (and related national strategies, policy concepts and policies) (Czech Presidency, 2019).

The present Polish presidency programme (2020/2021) highlights the importance of a common approach in CE initiatives; the exchange of experiences between central and local government officials, scientific units and research institutes on the one hand, and members of industry, in particular bioindustry of V4 countries responsible for planning, implementing and financing bioeconomy (an approach akin to the circular economy) activities, on the other (Polish Presidency, 2020).

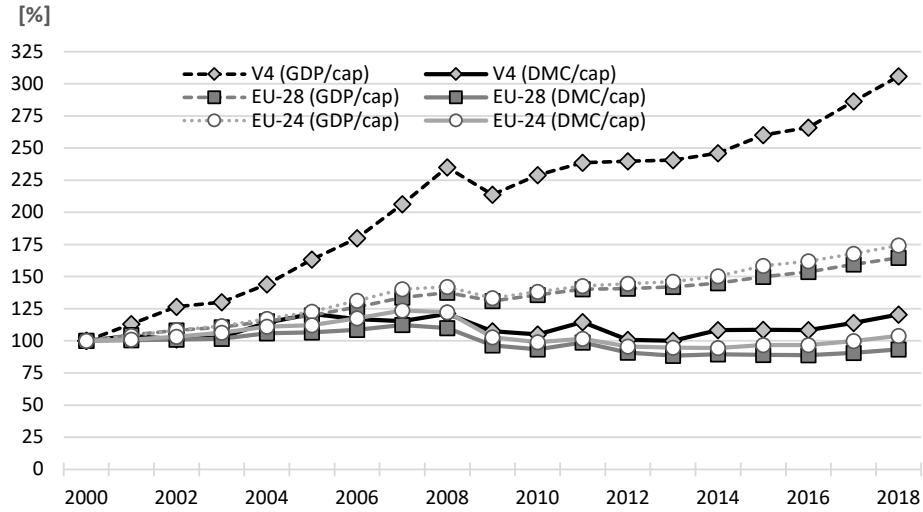

Fig. 3. Decoupling of GDP from domestic material consumption (DMC) by EU countries' groups, 2000–2018

Note: EU-24: excludes V4 from EU-28

Source: own work based on Eurostat data.

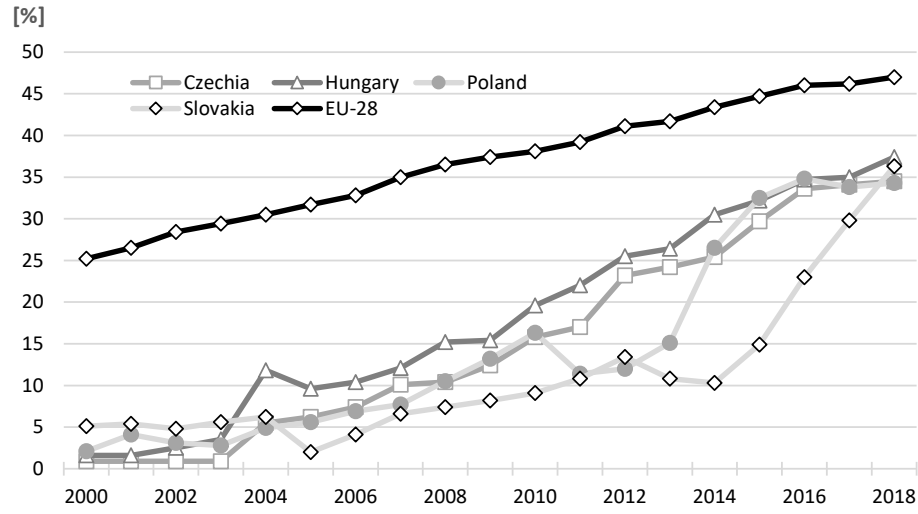

Fig. 4. Recycling rate of municipal waste in V4 countries, 2000–2018
Source: own work based on Eurostat data.

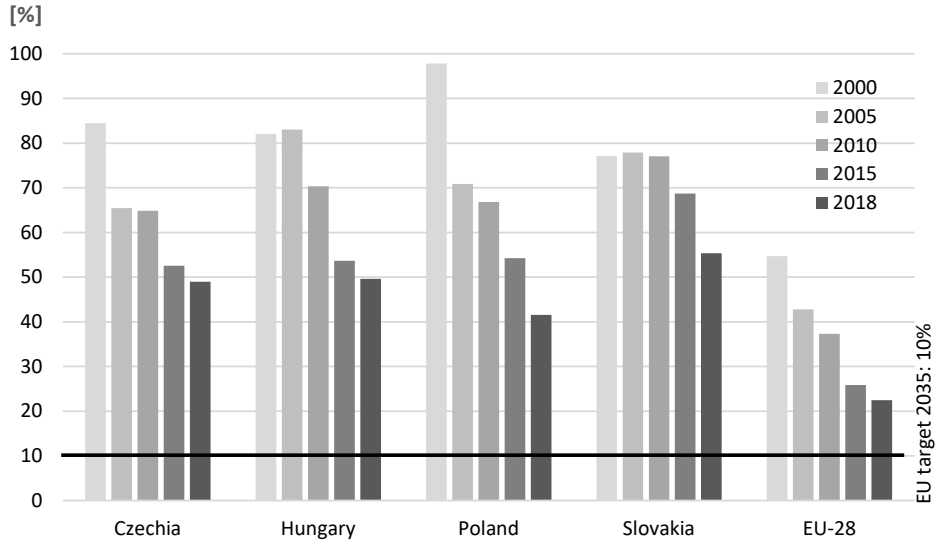

Fig. 5. Landfill rate of municipal waste in V4 countries, 2010–2018
Source: own work based on Eurostat data.

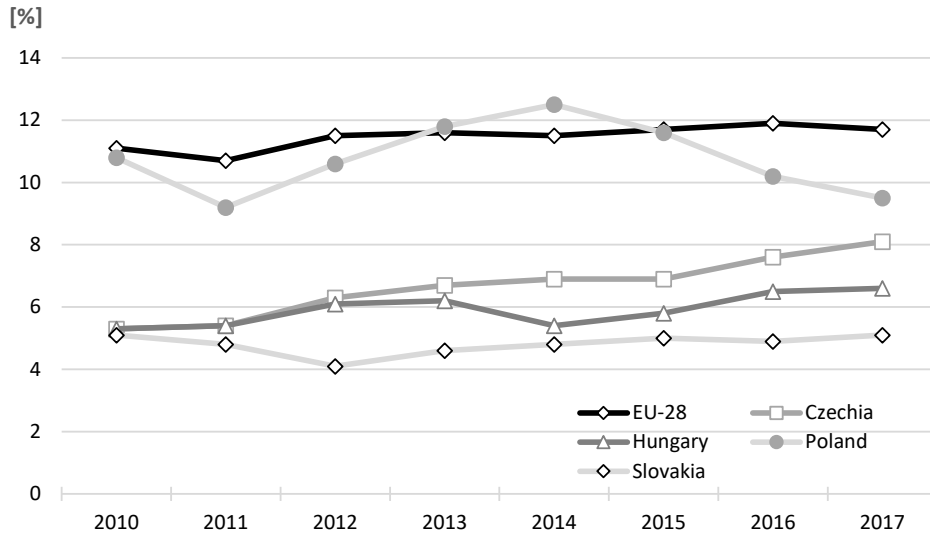

Fig. 6. Circular material use rate in V4 countries, 2010–2017
Source: own work based on Eurostat data.

A synoptic view of the annual change rates of DMC and GDP provides insights into the degree of decoupling[5]. Fig. 7 illustrates how far decoupling has been achieved in V4 and EU economies. The diagonal line denotes identical annual change rates of both GDP and DMC. Countries placed above this line have higher DMC growths than GDP growths and do not manage to decouple the two parameters simultaneously. Countries with faster growth of GDP than of DMC (relative decoupling) can be found below the diagonal line. Absolute decoupling occurs when DMC decreases while GDP increases. In the last two decades, the latter situation could not be observed in either Visegrad country. Fig. 7 highlights the years when individual V4 countries achieved their best and worst performances since 2000. One can see that V4 countries' worst performances occurred around the world economic crisis in 2008/2009 showing a strong relative decoupling. All the countries, after successful economic crisis management, achieved record growths both in GDP and material input propelling them towards the diagonal, i.e. to the border of no decoupling territory or beyond it. The process culminated between 2011 and 2014. Hungary looks like an extremist: on the one hand it spent 7 years in the no decoupling area, while in two years it was twice the best performer in the relative decoupling field. This high fluctuation shows, to a certain degree, the vulnerability of the Hungarian

[5] Recently, Antczak (2019) investigated the decoupling issue regarding municipal waste generation in Poland.

economy. The remaining three countries present more even trends with lower fluctuations, only Poland's economy indicates a somewhat similar economic and material use trajectory. V4 countries' mean performance slightly moved to the border of no decoupling but most of the time it remained in the relative decoupling territory. In the meanwhile, the EU-28 average also moved to this border, however, with a considerably narrower fluctuation.

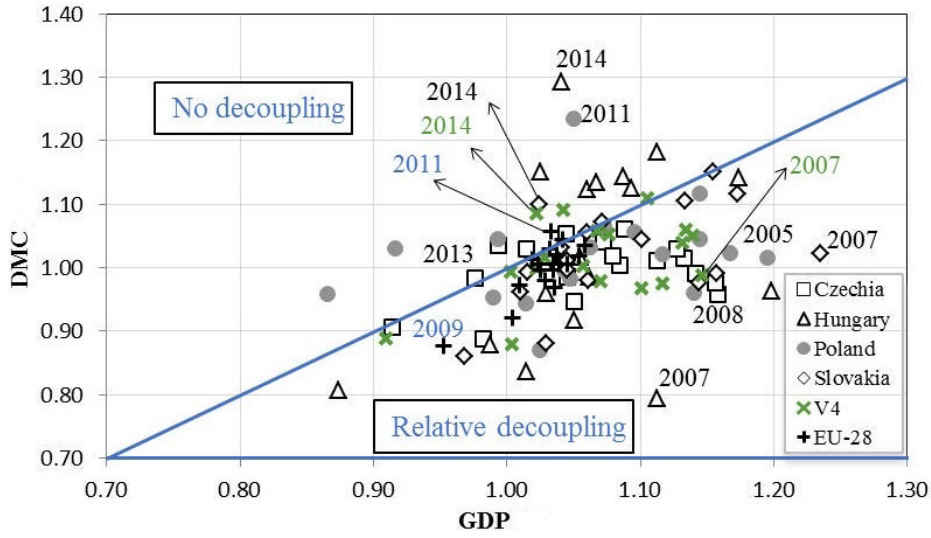

Fig. 7. Annual change rate of DMC and GDP in V4 countries, 2000–2018

Source: own work based on Eurostat data.

4.1. The Czech Republic

The 2012–2020 State Environmental Policy of the Czech Republic (SEP, updated in 2016) established a strategic framework for effective protection of the environment in the Czech Republic until 2020. The main objective of the Policy has been to ensure a healthy and high-quality environment for citizens, to significantly contribute to a more effective use of resources, and to minimise the negative impacts of human activities on the environment, including cross-border impacts, and thus contribute to the improvement of quality of life in Europe and worldwide. The SEP focuses on the following areas: the protection and sustainable use of resources; climate protection and improvement of ambient air quality; the protection of nature and landscape (Ministry of the Environment of the Czech Republic, 2012). According to the SEP, energy and

material intensity of the Czech economy is expected to decrease, and the environmental pressures (emissions into the air and water, impacts on landscape, waste generation, etc.) per unit of economic output will decrease. In general, the country supports CE principles and strategic direction, which enhances the management of waste as a resource.

In 2014, the Czech Government adopted the National Waste Management Plan for 2015–2024, which contains national waste prevention measures as well (Ministry of the Environment of the Czech Republic, 2014). It aims at enhancing the transition to a circular economy in the long term. Despite this political goal, there are only limited CE initiatives, as well as eco-innovative companies introducing the creative environmental, and ecological and socially responsible solutions (Švecová *et al.*, 2019). At the same time, regional waste management plans were also approved. All these efforts are expected to contribute to achieving long term recycling targets and promoting transition towards a circular economy.

In 2017, the 2030 Strategic Framework was adopted by the Government, describes such a development model in which the energy and material intensity of the economy will be reduced. The main strategic goal of this document is the most efficient and economical use of natural resources to minimise the external costs of their consumption. There is a need to reduce the intensity of greenhouse gas emissions connected with the production of gross domestic product (GDP) and increase energy and material efficiency (Office of the Government of the Czech Republic, 2019). The basis for the long-term economic growth is ensured by entrepreneurship, innovation, human creativity and skills, high value-added industries, circular economy, low carbon technologies, robotics, and digitalisation. This model is based on the principles of a social market economy, and in its centre there lies co-operation and co-ordination between public administration, business and civil society (Ministerstvo životniho prostředi, 2020).

The country has no specifically defined national CE strategy or a roadmap yet. Preparations for establishing a national strategy called Circular Czech Republic 2040 are still at an early stage, adoption is expected in 2020 (European Commission, 2019a). The CE concept and eco-innovation are still emerging fields in comparison with western and northern EU Member States, and there are many barriers related to human resources (e.g. a lack of knowledge) and targeted financing, particularly in the business sphere (Švecová *et al.*, 2019).

According to an OECD evaluation, the country performance in waste management is modest (Table 3). The country will have to take significant steps before moving towards a circular economy. The country emphasises the value of waste as a resource promoting reuse, recycling, and waste prevention. The implementation of these should be continued in parallel with the modernisation of the Czech economy, aligning different policies and efficient co-operation between relevant ministries (OECD, 2018a).

Table 3. Comparison of Visegrad countries by selected indicators, 2000–2018

	Year	CZ	HU	PL	SK	EU-28
Municipal waste generation, kg/cap *[CEI 3a]*	2000	335	446	320	254	521
	2005	289	461	319	273	515
	2010	318	403	316	319	504
	2015	316	377	286	329	481
	2018	351	381	329	414	489
Municipal waste treatment, kg/cap	2000	317	407	320	249	497
	2005	244	457	245	257	483
	2010	304	403	264	309	492
	2015	316	377	286	310	470
	2018	351	383	329	414	481
Municipal waste recycling rate, % *[CEI 5a]* *EU target: 50% (2020), 60% (2030)*	2000	0.9	1.6	2.1	5.1	25.2
	2005	6.2	9.6	5.6	2	31.7
	2010	15.8	19.6	16.3	9.1	38.3
	2015	29.7	32.2	32.5	14.9	44.7
	2018	34.5	37.4	34	36	47
Municipal waste landfilling rate, % *EU target: 10% (2035)*	2000	84.4	82.1	97.9	77.1	54.7
	2005	65.5	83.1	70.9	77.9	42.8
	2010	64.8	70.4	66.8	77.1	37.3
	2015	52.6	53.6	54.3	68.7	25.8
	2018	49	49.6	41.6	55.4	22.5
Circular material use, % *[CEI 7b]*	2005	.	.	.	.	8.9
	2010	5.3	5.3	10.8	5.1	11.1
	2015	6.9	5.8	11.6	5	11.7
	2018	8.1	6.6	9.5	5.1	11.7
Patents related to recycling and secondary raw materials, per million cap. *[CEI 10]*	2000	1.07	0.08	0.33	0.39	0.64
	2005	0.73	0.1	0.33	0	0.61
	2010	1.84	0.61	0.09	0.09	0.67
	2015	0.91	0.14	0.77	1.14	0.7
Domestic Material Consumption (DMC), t/cap	2000	17.5	11.7	14.1	10.1	15.1
	2005	18.4	17.7	14.5	14	15.9
	2010	16	9.8	17	13.3	13.8
	2015	15.9	12.7	16.9	12.5	13.1
	2019	16.1	17.6	18.5	13	13.4

	Year	CZ	HU	PL	SK	EU-28
Gross Domestic Product (GDP), EUR/cap.	2000	11 170	7 900	6 440	7 780	22 968
	2005	13 570	9 910	7 510	9 960	24 820
	2010	14 900	9 900	9 390	12 540	25 500
	2015	16 160	11 130	10 920	14 270	26 680
	2018	18 000	13 180	12 980	15 890	28 650
Resource productivity (RP=GDP/ DMC), EUR/kg	2000	0.64	0.67	0.46	0.77	1.52
	2005	0.74	0.56	0.52	0.72	1.56
	2010	0.93	1.01	0.56	0.95	1.85
	2015	1.02	0.88	0.65	1.14	2.05
	2018	1.12	0.75	0.71	1.22	2.14
Decoupling DMC from GDP, % (base year: 2000)	2000	0	0	0	0	0
	2005	60	29	30	38	13
	2010	139	114	75	172	42
	2015	155	119	112	231	61
	2018	210	141	131	263	71

Note: Shaded rows refer to the elements of the European Commissions' set of indicators for monitoring CE

Source: own work based on Eurostat data.

4.2. Hungary

The development of a circular economy action plan is still in its infancy. Although there is no separate policy framework for the development of a circular economy, several national strategic planning documents also address material and resource management issues to some extent, either directly or indirectly. The 2011–2020 National Environmental Technology Innovation Strategy (NETIS), the 2012–2024 National Sustainable Development Framework Strategy (NSDFS), and the 4th National Environmental Protection Programme (NEPP) for the period 2015–2020 have all identified material and resource efficiency as one of the policy goals.

The 2011–2020 NETIS (Government of Hungary, 2011) adopted in 2011 includes 17 targets for sustainable resource management by 2020, shows how efforts are being made to include resource efficiency, and CE considerations into some sectoral policies. The strategy includes a measurable target to reduce the material intensity of the economy by 20 per cent by 2020 in comparison with the base year of 2007, and the country is on a good track to achieving the target.

The 2012–2024 NSDFS (National Sustainable Development Council of Hungary, 2013) adopted in 2013 includes a regular monitoring of the state (both the quality and quantity) of natural resources and unsustainable trends and defines the desirable development directions. The 4th NEPP 2015–2020 (Hungarian Parliament, 2015) represents a strategic six-year plan for environmental and nature protection. It encompasses several different strategies and could, therefore, be an adequate starting point for planning the transition towards a circular economy. This programme also identifies resource efficiency as a policy priority.

The 2014–2020 National Waste Management Plan adopted in 2013 has been under revision since 2017 (Government of Hungary, 2013). One reason was so that it could consider the requirements of the EU circular economy package (2015), which was adopted in the meantime. The national waste management plan is complemented by its annual waste collection and utilisation service plans. The prevention and reduction of waste generation and increasing reuse and recycling rates (Fig. 4, Table 3) could make the country more resource-efficient while creating new business opportunities. It could also contribute to a more real transition to a circular economy by providing jobs in the recycling industry (European Commission, 2019b).

In the early 2020, The Hungarian Business Council for Sustainable Development published the findings of a survey on circular economy. According to the respondents, there was a clear need for a better understanding of CE solutions, sharing good practices, applying state incentives, and developing a national CE strategy (BCSDH, 2019).

The EU's 2017 Environmental Implementation Review included a suggested action for Hungary to develop an overarching CE policy framework. However, there are some challenges in this process, in particular, a lack of institutional coordination and a lack of dedicated funding. Initial expert dialogues and consultations mainly involved the waste management sector (European Commission, 2019b). Since the reshuffling of the Government in the mid-2018, the CE-related questions no longer belong to the Ministry of Agriculture, but to the Ministry for Innovation and Technology, which is also responsible for waste management issues.

The Hungarian Performance Review of the OECD published in the mid-2018 stated that the Government was looking at a transition towards circular economy as a pure waste management question. Other aspects of circular economy like sustainable material management were considered to a limited extent. The OECD has formulated an essential policy recommendation: "Introduce a whole-of-government approach through collaboration between relevant ministries to steer the transition to a circular economy; develop a national circular economy action plan with measurable targets and timelines" (OECD, 2018b, p. 39).

4.3. Poland

In July 2019, the Council of Ministers adopted the 2030 National Environmental Policy (Polityka Ekologiczna Państwa, PEP2030). PEP2030 has become the most important strategic document in the area of the environment and water management (Council of Ministers of Poland, 2019a). The role of PEP2030 is to ensure Poland's ecological safety and high quality of life for all residents. PEP2030 will be the basis for investing European funds from the financial perspective 2021–2027. PEP2030 also supports the implementation of Poland's objectives and commitments at the international level, including those of the EU and the UN, especially in the context of the EU's climate and energy policy objectives by 2030 and the sustainable development goals (SDGs) included in the Agenda 2030 (Council of Ministers of Poland, 2019a). The effectiveness of the implementation of PEP2030 will be monitored using a set of indicators (over 20, for example, municipal waste recycling rate) based on data from reliable sources, in particular, the State Environmental Monitoring System, Statistics Poland and the General Inspectorate for Environmental Protection.

One of the specific objectives of the PEP2030 is to ensure a sustainable management of environmental resources. There are two directions of implementation closely related to a circular economy: waste management towards a circular economy and managing geological resources by developing and implementing a State Raw Materials Policy (by 2050) (Ministry of Environment, 2019). The actions aim to fully implement a waste hierarchy in Poland in line with the concept of circular economy. First of all, it is necessary to ensure the implementation of actions which are at the highest levels of the waste hierarchy, i.e. prevent waste generation and create an indispensable infrastructure for separate waste collection at the source to ensure its preparation for reuse or effective recycling. These actions will also support climate protection by reducing greenhouse gas emissions from the waste management sector, mainly from landfills (Fig. 5).

The fundamental instrument for implementing PEP2030 in this area is the National Waste Management Plan 2022 (Krajowy plan gospodarki odpadami 2022, KPGO 2022). It was prepared to achieve waste management targets, implement the waste hierarchy and the principles of self-sufficiency and proximity, and to create and maintain an integrated and adequate network of waste management installations.

In September 2019, following a wide range of public consultations, the Council of Ministers approved the Roadmap towards a Transition to Circular Economy in Poland. The Roadmap prepared by the Interdepartmental Circular Economy Group under the umbrella of the Polish Ministry of Development indicates activities that primarily contribute to reducing waste and to the introduction of the CE model in Poland (Council of Ministers of Poland, 2019b). The Roadmap identifies actions to maximise the added value of raw materials/resources, materials and

products, and reduce waste generation while maintaining the condition of production efficiency and consumption processes. The document also comprises a set of legislative and non-legislative tools to foster the development of CE in Poland in the areas of sustainable industrial production, consumption, bioeconomy, and new business models. There are 41 measures proposed in these areas, assigned to relevant ministries. It also includes a separate action to develop a conceptual framework for monitoring the circular economy in Poland.

The Commission's "early warning report" named Poland among the countries unlikely to achieve the municipal waste recycling target by 2020 (Fig. 4, Table 3). More efforts will be necessary to meet the recycling targets set for the period after 2020 (European Commission, 2019c).

A research study identified transition barriers to a circular economy in Poland: a lack of funding, social barriers (a low level of public awareness, e.g. concerning proper selective waste collection), and technological barriers (a low level of eco-innovation) (Zielińska, 2019). Poland's embracing of the CE would be extremely beneficial from the macroeconomic point of view. The economy of closed loops could stimulate economic growth, and calculations show that even a minimal change in the Polish economy, i.e. a 1 per cent savings in the cost of materials and energy – could result in annual GDP growth of EUR 4.5 billion (Deloitte, 2018)

4.4. Slovakia

The Strategy of the Environmental Policy of the Slovak Republic by 2030 (Envirostrategy 2030) (Ministerstvo životného prostredia SR, 2019) adopted in 2017 has defined a vision until 2030, and identified the fundamental systemic problems, set the objectives by 2030, and proposed a framework for measures to improve the current situation. It also contains basic performance indicators (e.g. municipal waste recycling rate, per capita waste generation, and municipal waste landfilling rate) that will enable a verification of the results. The biggest environmental challenges in Slovakia, and hence areas that will be prioritised within the environmental policy by 2030, are issues such as waste management, air quality, and habitat and species conservation, especially in forest, meadow, and wetland ecosystems.

The basic vision of Envirostrategy 2030 is to achieve better environmental quality and CE, which is based on a rigorous protection of environmental resources and using as little non-renewable natural resources and hazardous substances as possible, which will lead to an improvement in public health. Environmental protection and sustainable consumption will be part of the general awareness of citizens and policymakers.

By 2030, the municipal waste recycling rate, including its preparation for reuse, will increase to 60 per cent and by 2035 the land-filling rate will be reduced to less than 25 per cent. Slovakia will use green public procurement procedures

for at least 70 per cent of the total value of public procurement. It will increase support for green innovation, science, and research. The disposal of food waste for supermarkets will be prohibited (Ministerstvo životného prostredia SR, 2019).

According to the European Commission's "early warning report" (European Commission, 2018e), Slovakia may not meet its municipal waste recycling rate target (Fig. 4, Table 3). The report recommended several urgent priority actions to be taken by Slovakia to bridge the implementation gap. The country will need to make greater efforts to meet post-2020 recycling targets.

The analytical work of the OECD clearly shows that better resource efficiency results in lower production costs and in the long term it improves economic competitiveness (OECD, 2016). It is of vital importance for a country with limited natural resources to implement coherent policies aiming at increasing resource efficiency and supporting green growth. A more efficient use of materials enhances both the decrease of domestic material consumption (DMC) and import dependency, the sooner these policies are being implemented the greater the economic and environmental benefits will be (OECD, 2017).

5. DISCUSSION AND CONCLUSIONS

The current performances of V4 countries in implementing the circular economic model lag behind the EU average, but a dynamic improvement of the presented indicators (excluding domestic material consumption) can be observed (Table 3, Fig. 3–6).

Resource productivity has improved significantly in V4 countries since the turn of the millennium (Fig. 1). The rate of municipal waste recycling in Hungary has barely lagged behind the EU average in the last few years, while that of the other countries is in the catching-up phase (Table 3). The circular material use ratio in the case of Poland is around the EU average, while the other three countries perform similarly but below the EU average (Fig. 6). Domestic material consumption decreased in the Czech Republic and Hungary, while it increased in Poland and Slovakia. The landfill rate has started to decline slowly in all V4 countries in recent years but it is still well above the EU average (Fig. 5).

The improvement showed by the selected indicators is likely to indicate the effectiveness of the wide range of the policy measures taken by V4 countries to support the transition to a circular economy.

To date, there has been no coherent Czech national policy that would include the CE, which is still just an emerging area in the Czech Republic. There are still many obstacles at the political level in terms of human resources and targeted funding, especially in the business sector.

In Hungary, both from an institutional and financial points of view, it is a challenge to develop the necessary framework to comply with the EU CE package adopted in 2015. Multi-stakeholder dialogues and consultations on circular economy have started, mainly in the waste management sector and the public sphere. Although the strategic thinking on the integration of the CE concept into the Hungarian economy is not yet broad enough, there is a political will for it.

One of the main challenges in Poland today is to link waste management projects to other elements of the loops to increase performance in waste management. Work on the CE, and, in particular, the roadmap toward the CE, should reflect not only the establishment of the framework but also the links and synergies with other policies.

In Slovakia, too, a more efficient use of materials helps reduce domestic material use (Table 3) and import dependency while reducing the burden on the environment and natural resources. The current strong economic growth offers an opportunity to stimulate such a transition through carefully selected policy reforms and the necessary investments.

The selected indicators show that V4 countries' performance is improving, however, they still lag behind the EU average by 15–20 years (Table 3). It remains a general feature, and the performance is incremental rather than leapfrogging, therefore, the catching up will be a very long process at the current pace of implementation. To sum up, in all Visegrad countries, more ambitious policies, workable institutional system, and enabling regulatory frameworks are needed to achieve relevant EU targets. Managing the transition from the current economic model to a circular economy in Visegrad countries requires new approaches, integrated and coordinated policies, in particular, economic, social, technological, institutional, and environmental innovations.

It would be promising to explore the structural driving forces behind circular economy, as well as national/regional institutional and/or governance issues. An analysis of the relationship between CE and other policies (such as economic policies, innovation policies including eco-innovation) could also be an interesting subject.

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PART II

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MIGRATIONS OF ELDERLY PEOPLE IN THE WORLD AND IN POLAND

Abstract. Migrations of seniors in the 21st century accurately reflect the socio-demographic changes in developed countries. Their intensity increases in various parts of the world. In Europe, pensioners from the north move to the region of the Mediterranean Sea. Seniors from the United States and Canada are attracted to the countries of Central and South America. The goal of this study is to identify the trends in foreign migrations of seniors in selected countries of the world, with special regard to the migration of Polish pensioners. The study shows that contemporary seniors can afford to purchase property abroad and the driving forces for the migration movement include: warm climate, beautiful landscape, and a healthier and slower pace of living at the final destination. However, when it comes to Polish pensioners, the main reason for their migrations is their attempt to improve their economic conditions.

Key words: pensioners, migrations of seniors, directions of migrations of seniors, causes of migration of seniors.

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1. INTRODUCTION

Migrations of elderly people have become one of the most significant socio-demographic changes in developed countries. A significant increase in these migrations began in the final decade of the 20th century and it has often been difficult to separate them from tourism. They may be observed in different regions of the world. Pensioners from the north of Europe migrate to the Mediterranean region, especially to such countries like Portugal, Italy, Greece, Turkey, and Spain. Pensioners from the USA and Canada prefer the countries of Central and South America, i.e. Mexico, Costa Rica, Guatemala, Colombia, Brazil, and Argentina. The migrations also apply to the generation born after the Second World War in the period of 1946–1964, which currently represents two thirds of the world population (Ptak, 2012).

Therefore, the goal of the study is to identify the trends in foreign migrations of pensioners in selected countries of the world, with particular regard to Polish pensioners. Basically, the time span of the analysis refers to the period of 1995–2018. The phenomena in question have been identified and discussed by combining the quantitative method – an analysis of statistical data from Statistics Poland – and the literature related to selected examples of researches on migrations of seniors around the world.

This question has not been the subject of any comprehensive studies as yet. The most important works include the ones by Warnes (1994), who used secondary data to demonstrate the growing significance of Southern Europe as a destination of residential migrations of pensioners from Northern Europe. Moreover, Jurado and Sánchez (1990) presented in their studies the economic consequences of the immigration of residents from Northern Europe to Mijas (Costa del Sol), one of the most densely populated municipalities in Spain. The attractiveness of Spain has also been underlined by Cribier (1982), Myklebost (1989) and Valenzuela (1991). According to the authors, seasonal migration might be the first step towards permanent migration and that applied to a significant number of the British and Germans. Studies of all types of British purchasers of property in France, conducted by Buller and Hoggart (1992, 1994, 1995), have shown a sharp increase in the purchases made by the British from 2,000 (1980) to 14,000 (1989). Property agencies played a key role in attracting buyers' attention to particular regions and locations (Williams *et al.*, 1997). This subject is gradually gaining popularity in Poland as well. Currently, migrations of Polish pensioners are primarily analysed by: Potrykowska (2003), Kałuża (2006, 2007, 2008), Kałuża-Kopias (2011, 2013), Jankowski and Pytel (2013), Pytel and Szkup (2013), Pytel (2014a, 2014b, 2017), and Pytel and Ociepka (2016).

2. RESEARCH CONCEPTS

Due to a large diversity and a multi-faceted nature of migration, new concepts aiming to explain this phenomenon are emerging constantly. Various scientific disciplines, such as geography, sociology, economics, demography, etc. are studying the topic. Their theoretical concepts differ in ways of explaining the causes and effects of migration, but they share a common subject of research, leading to the recognition of the phenomenon of human movements.

Selected theories concerning the migration of pensioners were presented by Kałuża (2008). Drawing on the key work of Longino and Bradley (2001), *Geographical distribution and migration*, she has stated that the most important concepts related to pensioners concern:

– life cycle,
– decision process on moving,
– loss of housing balance, and
– self-identification with the place of residence.

Kałuża (2008) has indicated that life cycle models refer to events occurring in specific periods of human life, as well as to the probability of their occurrence. She invoked the research of Litwak and Longino (1987) who had identified three types of senior migrations:

1. migrations of the youngest seniors as a consequence of their retirement,
2. migrations of slightly disabled pensioners, and
3. migrations to social welfare homes.

As the second group of concepts, Kałuża (2008) indicated the theories for deciding about moving and while making reference to Wiseman (1980), she has stated that migration is a consequence of the occurrence of push and pull factors. Wiseman (1980) has listed the reasons that imply the decision to migrate, namely: climate, living and family conditions, the costs of living, and social infrastructure. This concept was developed by Haas and Serow (1993) who transferred it to the field of pensioners' migration.

A model of loss of housing balance by pensioners is the third of the significant concepts. It implies that the main reason for pensioners' migration is their will to decrease their residential costs. Kałuża (2008) indicated that the research of Steinnes and Hogan (1993) had confirmed this hypothesis. They argued that pensioners migrated based on the differences in property prices in various regions of the United States.

This research is based on the approach proposed by Wolpert (1965) which assumed that the basic importance for the behaviour of migrants, including pensioners, are: the usefulness of a given place, the level of aspiration of an individual, the space of action and the phase of a person's life cycle. The usefulness of a given place is the sum of the benefits that a migrant – who is defined as a person seeking

to achieve an appropriate level of satisfaction – may obtain. If such a migrant falls below the level of needs, they will seek to find a new place of action. This search process varies with age and life cycle phase (Wolpert, 1965).

A review of numerous migration theories has indicated that the phenomenon of migratory movement is a multi-faceted process and should be considered broadly, with the use of scientific theories of various disciplines.

3. SOURCE DATA AND RESEARCH METHODS

The basis for studying migration and determining the main directions of displacement of Polish seniors were the figures purchased from Statistics Poland and concerning the years 2000–2010. Broader analyses of these migrations were possible on the basis of the data obtained from the website of Statistics Poland and covering the years 1995–2018. Only the migrants who moved permanently were included.

In the present work, a pensioner was defined as a person over 60 years of age for women and as a person over 65 years of age for men. Due to linguistic reasons this group of population is also referred to as: seniors, pensioners or elderly people.

The following research methods were applied: observational, analysis and criticism of the literature, and statistical. The observational method played a significant role. Observation is one of the oldest analytical methods that enables the formation of hypotheses, collection of data, verification and selection of material, clarification of issues, formulation of a thesis, and establishing contacts with the study group. Its characteristic feature is recurrence.

The second method was the method of analysis and criticism of literature. It can be used to determine what is known and what is unknown, what exists in literature and what is not yet available. This method makes it possible to determine whether a problem is original and different from the previously known discoveries. It enables one to indicate differences, similarities, relationships, dependencies, and significant features in existing theories.

The statistical method, which is inherent to this type of research, enables one to collect and organise scientific facts (data) regarding a given structure, system or process. It consists in drawing conclusions based on the distinguished features of sets of statistical elements. Its application makes it possible to identify irregularities in the characteristics (properties) of an entire community, based on the characteristics of a particular sample.

The empirical study was conducted using a set of indicators. These were primarily measures of the intensity of migratory traffic, i.e. the coefficients of migration inflow and outflow:

(1) Gross migration inflow rate: $m_N(t) = \frac{N(t)}{\overline{L(t)}} C$;

(2) Gross migration outflow rate: $m_O(t) = \frac{O(t)}{\overline{L(t)}} C$.

$O(t)$ – number of people who departed to the region concerned in the period "t"
$N(t)$ – number of people who arrived in the region concerned in the period "t"
$L(t)$ – average number of people in the post-working age in the period "t"
C – constant 1,000.

The third measure was the migration balance coefficient, also called the net migration coefficient. It is a quotient of the migration balance in a given territory in the period "t" and the average number of people in the post-working age of this territory in the period "t". It was calculated following the formula:

(3) Net migration rate (migration balance): $Sm(t) = \frac{N(t) - O(t)}{\overline{L(t)}} C$.

The next indicator was the migration efficiency indicator which shows what proportion of a migrating population settles in a given area in the period "t". The coefficient is interpreted in such a way that the closer the value is to zero, the less effective the migration flows are, because with a large "turnover" the balance is relatively small. It is calculated following the formula:

(4) Migration efficiency ratio: $Em(t) = \frac{N(t) - O(t)}{N(t) + O(t)} C$.

Constant "C" was assumed to be equal to 1.0. This indicator may reach values from -1.0 to 1.0.

Migration turnover (migratory mobility) was also applied, i.e. the sum of the outflow and inflow of population to a given territory in the period "t":

Migration turnover rate (migration mobility): $Om(t) = N(t) + O(t)$.

4. MIGRATIONS OF PENSIONERS IN EUROPE. SELECTED EXAMPLES

To properly discuss the migration of Polish pensioners, it is necessary to first identify this phenomenon in Europe. Senior migration is most widespread in Western Europe, therefore five countries from this region were selected as the background to illustrate the migration of Polish pensioners. All of them are characterised by the longest history of senior migration and by an important role it plays. Both in Poland and in other Central and Eastern European countries, the phenomenon of retiree migration is in its initial phase, which is why they cannot be used for comparison.

4.1. Italy

King and Patterson (1998), researchers who studied seniors migrating from the United Kingdom, have shown that the largest group is concentrated in Italy, in two Tuscan provinces, i.e. Florence and Siena. The migration of the British to these provinces has a long tradition, conditioned by history and tourist experiences. They choose Tuscany not only due to its climate or coastal attractions, but mainly for its landscape, high culture and 'the Italian lifestyle'. Migrations of the British are often complex. Moreover, firstly they settled in the region of Florence and Chianti, and the regions of southern Tuscany, i.e. Umbria and Marche, drew their attention much later. Changes in the population of the municipalities of Tuscany in the period of 1951–1991 were examined by Telleschi (1994). He concluded that the visible population increase in the area occurred in the years 1951–1971, and from the 1960s onwards the British became the most numerous group among the migrants coming to the region. However, the property market is presently dominated by German migrants. The houses they purchase are often their second homes.

4.2. France

About 71.0% of retired migrants had never lived in France before purchasing their property, and over 53.0% had not even had friends or relatives who lived in France for any period of time (Buller and Hoggart, 1994; Hoggart and Buller, 1995). The authors also indicated a surprisingly low level of leisure activity before purchasing a house. These differences could be partially explained by the fact that the emigration to France is linked to the house prices' boom that occurred in the United Kingdom in the 1980s. After that period, the British were more interested in purchasing homes in rural areas of France. Within the group who purchased property in France, 46.0% declared that their French houses were their main places of residence (53.0% of them were at the pre-pension age). The main reason for the purchase were the property prices which were lower than in the United Kingdom. Unfortunately, the next few years would presumably introduce some decrease in residential migration of elderly people to France. Real estate prices have been rising since 2000. This increase is much quicker than the gross income in households. In the period of 2000–2011, the prices of existing houses in France increased by more than 120.0%, while within the same time the disposable gross income in households increased by only 20.0%.

4.3. Spain

The largest and most important region of Europe where pensioners from other countries come voluntarily is Costa del Sol (Rodríguez *et al.*, 1998). Its particular and favourable configuration of its environmental, the social and econom-

ic conditions in southern Spain, and its accessibility from northern European countries have turned this beautiful tourist region into one of the most popular destinations for such migrations. Similar conditions may be found on other Mediterranean coasts of Spain, i.e. Costa Brava, Alicante, Murcia, the Balearic Islands, and the Canary Islands (Paunero, 1988; Myklebost, 1989; Montiel, 1990; Serrano, 1991).

Despite the growing awareness of the importance of pensioner migrations, the lack of adequate records remains the major problem in understanding them and implementing related suitable policies and planning. Official sources or studies have not produced convincing estimates of population sizes of pensioners in the area. According to the National Census of 1991, Spain had over 44,000 people aged 55 or more, who came from Northern European countries. It has been estimated that there were 50,000 people aged at least 65, and 15,000 from this group lived on Costa del Sol. Other estimates show that Spain is a country where over 100,000 British people aged over 60 have settled.

4.4. Malta

The settlement process in Malta has a very complex history which has run for longer than the one on Costa del Sol, in Algarve or in Tuscany. As a former British colony, Malta has close relations with the United Kingdom. Socially, that is reflected in the existence of numerous marriages between Maltese and British citizens. Currently, the attractiveness of the island for pensioners has decreased due to high population density and urbanisation, which have also affected housing developments and controlling policies for their stock. The domination of British citizens in immigration of pensioners was also limited as they started choosing other European countries, including Eastern Europe ones.

4.5. Portugal

Migrations of pensioners to Portugal are a relatively old form of spatial mobility, but a change in their scale in recent years has attracted the attention of both scientists and politicians. This is especially visible in Algarve where small centres of British communities have existed at least since 1930. However, the highest intensity of migrations of pensioners began in 1980s. As the studies of Williams and Patterson (1998) have shown, up to three quarters of pensioners arrived there after 1984. It was a result of the demographic changes in Northern Europe, increased number of early retirements, and gains from the house boom. It was also a result of cumulating experiences in the field of mobility in commuting or international tourism. As the direct research showed, the most significant reasons for migration to Algarve were its climate and the quality of the environment (approximately 58.0%

of respondents). The second was the dislike of the United Kingdom (15.0%), and the third – the Portuguese lifestyle (13.0%). Financial considerations were important to approximately 10.0% of the respondents (Williams and Patterson, 1998).

5. FOREIGN MIGRATIONS OF POLISH PENSIONERS

5.1. Migration destinations of pensioners

In the years 2000–2010, the largest migration turnover occurred in Germany and amounted to 11,296 people (Table 1). The reasons for this were the proximity of both countries and the ease of finding a job. It is equally easy to find a job in the United States or Canada, but it is much more difficult to migrate there. This has been reflected in the values of migration turnover, i.e. 3,464 people for the United States, and 884 people for Canada.

In order to detail the course of pensioners' migration, its analysis was carried out for two periods: 2000–2005 and 2006–2010.

Table 1. Total amounts and destinations of permanent migration of Polish seniors in the years 2000–2010 (in persons)

No.	Country	Number of immigrants	Number of emigrants	Migration balance	Migration turnover	Migration efficiency
		Total in the years 2000–2010				
1	Germany	2,535	8,761	-6,226	11,296	-0.55
2	United States of America	2,424	1,040	1,384	3,464	0.40
3	Canada	471	413	58	884	0.07
4	United Kingdom	390	150	240	540	0.44
5	France	315	130	185	445	0.42
6	Australia	239	159	80	398	0.20
7	Sweden	170	128	42	298	0.14
8	Ukraine	235	15	220	250	0.88
9	Austria	125	86	39	211	0.18
10	Kazakhstan	193	3	190	196	0.97
11	Italy	132	53	79	185	0.43
12	Russia	87	26	61	113	0.54
13	Belgium	71	26	45	97	0.46
14	Israel	51	8	43	59	0.73
15	Belarus	48	2	46	50	0.92

Source: own work based on data from Statistics Poland.

5.2. Immigration

In the period of 2000–2005, Polish pensioners came back mainly from the United States (1,200) and Germany (1,100). More than 200 people returned from the United Kingdom and Canada. A significant number of seniors returned from Kazakhstan and Ukraine (100 respectively). Returns have been mainly the consequence of previous migrations for economic reasons. The Poles migrated to the United States and Germany in order to improve their financial situations, and having reached their retirement age they came back to Poland with foreign pensions.

The situation in Ukraine and Kazakhstan is different. Immigration procedures particularly from Kazakhstan have always been difficult, and the waiting time for the return may even reach 10 years. The reason for that dates back to the times of the Polish-Russian war of 1920 when there were approximately 1.3 million Poles in the Soviet Union. They lived in the vicinity of Minsk, in Podole and Volhynia. In places where the Polish population dominated, two autonomous districts were established. When Stalin came into power, the Soviet Union commenced the so-called Polish Operation. As a result, 111,000 Poles were executed in the Soviet Union and over 60,000 were exiled far to forced labour camps. The Poles residing in Ukraine before the executions of 1937–1938, as well as at that time, were relocated to Kazakhstan during the "clearing" of the border zone along the river Zbrucz. After the war, only the exiles deported to Kazakhstan from the outskirts of Poland which had been occupied by Russia in the period of 1940–1941, and having Polish citizenship, returned to their homeland. The Poles deported from the Soviet Ukraine did not have the right to the so-called repatriation. Before the First World War they were Russian citizens and after the truce with Bolsheviks they were registered as Soviet citizens. For that reason they were not allowed to come back to Poland as repatriates after the war. Therefore, according to the present Polish law, they are foreigners who have to undergo the whole procedure of applying for visas to enter Poland.

In the second sub-period, i.e. 2006–2010, there was an increase in the number of migrants returning from Germany, which totalled 1400 in total. The number of migrants returning from the United States dropped slightly – to just over 1,100 people. There occurred a significantly lower inflow of people from Canada (300), France (200), or the United Kingdom (100).

5.3. Emigration

Having retired, Polish seniors mostly preferred Germany. In the period of 2000–2005, Germany was the destination of migrations for up to 4,700 pensioners. This country significantly dominated over other destinations: the United States was chosen by slightly more than 300 people, and Canada by less than 200 Polish citizens.

In the period of 2006–2010 as in the first 5 years of the new millennium, emigration to Germany was the highest and it totalled almost 4,100 migrants. Em-

igration to the United States increased significantly (700). The number of Poles moving to Canada exceeded 200 people. As far as the selection of North American countries is concerned, it is easier for pensioners to obtain visas and their command of English has continued to improve.

It should be emphasised that the outflow of pensioners from Poland to Germany was above the average throughout the whole studied period. It was conditioned by numerous reasons, especially close proximity and high standards of living. The availability of work was also important. The opportunity to receive a German pension – especially for very young pensioners – was an additional advantage. Having worked in Germany for five years and having reached the retirement age, one could apply for a basic pension. Miners were the group which frequently used this benefit. The emigration of pensioners to Germany in the period of 2006–2010 dominated in gminas of Śląskie and Opolskie Voivodeships (NUTS2 level of regions). According to Pytel (2017), people migrated mainly from such cities as: Ruda Śląska, Zabrze, Bytom, Piekary Śląskie, Katowice, and Gliwice. Miners migrating to Germany after their retirement, after finishing their work and reaching pension age received both Polish and German retirement pensions.

As for the migration balance, in the years 2000–2010 its highest values resulted from the migration of seniors to and from Germany (-6,200 people in total). However, cyclically, more pensioners have continued to leave for Germany than come to Poland. It is conditioned by the possibility of young pensioners to work in Germany as caregivers for children or elderly people.

The remaining countries listed in Table 1 recorded positive total values of the migration balance. The leader is the United States – 1,400 people, with migration turnover over 3 times lower than in Germany (3,500). Over 2,400 seniors returned to Poland after reaching the retirement age.

Other countries with high values of the migration balance and with a very low outflow are Ukraine and Kazakhstan. Such an outflow is a consequence of difficult living conditions in these countries.

The migration efficiency ratio for Germany (-0.55) indicates that migration flows are efficient and the surplus outflow from Poland dominates over the inflow. Very effective migration movements of pensioners were observed in Kazakhstan (0.97), Belarus (0.92) and Ukraine (0.88). For these countries, an excess inflow over the outflow constitutes a significant part of all migration flows. The least effective migration movements were observed for Canada (0.07), Sweden (0.14), and Austria (0.18).

5.4. Intensity of pensioners' migration

Research on external migration conducted over a longer period of time (1995–2018) enables one to notice that the inflow of migrant pensioners to Poland in 1995–2000 remained at a steady level (0.15 per 1,000 people in the post-working

age) – (Fig. 1). Since 2000, immigration slowed down to reach the lowest level in the whole period in 2016 (0.08 per 1,000 people in the post-working age). Then, an increase of this indicator was observed to 0.11 per 1,000 people in the post-working age in 2018. The situation was due to the fact that living conditions in Poland had become good and stable enough and hence seniors began to return to the country after having achieved an adequate material status.

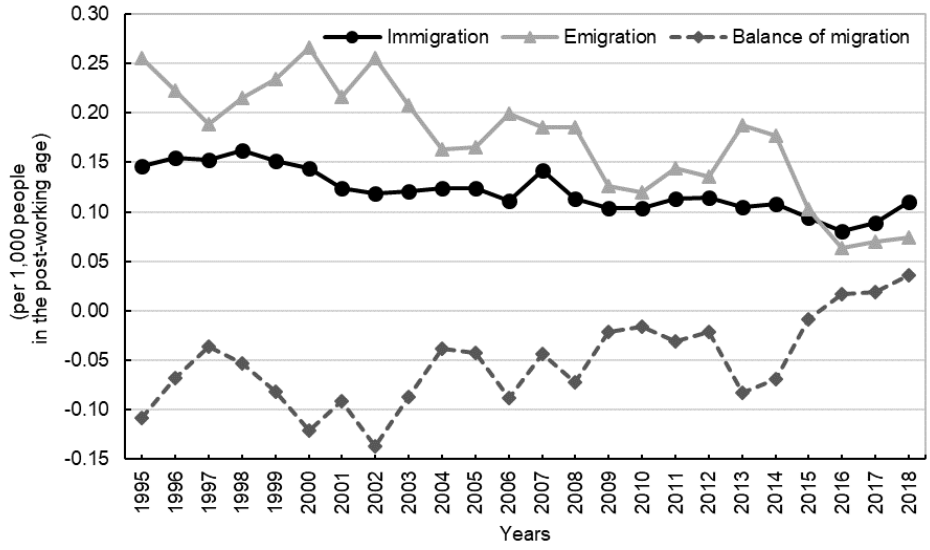

Fig. 1. The inflow, outflow and balance of migration of Polish pensioners per 1,000 people in the post-working age in the years 1995–2018

Source: own work based on data from Statistics Poland.

The process of foreign migration of Polish seniors had a varied course, but showed a visible downward trend. It reached its highest value (0.27 per 1,000 people in the post-working age) in 2000. A very similar level was recorded in 2002. In turn, the years 2016–2018 were the time when the migration outflow became lower than the inflow, amounting on average to 0.07 per 1,000 people in the post-working age.

In Poland, traveling abroad was significantly hindered until the early 1990s. It concerned not only emigration for work, but also tourist movements. When the situation changed and travelling opportunities appeared, young Poles as well as a large group of seniors went abroad in order to search for better sources of income. Pensioners – similarly to young people – engaged in work abroad, especially those who retired at the age of 50 or more, working in professions that enabled such a transition.

For 20 years, from 1995 to 2015 to be more precise, the balance of foreign migration was negative. Its maximum negative level occurred in 2002 and amount-

ed to -0.13 per 1,000 people in the post-working age. This indicates that Polish pensioners eagerly chose to live abroad. However, this was not dictated by the intention to improve health or climate conditions, as in other Western European countries, but to a large extent by a desire to improve economic status. Yet the activity on foreign labour markets was not the only reason for leaving. Seniors often joined their children, who had emigrated earlier, to look after their grandchildren. It is worth adding that in the years 2016–2018 the figures of migration balance were positive and even increasing, with the peek reached in the final year. This may be a sign of an improving standard of living in Poland, which encourages seniors to return to their homeland.

Scale plays an important role in the phenomenon of migration. Compared to other age groups, the pensioners seem not to play a large part in it. From 1995 to 2003, the share of seniors' immigration in the total immigration in Poland was on 11.8% average, not falling below 11.0% in particular years (Table 2). At that time, the highest percentage of pensioners arriving in the country was recorded, i.e. 12.8% in 1999 and it remained at a similar level until 2001. Since 2004, the share of people at the post-working age in the total number of immigrants decreased from a share of 8.6% and in 2009 it reached its lowest value within the entire 24-year period (4.4%). In the next sub-period the analysed value fluctuated between 5.1% (2010) and 7.5% (2014), and in 2018 it reached 6.8%. As far as emigration was concerned, the situation was completely different. In the years 1995–2018, the share of senior emigration in the total emigration in Poland averaged at 5.4%, and its peak (6.9%) was observed – similarly to that of immigration – in the final year of the 20th century. The stage of pensioners' emigration being close to the peak scale (at least 6.0% of the total) existed until 2003 and was observed again only in 2018. In 2006, the lowest level of this migration parameter was recorded (2.8%).

Table 2. Migrations of the pensioners and of the people of all ages in Poland in the years 1995–2018

Years	People in total			People in the post-working age		
	Immigration	Emigration	Balance of migration	Immigration	Emigration	Balance of migration
1995	8,121	26,344	-18,223	897	1,563	-666
1996	8,186	21,297	-13,111	959	1,380	-421
1997	8,426	20,222	-11,796	954	1,180	-226
1998	8,916	22,177	-13,261	1,025	1,359	-334
1999	7,525	21,536	-14,011	965	1,487	-522
2000	7,331	26,999	-19,668	927	1,706	-779
2001	6,625	23,368	-16,743	802	1,394	-592
2002	6,587	24,532	-17,945	769	1,653	-884

Years	People in total			People in the post-working age		
	Immigration	Emigration	Balance of migration	Immigration	Emigration	Balance of migration
2003	7,048	20,813	-13,765	785	1,348	-563
2004	9,495	18,877	-9,382	812	1,062	-250
2005	9,364	22,242	-12,878	810	1,087	-277
2006	10,802	46,936	-36,134	747	1,336	-589
2007	14,995	35,480	-20,485	976	1,273	-297
2008	15,275	30,140	-14,865	804	1,315	-511
2009	17,424	18,620	-1,196	759	917	-158
2010	15,246	17,360	-2,114	783	902	-119
2011	15,524	19,858	-4,334	882	1,124	-242
2012	14,583	21,200	-6,617	918	1,088	-170
2013	12,199	32,103	-19,904	868	1,553	-685
2014	12,330	28,080	-15,750	921	1,515	-594
2015	12,903	20,025	-7,123	826	902	-76
2016	13,475	11,970	1,505	732	576	156
2017	13,324	11,888	1,436	825	648	177
2018	15,461	11,849	3,612	1,044	707	337
Total	271,165	553,916	-282,752	20,790	29,075	-8,285

Source: own work based on data from Statistics Poland.

6. CONCLUSIONS

Migrations of pensioners exist in all regions of the world. Research shows that during the first years after retirement migrations are mainly affected by a search for a better standard of living, and then deterioration of health and the death of a spouse. Migrations of pensioners are also influenced by other conditions, i.e. environmental, health or even marital considerations. Interestingly, seniors migrate to benefit from better tax systems abroad. As the analyses have shown, the special advantage for immigrant/pensioners is the climate of a location. Moreover, seniors are attracted by appropriate infrastructure and relatively low costs of living and accommodation. The migrations of pensioners to foreign enclaves are triggered by tourism which, in turn, is supported by international transport opportunities. Most pensioners from Northern Europe move to the south of Europe (Costa del Sol, Tuscany, Algarve) initially treating the region as a place to spend their holidays. Similarly, in other regions of the world, i.e. in North America or South-East Asia,

the climate, low costs of living and well-developed infrastructure attract migrants from different – also highly-developed – countries. Migrations are facilitated by the fact that these societies can afford to purchase property abroad.

The migrations of a vast majority of Polish pensioners have been caused by economic reasons and a search for new jobs, and the main destination countries have included Germany, the United States, and Canada. Migrations of Polish seniors differ considerably from migrations of the retired people from other countries with similar levels of socio-economic development. Still many seniors living in Poland do not decide to live abroad as often as their counterparts from other nations due to economic conditions or inability to speak foreign languages. It is also affected by the Polish model of a multi-generation extended family in which seniors help their children in raising their children. Psychological barriers also constitute an obstacle due to the fact that for elderly people moving abroad is considered as a beginning of a completely new phase of life. Based on the studies of migrations of seniors in Western Europe, Polish pensioners should also be expected to migrate abroad in greater numbers in the future to find better living conditions.

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THE INFLUENCE OF LAND COVER ON THE SPATIAL DISTRIBUTION OF FIRE SITES: A CASE STUDY OF ŁÓDZKIE VOIVODESHIP, POLAND

Abstract. The paper continues from previous joint studies and their practical application at the confluence of human geography, safety-related research and Geographic Information Systems (GIS). The objective of the study was to identify the land cover types most at risk from fire. The study has contributed an original angle by taking into account various land cover types with a potential influence on the distribution of fires geocoded at the address level. The analysis considered 27,651 fire interventions, as recorded by the Polish State Fire Service between 2014 and 2016 in the country's central region known as Łódzkie Voivodeship. The main methods employed include various GIS tools, including Voronoi tessellation (to identify the areas most at risk of fire) and the fire location quotient (FLQ, a measure of the colocation between the number of fires and land cover). The most important conclusion is that of all the land cover types considered in the study, the built-up area type, especially the multi-family residential and retail and service area subtypes, was virtually the only one with a strong influence on the location of fires. The fire high-risk areas (FH-RA) identified here were primarily limited to urban areas.

Key words: fire incident, GIS**,** land cover, fire high-risk area, fire location quotient, Łódzkie Voivodeship.

1. INTRODUCTION. THEORETICAL AND EMPIRICAL BACKGROUND

Over the millennia, fire has accompanied mankind in its rise to civilisation. When tamed, it offered advantages, but uncontrolled and wild it brought calamity, tragedy and defeat. Fire can ravage vast areas, ruin settlements, and turn crops and forests into ashes. Losses of this kind cannot be fully expressed in any currency or the numbers of dead and injured. They can be minimised only if adequately

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equipped and trained fire services respond quickly to fire incidents. Optimisation of the response time and of the efficient deployment of resources demands an accurate identification of the needs in terms of the distribution and operating range of fire service units, which can be obtained through complex analyses performed by local authorities and the fire-service command structures.

The spatial dimension of the distribution and conditions for fire interventions is the subject of research at various spatial scales ranging from national (Eswatini – Dlamini, 2011; New Zealand, UK – Moffat and Pearce, 2013; Poland – Woźniak, 2014), through regional (Espirito Santo – Eugenio *et al.*, 2016; Dalmatia – Jajtić *et al.*, 2019; Mazovia – Kozioł, 2019), areas and districts (West Midlands – Hastie and Searle, 2016; Bodrum – Akay and Sahin, 2019), individual cities or towns (Toronto – Asgary *et al.*, 2010; Warsaw – Mazur, 2014; Vilnius – Vasiliauskas and Beconytė, 2015; Yichun – Guo *et al.*, 2017; Nanjing – Xia *et al.*, 2019), and, finally, to a micro scale of just several buildings (in Jos, Nigeria – Nimlyat *et al.*, 2017). In general, such studies can be divided into those focusing on inhabited areas and those focusing on forest areas.

An example of the application of GIS and remote sensing methods in the analysis of the distribution and causes of fires is a study of the African state of Eswatini (Dlamini, 2011). The author studied the interrelations between a range of factors with a potential impact on the location of fires and their real distribution. He considered altitude above sea level, angle of slope, average annual rainfall, average annual temperature, relative humidity, land ownership, soil category, population density, road density, distance from buildings, presence or absence of domestic animals, and land cover. Dlamini then assessed the fire risk across the country and his resulting map achieved satisfactory levels of similarity when compared with the actual distribution of fires. The author has concluded that land cover has a significant influence on fire risk.

Mazur and Kwasiborski (2013) analysed the distribution of selected detailed characteristics of fires in Poland from reports covering the period 2007–2012. The detailed specifications considered included: the overall number of fires and the number of people affected, both overall and by type of item on fire. The analysis yielded an assessment of the safety and types of items with the highest levels of fire risk. Apparently, as the number of fires reported in this period increased, the number of injured and dead per fire decreased. The highest ratios of victims, both injured and casualties, per fire were reported for residential buildings, which was the third most frequently affected type, after fires in agriculture and transport.

Subject literature often includes a discussion about fire risk assessment in urban areas[1]. Authors tend to consider two main issues: i) how to identify urban areas with a high fire risk/likelihood (Mazur, 2014), or ii) which characteristics of an urban environment are most associated with a fire risk (Jennings, 2013; Vasi-

[1] Fire risk is understood as the likelihood or forecasted frequency of occurrence of fires in a given area.

liauskas and Beconytė, 2015). In general, earlier research suggested that the main factors determining the number of fires in urban areas were the social, economic and environmental characteristics of the local community. It was only in the early 21st century, as GIS techniques became sufficiently popular, that researchers also noted other important variables of fire risk. Jennings (2013) offered a review of literature focusing on fire risk factors in US residential areas. He used the review to build a conceptual model of fire risk. According to this model, a fire can be caused by internal factors (inherent in the nature of a given dwelling) or external factors (the physical environment and weather conditions, the character of a neighbourhood, and individual behaviour). The main components of the model included: dwelling characteristics (dwelling materials, structure, age, equipment, content, and electrical fittings); physical environment (setting, vegetation cover, and topography); weather conditions (temperature, wind speed, rainfall/snowfall, and humidity); neighbourhood characteristics (demography, socio-economic status, and cultural practices) and individual behaviour (perception/attitude, values and beliefs, socio-economic status, and cultural background). Other factors with a lesser influence on fire risk included calendar events or group behaviour (family lifecycle, household size, and household composition). The fire risk factors included in this model were successfully tested by the British researchers Hastie and Searle (2016). They focused on analysing the socio-economic and demographic factors correlated with accidental residential fires. The study confirmed that the ethnic structure of a given area (particularly the proportion of Black African-Caribbean residents), and economic deprivation (most notably the levels of wordlessness) are strong indicators of areas with a frequent incidence of fire.

Asgary *et al.* (2010) published a spatio-temporal analysis of fires in Toronto. He found that fires were the most frequent in the downtown area and along the main streets where city life was at its most intense (and many fires were due to arson). Outside the downtown, fires tended to erupt in lower income areas. The least fires were reported in areas with low population density, with modern houses and with higher incomes. The city centre was also identified as the peak fire area in Warsaw (Poland) by Mazur (2014) and by Mazur and Guzewski (2014). Fire hot spot areas, identified using the kernel density estimation method, were found to coincide with the most densely developed areas. The authors also established that the number one cause of fires in Warsaw was the human factor (73%). Arson (35%) and the careless handling of open fires by adults (15%) were followed by technical causes (electrical wiring and appliances, and solid-fuel fired heating at 11%). A study of the city of Jos in Nigeria found that the number one cause of fires in high-rise buildings was electrical faults (Nimlyat *et al.*, 2017). Hence they recommended that designers and property owners should equip buildings with fire safety measures. These measures should be present, adequate and in locations well known and visible to the inhabitants. In another study, Holborn *et al.* (2003) concluded that of all the occasional fires reported in London (1996–2000), a half

(47%) started with a cigarette or a cigar (followed by kitchen appliances at 14%); more than a half of the deaths due to fire applied to people aged 60 or more; the most occasional fires started in the lounge or drawing room (33%), followed by the bathroom (29%) and the kitchen (20%).

Xia *et al.* (2019) used local and global colocation pattern measures to identify the most fire-prone region in Nanjing (China) where fire sites clearly tended to concentrate in certain areas. The study demonstrated that different urban land uses were linked with different types of fire incidents. For example, the incidence of dwelling fires was strongly correlated with the presence of residential areas, while non-residential buildings caught fire most frequently if they adjoined entertainment sites, and vehicle fires occurred in downtown commercial districts.

Forest fires are less frequent than urban incidents, but when they emerge, they can grow considerably. Indeed, to a firefighter a forest is a large stock of fuel. Forest fires also cause long-lasting changes in the ecosystem as forests take much longer to recover than human settlements. For these reasons, forest monitoring and rapid reaction to incidents is a very important objective for fire services. This paper uses the Brazilian state of Espírito Santo to discuss the development of a model for mapping forest fire risk (Eugenio *et al.*, 2016). Maps of this type are among the most important environmental protection instruments. The GIS-based model weighted two types of characteristics: physical (e.g. slope angle, land cover, and proximity of road infrastructure) and climatic (e.g. precipitation, temperature, water deficit, and evaporation). The resulting map divided the whole area into five risk levels: low, medium, high, very high, and extreme. Using this approach and other studies, fire hazard factors in forests can be divided into four groups: stand/vegetation structure, topographic factors, proximity/distance to … (e.g. residential area, roads, water bodies), and climatic factors (Paysen *et al.*, 2000; Moffat and Pearce, 2013; Akay and Erdogan, 2017; Guo *et al.*, 2017; Akay and Sahin, 2019; Schaefer and Magi, 2019; Feurdean *et al.*, 2020). Population density is also considered to help assess transitional zones where residential development mixes with forests (Guo *et al.*, 2017). Among the factors associated with stand structure, the following are considered important: tree species, crown closure, and tree stage. Other groups of factors include: topographic factors, such as ground slope, aspect (as a function of humidity and temperature), and elevation; climatic factors, including temperature, humidity, precipitation, and wind; and, finally, proximity to roads, railways, settlements, and water resources. There are also the kinds of circumstances that impact the fire risk in forests and are modified by seasons, days of the week, time of day, remaining weather conditions, or human presence or lack thereof in the forest (Feurdean *et al.*, 2020). Researchers assign a different weighting to each factor depending on the area of study. Akay and Sahin (2019), for instance, selected tree species, tree stage and water resources as the most important variables in the Bodrum province, Turkey. Yichun, in turn, selected ground slope, elevation, distance from a railway, water resources, and humidity in the Chinese study (Guo *et al.*, 2017).

A separate category of firefighting-related papers, interesting from the geographer's perspective, considers the deployment of fire fighting services. Fairness and efficiency are the two main criteria that tend to be used in determining the location for new fire stations (FS) or in evaluating existing FS networks. Fairness requires that the same level of protection be provided to everyone, while efficiency prioritises the most efficient ways of distributing the available hardware and personnel resources. A frequent measure of the efficiency and effectiveness of fire fighting services is their response time (from receiving a fire incident report to arriving on the site of the fire) which can minimise the risk to life, health and property. In their study of the optimal FS location in China, Zhang and Jiang (2011) indicated the optimal fire-service response time at 5 minutes. A similar result was obtained by Yang *et al.* (2001) for Derbyshire (UK) as the response time varied depending on the fire risk category between 4–5 minutes for high-risk incidents and 10–20 minutes for low risk fires.

Various researchers build functional and optimisation models of FS distribution. For instance, Huang *et al.* (2005), Yang *et al.* (2007), and Zhang and Jiang (2011) have built their models by stressing the need to minimise the travel time from an FS to an accident site, maximise service coverage, distance balancing (distribution of FSs), minimise the overlap of FS service areas, minimise the distance between an FS and an accident site, minimise the total setup costs of an FS, and minimise associated costs. They did not, however, consider such objectives as, for example: determining a reasonable number of FSs, minimising the distance between an FS and high-risk areas, maximising the service for high-risk areas (Erden and Coşkun, 2010) in identifying the location.

In this study we undertook to understand the spatial relationships between the distribution of fires and land cover types using the colocation indicator (fire location quotient, FLQ). To derive spatial colocation patterns, we studied the distribution of fire sites classified under three size groups versus 16 land cover types and subtypes. The study used this distribution of fire sites to identify an area with the highest fire risk and this area was further researched using FLQ.

2. THE DATA AND METHODS

2.1. Data

For the purpose of this study, two types of data and information were gathered about fire interventions and about the land cover in the Łódzkie Voivodeship (region) in central Poland. The fire intervention data, spanning 2014–2016, was released by the Regional HQ of the State Fire Service (Komenda Wojewódzka

Państwowej Straży Pożarnej) in the city of Łódź. The information was compiled by the Operational Department of the Fire Service and exported from the Command Support System ST[2] (SWD-ST) database into a spreadsheet. The details contained therein included: the time of incoming report, unit ID, fire type, geographic latitude and longitude, number of crews, damage, and the address and type of property affected. The Fire Service only started gathering fire intervention data in the system in 2014 and this is the reason for selecting the 2014–2016 for the study. The breakdown of the information contained in the system is shown in Table 1.

The type of fire data obtained for the Łódzkie Voivodeship posed two problems. The first was the need to convert geographical coordinates into the GPS – WGS 84 (code 4326) system and then to export the point layer in the .shp format arranged in the PUWG 92, CS92 (code 2180) structure. Apparently due to inaccuracies in the original recording of the coordinates the resulting approximate locations of the fire sites were not entirely precise. Indeed, the rounding of seconds in coordinate data shifted locations by between ten and several tens of metres away from actual addresses, if an address was even available in the first place. Indeed, the address data was also lacking in terms of accuracy and sometimes missing altogether, which forced the authors to limit themselves in identifying fire site locations to just providing converted geographical coordinates.

When a total of 27,651 incidents were geocoded, 142 (0.51%) 'fell outside' of the voivodeship borders. All of these fortunately had accurate addresses and could be brought back in. Additionally, of the 76 interventions that 'fell out' of their district boundaries, 62% could be restored to the right locations. A certain degree, probably a minor one, of location error should be expected in any further analysis of the point data for fire interventions.

There is an interesting research project involving a breakdown of the sites affected by fire into eight categories that are proposed in the Operating manual (*Podręcznik użytkownika Systemu…*(2014)) used in operating the SWD-ST database. The author, however, has not succeeded in obtaining access to the categorisation, and the actual database only featured descriptive characteristics of these sites. Appealing as an analysis of this categorisation would have been, the sheer volume of records that would have to be processed manually forced the author not to pursue this line of action.

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[2] Command Support System ST (SWD-ST) is an Oracle-based IT system. It contains information about incidents, time, space and statistical data on the resources and personnel used, the type and causes of the intervention, and its results. The system is used to exchange information between PSP (State Fire Service) units and with the external world. It supports the handling of cases in real time and the application of personnel and equipment of both the professional and volunteer fire units (*Podręcznik użytkownika Systemu…*, 2014).

Table 1. Scheme for a fire intervention database provided by the Regional Headquarters of the State Fire Service (KW PSP)

Field	Description
Code	- Unique variable identifying the incident
Incident reporting time	- dd-mm-yyyy hh:mm:ss, - Automatically generated by the system upon the first saving of the incident file
Unit	- Main unit responsible for the incident
Type	- Selected from: fire, local threat, false alarm
Size	- P/M – small fire (destruction or burning down of items such as: movable items, storage sites, machines and equipment up to 70 sq. m or 350 cubic m, forests, crops, grasses, peat bogs or idle land up to 1 ha), - P/Ś – medium-size fire (affecting items with an area from 71 sq. m to 300 sq. m, and volume from 351 cubic m to 1,500 cubic m, or areas with a size from 1 ha to 10 ha; intervention involving simultaneous deployment of 5–12 streams*), - P/D – large-size fire (affecting items with a square area from 301 sq. m to 1,000 sq. m or volume from 1,501 cubic m to 5,000 cubic m, or areas from 10 ha to 100 ha; the intervention involving simultaneous deployment of 13–36 streams*), - P/BD – very large-size fire (affecting items with larger square areas or volumes or involved simultaneous deployment of 37 or more streams*; environmental catastrophe).
Longitude	- DMS format: degrees, minutes, seconds
Latitude	
Crews	- Number of crews present at the intervention site, - A crew is formed by three to six firemen, including the chief, and is equipped with an engine relevant to the task
Damage [thousand PLN]	- Estimated damage
Town	- Details of the town, street and building/apartment number of the incident, if available.
Street	
Building/apartment No.	
Object	- Descriptive value

* fire-fighting agent (typically water) leaving the nozzle in concentrated, dispersed or mist form

Source: own work.

A range of sources was used to obtain the spatial data. For example, the voivodeship road network was downloaded from the resources of the OpenStreetMap

service under the Open Database License (OSM), while the official administrative boundaries and the topographical site database BDOO10k for the Łódzkie Voivodeship were downloaded from the website of the Head Office of Geodesy and Cartography (GUGiK). The topographical site database was reorganised for the purposes of this study by selecting only the most relevant land cover types, summarised in Table 2 and Fig. 2.

Table 2. Land cover in Łódzkie Voivodeship in 2015 (BDOO10k), classified into major land-cover types

Land cover	Area	
	km²	Voivodeship = 100
Built-up area	1 519.2	8.3
Single-family housing	1 386.2	7.6
Multi-family housing	51.4	0.3
Commercial and services area	3.0	0.0
Industrial and warehouse zones	48.9	0.3
Remaining	29.7	0.2
Arable land and grassland	11 447.9	62.9
Arable land	8 281.5	45.5
Grassland	3 166.4	17.4
Permanent cultures	338.9	1.9
Orchard	310.5	1.7
Plantations	21.7	0.1
Allotment gardens	6.0	0.0
Seedbeds	0.8	0.0
Forestry area	4 723.9	26.0
Remaining area	164.5	0.9
Łódzkie Voivodeship	18 194.4	100.0

Source: own work based on the data of the GUGiK.

For various reasons, a number of otherwise significant land cover types are missing from the selection adopted and these have been grouped together as the remaining area. They include water bodies, landfill sites, mines, dumps, construction sites, unused land (omitted mainly due to their small size or negligible importance from the fire-fighting perspective), or road and rail networks and associated land (omitted due to their linear nature and the geocoding precision issues mentioned above).

2.2. The methods

The literature reports a number of methods of statistical and spatial analysis that have been used to identify areas susceptible to fire incidents. The simplest of these employ the weighting of threats, such as the one proposed by Eugenio *et al.* (2016), and Kozioł (2019). The spread of GIS techniques has made it easier to apply more advanced methods and indicators (Corcoran *et al.*, 2007), such as the analytic hierarchy process AHP (Habibi *et al.*, 2008; Erden and Coşkun 2010; Akay, Erdogan, 2017; Akay, Sahin, 2019), kernel density estimation, KDE (Corcoran *et al.*, 2007; Asgary *et al.*, 2010; Mazur, 2014), geographically weighted logistic regression (Guo *et al.*, 2017), multiple regression (Shai, 2006), and colocation quotient (Xia *et al.*, 2019). These studies employ a variety of factors and circumstances influencing the potential occurrence and spread of fires. Only a few studies have restricted themselves to simply considering at the actual sites of fires.

This study identifies fire high-risk areas (FH-RA) solely on the basis of the sites of actual fires of various sizes. The author has assumed that weighting alone would have made it difficult to authoritatively determine the difference in the degree of danger between fires classified by the State Fire Service as very large and small. For this reason, the analysis started by determining three different hot spots for each of the three fire size groups: small, medium, and large/very large. These three areas were then overlaid and the part of the area that was common to all three represented the output fire high-risk area (FH-RA). Three fire high-risk areas were obtained generating Voronoi tessellations. The authors assumed that small-size Voronoi polygons developed in areas with high fire incidence and, therefore, small-size polygons identified fire hot spots. A threshold was adopted for the three fire size groups, below which a Voronoi polygon would be classified as small. The threshold value was derived using the Jenks natural breaks classification method. The overlap of the three fire size groups, and the outcome in the form of an identified fire high-risk area (FH-RA), is shown on Fig. 5. Voronoi polygons are widely used in solving spatial optimisation problems, especially in the identification of the reach of various services, such as emergency management, public service facilities, electric vehicle charging stations, and the middle school service (Lee and Lee, 2009; Zhu *et al.*, 2008; Qiao *et al.*, 2018; Wang and Kwan, 2018).

Colocations between the land cover types and the number of fire incidents were assessed using the fire location quotient (FLQ). A conceptual outline of its application to the analysis of crime distribution determinants was proposed by Sypion-Dutkowska and Leintner (2017). In spatial analysis literature, this method is reported under several variants and names (Isard, *et al.*, 1962, p. 123; Kostrubiec, 1972, p. 21; Runge, 2006, p. 322; Suchecki, 2010). FLQ follows the formula:

$$FLQ_s^t = \frac{\frac{NF_s^t}{A^t}}{\frac{NF_s}{A}}$$

where: FLQ_s^t – the FLQ for fire size *s* and land cover type *t*; NF_s^t – the number of incidents for fire size *s* within the area of land cover type (or sub-type) *t*; A^t – the area of land cover type (or sub-type) *t*; NF_s – the number of incidents for fire size *s* within the total area; A – the total area; T – defines the 16 land cover types and sub-types (*t* = 1–16); S – defines the number of fires in total and the three individual fire sizes (*s* = 1–3).

The FLQ determined for land cover forms and fire size groups reveals the strength and direction of the relationships linking two values. At the centre of the strength spectrum, the value of one denotes a lack or balance of influence. From this value upwards the strength of a colocation increases while from one towards zero repulsion grows. The general scheme of the methodological approach to this work is presented in Fig. 1.

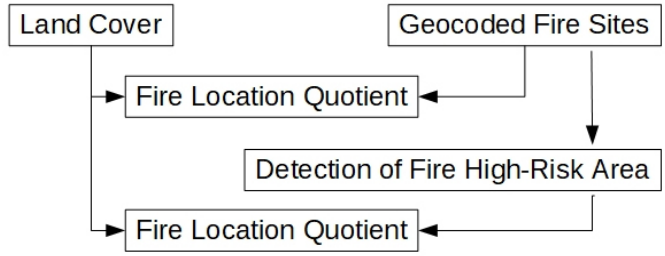


Fig. 1. Scheme of methodological approach

Source: own work.

The density of fire interventions in this study is shown using kernel density estimation (KDE). KDE produces an easily interpreted quasi-continuous fire density surface and its highest intensity identifies the fire hot spots. In this particular case, KDE provided a detailed spatial distribution of the phenomenon being studied and its concentrations. Moreover, thanks to the small grid cell size the reference surfaces offer a better alignment with the actual fire site distribution offering a good level of accuracy in the estimation of hot spots. The technique has a very strong statistical foundation and is highly modifiable, as it allows the selection of dedicated sets of parameters. This study followed the approach proposed by Hart and Zandbergen (2014) and used the following measures: density function/interpolation method – triangular, function reach/bandwidth – fixed, value: 10 km.

3. ORGANISATION OF THE FIRE SERVICE IN POLAND. THE CASE STUDY AREA

The Polish National Firefighting and Rescue System (KSRG) was established in 1995 as an integral part of the country's internal security organisation. KSRG's mission is to protect human life and health, property, and the environment, which the service does by combating fires and other localised threats and by working with medical, technical, chemical, and environmental units of the rescue system (Official Journal of 1991 No. 81 Item 351). The KSRG comprises rescue and auxiliary bodies from the State Fire Service (PSP), the Voluntary Fire Service (OSP; 4306 units in 2016) and industrial, airport, and military fire protection units (15). PSP, at its basic level, consists of Firefighting and Rescue Units (JRG; 496 units in 2016) equipped with resources to independently perform rescue missions. KSRG consisted of approximately 30,000 career PSP firefighters; more than 140,000 OSP rescuers aged 18–65 years, with more than 9000 fire fighting vehicles; and 518 rescuers with 80 various type vehicles in other fire protection units.

Łódzkie Voivodeship (NUTS 2 under EU terminology) was selected for a detailed analysis of the distribution of fire call-outs. This centrally located voivodeship occupies an area of 18,200 square kilometres (i.e. 5.8% of Poland's territory) and has a population of 2.49 million (6.4% of the overall population). Its capital and the largest city is Łódź with approximately 700,000 inhabitants. During the period 2014–2016, the Łódzkie Voivodeship accounted for 7.3% of the national firefighting and rescue incidents (i.e. fires, local emergencies and false alarms), including 6.1% of all fires reported in Poland.

In 2016, the regional PSP structures in the voivodeship included: the regional headquarters, 22 district (municipal) headquarters and 34 JRG units (including 26 with more than 36 FTEs and 8 smaller ones) (Fig. 2). The PSP had 2,229 career firefighters. Beyond PSP, KSRG included 326 OSP units (plus 1,132 smaller and less well equipped OSP units outside KSRG) (all data: *Information Bulletin*… 2017). The largest concentration of units belonging to KSRG is found in the centre of the voivodeship, while units located in the northern and south-eastern parts are fewer and have larger service areas. The legally prescribed arrival time for rescuers in the system is between 8 and 15 minutes (Regulation of the Ministry of the Interior, *Rozporządzenie Ministra Spraw …*, 2011) and when this is impossible, the mobilisation of additional OSP units in the system should be considered.

Aside from the main line of research, the authors also analysed the arrival time of KSRG units to the various parts of the voivodeship. The highlights of these efforts, if not a detailed report, may be interesting here. KSRG units have been found to be able to reach just 49% of the voivodeship's territory (as calculated using parameters developed by Mazur *et al.*, 2015) in the prescribed time of 15 minutes (including 22% in up to 8 minutes and 27% in 8 to 15 minutes). These

time accessibility values varied between locations and were found to be highest in the western and central parts of the voivodeship and to diminish outwards from these areas in the direction of the voivodeship boundaries, as well as south-eastwards where the value reached its lowest point. While only less than a half of the territory could be served within the maximum time of 15 minutes, this appeared better in terms of the population. The study has calculated that areas inhabited by 73% of the population could be reached by KSRG fire-fighting units in that maximum time.

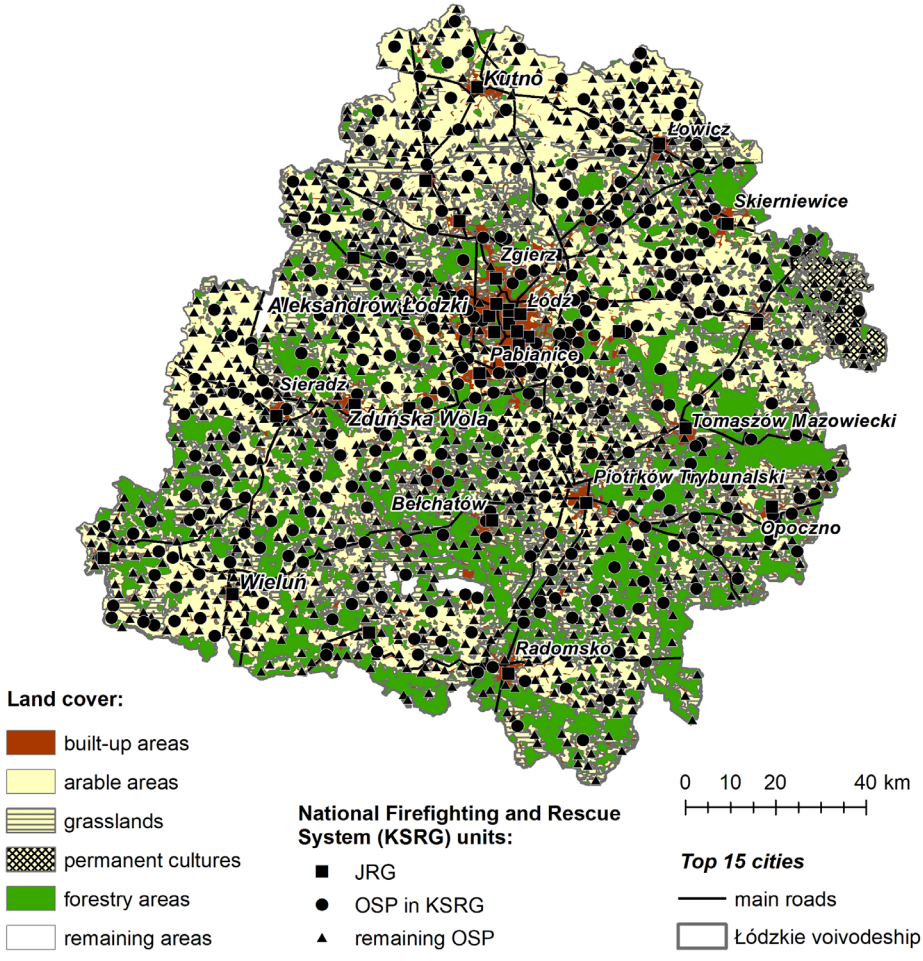


Fig. 2. Łódź voivodeship – the study area

Source: own work.

Arable land and grasslands dominate the overall land cover composition of the voivodeship. When permanent cultures are added (Tab. 2, Fig. 2), the three types account for nearly 2/3 of the territory of the voivodeship. The next important land cover type is forests, accounting for 26% of the territory. Built-up areas cover just 8.3% of the voivodeship area and consist of housing areas (7.9%), industrial and warehouse zones (0.3%), and commercial and services areas. According to numerous researchers from various parts of the world, it is the built-up area type that is regarded as the most at risk of fire (Asgary *et al.*, 2010; Haas *et al.*, 2013; Scott *et al.*, 2013; Mazur, 2014).

4. THE RESULTS

4.1. Distribution of fire sites

The analysis of the distribution of fire sites in the Łódzkie Voivodeship was based on data provided by the Regional HQ of the State Fire Service in Łódź. Over the three-year period spanning 2014–2016, there were 27,651 fire interventions, including 11,420 in 2015 (more than 41%), followed by 8,768 in 2014 (32%) and 7,463 in 2016 (27%). In relative terms this means that during the study period there were on average 1.5 fire incidents per square kilometre, or 0.5 fire incidents per square kilometre per annum.

Fire-fighting units were engaged throughout the study area and across the time accessibility spectrum (distribution shown in Fig. 2). It appeared, however, that there was a positive correlation between the KSRG time accessibility and the actual number of fire incidents. More than 70% of all fires during the study period occurred in areas accessible within 8 minutes and a further 18% in areas accessible in between 8 and 15 minutes. Just 12% of the total fires occurred in areas not reachable within the maximum of 15 minutes. When compared with areas of the UK or China featured in studies (Yang *et al.*, 2001; Zhang and Jiang, 2011), the efficiency of fire unit distribution in the Łódzkie Voivodeship is quite good.

Viewed on a map (Fig. 3) fire sites congregate into a dozen areas of considerable density. The largest of these is the city of Łódź metropolitan area at the centre of the voivodeship, while smaller ones are centred on other major towns. Outside urban areas, large and medium-sized fires were recorded throughout the area. If there was a pattern to these, it would be the proximity of both large and medium-size fires to main roads and the incidence of large fires in suburban areas.

A certain number of fires covered by the study was widely publicised in the media at the time of their occurrence. For example, a large fire in June 2016 consumed the Chancellor's Building of the Lodz University of Technology. Other notable cases of sites that caught fire and public attention included a wholesale

warehouse and a fitness club in Konstantynów Łódzki (June 2014) and the Krywań Inn in Słostowice in the south of the voivodeship (October 2016). Finally, a large fire of a warehouse hall in Skierniewice involved 191 fire-fighting crews, the largest number in a single mission (November 2014).

The concentration of the phenomenon at hand was identified by use of the Gini coefficient. Its high overall value (G=0.74) suggested a highly unequal distribution, probably mainly driven by small fires (G=0.79) with medium-sized events (G=0.68) only slightly more equally distributed than the average. Large and very large fires had much lower Gini coefficient values (0.39 and 0.47, respectively).

The trend for small fires to concentrate in town centres is not specific to this voivodeship. Similar findings were established by Mazur (2014) in Warsaw. Elsewhere, this pattern was also identified in Philadelphia, USA (Shai, 2006), Toronto, Canada (Asgary *et al.*, 2010), Vilnius, Lithuania (Vasiliauskas and Beconytė, 2015), and the two Chinese cities of Yichun (Guo, 2017), and Nanjing (Xia *et al.*, 2019).

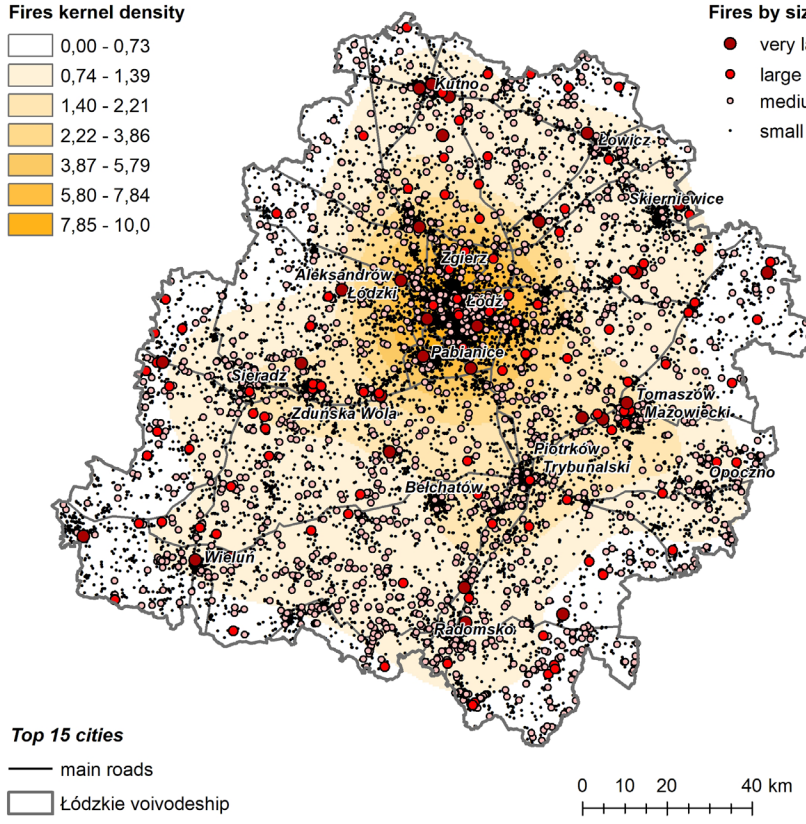
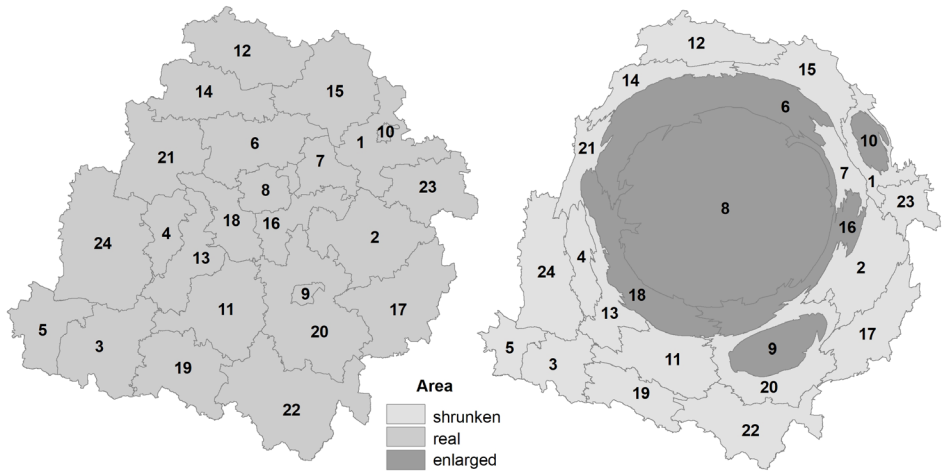


Fig. 3. Distribution and density of fire sites in the Łódzkie Voivodeship, 2014–2016

Source: own work.

As shown in Fig. 3, the distribution of fire site density in the study area follows a clearly concentric pattern. This density reaches its peak in the regional capital, the city of Łódź, from which it diminishes outwards towards the boundaries of the voivodeship. This nearly perfect density pattern is somewhat distorted by medium sized towns: Sieradz, Zduńska Wola, Bełchatów, Piotrków Trybunalski, and Tomaszów Mazowiecki.

To provide an additional visualisation of the concentration of fire sites across the voivodeship, an anamorphic cartogram was used (Fig. 4). The fact of considering the number of fire-fighting interventions during the study period had a distorting effect on the administrative boundaries of *poviats* (districts). The sizes of approximately 75% of poviats were diminished and just six poviats were inflated. The most distorted is the town of Skierniewice, the territory of which has the greatest error margin (based on the distortion of the GRID projection). Łódź is the most inflated of the poviats, followed by: the poviat of Zgierz, the town of Piotrków Trybunalski, the poviat of Pabianice, the poviat of Łódź-East, and the town of Skierniewice. The lowest error margin was recorded in the poviat of Skierniewice (outside of its town part), while the most diminished territory is that of the poviat of Piotrków Trybunalski (outside of its town part).



Poviats: 1. skierniewicki, 2. tomaszowski, 3. wieluński, 4. zduńskowolski, 5. wieruszowski, 6. zgierski, 7. brzeziński, 8. Łódź, 9. Piotrków Trybunalski, 10. Skierniewice, 11. bełchatowski, 12. kutnowski, 13. łaski, 14. łęczycki, 15. łowicki, 16. łódzki wschodni, 17. opoczyński, 18. pabianicki, 19. pajęczański, 20. piotrkowski, 21. poddębicki, 22. radomszczański, 23. rawski, 24. sieradzki

Fig 4. Geographically accurate map of poviats (left) and the square areas of poviats taking into account the number of fire incidents recorded in the Łódź Voivodeship in 2014–2016

Source: own work using the application ScapeToad v. 11.

4.2. Land cover types conducive or non-conducive to fires

There is a considerable range of variability in the FLQ-measured colocation of fires overall and of some of their size categories, and the various land cover types. This means that different land cover types have different susceptibilities to fire risk (Tab. 3). In the case of all subtypes of built-up area and of allotment gardens (a subtype of permanent cultures), this correlation can be seen to reflect conduciveness of these areas to the incidence of fires.

With their FLQ reaching extremely high values, two land cover subtypes display particularly strong conduciveness to all fire sizes: commercial and services, and multi-family housing. The very high FLQ values clearly also owe much to the small proportion that these land cover types represent in the overall area of the voivodeship, in addition to the sheer number of fires reported from these areas. They are followed by industrial and warehouse zones, remaining built-up areas, and single-family housing areas that also display strong colocations with fire sites. For these three land cover subtypes, FLQ reaches very high values for all fire sizes (with few exceptions). Other research regarding Poland and Warsaw corroborates the finding that residential areas (primarily dense urban fabric with a majority of old-style townhouses and concrete-slab housing projects) are extremely susceptible to fire risks (Mazur, 2014; Kozioł, 2019). A study of Toronto demonstrated that in addition to downtown residential areas, commercial areas along main streets, and single-family residential areas are also at risk (Asgary *et al.*, 2010). In the Chinese city of Nanjing, high values of the colocation index (> 2.0) were obtained for various types of fire in the following land-use facility types: residential and commercial buildings, schools, green space, and entertainment and shopping sites, which results were generally compatible with the land cover types indicated in this study (Xia *et al.*, 2019).

Table 3. FLQs of total fires and fire sizes by land cover type

Land cover	Fire size			
	Total	Large and very large	Medium	Small
Built-up area	8.23	7.03	5.96	8.37
Single-family housing	6.03	6.09	5.60	6.06
Multi-family housing	57.73	12.82	8.88	60.89
Commercial and services area	71.41	43.89	27.30	74.19
Industrial and warehouse zones	13.50	29.64	12.69	13.46
Remaining	9.94	-	4.74	10.30
Arable land and grassland	0.39	0.60	0.65	0.38
Arable land	0.32	0.57	0.55	0.31
Grassland	0.57	0.67	0.91	0.55

Land cover	Fire size			
	Total	**Large and very large**	**Medium**	**Small**
Permanent cultures	0.28	-	0.38	0.28
Orchard	0.23	-	0.34	0.22
Plantations	0.12	-	1.08	0.06
Allotment gardens	3.74	-	-	3.98
Seedbeds	-	-	-	-
Forestry area	0.22	0.14	0.30	0.22
Remaining area	0.31	-	0.71	0.29

Source: own work.

Allotment gardens form another high-risk subtype, but, uniquely, it is exclusively linked to small-sized fires. Just as in the case of built-up areas, allotment gardens involve extensive human presence and the human factor is known to be the number one cause of fires in Poland (Mazur and Kwasiborski, 2013; Mazur and Guzewski, 2014; Kozioł, 2019).

The fire risk in forests, on arable land and grasslands, on permanent cultures, and on remaining areas was low to very low. Fire concentrations in these areas across the voivodeship were very low, especially in the case of small fires. These land cover types could be perceived as non-conducive to large-size fire incidents. Only medium-sized fires in grasslands and plantations reached FLQ values close to 1, or the average colocation value, similar to the values achieved by all land cover types in the voivodeship. It is also worth noting that certain fire sizes never occur in certain land cover areas. The low incidence of fires in agricultural areas, including grasslands, has already been indicated by Paysen *et al.* (2000) and Scott *et al.* (2013). The opposite, however, was found in the Croatian province of Dalmatia where rural areas, characterised at the same time by a high proportion of agricultural occupation and depopulation, were the ones most affected by fires. Here, grasslands and shrublands were identified as the most fire-prone land cover type (Jajtić *et al.*, 2019). FLQ values for England and Wales quoted by Moffat and Pearce (2013) were much lower in built-up areas, but higher in arable land and grasslands, and forests.

The FLQ values obtained indicate a low fire risk in the vast forest areas in the Łódzkie Voivodeship as a whole. Paradoxically, this may partly be explained by the fact that the entire voivodeship is included in medium or high fire-risk zones designated by Lasy Państwowe, the Polish Forestry Administration. Indeed, an efficient observation and alert system has been established for this land cover type alone. The system consists of: automatic fire spotting (observation towers with CCTV), alert management points, on-ground patrols (patrols/fire-fighting

vehicles), forest aviation bases, water abstraction points, and access roads (an adequately distributed and maintained forest road network). During risk periods, fire-spotting points actively monitor forests and flag all suspect smoke emissions to alert management points. Precision alidades are used to determine angles used in locating such smoke emissions, thus helping alert management points to accurately determine the location of a potential fire and take adequate steps (*Instrukcja ochrony przeciwpożarowej lasu*, 2020).

Unfortunately, this paper cannot present a thorough discussion in relation to the results obtained by other authors due to the research approach employed and the fact that the study area is not adequately represented in the literature (there are few studies relating to Central Europe that address the spatial conditions underlying the distribution of fires, in contrast to those relating to the Mediterranean area for which literature sources are very rich). Our results could be compared with the results produced with the use of a similar methodology (relationships with land cover and colocation quotient) and for an area with similar climatic conditions. The relationships between the number of fires on individual land cover types and climate zones on a global scale were well described by Schaefer and Magi (2019). Meanwhile, Bajocco *et al.* (2010) have proven the relationships between the number of fires on various types of land cover and three climatic subtypes distinguished in Sardinia, namely the Mediterranean, transitional Mediterranean, and transitional temperate subtypes (mainly characterised by a clear gradient of decreasing summer drought). Despite such a small research area, the above paper demonstrates that for the first climatic subtype, the relationships between the occurrence of fires and urban areas, arable lands, and permanent crops are significant. By contrast, in the other two subzones fires were more likely to occur within heterogeneous agricultural areas, forests, natural grasslands and pastures, and sclerophyllous vegetation areas. The comparisons made in the said study with the texts by Moffat and Pearce (2013), and Xia *et al.* (2019) do not satisfy the condition of similarity between climatic conditions, although the analyses presented there identified a relationship between the fire location and land cover. However, most of the available literature focuses on analyses of fires occurring in areas with individual land cover types, mostly urban areas (e.g. Asgary *et al.*, 2010; Jennings, 2013) or forests (Akay and Şahin, 2019; Feurdean *et al.*, 2020), rarely arable land (Li *et al.*, 2017).

4.3. Detecting fire high-risk areas (FH-RA)

FH-RAs were obtained by generating a Voronoi tessellation. The author adopted the assumption that small polygons were indicative of short distances between fire sites thus representing high-density areas, which, in turn, could be identified as fire hot spots. The FH-RA was generated by overlaying areas with the smallest

Voronoi polygons obtained separately for three size groups of fires: small, medium-sized, and large/very large fires (Fig. 5). This method has the benefit of generating a natural area with all groups of fires occurring close to each other without the need to convert their number into some other additional areas, i.e. without the need to design density indicators.

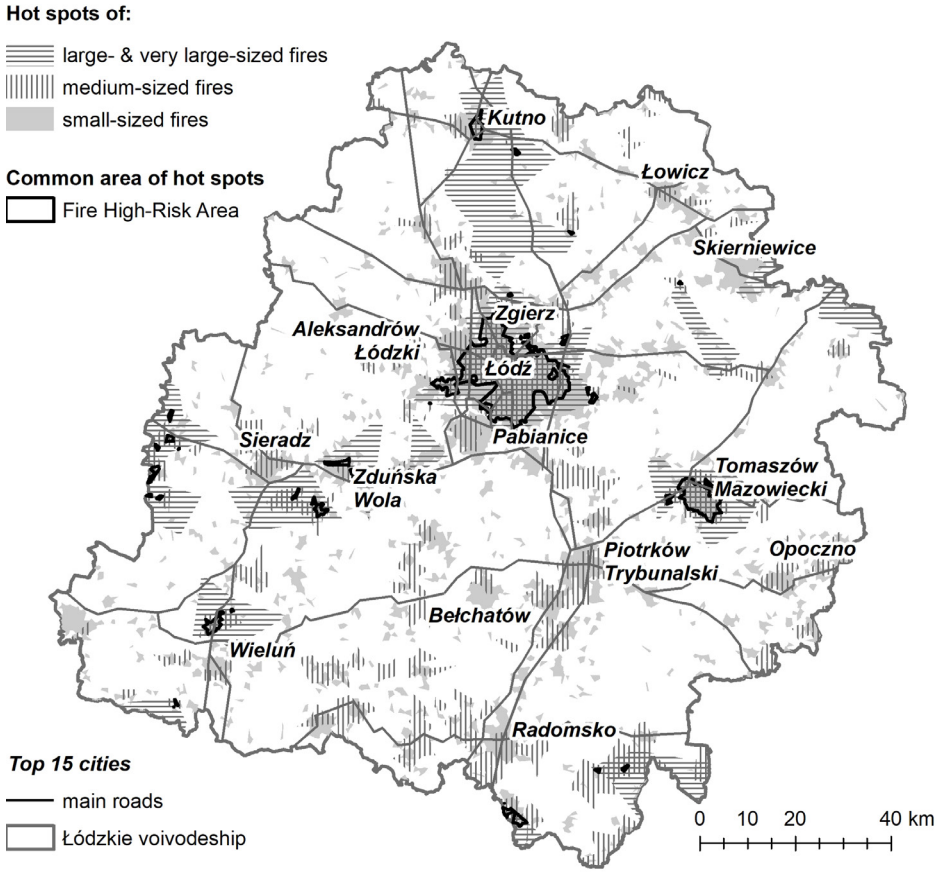


Fig. 5. Fire high-risk area (FH-RA) within Łódź voivodeship space
Source: own work.

Hot spots identified for large/very large fires covered 2,512 sq. km (14% of the voivodeship area), the medium-sized fire hot spots covered 2,312 sq. km (13%), and the ones for small fires occupied 2,650 sq. km (15%), as depicted in Fig. 5. Those areas where hot spots of all three sizes of fire overlapped could be identified as FH-RAs. Thus determined, the FH-RAs covered 346.8 sq. km, or 1.9% of the area of the voivodeship. It was divided into 41 constituent parts, nine of

which were bigger than 2 sq. km. The largest portion of the FH-RAs (275 sq. km) included large parts of the city of Łódź and the towns of Zgierz and Konstantynów Łódzki. The next largest part of the FH-RA was much smaller and covered the town of Tomaszów Mazowiecki (43 sq. km), followed by the town of Kutno (nearly 9 sq. km) and sections of the *gminas* (municipalities) of Czarnożyły and Ostrówek (8 sq. km north of the town of Wieluń).

The main characteristics of the fires that occurred within the FH-RAs are summarised in Tab. 4. They indicate a considerable degree of concentration of various-sized fires (nearly 24 fires per sq. km on average) within the confines of the FH-RAs, of the resulting material damage and of the involvement of fire fighting crews. The high FLQ value of 15.7 obtained for the areas indicates a serious fire risk. This risk is particularly high in the case of small fires (FLQ=16.3). The FLQs for medium-sized and large/very large fires, while clearly lower (at 6.3 and 7.5, respectively), still indicate that these two groups of fires are concentrated in the areas.

Table 4. Main characteristics of fires within the FH-RAs

	Number (according to the size of fire)					Damage (M PLN)	Fire-fighting crews engaged
	Total	Very large	Large	Medium	Small		
FH-RAs	8767	3	18	197	8549	151.6	19102
FH-RAs as share of voivodeship	32%	10%	17%	13%	33%	32%	29%

Source: own work.

The land cover structure within the FH-RA clearly differs from that of the voivodeship as a whole. It is dominated by a built-up environment (at 58%) at the expense of all other types of land cover. There is only 30% of arable land and grasslands (although grasslands alone have the same percentage as in the voivodeship), forests cover 11%, and permanent crops occupy 1%. The main components of the built-up areas include: single-family housing (41%), multi-family housing (9%), and industrial-warehouse zones (5%).

FLQ values were computed for each land cover type within the FH-RA to identify the level of colocation within the area (Tab. 5). What was immediately striking was that there were much lower FLQ values for the land cover types most at risk, when compared with the values obtained for the entire voivodeship. Within the FH-RA, built-up areas showed a strong correlation with the occurrence of fires, which was even stronger in their constituent parts: commercial and services areas, and multi-family housing. Commercial and services areas, found both

in town centres and on their peripheries, seemed conducive to fires of all sizes. Indeed, multi-family housing had a strong colocation with just the smallest fires (often just fires in waste containers, waste bin compartments, waste chutes, or vehicles). Yet industrial and warehouse zones suffered less from small fires, and a fire-fighting intervention in this type of area is normally associated with at least a medium-sized fire. The only high FLQ value in a non-built-up area was obtained for the remaining area group. This is explained by the occurrence of several medium-sized grass fires in dump areas.

Table 5. FLQs of total fires and fire sizes in land cover types within the FH-RA

Land cover	Fire size			
	Total	**Large and very large**	**Medium**	**Small**
Built-up area	1.61	1.55	1.45	1.62
Single-family housing	0.98	1.29	1.24	0.98
Multi-family housing	4.37	1.60	1.08	4.45
Commercial and services area	6.01	7.91	5.06	6.02
Industrial and warehouse zones	1.51	3.51	3.74	1.45
Remaining uses	1.21	0. 00	0.54	1.22
Arable land and grassland	0.12	0.32	0.38	0.12
Permanent cultures	0.35	0.00	0.00	0.36
Forestry area	0.15	0.00	0.28	0.15
Remaining area	0.45	0.00	2.34	0,40

Source: own work.

The FH-RAs are well located in terms of accessibility. As much as 82% of their territory was reachable within 8 minutes and another 16% in between 8 and 15 minutes. Only very few sections of the area took fire-crews longer than 15 minutes to reach.

5. CONCLUSIONS

The main accomplishment of this study has been the identification of areas and land cover types that are actually, rather than just potentially, associated with fire risks. This was possible thanks to the use of the distribution data on actual fires geocoded at the address level. Therefore, the estimation of the risks and the colocation indices were not dependent on the internal administrative division of the

study area, but only on the location of each fire incident and their trends to aggregate in certain areas. This has made a fundamental difference when compared to other studies where the aggregation of data at the administrative unit level has always led to a uniform treatment of those areas that, in terms of fire hazard, are far from uniform.

The authors realise that the spatial structure of fire-fighting interventions depends on a number of different characteristics: residential development, physical environment, neighbouring areas, weather, climate, and many more. In this study, however, they only explored the relationship between fire sites and land cover types from a spatial perspective. Based on their research the authors arrived at three main conclusions. Firstly, the area of the Łódź Voivodeship is not uniform in terms of fire risk, whose non-random distribution patterns are not dissimilar to ones found in numerous English-language studies published for several different areas worldwide. It is possible to pinpoint areas with more frequent fires, which, significantly, coincide with urban areas. Secondly, areas most at risk from fire are not the ones located far from the units of the fire fighting system. On the contrary, most fires occur in the parts of the voivodeship which are most quickly accessible to fire fighters. Due to the length limitations imposed on this paper the authors have only presented the highlights of their additional analysis that positively assessed the voivodeship's distribution of fire-fighting units (both professional and voluntary). Indeed, crews are able reach a large portion of the voivodeship in an adequately short time. Finally, there are strong relationships between the distribution of fire sites and land cover types. The latter have different degrees of impact on the distribution of fires across the voivodeship in general and in their size groups in particular. Built-up areas are the most at risk of fire, especially of small fires. All other land cover types have low to very low colocation values. The results of this study also support certain other pieces of published research that considered land cover types. Indeed, as found in other studies, commercial and services areas, multi-family housing, and industrial and warehouse zones proved to be the land use types conducive to the most fires. It is postulated that this analysis of the relationships between the distribution of fires and land cover types should be complemented by a study of the causes and the backgrounds of these relationships.

The objectives here were to determine the spatial relationships between the distribution of fires and land cover types using an index of colocation (i.e. the fire location quotient, FLQ), and to use the fire distribution to identify fire high-risk areas. Both objectives have been achieved. The working hypothesis that certain land cover types are either strongly conducive to fires, or vice-versa, and in this way have an impact on the distribution of fires, has been confirmed. The fire high-risk area (FH-RA) has been determined using a simple tool (Voronoi tessellation), but it does conform to the actual and frequent occurrences of fire sites.

The results permit the formulation of certain recommendations for social policy and spatial planning. Residential areas are at too great a risk of fire. Regional and local authorities could use the sites and land cover types identified in this study to consider drafting plans to mitigate this fire hazard. From the methodological point of view, the study suggests a need to improve the PSP database to make it more useful for spatial analysis. Its main problems are incompleteness and inaccuracy. What must necessarily be done, and done urgently, is the identification of the locations of fire incidents with precise descriptions. Also, the FLQ values obtained in this study could be useful in determining the weighting of the various land cover types in any future research into the multiple factors affecting fire hazard. From this point of view, the study could contribute valuable information to the estimation of fire risks and the management of the deployment of fire service resources. The understanding of colocation patterns between fire sites and land cover types could help explain fundamental factors conducive to the development of fires. Researchers trying to identify optimum fire-fighting service networks with theoretical accessibility models could also learn that most fires do not occur in those areas where fire fighters need the longest time to arrive. The spatial analyses of fire distribution presented in this paper can be used to design the operations of fire departments in such a manner that they woud correspond to the risks they face and their two essential tasks, namely fire prevention and fire preparedness. Effective fire suppression is a last resort, which should not be allowed to happen in the first place. In line with the guidance of the Food and Agriculture Organization of the United Nations on fire prevention, it is possible to devise cost-efficient and effective fire protection programmes for any area at risk of fire. Preventing rogue fires is always less costly than suppressing them. Fire prevention programmes should be accepted and promoted within the community in order to prevent damage to goods and resources. Effective preparedness strategies include staff training and appropriate relocation of technical resources. A fire preparedness programme should be based on "fire and resource management planning", and it should consider funding for local safety tasks, weather, and risky human behaviour and activity (Fire Management ..., 2006).

The analysis of the distribution of fire call-outs in the Łódź Voivodeship has offered a preliminary confirmation to some rather obvious assumptions made about the impact of dense development on the density of fire fighting interventions. It would be difficult to add any more details to the determination of the relationships at the voivodeship level. Although this analysis certainly does not exhaust the topic of the distribution of fire fighting interventions in this voivodeship, it would be a challenge in the future to try and relate these results to smaller study areas. Such an analysis could also look at physical, climatic, and socio-demographic characteristics. Comparing such future analyses with the results of this study could offer a new perspective for the identification of fire risk areas.

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HIDDEN PROPERTIES OF CITY PLANS: A CASE STUDY OF ŁÓDŹ

Abstract. The article analyses the transformations and the internal diversity of the oldest urban structures of central Łódź, one of the biggest Polish cities. 19th-century Łódź was one of the greatest centres of the textile industry in Europe. Currently, the city faces major challenges, including a dramatic population decrease, population ageing as well as a vast revitalisation of urban structures aimed at reinforcing the new idea of the city's inward development. The research on the layout of Łódź is based on the modern image of the city as well as four images preserved in historical plans. The subsequent, chronological models are analysed in terms of topological features with the use of space syntax methods. The conducted research made it possible to identify the internal, configurational diversity of the historic urban core of Łódź. A seemingly monotonous, orthogonal urban layout is, from a topological perspective, highly diversified. Due to the actions undertaken in Łódź and aimed at restoring urban structures in the broad sense, the study not only has a cognitive goal, but it also carries a practical context.
Key words: historic urban core, urban morphology, space syntax, city centre, centrality measures Łódź.

1. INTRODUCTION

A spatial layout is one of the most permanent and stable attributes of a city. A plan, filled with physical substance and activities of city inhabitants, is a fixed, hard-to-change framework for the social and economic processes occurring within. As a result, the urban layout may have a major influence on the society that functions in this framework. The internal diversity of a plan (the urban grain) determines, for instance, the availability of spaces or the 'permeability' of urban tissue, therefore it can spatially marginalise some inhabitants or control their mobility. This, in turn, influences the recurring diversification of the city area on the economic and social levels.

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Many cities see changes to their urban layouts over long enough term. These changes are caused by the overlapping, fading and merging of planned and spontaneous actions of the societies who live there and make use of the space. For this reason, a plan is often compared to a palimpsest, where the existing grows on the foundation of the historical (Azimzadeh and Bjur, 2007).

The present research focuses on the evolution of the urban layout of central Łódź – one of the largest Polish cities. Its purpose is to identify, firstly, the selected topological features of a city plan in subsequent historical periods and, secondly, the areas crucial to the proper functioning of Łódź. The spatial range of the analysis comprises the Historic Urban Core of Łódź, i.e. an area of its historical core of approx. 1,400 ha (almost 5% of the city surface), inhabited by approx. 20% of all city residents. It is the area with the most intense building development, high city and culture-shaping properties and functional diversity, where the urban functions, both local and metropolitan, concentrate. Currently the actions of self-governments aimed at improving both the functioning of the city and the quality of life of its inhabitants also focus on this area.

The study's analyses were based on the theory and methods of space syntax. They enabled me to analyse urban structures, both current and reconstructed or preserved on historical plans. Space syntax theory is built on the observed correlations between space and the society that uses it. The ability to change one's own position in space, spatial thinking, understanding or remembering spatial relations, assessing the relations between objects and places in space shape human sensitivity to spatial features. That is how the configuration of space – mostly its topological aspects (e.g. the curvature of the road) and psychological ones (e.g. the good continuity principle), but also the geometrical ones (distance, angular distance, etc.) – influences the functioning of a society.

The notion of space syntax was conceived and developed by Bill Hillier and his colleagues at The Bartlett School of Architecture, University College London. The most important publications in this field include *The social logic of space* (Hillier and Hanson, 1984) and *Space is the machine: a configurational theory of architecture* (Hillier, 2007) although works that raise the issue of morphic language, such as *Space syntax* (Hillier *et al.*, 1976), appeared much earlier.

The creators of the concept of space syntax defined it as a theory of space and a set of analytical, quantitative and descriptive methods used to analyse the spatial layout of buildings and cities (UCL Space syntax, n.d.). It is also described as a research program whose purpose is to search for the relationships between a society and the inhabited space shaped by material structures of buildings, housing estates, cities, etc. (Bafna, 2003)[1].

[1] 'Space syntax is best described as a research program that investigates the relationship between human societies and space from the perspective of a general theory of the structure of inhabited space in all its diverse forms: buildings, settlements, cities, or even landscapes'.

Space in space syntax is understood as relatedness. A stretch of spaces such as streets or squares that comprises material objects produces a system of connections in which a given society functions. They work as a system, whose fundamental function is to enable mobility to fulfil needs. Each element has its specific role. Local changes, such as the closing of a street or the emergence of a new one on the city outskirts, have consequences on a global scale. These changes involve not only the direction and intensity of the flows, but also constitute deep and long-term consequences on other levels, e.g. in social or economic activities or the spatial segregation of inhabitants. In space syntax, the collection of spatial relations between parts of the system (e.g. city streets), dependant on the whole system, is known as the configuration (UCL Space syntax, n.d.).

The weaknesses of space syntax include purely technical matters, such as the way of building a city model allowing researchers little room for interpretation (Kostakos, 2010; Ratti, 2004), as well as those concerning methodological and theoretical assumptions. The latter are based on accusations regarding: omitting such features of city space as its metric properties (e.g. length of streets, surface area), conducting analyses on the basis of merely two dimensions (a two-dimensional city plan), and overestimating the role of spatial configuration in the functioning of societies. Issues that appear in numerous studies, such as the edge effect, the changeability of results depending on the spatial scale of the research and difficulties in identifying and capturing the space-and-time variability, also remain unsolved (Montello, 2007; Ratti 2004; Pafka *et al.*, 2018). The theoretical part is said to strip space of its semantic meanings and reduce social actors to unified machines trapped between material obstacles (Netto, 2016). Yet it should be emphasised that space syntax considers the vital notion of the agency of space. This agency is hard to overrate considering human adaptation to movement (spatial abilities, motor skills, etc.) shaped throughout the millions of years of evolution. Space syntax attempts to assess this agency by analysing the configuration of space and the actions of social units and groups occurring within. Space syntax seeks the social logic of space by focusing on mass observations and statistical generalisations. The identification of specific spatial models does not mean the removal of individuals' rights to their unique, unpredictable decisions. These individuals creatively configure and transform space, forming, by themselves, the urban environment.

2. THE RESEARCH CONTEXT IN LIGHT OF SUBJECT LITERATURE

From the perspective of space syntax, the configuration of space is perceived, analysed and assessed as a framework influencing the functioning of the societies that use it. This approach became the foundation of numerous inspiring analyses

developed in the past decades. Those have indicated a relationship between various aspects of socio-economic life and the configuration of urban space. There are relationships with pedestrian movement (e.g. Hillier *et al.*, 1993; Baran *et al.*, 2008; Jiang, 2009; Sharmin and Kamruzzaman, 2018), bicycle and motor traffic (Jiang and Liu, 2009; Raford *et al.*, 2007), spatial segregation of the inhabitants (Vaughan and Penn, 2006), land use and location of businesses (Kim and Sohn, 2002; Porta *et al.*, 2012), rent rates and fixed property value (Enström and Netzell, 2008; Chiaradia *et al.*, 2009) as well as the level of crime (Van Nes and López, 2010; Nubani and Wineman, 2005). In the field of space syntax, the increasing knowledge on the social and economic consequences of the spatial configuration of the urban environment has enabled the development of studies that are historical in nature (Griffiths, 2012).

City centres are one of the main subjects of historical studies on space syntax. They usually consist of valuable, old, urban structures significantly influencing the functioning of whole urban organisms[2]. The analyses dedicated to them usually deal with issues of various social phenomena rooted within and consider their centrality (understood differently by various entities) often in the context of the planned or conducted transformations of urban tissue[3]. Such research includes, for instance, the analysis of the changes in the configuration of space of Gothenburg in various timeframes. It identified the shift (dispersion) of the urban integration core, simultaneously revealing the hierarchical properties of the city's spatial structure (Azimzadeh and Bjur, 2007). Another example has involved the studies of archival maps and satellite images of Dhaka. They showed that the organic development of urbanised structures generates a plan with a higher level of integration (which reflects how close origin space is to all other spaces) and connectivity (the number of spaces immediately connected to a space of origin) of the street network (Ahmed *et al.*, 2014). A process involving a shift of the integration core (pattern made of the most integrated spaces) within the urban space in time was also observed (Nilufar, 2010). An analysis of the transformations of Beijing old town's street network occurring throughout 100 years made it possible to discover its internal diversity in terms of structure stability, for instance its street network and active centres (Wang *et al.*, 2018). The analysis of the changeability of the spatial structure of Wrocław has provided evidence of the integration core shifting from the historical centre to the younger part of the city, while the attributes of centrality were being preserved in the historical core (Saeid and Masztalski, 2009).

Some studies on the evolution of city plans have focussed on a given city's contemporary image and the ongoing or planned actions aimed at converting ur-

[2] That is all sub-components of the city, understood as an organic, complementary and cooperative whole (Marshall, 2009).

[3] Which can be understood, in the most general sense, as the arrangement of streets and block (Kropf, 1996).

ban structures (e.g. as part of revitalisation projects). Among them there is an article on the harbour area of Rio de Janeiro (Dias and de Arruda Campos, 2015). The collapse of the harbour and the economic collapse of its district resulted in the emergence of numerous negative phenomena such as the deterioration of development, a decrease in the number of pedestrians on the streets, and higher crime rates. The city authorities responded by introducing 'Porto Maravilha', an Olympic Games-inspired revitalisation project. Its analysis showed that despite the architectural projects which improved the accessibility of individual parts of the harbour (decrease of topological distances), the urban intervention conducted had a limited influence on the general accessibility of the area. Another example offered a study of the development of the neighbourhood of the historic core of Jeddah, Saudi Arabia, conducted without a plan. In this case, the analyses focused on the search for precise, therefore also spatially restricted, effective intervention in the spatial structure of the city (Karimi *et al.*, 2007). One of the purposes for the analysis of the configuration of a fragment of Istanbul's urban space was to suggest new communication solutions in order to decrease the level of isolation in some city areas (Önder and Gigi, 2010). Finally, Trigueiro and Medeiros (2007) have discussed the strategy of reclassifying the old centre of Natal in Brazil and the consequences of interventions planned in this part of the city.

To date, there has been no analysis of urban layout changes from a topological perspective regarding Łódź, although in the 19th century it was one of the fastest developing European cities – the fact proven by the spatial layout of its historical centre, which helps one identify several crucial stages of the city's territorial development (Fig. 1).

Although Łódź was granted a city charter in the 15th century, it was the 19th-century industrialisation that shattered the city's agricultural image. Hundreds of thousands of new residents flooded Łódź in reaction to the intense development of the textile industry. In the first half of the 19th century, the authorities controlled the city's dynamic development, maintaining its spatial constrictions imposed by a thought-out, orthogonal city plan. In the subsequent decades, the settlement upheaval was out of control. Residential developments spread along illicitly extended or chaotically marked out roads. The industry, freed from the driving force of rivers thanks to the invention of the steam engine, started settling available plots among the residential urban structures. Thus the urban structures that constitute the current Historic Urban Core of Łódź were filled in and densified.

After the end of the Second World War, the leading role of industry in the economy of Łódź was maintained in accordance with the idea of socialist economy. The construction of vast, multi-family housing estates began in areas incorporated into the city. The period was characterised by the city's major territorial development and continuing increase in the number of inhabitants with relatively small changes to the plan of its central part.

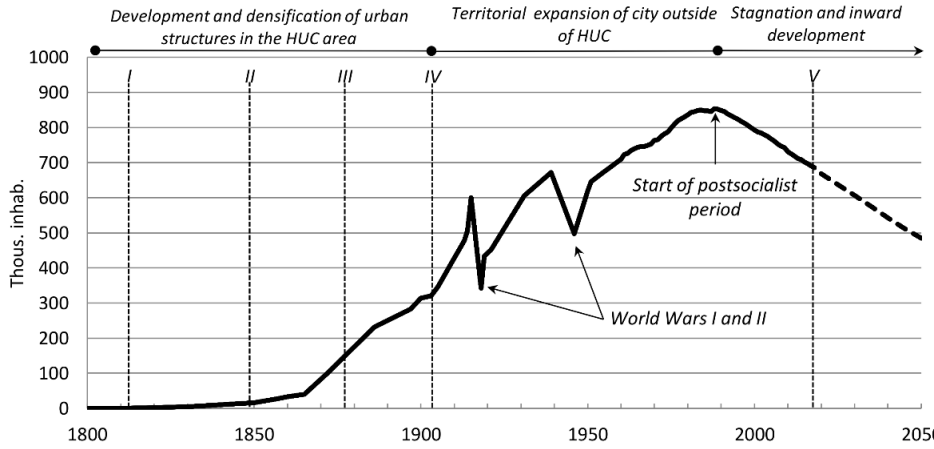

Fig. 1. Population and features of spatial development of Łódź between 1800 and 2050
The dashed line marks a forecasted number of inhabitants, according to the Łódź Population Projection 2015–2050 (Statistical Office in Łódź, 2014).
Vertical lines mark the analysed moments in the development of Łódź plans.

Source: own work.

The early 1990s and Poland's return to the path of market economy have revealed the weakness of the city's economic foundations, leading to serious social problems (a collapse of the industry, unemployment, poverty, and decreased attractiveness of the city to immigrants). As a result, contemporary Łódź features a continuous decrease in the number of inhabitants – the highest decline of the kind in the country and one of the highest in Europe. Between 1988 and 2019, the city lost nearly 170,000 people (18.7% of its population).[4] The loss of residents is especially strong in the city centre, where the major deterioration of the urban tissue, containing also numerous post-industrial areas, is clearly visible. It is estimated that the building development of the Historic Urban Core suffers from major decapitalisation, spreading across the area of several hundred hectares.

In the face of changes threatening the functioning of Łódź, the current strategy of spatial development intends to replace territorial expansion with inward development by, for instance, limiting urban sprawl and facilitating the thriving of the city centre. The Historic Urban Core was considered an area crucial to the city's development (Fig. 2). This, in turn, resulted in implementing a revitalisation program encompassing the central part of the city of approx. 1,783 ha (Łódź City Hall, 2020).

[4] The urban depopulation of Łódź is largely caused by the negative rate of natural increase. In general, it is a result of the low inflow of immigrants and the ageing of the city's population.

Fig. 2. Territory of Łódź and the area of the Historic Urban Core of Łódź

Dashed black lines mark the borders of the HUC. Thick black line represents the Piotrkowska street, the main street of Łódź. Hatching marks the approximate area of: A – Old Town, B – New Town, C – New Centre of Łódź

Source: own work.

Currently, the Historic Urban Core of Łódź faces major challenges. They include the restoration of the urban tissue, street upgrades, the establishment of woonerfs, as well as changes to the configuration of the street network (caused by, for instance, the construction of the New Centre of Łódź). The fact that the International Association of Horticultural Producers has granted Łódź the right to organize EXPO Horticultural in 2024 may have also provided a strong stimulus for making changes to the urban space. These transformations became an inspiration for the research on the evolution of the urban layout of the central part of Łódź presented below.

3. DATA SOURCES AND RESEARCH METHODS

The presented study was based on five images of Łódź, each from a different point of its development. It comprised the modern street layout and the city's historical plans[5]. The adopted spatial range made it possible to analyse the changes to the spatial layout of the central part of the city from the beginning of its urbanisation to the present day[6]. In the case of archival plans of the city, the analysis encompassed the visible outline of streets, including those without building developments[7]. In the case of the contemporary image of the city, the analysis omitted transport routes intended for only vehicles or only pedestrians (such as underpasses or paths and alleys in parks), as well as spaces that did not constitute streets, e.g. car parks or the outskirts of shopping centres.

The selected plans served as the foundation for constructing the models of urban space. This process involved the transformation of subsequent two-dimensional plans of Łódź into sets of lines representing spaces (streets) of the analysed structures. There are several methods of creating a graphic representation of a city plan. The discussed study utilised a model based on natural streets (Jiang *et al.*, 2008).

In the following stage, natural streets were transformed into dual graphs, whose vertices represented lines (i.e. streets), while edges represented line crossings (streets intersections). Further, dual graphs were analysed using selected space syntax measures (Fig. 3). Each stage of the process required the use of computer software. The vectorisation of the street network on archive maps (in the form of street axes), the corrections of topological mistakes of the current street network in the Georeference

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[5] The modern image of the street network of Łódź was created on the basis of the Georeference Database of Topographic Objects created by the Regional Surveying and Cartographic Documentation Centre in Łódź. The historical plans and information on them were acquired from the Łódź Internet System for Area Information (Geodesy Centre in Łódź, n.d.) as well as the published collection of maps of Łódź (Janik *et al.*, 2012). The following historical plans were analysed (identified as in Fig. 1): (I) *Brulion. Plan klucza łódzkiego* at 1:5,000 from 1812–1813 by Johnney, F.; (II) *Rys ręczny miasta fabrycznego Łodzi* at 1:10,500 from 1849 by Lenartowski, J.; (III) *Plan der Grundbesitzungen samt Fabricken seiner hochwohlgeboren des Herrn Prezes Karl Scheibler mit der Umgebung der Stadt Lodz* at 1:5,000 from 1877 by Miciński, R.; (IV) *Płan goroda Łodzi pietrkowskoj guberni* at 1:1,680 from 1894–1896 by Starzyński, J.W. and its supplement: *Płan goroda Łodzi* at 1:8,400 from approx. 1903 by Chełmiński, F. and Zambrzycki, C.).

[6] As a result of the 20th century territorial development of Łódź, the contemporary plan differs greatly from previous ones. Currently the Historic Urban Core is merely a small part of Łódź. To preserve the spatial scale of the study and maintain internal diversity while partially reducing the edge effect, the analysed area was expanded by a street network only within 400 m of the Historic Urban Core. The value of 400 m was determined by the neighbourhood of the studied area, easy to access by pedestrians.

[7] It was assumed that the marked out streets presented an opportunity to move, even without a fully-developed frontage. In light of the dynamic development of Łódź in the 19th century, most of the marked out streets were quickly overgrown with urban tissue. The analysis omits communication routes in the form of twisting/sinusoidal lines that are rural in nature, visible on historical plans, since, in time, they had a tendency to disappear from city plans altogether.

Database of Topographic Objects (Regional Surveying and Cartographic Documentation Centre in Łódź) as well as their export to shapefiles were carried out in AutoCAD Civil 3D (Autodesk Inc. 2020). The Axwoman 6.3 (Jiang, 2015) and Pajek32 5.08 (Batagelj and Mrvar, 2019) programs were used to generate street segments, track the transformations of street segments into natural streets, calculate syntactic measures, etc. The visualisation of the results was possible using the ArcGIS 10.4 software (Environmental Systems Research Institute, 2011).

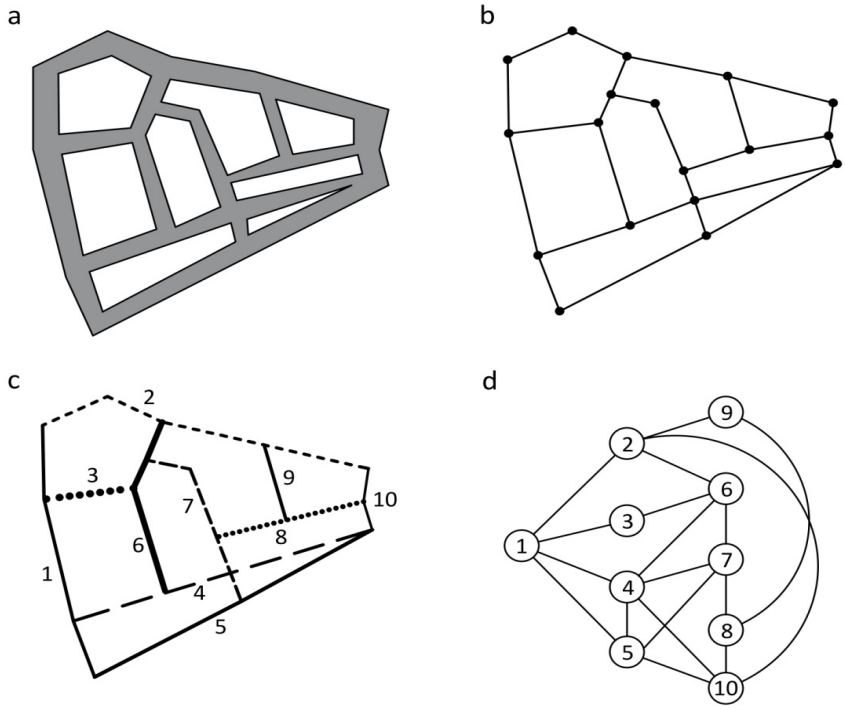

Fig. 3. Structure of a model that represents urban space

(a) a fictional city system with marked street spaces, (b) segments of street axes with marked ends, (c) natural streets, with different lines denoting separate paths of combined segments, (d) justified graph, in this case space no. 1 is a root.

Source: own work on the basis of Jiang and Claramunt (2002).

The results obtained were arranged according to the calculated values, delimiting core-ranked spaces (5% of natural streets with the highest values) and their supplements (another 5–10%), secondary and tertiary routes (further 10–25% and 25–50%, respectively), as well as those of the lowest significance (the remaining

50% of natural streets with the lowest values) (Hillier and Hanson, 1984). In the illustration of the obtained hierarchy of the street network, thick black lines mark the highest values (well-connected or most integrated spaces) and dotted grey lines mark the lowest values (weakly-connected or most separated spaces).

Two centrality measures – choice and integration – were used to assess the urban system in Łódź in subsequent historical periods, both commonly considered crucial in the interpretation of spatial structures in cities. The goal was to identify the urban spaces that made up a city's core, or, in other words, were capable of shaping its cohesion, inhabitant-friendly conditions, safety on a local scale, clarity of the spatial layout, etc. (Scellato *et al.*, 2006).

The choice measure suggests how often a given space may theoretically be selected by pedestrians moving through a city. High values mark spaces crucial to the flow of pedestrians, low values mark spaces of lesser or marginal significance. The choices were calculated for each apex in the graph in accordance with the formula:

$$\boldsymbol{Ch_i = \frac{\sigma(i)}{\sigma}}$$

where: σ(i) was the number of shortest paths that passed through vertex i, σ was the number of all the shortest paths.

The choice values were solely the results of the system configuration, i.e. its topological foundations. They could influence the social and economic processes within the city space. By influencing the selection of a pedestrian route, system topology can, for instance, increase the attractiveness of a location of a city areas for service entities.

Integration is a normalised measure describing the relations (topological distance) between spaces and all other spaces in a studied layout (Al-Sayed *et al.*, 2014; Teklenburg *et al.*, 1993). It is calculated for each apex in the graph in accordance with the formula:

$$INT_i = \frac{1}{RRA_i}$$

where:

RRA_i (Real Relative Asymmetry) = $\frac{RA_i}{D_{value}}$,

RA_i (Relative Asymmetry) = $\frac{2(MD_i-1)}{n-2}$,

MD_i (Mean Depth axial line) = $\frac{D_i}{n-1}$

D_i (Total Depth of axial line) = $\sum_{j=1}^{n-1} d_{ij}$

D_{value} = $\frac{2\left\{n\left[\log_2\left(\frac{n+2}{3}\right)-1\right]+1\right\}}{(n-1)(n-2)}$

n – number of vertices in the system,

D_{value} symbolizes the Total Depth of the root in a rooted, diamond-shaped graph

Integration values reflect the number of spaces to be crossed in order to reach all other spaces in a studied layout from a specific place. The less spaces there are to cross, the higher the integration (in the topological sense) of a place with the whole system considered. As the number of topological steps necessary to achieve all other spaces (e.g. streets in a city) increases, so does the level of separation in a place. Integration is considered a measure of the quality of city space. Places with high levels of integration can support social cohesion, make places vibrant and safe, facilitate human interaction, reduce travel times, and enhance the physical activities improving the health of citizens in urban spaces (Fathi, 2020).

4. RESULTS

The oldest analysed plan shows the layout of Łódź in the early 19th century. In reality, it also depicts the earlier centuries, since there was no city development at that time (the so-called period of agricultural Łódź). In light of the choice measure, the communication axis of the town at that time (current Old Town) was a longitudinal route (Fig. 4). This road was of the highest importance, also to the integration of the whole system layout (Fig. 5). The distance between the road and all other places in the analysed layout was the shortest, which contributed to its central significance. It should be emphasised that this image is reflected in the historical data, as well as the functional and spatial structures of the old town. The longitudinal axis was of major transport significance both on the regional and local scales. It led to cities of higher rank than Łódź situated further north and south. At the same time the road was the western frontage of the church and market squares, where the town life concentrated. Undoubtedly, the road was the busiest space in old Łódź, important to the functioning of the whole community.

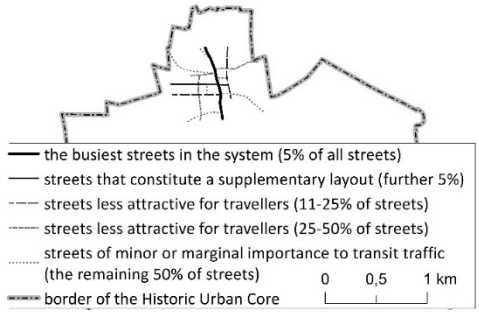

Fig. 4. Distribution of the choice value in Łódź in the early 19th century

Source: own work.

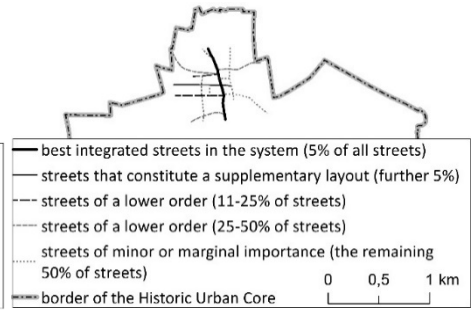

Fig. 5. Distribution of the integration value in Łódź in the early 19th century

Source: own work.

The plan from the mid-19th century reflects the planning decisions from the 1920s, 30s and 40s, which shaped the subsequent morphological units of Łódź, quickly filled with new settlers. The Old Town axis was extended, reaching the southern edges of the modern Historic Urban Core. Its rank, in light of both centrality measures, was dominating, despite the visible city development on the right side at the time. In light of the choice value (Fig. 6), despite the geometrically-peripheral location, a stretch of roads on the western side of the layout also had a significant role. It reinforced the longitudinal axis of Łódź, creating the most topologically attractive flow spaces cutting through the area of the city at that time. The same space dominated in the integration value. The topology of the Łódź spatial layout imposed a high integration potential on this part of the city. Three latitudinal streets constituted similar integration cores at the time, although they lost their significance after further changes to the city plan were made (Fig. 7).

Fig. 6. Distribution of choice values in Łódź in mid-19th century (marked as in Fig. 4)

Source: own work.

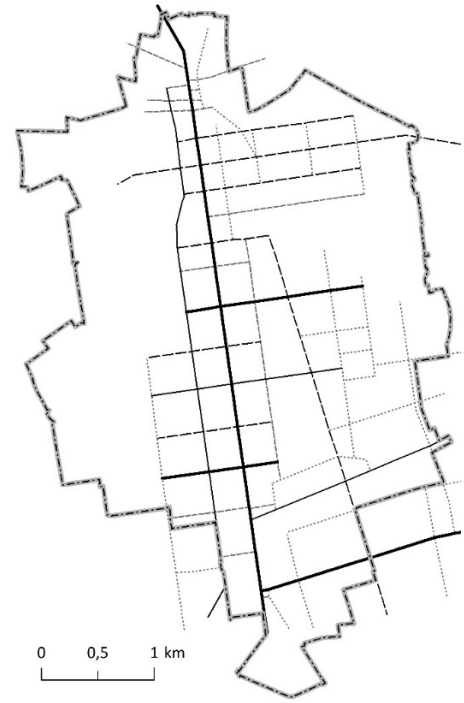

Fig. 7. Distribution of integration values in Łódź in mid-19th century (marked as in Fig. 5)

Source: own work.

As early as in the 1960s, a layout planned in such a way could not contain the subsequent waves of labourers attracted by the dynamically developing industry. In the third quarter of the 19th century, this led to a visible densification of the existing street network and, to a lesser degree, territorial expansion. It also changed,

to some extent, the significance of streets existing prior to 1960s. In general, the spatial patterns of choice and integration measures were similar (Figures 8 and 9). They invariably constituted an axis extended from the Old Town, accompanied by another, parallel stretch of streets in the eastern part of the city. A new core with a latitudinal route appeared in the geometrical centre of this system. The three enumerated street routes would not lose their dominating position in the studied area. Yet in the eastern part of the city there is a noticeable influence of the railway, whose construction began in 1865. It acted as a barrier preventing the merging of streets in the central part of the eastern wing of the Historic Urban Core. This image prevailed in the city plan for the next 150 years.

Fig. 8. Distribution of choice values in Łódź in the 1870s (marked as in Fig. 4)

Source: own work.

Fig. 9. Distribution of integration values in Łódź in the 1870s (marked as in Fig. 5)

Source: own work.

The end of the 19th century brought an established system of streets (Figures 10 and 11) similar to the contemporary one (Figures 12 and 13). This similarity illustrates the development of the plan of Łódź, whose 21st-century territorial expansion was its main characteristic feature. The 19th-century urban layout filled in significant areas, which hindered changes and resulted in its *freezing*. As a result, the contemporary role of streets, on the level limited to the city centre, was established as early as at the turns of the 19th and 21st centuries (Table 1).

Fig. 10. Distribution of choice values in Łódź in late 19th century (marked as in Fig. 4)

Source: own work.

Fig. 11. Distribution of integration values in Łódź in late 19th century (marked as in Fig. 5)

Source: own work.

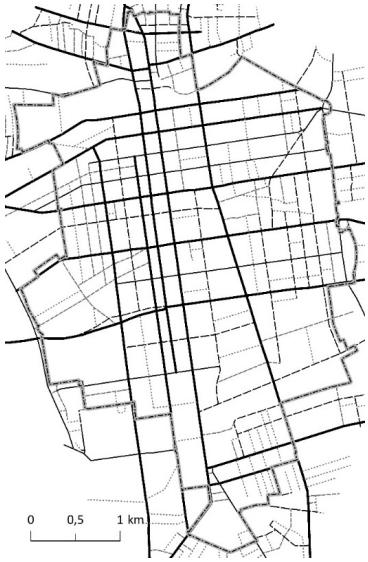

Fig. 12. Distribution of choice values in the Historic Urban Core of Łódź in the second decade of the 21th century (marked as in Fig. 4)

Source: own work.

Fig. 13. Distribution of integration values in the Historic Urban Core of Łódź in the second decade of the 21th century (marked as in Fig. 5)

Source: own work.

Table 1. Evolution of the street network within the Historic Urban Core in light of the analysed plans

Time period (marks as in Fig. 1)	**Average distance between intersections [m]**	**Street network density [km/100 ha]**	**Characteristic features**
I (early 19th century)	129	0.37	Pre-industrial Łódź, plan based on medieval layout. The surface area of the city was a small part of the HUC. The street network density was low, but the intensity of connections was the highest (short access routes).
II (mid-19th century)	270	4.38	Plans of new city structures for industrialisation. Street network expansion. On a global scale, a major increase in the density of the street network with a simultaneous decrease in the density of connections.
III (the 1870s)	251	5.45	Stage where the urban structures designed earlier on were filled, inner densification of the street network.
IV (late 19th century)	172	7.91	Filling the HUC area further. A relatively large increase in the length of streets and the density of their connections. Beginnings of the expansion of the street network outside of the studied area.
V (21st century)	162	8.71	Only slight changes despite the passage of time (over 100 years), *frozen* street layout. Expansion and development of urban structures outside of the HUC.

Source: own work.

Both choice and integration quite explicitly set a contemporary, configurational centre, crucial to the functioning of the Historic Urban Core. It constitutes an axis that is genetically connected to the Old Town (currently located on the outskirts) and stretches longitudinally throughout nearly the whole studied area. Its potential is especially high in the centre of the Historic Urban Core: several parallel street routes mark the central space of the city, visibly belt-shaped in nature. The area has its own specificity (vast quarters and post-industrial areas, among others), co-determining its current condition, yet it has configurational priority in fulfilling the central functions in this system.

The changes in the degree of the correlation between choice and integration values also indicate a direction of the evolution of the analysed layout (Table 2).

Table 2. Pearson's coefficient of the correlation between choice and integration values calculated for natural streets in analysed plans

Time period (marks as in fig. 1)	R	R^2	P-value
I (early 19th century)	0.9498	0.9021	0.001
II (mid-19th century)	0.7148	0.5110	0.001
III (the 1870s)	0.7991	0.6386	0.001
IV (late 19th century)	0.6017	0.3620	0.001
V (21st century)	0.5634	0.3175	0.001

Source: own work.

The value of the correlation index decreases with each analysed plan (with the exception of time period III – the first stage of filling the urban layout). It indicates that the complexity of a city plan increases with time. In pre-industrial Łódź, spaces with high integration values also had high choice values, while spaces with low integration values had low choice values. Therefore, from the topological perspective, both the topological centres and outskirts of Łódź of that time could be clearly identified in terms of both analysed features. The current values of these features are much more divergent. This divergence is not very strong (as shown in a generalised way in Figures 11 and 12), but confirms a larger diversification of the analysed area and, therefore, a lower predictability of the socio-economic processes occurring there. The spaces theoretically most often selected by pedestrians do not necessary have the highest integration values and vice versa: rarely selected routes can have the lowest integration values.

The outskirts of the studied territory visible on its geometrical edges should be assessed carefully, since the study was limited to the inner zone of the modern city. The information about the configurational peripheries 'rooted' in the Historic Urban Core, often in the direct neighbourhood or within the belt of the central zone, is much more valuable. These places are, similarly to the central zone, special in certain aspects. They are usually small, short spaces, located out of the way of the flows that occur within the city. Their air-tight nature provides certain 'locality in the centre', which may increase the attractiveness of these spaces (in terms of location) for some residents, facilitating the shaping of good neighbourhoods (as perceived by Jane Jacobs). However, for that same reason their isolation may result in the development and strengthening of negative social and economic phenomena.

The south-eastern part of the central Historic Urban Core is also peripheral in nature. Its internal integration is poor. This is caused by the presence of the railway line and station operating in this part of the city. The railway has been

dividing the urban structures of the city for over 150 years, producing the effects in the configuration of its central part that are visible to this day. In the 2010s, the railway line and station were moved underground. This railway investment, one of the most modern and biggest ones in Europe, is part of the established New Centre of Łódź. However, in the context of the intended, central rank of the area, its position on the configurational map of the city centre, despite the restructuring of the street network, is still not optimal. There is a visible lack of an axis that would integrate the area both internally and with the central city zone.

Yet another interesting and crucial phenomenon is the problem of the progressing configurational marginalisation of the Old Town. The notion, however, is hard to assess due to the spatial nature of the analyses conducted.

The choice measure has identified those spaces in the layout that are the most attractive to travellers due to their topological properties (Fig. 12). Theoretically, they entail the important responsibility to ensure the efficient movement of travellers. At the same time, these can be spaces particularly at risk of being pressured by movement floods. The efficient functioning of whole central Łódź and, therefore, the whole city depends, to a major degree, on their 'friendliness' to the flows of people, that is the traffic capacity, and the clarity and quality of route surface. Streets with the lowest choice values may be less frequently chosen by travellers due to 'the nature of the layout'. Therefore, it can be assumed they are not as important for ensuring the efficient circulation of residents and users of the city.

The space of the Historic Urban Core of Łódź is diverse with regards to the integration level (Fig. 13). The most integrated part is made up of the orthogonal street layout, resembling an inverted letter L (or letter F). It can be assumed that the intensity of traffic resulting from a beneficial configurational location is relatively high there, thus facilitating social contact. The streets are attractive in terms of location for businesses that benefit from the presence of potential clients. Spaces with the lowest integration, which are theoretically less frequented (marked in grey), are at the other end of the scale.

5. DISCUSSION AND CONCLUSION

The specificity and the difference in the development of individual parts of the territory of a city is set on the relatively strong foundations created by its plan. In the long term, it may be of crucial significance to city functioning. The configuration of a city plan may slowly diversify social and economic processes occurring within the city. In this context, the actions whose functional program is in a spatial mismatch with the configurational determinants may end in failure revealed after a longer time.

The configurational analysis has shown a contemporary, internal diversity of the Historic Urban Core. It is determined by a strong changeability of choice and integration values in the centre of the studied area. The close vicinity of areas that are central or marginal in terms of configuration is surprising in light of the orthogonal and relatively monotonous layout of the street network. The topological features of space in Łódź probably influence the currently noticeable diversity of economic processes in the Historic Urban Core. This conclusion requires a further, separate study (currently in preparation), yet a series of topologically peripheral streets in Łódź appears synonymous with areas of socio-economic collapse (partially under revitalisation).

The analyses facilitate the assessment of the stability/changeability of the Historic Urban Core plan only to some extent. Historically, the city centre was relatively young, shaped within the last 200 years. Its evolution up until now has mostly involved a territorial expansion and densification of the street network as well as a temporary (in light of the actions planned and conducted) 'freezing' of the plan in the 21st century.

Undoubtedly, the most permanent and stable element of the plan of Łódź is the extended, axial (belt-shaped) centre. It is genetically anchored in the medieval urban layout and constitutes its contemporary, vast continuation. The marginal location of numerous streets of Łódź, similarly to the central location (in the topological sense) was imposed by the plan upon their creation. This was the case mostly with streets created in the late 19th century. To this day, they have remained in their rigid configurational framework, which may influence their developmental path.

The contemporary transformations to the Historic Urban Core of Łódź aim at improving the quality of life of its inhabitants. In this context, it is important to consider the predispositions of individual areas of the city, resulting from its plan arrangement. The knowledge of the hidden consequences of the city plan makes it possible to obviate the dangers it causes and, simultaneously, set the social and economic activity more aptly in space. The activity does not always involve a physical intervention in the urban tissue, which is usually hard to conduct. It may involve micro-scale, but also long-term programs aimed at maintaining the social and economic activities, creating a sense of community, and increasing the attractiveness of a place on both the physical and symbolic level (*genius loci*).

It would be advisable for Łódź to pay particular, long-term attention to the areas with low integration values identified in the city centre. Some of them are currently undergoing revitalisation involving, for instance, the transformation of streets into woonerfs. However, these actions without the improvement of the local typological features of the layout may, in some cases and in the long term, prove insufficient to really streamline their functioning. Movement conditions in spaces with the highest intensity of pedestrian traffic should also be improved. This may largely facilitate the implementation of the idea of new urbanism as well as the creation of liveable sustainable communities.

The improvement in the integration of the New Centre of Łódź with its surroundings, and especially the axial core of the Historic Urban Core, would also be reasonable. The implementation of new, clear and pedestrian-friendly transport solutions between these two vital city areas should be considered. The merely mentioned peripheral location of the Old Town, which lost its city-wide, central functions during the time of territorial development, is also crucial and requires separate research.

By dint of the established theoretical foundations as well as specific research methods, space syntax makes it possible to analyse the contemporary and historical images of the city, as well as the process of its evolution. Space syntax supplements the traditional model representing urban space, based on geometrical relations, with an approach based on topological relations. Both models should be considered complementary images of the same reality. The model proposed by space syntax, due to the relatively short development period and potential that is still being discovered, appears more interesting from both theoretical and empirical perspectives.

Both the presented and quoted studies indicate that space syntax methods make it possible to obtain results that are spatially precise in context. Aside from the cognitive advantages, space syntax is also an advantageous practical tool. The only long-term goal of building or transforming urban structures is to obtain an environment in which the socio-economic processes will be successfully conducted. Space syntax can facilitate the fulfilment of such aims by limiting the situations where an investment implemented is shortly abandoned for other, more competitive places. Moreover, the continuous monitoring of configurational transformations can provide important data on the functioning of the whole urban organism.

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