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ARE NATURE-BASED SOLUTIONS A NEW APPROACH IN POST-INDUSTRIAL REGENERATION PROJECTS?

Mariana Diana Rodica PÂNZARU, Cristian I. IOJĂ* & Andreea NIȚĂ

*University of Bucharest, Center for Environmental Research and Impact Studies, 1 Nicolae Balcescu, 010041, Bucharest, Romania, *Correspondence author; E-mail: cristian.ioja@geo.unibuc.ro*

Abstract: Urban regeneration seeks to improve the quality of the urban environment, to develop new urban land use, to stimulate social cohesion and economic activity, as well as the protection of urban land and ecosystems. They follow to provide environmental, social and economic benefits, which complies with Nature-based Solutions (NbSs). The aim of the paper is to test if the different features of NbSs could be identified in former post-industrial regeneration projects. For our analysis, we considered 32 projects from 28 post-industrial cities and 11 European countries. For these projects, we perform a content-analysis to identify how the different key features that define NbSs (Eklipse Challenge's, human interventions, processes, social benefits, co-benefits and stakeholder involvement) have been addressed. We use Social Network Analysis (SNA) in order to investigate the role and influence of the stakeholders within the network. Our findings show that there is a moderate compatibility between former post-industrial regeneration projects and the key features of NbSs. However, the past experiences point out that municipalities and experts are key stakeholders that initiate and support the implementation of the regeneration projects. Understanding how former post-industrial regeneration projects have worked helps the development of the effective approaches to promote sustainable solutions, including NbSs.

Keywords: post-industrial regeneration, Nature-based Solutions, stakeholders, social network analysis

1. INTRODUCTION

Sustainable Development Goal 11- Sustainability cities and communities recognizes that "*sustainable development cannot be achieved without significantly transforming the way we built and manage our urban spaces*" (United Nations, 2015). However, choosing a sustainability-oriented system to keep human security, well-being, and health and to consider linkages between nature and society are not easy tasks (Liu et al., 2015). Attaining sustainability requires concerted interactive efforts among scientists, stakeholders and practitioners (Badiu et al., 2019a; Hossu et al., 2020; McMichael et al., 2003) to adapt smart solutions in urban settings (Addanki & Venkataraman, 2017).

Urban regeneration is an obvious process that seeks to improve the quality of the urban environment, to develop new urban land use, to stimulate social cohesion and economic activity, as well as the protection of urban land and ecosystems (Bartke et al., 2018). It is often considered the derelict areas affected by the deindustrialization processes that needs to be brought back to functionality and reintegrated into the urban matrix (Ekman, 2004; Urbancová et al., 2014). These areas can conserve historical and cultural values that coexist with a series of environmental disturbances (Kristiánová et al., 2016), like persistent land contamination, abandoned land and/or buildings, impervious surfaces, and unaesthetic or unattractive landscapes (Grădinaru et al., 2015; Sanches & Pellegrino, 2016).

Regeneration of industrial areas requires significant resources (Filip & Cocean, 2012; Gavrilidis et al., 2011) and seeks to improve the economic, social and biophysical conditions of the derelict areas, by adapting their functionality to current challenges (Raymond et al., 2017). They can take the form of commercial or residential areas, but they are often transformed into green spaces, being embedded in the green infrastructure functionality of a city (Kristiánová et al., 2016).

In Europe, there are numerous examples of urban regeneration in post-industrial cities. These are the proof of good practices which combine elements of nature with those architectural ones in order to create a unique ensemble with various social, economic and environmental benefits. It was proven that repurposing a heritage industrial site allows to maintain their historical values, while adapting to the current societal needs (Laraia, 2019). To an increasing extent, solutions "*inspired by, supported by or copied from nature*" (European Commission, 2015) are adapted in the urban regeneration projects to respond to societal challenges (Fan et al., 2017; Loures, 2015; Nefedov et al., 2012). According to Raymond et al., (2017), the consideration of Nature based Solutions (NbSs) into regeneration projects could be related with urban regeneration processes, aesthetic and design improvement, energy and water resources efficiency, climate change adaptation and/or the green infrastructure extension (Artmann et al., 2019; Badiu et al., 2019b; Csete & Gulyás, 2019; Gavrilidis et al., 2019; Iojă et al., 2018; Song et al., 2019). Nature-based Solutions are bringing multiple benefits, enhancing the ecosystem services supply, the socio-cultural conditions (Dong et al., 2017) and cities aesthetic attractiveness (Laraia, 2019).

To implement regeneration projects, considering NbSs, multidisciplinary collaboration and multiple stakeholders engagement of key stakeholders are required (Delft University & Wageningen University, 2019) to support more efficient and sustainable decisions (Reed, 2008), to facilitate dissemination and transparency (Soma et al., 2018) and to minimize potential risks (Ianoş et al., 2012; Zedan & Miller, 2017). The understanding of the power and influence of each stakeholder is critical for the success of a regeneration project. Therefore, network analysis is a useful tool to investigate different patterns in the collaboration network, which might supply critical information to analyse how specific collaborative efforts progress (Berardo, 2014), such it is the case of the projects and programmes that envisage Nature-based Solutions.

In former urban regeneration projects, there is a high diversity regarding the level of human intervention, the nature of the underlying processes and the consideration of co-benefits and stakeholders' involvement. Nevertheless, there is a lack of knowledge regarding that way in which former regeneration projects consider and implement NbSs principles. Furthermore, the connections established between the stakeholders require more details in order to understand how the collaboration relationships influence this type of projects.

The aim of the paper is to test if the different features of Nature-based Solutions could be identified in former urban regeneration projects. Considering 32 European urban regeneration projects, we envisage the following specific objectives: (a) to identify how different key features that define NbSs (Eklipse Challenge, human interventions, processes, social benefits, co-benefits and stakeholder's involvement) have been addressed and (2) to identify the specific patterns of the collaboration relationships established between the different stakeholders involved in the analysed projects.

2. METHODS

2.1. Background data

Using Landazine database, "*the largest collection of landscape projects online*" (Zaš et al., 2009), we extracted 32 post-industrial urban regeneration projects from European cities. For all selected projects, we consider for analysis: (a) the *surface*, to characterize the project's amplitude by reporting to city surface; (b) the *purpose*, to identify the addressed societal challenge and targeted ecosystem services; (c) the *history*, that point out the former industrial activities; (d) the *cessation moment*, that marks the moment when the industrial site stops to be active; (e) the *mention regarding abandonment*, to emphasize the disconnection on the city structure and function; (f) the *current land use*, to show the result of regeneration work; (g) the *relevant stakeholders* (i.e. SMEs, educational and research institutions, administrative institutions, etc.); (h) *the degree of assimilation with NbSs*, considering human interventions, processes, social benefits, co-benefits and stakeholder involvement. Using OSM (Open Street Map) and processed in ArcGIS Pro version 2.4, we extract details about morphological features of the projects and cities. Demographic and economic data has been considered, using EUROSTAT database (Eurostat, 2019).

To assess the level of similarity between the measures promoted in post-industrial regeneration project and NbSs, we have used the binary content analysis (0 - absence, 1 - presence) to test the consideration of the following NbSs features after (Raymond et al., 2017): 1) addressed societal challenge (considering Eklipse categories); 2) the level of human intervention (grey infrastructure OR green/blue infrastructures), 3) the nature of the underlying processes (anthropogenic or natural); and 4) the co-benefits.

2.2. Network analysis

In order to create the collaboration matrix, we used extracted data about stakeholders for each project. We standardized each stakeholder's name in order to avoid overlapping. Further, we classified the stakeholders in leaders and partners, considering also the following categories as attributes: 1) public institutions, 2) research and education institutions, 3) small and medium enterprises, 4) experts and 5) NGOs. We performed the network analyses using UCINET software (Borgatti et al., 1996).

To evaluate the role and influence of the network stakeholders, we calculated centrality metrics: degree and eigenvector normalized centrality (Manolache et al., 2018; Niţă et al., 2016). The more connections a stakeholder (node in the network) has, the more likely it is to have access to information and to influence the decisions of others (Zedan & Miller, 2017).

In the context of our study, the degree centrality measures the level of connections a stakeholder has at network level, while the eigenvector values are useful as measures of centrality (Bonacich, 2007) and in our study shows the influence of a stakeholder upon other actors within the network (Rozylowicz et al., 2019).

3. RESULTS

3.1. Project background data

The 32 selected post-industrial regeneration projects are located in 11 European countries (10 EU members) from 28 cities (Table 2, Fig. 1). These projects are related with the interest to convert post-industrial areas in the cities with different services. Resulted from three different industrial revolution (Spielvogel, 2005), post-industrial sites start to be reconverted during the 1960-1970 period (Jigoria-Oprea & Ignea, 2014), being an ongoing process. The case studies are from cities with different size, the lowest being Carinthia, Austria (4077 inhabitants, 6980 ha city area) and Henin-Beaumont, France (25901 inhabitants, 2070 ha city area), while the highest being Berlin (3644826 inhabitants, 89100 ha city area). The highest surface of the case study projects is specific for Germany, France and Belgium, countries that have experimented the most intensive industrialization (Fig. 1). The smallest post-industrial sites are from Carinthia, Austria (9 ha, and 0.13 ha from city area), and the largest Hamburg-Wilhelmsburg (2718 ha, 3,6% from city area) and Berlin (2325.51 ha, 2.61 % from city surface). The highest impact on the city area have the projects from Genk, Belgium (15.15% from city area), Eindhoven, Netherland (11.05%) and Esch-sur-Alzette, Luxembourg (10.76%) (Table 2).

3.2. Are there any similarities of post-industrial regeneration projects with NbSs?

From the total projects analysed, 30 projects address at least one of the societal challenges listed in the EKLIPSE report. Most of them address one (15) and two (15) challenges, the most frequent being the challenge VI – Urban Regeneration (32 projects). The challenge IV – Green Space Management (8 projects), I – Climate resilience (5 projects) and II – Water Management (5 projects) are registered. The challenges III – Coastal Resilience, V – Air Quality, VII – Participatory Planning and Governance, VIII – Social Justice and Social Cohesion X – Potential for Economic Opportunities and Green Jobs have reported in no project (Table 3). Also, 30 projects have used a combination of Grey and Green/Blue infrastructure to create environmental, social and economic benefits.

The post-industrial regeneration projects tend to add value to the areas and also to conduct to the creation of co-benefits for the citizens. The measures used in these projects are often based on natural processes (30 projects), meaning that their viability is sustained by nature without human intervention assistance in order to be operational.

A percentage of 69% of the analysed case studies has experienced a cessation activity starting with 1970 (Table 1). Historical activities that have shaped these industrial landscapes over the years, it turned out to be consisting especially in factories (28%) and mining (25%).

Table 1. Cessation time of industrial activities

Activity cessation	No. projects
<1980	5
1981-1990	7
1991-2000	4
> 2001	6
No information available	10

3.3. Stakeholders power and connections

There were recorded 98 different stakeholders involved in 32 investigated projects (between 2-9 stakeholders per project, with a median of 4).

In most cases, the project leaders are often represented by the cities' municipality (20 projects), especially where areas have been abandoned. In the rest of 12 projects, the leader is represented by private entrepreneurs, governmental institutions or NGOs. We found that governmental institutions and NGOs are leaders for the complex projects, such as *La Tancada Salt Fields* (Spain), where Catalunya Caixa Foundation, Spanish Minister of Environment, Natural

Table 1. Post-industrial project features

Country	Region	City	Inhabitants	City area (ha)	City industrial area surface (%)[1]
Austria	Carinthia	Eisenstadt-Sankt Margarethen	4077	6980	0.13%
Belgium	Flanders	Beringen	46346	7830	4.27%
		Genk	66227	8790	15.15%
		Kortrijk	76735	8000	5.46%
Denmark	Nordjylland	Aalborg	210316	114400	1.09%
	Central Denmark Region	Skanderborg-Laasby	59481	46200	1.21%
Switzerland	Eastern Switzerland	Glarus Nord – Spinnerei strasse, Ziegelbrücke	18418	14700	0.46%
	Zurich	Zurich	415215	8790	1.61%
France	Hauts-de-France	Henin-Beaumont	25901	2070	3.74%
	Hauts-de-France	Lille	232440	3480	4.28%
	Pays de la Loire	Nantes	306694	6520	4.93%
	Hauts-de-France	Lens	30689	1170	6.03%
	Ile de France	Paris	2190327	10600	0.44%
	Normandie	Rouen	110117	2140	5.72%
Germany	North Rhine-Westphalia	Elsdorf	21663	6620	0.59%
	Berlin	Berlin	3644826	89100	2.61%
	Baden-Württemberg	Dormettingen	4627	2330	0.50%
	North Rhine-Westphalia	Duisburg	498590	23300	3.68%
	North Rhine-Westphalia	Essen	583109	21000	4.32%
	Hessen	Frankfurt	753056	24800	6.70%
	Baden-Württemberg	Freiburg im Breisgau	230241	15300	2.71%
	Hamburg	Hamburg Wilhelmsburg	1841179	75500	3.60%
Italy	Piedmont	Torino	875698	13000	3.98%
Luxembourg	Luxembourg	Esch-sur-Alzette	35382	1430	10.76%
Netherlands	North Brabant	Eindhoven	231469	8770	11.05%
	Utrecht	Utrecht	352795	9430	7.68%
Spain	Catalunia	Amposta	20606	13800	0.68%
Hungary	Budapest	Budapest	1749734	52500	2.44%
	South Transdanubia	Pécs	144188	16300	6.91%

Figure 1. Post-industrial regeneration projects

[1] Open Street Maps - http://overpass-turbo.eu/

Table 2. Regeneration measures potential to be assimilated with NbSs (0 – absence, 1- presence)

Project	Country	Eklipse challenges adressed	Human intervention		Processes		Social benefits	Co-benefits
			Grey infrastr	Green/blue infrastr.	Anthropogenic	Natural		
Old airfield kalbach frankfurt am main	Germany	IV, VI	0	1	0	1	1	1
La tancada salt fields	Spain	II, VI	0	1	0	1	1	1
Old railway	Denmark	I	0	1	0	1	1	1
Terra nova biospherebelt	Germany	VI	1	0	0	0	1	1
Play landscape be-mine	Belgium	VI, IX	1	1	0	1	1	1
Garden malzfabrik	Germany	VI	1	0	1	0	1	0
Sudgelande nature park	Germany	VI	0	1	0	1	1	1
Millenary park	Hungary	IV, VI	1	1	1	1	1	1
Shale experience park	Germany	II, IV	1	1	1	1	1	1
Parc des iles	France	I, II, VI	1	1	1	1	1	1
Landscape park duisburg north	Germany	VI	1	1	1	1	1	1
Rhine park	Germany	VI	1	1	1	1	1	1
Strijp s	Netherlands	VI	1	1	0	1	1	1
City square developing	Luxembourg	VI	1	1	0	1	1	1
Zollverein park	Germany	VI, IX	1	1	0	1	1	1
Zollhallen plaza	Germany	I, II, VI	1	1	1	1	1	1
Genk cmine	Belgium	VI	1	1	0	1	1	1
Georgswerder energy hill	Germany	II, VI	1	1	0	1	1	1
Wuwei	Belgium	VI, IX	1	1	1	1	1	1
Laasby sea park	Denmark	I, VI	1	1	0	1	1	1
Haute deule river banks	France	II, VI	1	1	1	1	1	1
Foundries garden	France	VI	1	1	1	1	1	1
Museum park louvre lens	France	IV, VI	1	1	0	1	1	1
Rosa luxemburg garden	France	VI, IX	1	1	1	1	1	1
The rehabilitation of the zsolnay factory	Hungary	VI	1	1	1	1	1	1
Presqu ile rollet park	France	VI	1	1	1	1	1	1
Roman quarry redesign	Austria	VI	1	1	0	1	1	1
Lower factory pond	Switzerland	I, VI	1	1	1	1	1	1
Parco dora	Italy	IV, VI	1	1	1	1	1	1
National military museum, soesterberg	Netherlands	II, VI	1	1	0	1	1	1
Latvian viaduct	Switzerland	VI	1	1	0	1	1	1
Mfo park	Switzerland	VI	0	1	0	1	1	1
		TOTAL	27	30	15	30	32	31

Park Administration Delte de l'Ebre and the Institute of Agricultural Research join together to restore a degraded ecosystem.

The partners of these post-industrial projects are urban planners, designers, constructions companies, experts (architects, designers, planners or ecologists) and members of local communities. Their established collaboration through the project's implementation allowed to propose and implement the suitable solutions.

Considering the total number of stakeholders involved, 59.6% are small and medium enterprises, more involved in designing and implementation phase of post-industrial regeneration projects. Public institutions (19.9%) are represented in all projects, occupying especially the leader and advisory position. NGOs (2.9%), research institutes (5.1%) and experts (12.5%) are the least represented stakeholders, being considered especially in planning and design phase.

The one-mode stakeholders' network contains 98 different actors involved in the regeneration projects implementation. The representation of the collaboration network shows that only two groups of stakeholders have linking roles / abilities (Fig. 2).

When analysing the collaboration ties between stakeholders, city municipalities (ID = 62) play the most important role among all the stakeholders, having the highest degree centrality 0.68 and eigenvector centrality 0.65 (Fig. 2). Therefore, municipalities establish important links with diverse groups of stakeholders, supporting knowledge transfer and new collaborations. In terms of stakeholders' importance, also the experts (ID = 47) play an important role, recording high values for the centrality metrics calculated (degree centrality = 0.619, eigenvector = 0.629). Their position within the network show that experts are considered to be the *controllers* of the network. A c*ontroller* play an important role due to his extensive knowledge in various areas, access to information and decision-making power within projects (Kronenberg et al., 2017).

In the analysed network, several stakeholders registered a degree and eigenvector centrality above average (34 stakeholders have a degree centrality above the average of 0.06 and 50 stakeholders have eigenvector centrality above the average of 0.1). They are represented by local communities (e.g. the Bedburg Community, Germany, Henin-Carvin Urban Agglomeration Community and Lille Metropolitan Community), state institutions (e.g. Essen City Council), small and medium enterprises for landscape engineering, architecture and urban planning (e.g. Studio Bruel-Delmar, Venna, Stucky, AGH haut debit, SORELI) and last but not least research and education institutions (e.g. Strijp Park Administration). Having the values of centrality metrics above average, without occupying leading positions, these stakeholders can be considered as *innovators* since they contribute into collaborative projects formed between various interest groups. Therefore, they can ensure a continuous flow of information within and across the network boundaries, keeping the network updated and open for improvement or new sustainable solutions. However, about 61% of the identified actors presents a lower importance within the network, having a degree and eigenvector centrality below average. This could be explained by the fact that some stakeholders were involved in the implementation of only one project and after that they didn't established new partnerships.

As mentioned before, experts (ID=47) are the second influential group after municipalities, having the eigenvector centrality of 0.629 units (Fig. 2). Given this result, they represent a decisional factor in initiating projects, comprising various actors from diverse fields of activity such as: architects, engineers, planner, designers, and ecologists. Therefore, through a collaborative participation of the two groups (municipalities and experts) for the post-industrial regeneration projects' implementation, new collaboration opportunities could be achieved with various organizations positioned in the central part of the network.

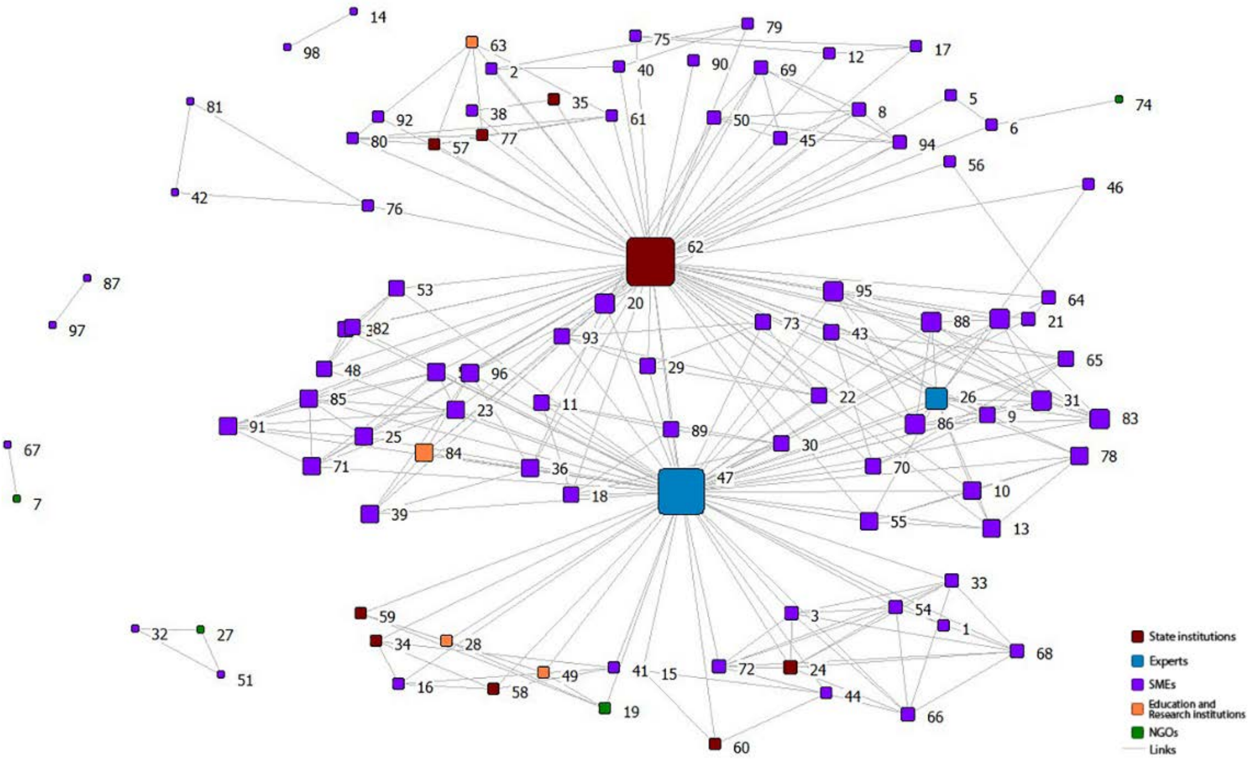

Figure 2. Stakeholder's network by the type of stakeholders

Even though the network of actors is created around the municipalities and experts, some isolated networks illustrate that the model of mutual collaboration is established between private organizations predominates (Fig. 2).

4. DISCUSSIONS

The concentration of projects with large transformed areas in Germany, France and Netherlands (Fig. 1) is influenced by their economic power and research investments. Also, the extent of their historical past in heavy industry is a criterion that might influence the size of the projects.

The major finding shows that there is a moderate compatibility between post-industrial regeneration projects and the key features of NbSs. We have found many similarities with NbSs, especially related with green infrastructure development, social benefits and co-benefits. However, they cannot be considered NbSs because high level of human intervention in management phase of regeneration projects. This is proven to be critical to have all features of NbSs, no isolated-one being able to obtain the maximum diversity of ecological, social and ecological benefits (Raymond et al, 2017).

By calculating the centrality metrics of the stakeholders in the analysed network, we highlighted the most influential and involved actors in representative urban regeneration projects of post-industrial areas from Europe. As expected, municipalities have the highest influence in the network given the eigenvector centrality results. This can be explained by the fact that most often they are the initiators in the regeneration projects. Due to their statute within cities, municipalities are directly responsible for the citizen's well-being and the sustainability of urban centres. Therefore, the degree of confidence that they rise among people, due to their role and attributions as state institution, justifies the high involvement in such projects.

Furthermore, along with city municipalities, experts are also very influential stakeholders of the network. Because of the many connections established with other important stakeholders (especially SMEs), they are an inexhaustible source of information, knowledge and relationships with different fields of activity. On the other hand, municipalities can adopt innovative solutions as regeneration measures (e.g. Natural based Solutions) while encouraging collective learning through stakeholder's involvement (Wamsler, 2017). At local level, they have the ability to act as decision makers *(controllers), along with individuals (public),* who set the general framework for social and institutional structures (Kronenberg et al., 2017). The constraining potential that they show can be an effective method in promoting NbSs in the current legal framework as regeneration measure. Thereby, municipalities can have the power to promote NbSs, taking in consideration that it is their responsibility to build and maintain a sustainable urban environment (Li et al., 2018).

Municipalities, experts and local communities share their project experience with a large part of the network stakeholders. This shows that they function as an information and knowledge disperser (Rozylowicz et al., 2019). As the degree of centrality of an actor depends on the number of collaborations (links) with other network actors (Manolache et al., 2018), its high values are expected to be recorded for actors such as municipalities. Thus, when the number of contributors within a project is low, indirect beneficiaries of projects (such as the population) must also be considered in order to ensure collaboration and information exchange.

The high values of the eigenvector centrality were recorded by a small group of actors, mainly represented by municipalities, experts and groups of local communities. This can be explained by the fact that NbSs has been increasingly promoted by civil society through bottom-up initiatives, due to their benefits for enhancing well-being (European Commission, 2015). In other words, the use of NbSs in post-industrial urban regeneration projects starts at the initiative of local communities that have the power to influence the priorities within a city, consolidating them through the decision-making power of municipalities. The need to integrate NbSs in this kind of projects appeared along with an increasing awareness of environmental protection and environmental impact reduction (Niţă, 2019). Thus, municipalities have the obligation to meet the needs of the public, the latter also having a very important role. Collaboration between experts from various activity fields (architecture, urbanism, geography, biology, ecology) alongside diverse organizations (SMEs, Research and education institutions, State institutions, NGOs) can maintain a continuous flow of information around the network.

Despite the important role that they play (Andersson et al., 2017), this study reveals that a small number of experts and research institutions were engaged within the projects. The results shows that public opinion was neglected too These deficiencies can put pressure on the implementation and NbSs acceptability (Giordano et al., 2020), arising frustration and potential conflicts between various groups (Ianoş et al., 2012; Shacham et al., 2016). According to Somarakis et al., (2019) "*Everyone who has responsibility in the planning of the structural, architectural, and technical aspects at the site where the NbSs is foreseen should take part in the planning process*". Highlighting such limitations, new opportunities rise for further studies, in which the expert's opinion from various disciplines and scientific fields alongside with the collaborative participation of citizens should be thoroughly studied.

5. CONCLUSIONS

Understanding how former post-industrial regeneration projects have worked, it helps to develop effective approaches to promote sustainable solutions, including NbSs. Even if there are only moderate similarities with NbSs, former post-industrial regeneration projects offer a significant input for NbSs implementation in different urban settings.

Social network approach can play an important role in terms of building collaboration for promoting NbSs as regeneration measures. Through this study, we succeeded to highlight that participative collaboration between stakeholders from various fields of activity, which can be a suitable approach in order to facilitate the use of NbSs on a large scale. Considering the limited amount of information available in the literature on this topic, our analysis may also be an important tool in assessing stakeholder's characteristics, given the fact that network analysis facilitates the identification and grouping of the proper stakeholders according to their potential to collaborate with others. By understanding the role and influence that each stakeholder has within the network, the present study can help to identify deficiencies and opportunities that can facilitate or limit the integration of NbSs in post-industrial urban landscapes.

Improving collaboration between stakeholders in a way that goes beyond the basics of common relationships will allow other actors to have a strategic position in the network, contributing to an efficient dissemination of information and transparency in the implementation of post-industrial regeneration projects.

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