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Introducing nature-based solutions into urban policy – facts and gaps. Case study of Poznań

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ABSTRACT

Cities often don't appreciate the benefits of green infrastructure (GI) enough. To recognise the extent to which green infrastructure and nature-based solutions (NbS) are present in the urban policy, we conducted a review of planning, strategic and programming documents of Poznań City as a Case Study. The study is aimed at 1) diagnosing of current position NbS in the tasks and directions of planning, strategic and programming documents; 2) characteristic of activities related to NbS according to the form of human-nature interaction; 3) determining the potential of including NbS in the local policy; 4) identifying the role of NbS in facing 4 main challenges in urban policy: resilience and climate change adaptation, health and well-being, social cohesion, economic development potential. The results show that a significant number of actions focus on GI changes towards its multifunctionality and better quality, while there are not many actions towards supporting citizens in using it. Also, despite urban pressure, new green spaces are still planned to be created. The role of NbS within GI in urban resilience is well recognised. Yet, the adaptation to climate change has gained a low priority so far. Linkages between GI and the wellbeing of inhabitants are well understood. However, the possibility to build and strengthen social cohesion based on GI is rather marginally noticed. The least recognised is the influence of NbS on the economic development potential. It is an area that still needs to be investigated to bring evidence in this field. We conclude that to support large-scale, nature-based solution implementation in cities, the crucial step is to bring them into the local urban agenda. An evaluation of urban policy documents based on the presented approach can serve as a guideline for identifying gaps and potentials for NbS inclusion. As a result, it can help the better organisation of urban policy and harmonisation of different sectors through NbS.

1. Introduction

Cities, as places of population concentration (Hall and Hay, 1980; Kabisch and Haase, 2011) and high economic potential (Quentin et al., 2013), with diverse natural conditions, face many challenges connected with the simultaneous provision of a high quality of life for the inhabitants and the resilience of the city to human pressure and extreme events, including changing climatic conditions. The key role in solving these problems is played by the local authorities (Bulkeley and Kern, 2006; Lankao, 2007).

From the point of view of the city management, the concept of Nature-based Solutions (NbS) seems to be particularly interesting, giving multidimensional benefits. NbS are recognised as a transdisciplinary umbrella concept that builds upon pre-existing concepts, such as blue-green infrastructure, natural capital, ecosystem services, and landscape functions in environmental planning (Albert et al., 2017). Eggermont et al. (2015) point out, that even though NbS are often referred to as innovative, they also encompass existing ideas that build on lessons from the past.

Against this background Nature-based Solutions are defined as "actions which are inspired by, supported by or copied from nature". They involve "the innovative application of knowledge about nature, inspired and supported by nature, and they maintain and enhance natural capital" (EU, 2015), that "address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016). Thus NbS are treated as a solution to contemporary societal challenges that meet environmental, social and economic objectives of sustainable development (EU, 2015) similarly to other pre-existing approaches (Faivre et al., 2017; Nesshöver et al., 2017).

The NbS concept has emerged as an operationalisation of an ecosystem services concept within spatial planning policies and practices

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(Scott and Lennon, 2016). Since NbS are based, in large part, on natural areas and features in and around cities (EU, 2015), the presence of green infrastructure (GI), which is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services (COM, 2013) is fundamental. As NbS may result from increased provisioning and improved availability of urban green spaces (Kabisch et al., 2016), development of GI elements is a key issue. In this respect, GI can be recognized as a physical structure, whereas NbS are activities aimed at the conscious, goal oriented development and/or the use of GI potential to solve urban problems. They rely on the application of knowledge about environmental processes, ecosystem services and benefits provided by GI. In this context, if GI planning, design and management are intentionally oriented to tackle environmental, social and economic challenges, they can be recognized as NbS. In summary, the term GI describes spatial structure of ecosystems, whereas NbS is seen as a human action oriented on the GI functions. However, it has to be bear in mind that the ecosystem services flow that benefits people, often require human investment (Maes and Jacobs, 2017). Therefore it is crucial to consider what should be understood as "nature" (Nesshöver et al., 2017) especially in the urban context. A mixture of green and man-made infrastructure (parks, green roofs) of different proportion and configuration sometimes can make the distinction between green and grey solutions ambiguous (Raymond et al., 2017a). As broad framings can lead to uncertainties and unclearness in the common understanding of NbS and its relation to pre-existing concepts, each case needs to be explicitly explain what is meant by NbS (Nesshöver et al., 2017).

With the ambition of positioning Europe as a world leader in responsible innovation in Nature-based Solutions, the EU's research & innovation (R & I) policy introduces the concept of NbS to the family of approaches building on the usefulness of ecosystems to humans (EU, 2015). EU supports and encourages local authorities to implement an integrated approach to the urban economy through, among others, Thematic Strategy on Urban Environment (COM, 2004). At the same time, it indicates solutions based on green infrastructure (COM, 2013) that, having diverse functions, provide a bundle of ecosystem services, which is particularly beneficial in the urban environment. In order to promote good practices, the EU facilitates their dissemination and supports cooperation and exchange of experiences between the cities at various planes. Oriented towards transition in cities, the projects focusing on NbS, for example: CONNECTING Nature (CONNECTING - COproductioN with NaturE for City Transitioning, INnovation and Governance) are executed within the framework of Horizon 2020 (EC, 2016).

In urban environment management, it is required to have an integrated strategic approach (Jamnický, 2006; Ramezani et al., 2015; Pazouki et al., 2017) based on long-term and medium-term plans of activities, including connections between different policies. The cities take various actions to improve living conditions; however, they often do not make use of the potential of the natural environment and the resulting benefits, of which the source is problem or opportunity oriented GI. We are convinced that the multiplication of NbS largely depends not only on the understanding of their benefits and cost-effectiveness by policymakers but also on the position of NbS in urban policy.

Against this background, to support cities in their transition process towards more sustainable development through NbS, we provide a procedure to identify existing and potential NbS inclusion in the strategic, planning and programming documents developed for the cities. The objectives of the paper are:

a) diagnosis of NbS position in the tasks and directions of planning, strategic and programming documents;
b) characteristic of activities related to NbS according to the form of human-nature interaction
c) determining the potential of including NbS in the local policy;
d) identifying the role of NbS in facing 4 main challenges in urban policy: resilience and climate change adaptation, health and well-being, social cohesion, economic development potential.

In this paper, we intend to bridge the gap in knowledge of the extent to which planning, design and management of GI are intentionally oriented to face urban challenges such as resilience and climate change adaptation, human health and well-being, social cohesion as well as green economic growth. To recognise how far actions recognized as NbS are currently present in the directions of development and tasks, and what is the potential to include it, we conducted a review of planning, strategic and programming documents of Poznań City as a Case Study.

Poznań is an interesting city for study, as it is in the transition process towards sustainable innovations through participation in the CONNECTING Nature Project under HORIZON 2020 in which it leads actions on NbS for being 'Smart and Sustainable'.

2. Material and methods

2.1. Study area

Poznań is the fifth largest city in Poland with a population of over 540 000 inhabitants and area of 262 km^2 (SP, 2017). Simultaneously it is one of the most important economic centres and most urbanised areas in Poland (KSRR, 2010; Węcławowicz, 2016). In addition, it has a well-established green infrastructure and faces contemporary urban challenges such as suburbanization and urban pressure on GI on one hand and depopulation process on the other (Kaczmarek, 2017). These challenges are reflected in the city's vision and directions of development. The strategic goal of "improving the quality of life for all residents" (DSP, 2017) is included in urban strategies, plans and programs.

Although Poznań is a city rich in green infrastructure, with the total share of 58,5% of green and blue areas in land use structure (Urban Atlas, 2012), their distribution is spatially diversified across the city. The characteristic system of green wedges and rings developed in the 1930s in order to provide proper ventilation of the city and protect surface waters (DSRW, 2012; SCDSD, 2014) stands out on the urban fabric (Fig. 1). The main green wedges extend from the suburban areas to the city centre along the Warta river valley and its tributaries providing spatial continuity, internal diversity and connection with the surrounding ecosystems.

The concentric green rings formed by the ramparts of the city and the Prussian fortifications (Raszeja and Gałecka-Drozda, 2015; Klause et al., 2016) are less visible in the urban structure. On the other hand, densely populated areas such as the historical center of the city, districts of the dense quarter buildings and multi-family block buildings have the smallest share of green areas.

Considering these conditions, Poznań faces an opportunity to use and develop existing green infrastructure as a solution for improving urban living conditions and facing related demographic challenges, while supporting urban resilience.

2.2. Urban policy documents

We focused on planning, strategic and programming documents referring to various aspects of the environment management, which are particularly relevant for practical implementation of the Nature-based Solutions. Such documents define the policy of development of the city through the identification of key challenges, problems and needs of its inhabitants. They also specify the goals and directions of the activities aiming at the improvement of the state of the environment and quality of life in the city. Ten interrelated urban documents concerning urban policy of Poznań were reviewed for the identification of NbS-related

Fig. 1. Location of the study area – City of Poznań. Source: own elaboration.

content (Fig. 2).

From the analysed set of documents, development strategy is one of the most important documents that comprehensively programs a city's development. Together with a study of conditions and directions of spatial development and a long-term financial forecast, they represent document of strategic character, which ensure implementation of development policy. Simultaneously goals of strategies are transposed to the programming documents, which are more sectoral in nature and are linked to specific and narrow issues of development policy. Programming documents like plans and programs have an executive character.

2.3. Methods and procedures of NbS identification in policy documents

In order to achieve defined goals, we developed an operational definition of Nature-based Solutions and criteria for identification of NbS-related contents in the urban policy documents. We assumed that the Nature-based Solutions are the conscious activities that increase the ecosystem services capacity of green infrastructure that contributes to solving urban problems. They include creation of new GI elements, strengthening its quality and/or multifunctionality and supporting its usage in diverse ways. NbS-related contents were identified in the text of urban policies and grouped taking into account types of human actions within GI and potential to the inclusion of GI in solving urban problems (Fig. 3).

The procedure for grouping the activities related to NbS and those with potential for introducing NbS in local policy documents consisted of a few steps (Fig. 4).

We treated the directions of development and tasks in the document as being related to NbS when the contents of the text clearly showed that they are based on a green infrastructure (group A). The main criterion in grouping the activities related to NbS was the qualitative character of the human-nature interaction, which could be identified as a physical change or activities that do not lead to physical changes within GI element(s). We distinguished activities, in which new GI elements were physically created and, as a result, the area of GI was increased (subgroup A1). Such solutions include, for example, creating new parks, tree planting or soil unsealing. Another NbS subgroup (A2) includes the activities that lead to physical changes in existing GI elements in order to make them more multifunctional or to improve their quality. As a result, qualitative changes within GI occur, for example, creating rain gardens and absorptive hollows extending water cycle (EPA, 2010; Hoyer et al., 2011; Church, 2017). Within this subgroup, the surface of GI may be slightly decreased, for example, through building bicycle and pedestrian paths in the green areas. The last subgroup (A3) covers the activities that increase the usage of GI without physical changes. An example of such activity can be organising or promoting leisure in the green areas.

The directions of the development and tasks that have the potential to use NbS were analysed as a separate group. Into group B we included provisions, which do not indicate the use of GI for solving urban problems, but on the basis of well known expert-based knowledge can be realised innovatively as NbS. Yet, these contents cannot be treated directly as NbS. An example of such a task is thermo-modernisation of buildings, which typically use artificial materials (mineral wool, polystyrene, polyurethane). However, it has the potential to include the green roofs and vertical greenery systems at least as a complement to artificial insulation.

Reymond et al. (2017) found that NbS can have environmental, social and economic co-benefits and/or costs within and across 10 societal challenges including: climate mitigation and adaptation, water management, coastal resilience, green space management, air quality, urban regeneration, participatory planning and governance, social justice and social cohesion, public health and well-being, economic opportunities and green jobs. In this work, all NbS-related activities (group A) were assessed taking into account their influence on selected urban challenges. We focused on recognising their direct influence on 4 key urban challenges: (1) resilience and climate change adaptation (R& CCA), (2) health and well-being (H&W), (3) social cohesion (SC), (4) economic development potential (EDP). We identified the direct influence of NbS, only when it was explicitly expressed in the text of the document.

In this study, resilience is treated as the capacity of a system to absorb disturbance and reorganise while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks (Walker et al., 2004). Climate change adaptation is understood as an adjustment of ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and

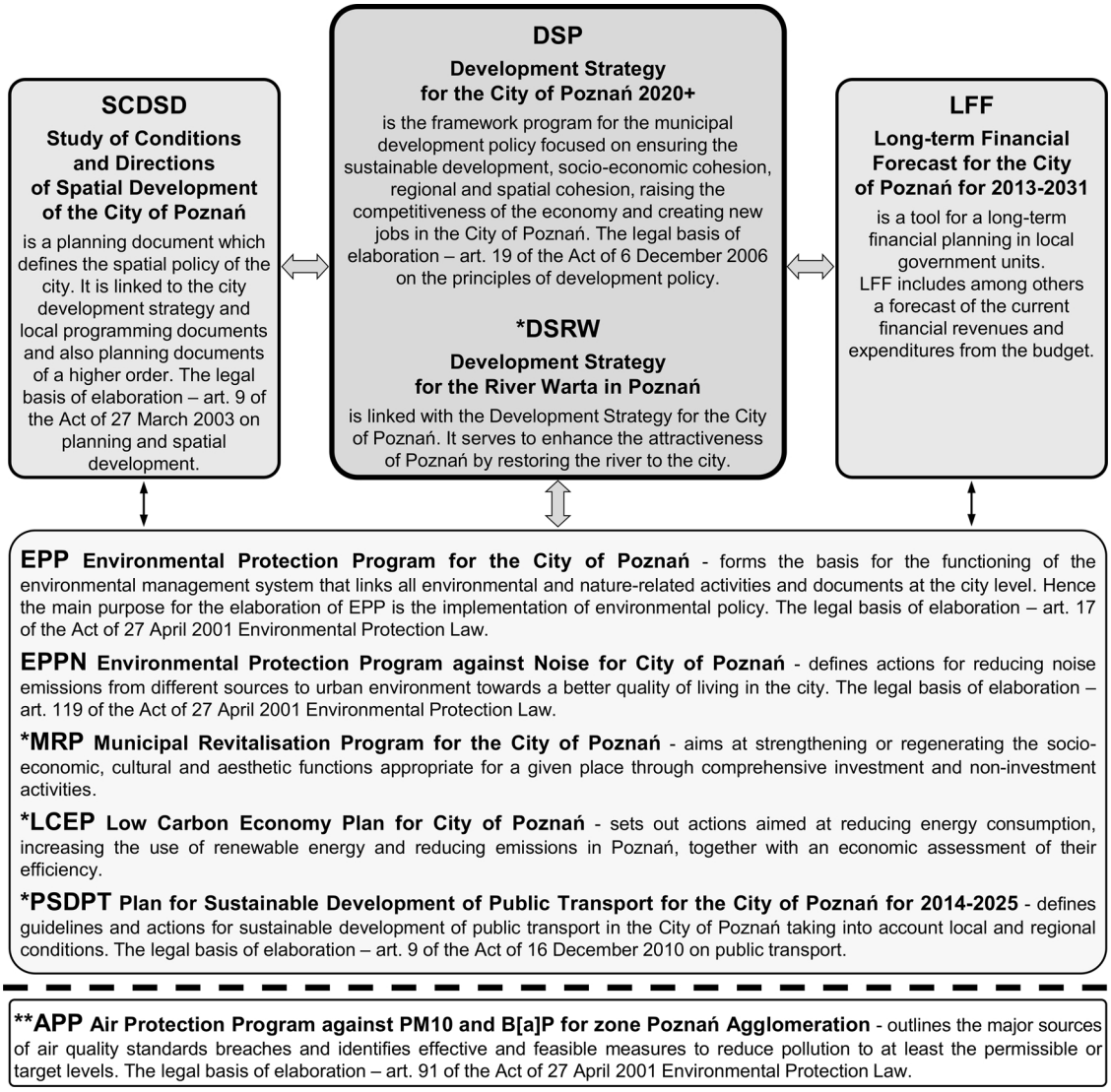

Fig. 2. Reviewed urban policy documents. Source: own elaboration.
* Elaboration of the document is voluntary.
** Elaboration of APP is mandatory if the levels of permissible concentrations of pollutants are exceeded. This is the only document from the selection which is commissioned by the regional authority (Board of Wielkopolskie Voivodeship, Marshal Office). The elaboration of the rest of documents is commissioned by the local authority (President of City of Poznań, City Hall).

impacts in order to alleviate adverse impacts of change or take advantage of new opportunities (Adger et al., 2005). In relation to human well-being, the authors consider it as a context- and situation-dependent state, comprising basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience (MEA, 2005), while health, is defined in accordance with WHO (2006) as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. The third area of influence relates to social cohesion that creates a sense of belonging, promotes trust and offers its members the opportunity for upward social mobility. It also fights with exclusion and marginalisation (OECD, 2011). Finally, as an economic development potential, we considered the impact of implementation of a given NbS in terms of possibilities to strengthen the economic development of the city. As Maes and Jacobs (2017) noticed NbS have a high potential to generate considerable socioeconomic benefits in a resource-efficient way supporting the real-life transition towards a green and sustainable economy.

The identification of NbS-related contents was based on the document analysis by skimming (superficial examination), reading (thorough examination) and interpretation (Bowen, 2009). A popular variant of this method is content analysis (see Graneheim and Lundman, 2004; Hsieh and Shannon, 2005; Rall et al., 2015; Mascarenhas et al., 2015; Kabisch et al., 2015; Mączka et al., 2016; Geneletti and Zardo, 2016; Cortinovis and Geneletti, 2018).

Four reviewers (coders) conducted review using previously described criteria and a spreadsheet (database) in which the primal results where entered. The database contained the following attributes: name of the analysed document, NbS-related content - original and aggregated record, NbS-related content group (A1, A2, A3 or B), NbS-related content influence on 4 selected urban challenges (R&CCA, H&W, SC, EDP), the coder's ID and potential comments. Data collected in the spreadsheet was the basis for all calculations. The inconsistencies in coding, encountered in identifying the NbS-related contents were subjected to joint consultations. We have repeatedly compared, interpret and correct the partial results to improve the proposed procedure of document analysis. Helpful in this process were the guidelines presented by Stevens et al. (2014).

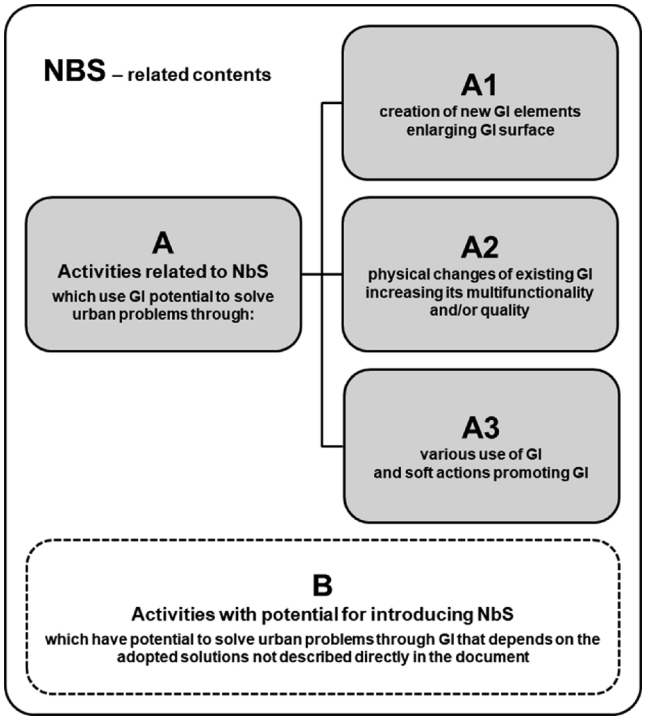

Fig. 3. Groups of NbS-related content in urban policy documents. Source: own elaboration.

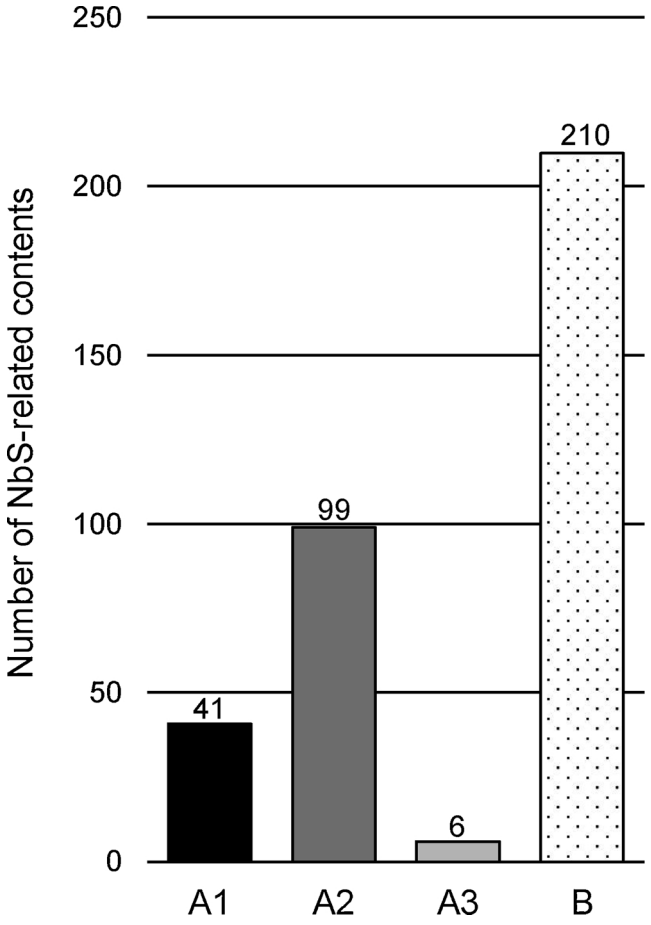

Fig. 5. The diversity of NbS-related contents in analysed urban policy documents in Poznań. Source: own elaboration.

3. Results

3.1. NbS-related content in urban policy

In total, 356 provisions referring to the Nature-based Solutions were distinguished from the contents of the analysed documents (Fig. 5).

146 provisions proposing solutions with the use of green infrastructure (group A) were identified. From this group, 99 provisions

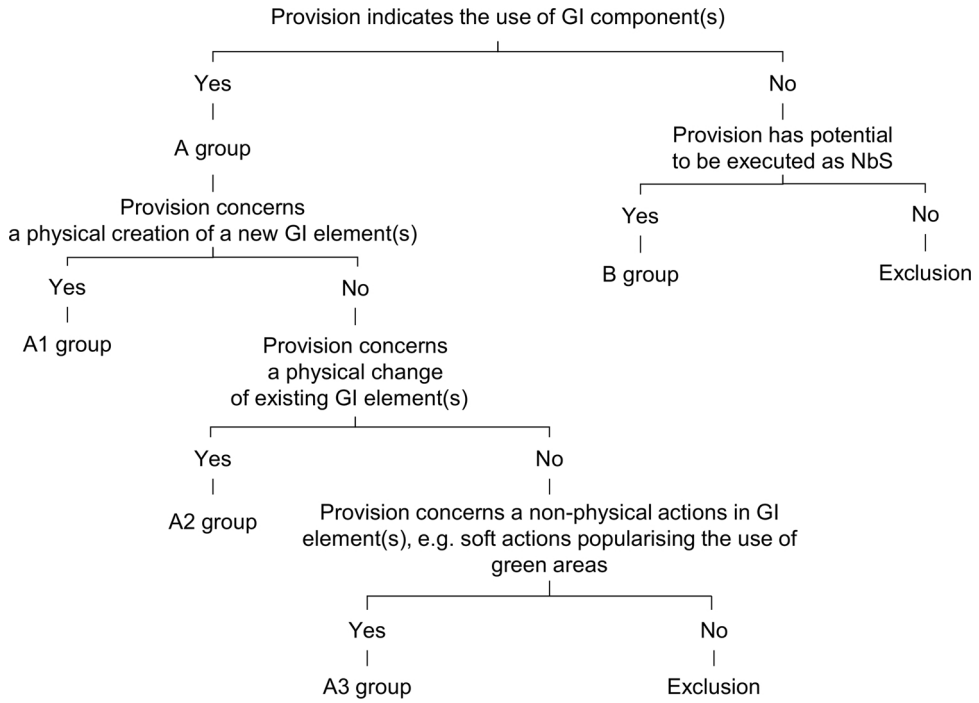

Fig. 4. Procedure and criteria for grouping activities related to NbS (group A) and activities with potential for introducing NbS (group B) in urban policy documents. Source: own elaboration.

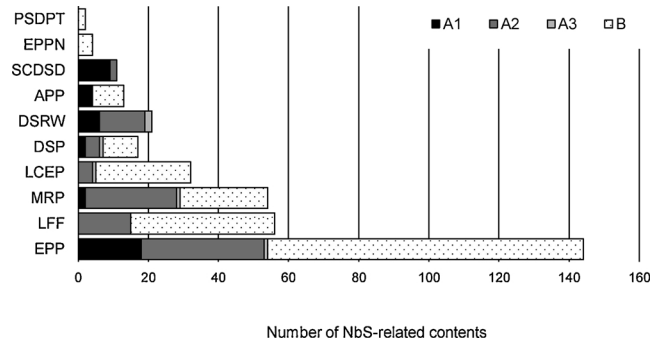

Fig. 6. Number and structure of NbS-related contents in analysed documents. For the documents' acronyms please refer to Fig. 2. Source: own elaboration.

refer to the physical transformation of existing GI (A2), and 41 to the creation of new GI elements (A1). Only 6 provisions refer to the activities that include using or promoting the use of existing greenery (A3). As many as 210 expressions of general character, not indicating the type of solution (grey or green) were identified as having the potential to include NbS. The provisions have been included in group B.

The number of provisions and their structure differed depending on the document. General documents such as Development Strategy and Study of Conditions and Directions of Development contain a relatively small number of provisions; however, recommendations are of citywide character, determining the directions of development. The largest number of the provisions was included in the Environmental Protection Program that contains detailed tasks to be executed in this field. The documents are diversified in terms of the structure of NbS-related contents (Fig. 6)

NbS-related activities (group A) most often occur in the Environmental Protection Program and in Municipal Revitalisation Program. Actions with potential for NbS inclusion occur most often in the Environmental Protection Program.

The documents were also analysed in terms of perceiving the impact of the activities related to NbS classified to group A on the resilience and climate change adaptation (R&CCA), health and well-being (H&W), social cohesion (SC) and economic development potential (EDP) (Fig. 7). The provisions directly expressing the contribution of NbS in solving urban problems were identified, and each of them could refer to more than one area of influence.

The contribution of NbS to resilience (56%) and health and well-being (49%) is most often present in the urban policy. The use of NbS

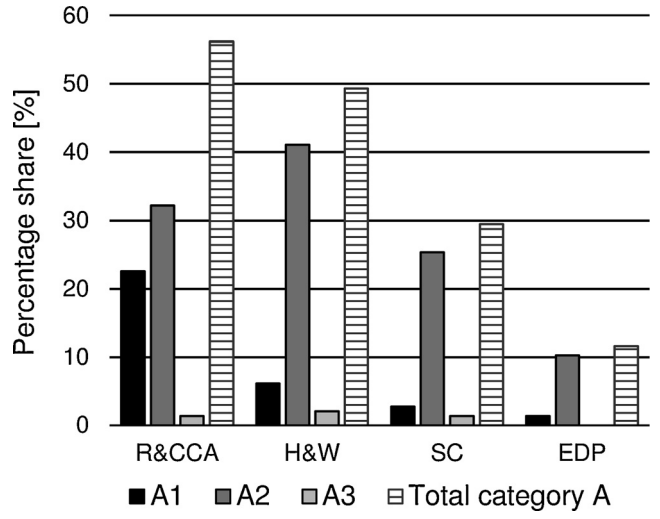

Fig. 7. The role of particular NbS subgroups in solving urban problems according to analysed areas of impact. Source: own elaboration.

for supporting social cohesion (39% of identified provisions) was less visible. The references to economic development potential were identified only in 12% of the provisions. The most significant emphasis in solving urban problems by NbS is put on the physical changes in green infrastructure (subgroup A2); the lesser stress is put on the creation of new green areas (subgroup A1) and the lowest on various use or promotion of existing greenery (subgroup A3) (Table 1).

The thematic scope of one hundred and forty six NbS-related provisions showing the role of GI in solving urban problems is very diverse, also within three main subgroups. To have a more detailed insight into provisions and to expose the activities characteristic for the city of Poznań, we grouped them according to their thematic similarity. Next we identified their relations to the main challenges in urban policy (Table 2). This shows that the most thematically diverse are activities transforming GI elements (subgroup A2).

3.2. Activities related to NbS (group A)

3.2.1. NbS through creation of new green infrastructure elements (subgroup A1)

The tasks related to the creation of new green infrastructure elements (A1) occur mainly in SCDSD (2014) and EPP (2017). The provisions increasing the share of green areas towards the development of an ecological system refer to the city scale. Here, the activities focus on the reconstruction of continuity and strengthening the existing elements of ecological system, mainly green wedges, through increasing the surface of green areas and maintaining their connectivity in the particular urban units (creating parks, squares, lawns, tree planting along streets – especially in the city centre). The provisions expressed also the need for afforestation of areas not suitable for agricultural production or wasteland and reclaimed areas as well as planting of street trees or trees and mid-field shrubs that protect against soil erosion.

Increasing the surface of greenery is treated in the documents as a way to solve urban problems resulting from functional and spatial conflicts, accumulation of air pollution and acoustic discomfort. The activities in this regard focused on introducing screening greenery in the housing areas located along the streets, tramway routes and railway tracks, planting trees in the avenues, creating green belts along traffic routes and separating bicycle paths and pavements from the roadways by planting trees, bushes or lawns. With reference to the improvement of the acoustic climate of the city, sound-screening greenery in the form of green walls or green acoustic screens should be introduced. However, such solutions are not indicated in EPPN (2013).

The provisions classified in subgroup A1 include increasing the share of green areas for recreational and educational purposes. Such NbS include: creating new parks in the city that form connected system linking recreational areas around urban lakes with the largest residential areas, introducing cultivated greenery (district and housing estate parks, squares) to the areas of residential and service development, increasing the acreage of forests and creating school gardens. The activities specific to Poznań include an adaptation of green spaces associated with the fortification objects for recreational purposes as parks.

In the provisions of the documents, shaping the hydrographic network of the city through solutions based on increasing retention surface of existing rivers, creating additional watercourses within the floodplains, carrying water in the periods of swelling, restoring historical watercourses are also underlined.

In subgroup A1, we also identified the actions related to NbS concerning the development of GI for the purposes of rainwater management, aimed at increasing absorptive surfaces allowing infiltration of rainwaters and meltwaters.

NbS are the least present in remediation. One provision in the EPP (2017) concerned grass seeding and planting trees in the landfill site.

Table 1
The role of particular NbS subgroups in solving urban problems expressed in number and proportion of NbS-related activities targeting one or more areas of impact. Source: own elaboration.

Subgroups	Activities related to NbS		Area of impact of NbS							
			R&CCA		H&W		SC		EDP	
	number	%	number	%	number	%	number	%	number	%
A1	41	28	33	23	9	6	4	3	2	1
A2	99	68	47	32	60	41	37	25	15	10
A3	6	4	2	1	3	2	2	1	0	0
Total	146	**100**	82	**56**	72	**49**	43	**29**	17	**12**

3.2.2. NbS through physical changes of existing GI (subgroup A2)

The provisions concerning NbS classified to subgroup A2, mostly refer to the revival and restoration of existing green areas. The activities in this regard are, on the one hand, of general character and refer to green areas in the city, indicating mainly the need of restoration, revitalisation and development of urban parks, areas near the Warta river and lakes, or the need of protection, maintenance and reconstruction of habitats of the species. On the other hand, the activities refer to site specific locations (specific park, street etc.).

In terms of frequency of occurring in the documents, another group of the provisions concerning NbS is a development of a network of bicycle paths, bicycle and pedestrian shared paths, tourist and didactic trails running through green areas. Just like in the previous group, the provisions refer to both: site and city scale. The activities in this respect show the need for the development of a system of didactic trails in the forested areas, development of a system of bicycle and walking paths, the need for building new footbridges and bridges for the cyclists across the Warta river. The provisions referring to the development of waterside areas and restoration of watercourses are also highlighted in the documents. The goal of the following activities: building marinas, development of waterside infrastructure, river transport, an organisation of beaches near the lakes and Warta, is to develop leisure and recreation on the basis of blue infrastructure. Only in the two analysed documents (EPP, 2017; LFF, 2017) can we find NbS-related activities connected with water purification, remediation and modernisation of water reservoirs. The activities in this regard concern mainly modernisation and rebuilding water reservoirs to improve the quality of water and their retention. The activities related to development and modernisation of sports facilities in the green areas, included in DSRW (2012), also belong to subgroup A2. Finally, one provision in this subgroup refers to the use of NbS in agriculture and concerns the reclamation to obtain optimal water conditions for agriculture through retention.

3.2.3. NbS through non-physical actions (subgroup A3)

Much less NbS-related contents were recognised in a subgroup A3. They are connected with supporting the active use of green infrastructure. They refer to promoting an active way of spending time in the riverside areas, strengthening its tourist attractiveness and using the historical forts in order to create new tourist routes. The provisions supporting activation and social integration through the execution of research and application projects connected with green infrastructure, e.g. CONNECTING Nature (see https://connectingnature.eu/) (MRP, 2017) were also identified. Different, single NbS-related provisions concerning the possibility of using compost from maintaining green infrastructure (LCEP, 2016) to reduce organic waste landfilling are also part of subgroup A3.

3.3. The potential for implementation of NbS (group B)

Within the thematic scope, the directions of activities and tasks in the urban policy are focused on society, broadly defined infrastructure, environment and space.

Within social tasks, the urban policy assumes supporting the mental and physical health of the inhabitants, activation, and integration of society, ecological education, as well as the promotion of the development of innovativeness. They are undoubtedly areas of activities, in which, apart from standard solutions, NbS can be introduced.

The provisions concerning the development of infrastructure with the potential to use NbS include both the building industry and transport. It is a group of activities, in which NbS can be broadly applied, but they have not been popularised yet. Within the scope of the building industry, nature-based engineered solutions can be used both in building and modernisation, including thermo-modernisation of the buildings. The provisions concerning road infrastructure are focused both on road investments and creating bicycle and pedestrian paths. The location of bicycle and pedestrian paths in the GI or introducing greenery along existing communication routes that shall provide diverse regulating and cultural services are a combination of technical and natural solutions that can contribute to solving urban problems, therefore, they have premises to be classified as NbS.

Area of activity in the city of significant potential of application of NbS is spatial development, including space restoration and revitalisation, especially on the wasteland such as post-military and post-industrial areas. Undeveloped wastelands may be transformed into new multifunctional green space. Moreover, single provisions, in which NbS would be used include animal species protection, management of rainwaters and meltwaters, protection of air and acoustic climate, as well as development of using renewable sources of energy (including organic matter from GI) and reduction of waste landfilling.

3.4. The role of NbS in selected urban challenges

3.4.1. Resilience and climate change adaptation

The adequately shaped system of greenery allows strengthening resilience and adaptation to climate change, which makes it a Nature-based Solution. In the urban policy, multifunctional role of the system of green spaces is well recognised and understood. It strengthens urban resilience through protection of nature and waters, provision of proper ventilation of the city, as well as the provision of attractive landscape and natural recreational space for the inhabitants. Introduction of greenery as an element of space development is recognised as a way of creating an screening barrier from the noise or pollutants, as well as a mean of land remediation. However, different documents refer to such solution to a different extent.

In this light, the activities aiming at increasing the surface of greenery (A1) and its restoration (A2) must be treated as supporting the natural system of the city and contributing to resilience.

The activities aiming at strengthening the resilience with the potential for application of NbS also include: development of a network of bicycle lanes (MRP, 2017; LCEP, 2016), modernisation of public transport (MRP, 2017) and improvement of housing conditions (MRP, 2017) limiting the impact on the environment.

The issue of adaptation to climate change is present in the policy of the city of Poznań to the limited extent. It is clearly indicated by the

Table 2
The provisions concerning NbS according to thematic groups. Each group of provisions could refer to more than one area of impact.
Source: own elaboration.

Subgroups	Thematic group of NbS	Urban resilience							
		Climate mitigation and adaptation	Water management	Green space management	Air/ambient quality	Public health and well-being	Social cohesion	Economic development potential	Number of NbS related contents
A1	1. Development of GI for rainwaters and meltwaters management		2					1	2
	2. Development of hydrographic network	5	5						5
	3. Development of ecological system		1	15	2	4	2		19
	4. Introducing screening greenery			5		3			8
	5. Introducing greenery within the framework of remediation			1					1
	6. Creating green areas for recreational purposes (parks, squares etc.)			4		2	2	1	6
	Total								**41**
A2	1. Development and management of urban beaches					1	1		2
	2. Water purification, remediation and modernisation of water reservoirs		14						14
	3. Arrangement of riverside areas and restoration of watercourses		1	2		7	2		7
	4. The reclamations to obtain optimal water conditions for agriculture through retention		1						1
	5. Arrangement of green areas, including restoration			15		31	22	15	49
	6. Development of bicycle and pedestrian paths, tourist and didactic trails in the green areas	3		3	13	19	12		24
	7. Development, building or modernisation of outdoor sports facilities within GI					2			2
	Total								**99**
A3	1. Reduction of organic waste landfilling (use of organic matter produced by GI)	1		1					1
	2. Promoting active living and social integration connected with GI						1		1
	3. Supporting the active use of GI				1	3	1		4
	Total								**6**

Strategy for the Development of the River Warta, where the consequences and threats caused by climate change are presented and, as a response, the execution of the tasks in order to provide flood safety was proposed.

3.4.2. Health and well-being

NbS showing a direct impact on health and well-being most often (84%) occur in the activities oriented towards strengthening the quality and/or multifunctionality of GI (subgroup A2). They predominantly concern general forms of GI development and restoration as well as development of a network of bicycle and pedestrian paths, tourist and didactic trails running through green areas. The provisions show the importance of these solutions in shaping the space for the recreation, leisure and tourism, as a significant element affecting the quality of mental and physical life of the inhabitants.

The provisions from subgroup A2 of operational character are present in DSRW (2012) and MRP (2017) and indicate specific activities concerning the development of riverside areas, reconstruction of watercourses, construction, development and modernisation of sports facilities within the GI.

The tasks that include creating new green areas (subgroup A1) referring to health and well-being are focused on creating green areas for recreational purposes (SCDSD, 2014; MRP, 2017), development of an ecological system of the city (SCDSD, 2014) and possibility of introducing screening greenery for improvement of acoustic climate (APP, 2015). Single provisions referring to H&W also emerged in subgroup A3, and referred to supporting active use of GI (DSP, 2017; EPP, 2017).

3.4.3. Social cohesion

The provisions indicating directly the possibility of using NbS for social cohesion emerge in two analysed documents (MRP, 2017 and LFF, 2017). In the first document, the references to SC emerge in most of the provisions (over 60%), but in the second document, only in one provision. They refer predominantly to the tasks from subgroup A2 within the scope of development of green areas, including restoration and development of bicycle paths, tourist and didactic trails in the green areas the only LFF (2017) provision was found in this category of tasks). In the provisions of MRP (2017), there are also tasks that would be executed based on nature (group B) and they primarily connected with activation and social integration. Single provisions that include SC can be found in the subgroups A1 and A3, and they concern the tasks connected with building or planning parks, playgrounds, squares, outdoor gyms, social gardens. In the remaining planning documents, there are no provisions directly showing the possibility of solving problems within the scope of SC with the use of NbS.

3.4.4. Economic development potential

The direct impact of NbS-related contents on economic development potential was identified in several provisions in MRP (2017) and SCDSD (2014). It concerned the provisions related to the development of green areas and their restoration (in subgroup A2, for example, the revitalisation of the buildings of nineteenth-century fortifications of Poznań fortress for touristic and cultural purposes), creating green areas for recreational purposes (in subgroup A1, for example, the development of old channel of the Warta River that includes creating a system of new urban parks) and development of green infrastructure for management of rainwaters and meltwaters (in subgroup A2, for example, shaping greenery in a way that allows infiltration of rainwaters and meltwaters, maintaining the most largest possible unsealed surface). It was indicated in both documents that comprehensive execution of scheduled activities shall contribute to the improvement of working and living conditions in Poznań and make it more attractive for current and potential inhabitants. This in turn may inhibit the process of depopulation of the city and related decrease in budget revenue from taxes. A decreasing number of the inhabitants of Poznań contributes to the deterioration of the city's economic situation because the city incurs the significant costs of provision of public services, the maintenance of infrastructure or the urban development.

4. Discussion

4.1. Diversity of NbS in the urban policy context

The case study of urban policy in Poznań shows that Nature-based Solutions can be identified in directions of development and specific tasks, even though they are not explicitly expressed in the documents. Our approach allows to identify contents of urban policies related to NbS and to assess their diversification regarding the type of human actions within green infrastructure and their application in solving selected urban problems.

Interesting division of NbS in terms of their goals was also presented by Lafortezza et al. (2018), for example: (1) urban regeneration through NbS; (2) NbS for improving well-being in urban areas; (3) establishing NbS for coastal resilience; (4) multifunctional nature-based watershed management and ecosystem restoration; (5) NbS for increasing the sustainable use of matter and energy; (6) NbS for enhancing the insurance value of ecosystems; and (7) increasing carbon sequestration through NbS. Different classification of NbS, in terms of the character of activities, was proposed by Eggermont et al. (2015). NbS were characterised as activities changing along two gradients 1. "How much engineering of biodiversity and ecosystems is involved in NbS?", 2. "How many ecosystem services and stakeholder groups are targeted by a given NbS?". Type 1 consists of no or minimal intervention in ecosystems, with the objectives of maintaining or improving the delivery of a range of ES. Type 2 corresponds to the definition and implementation of management approaches that develop sustainable and multifunctional ecosystems and landscapes and improve the delivery of selected ecosystem services compared to what would be obtained with a more conventional intervention. Type 3 consists of managing ecosystems in very intrusive ways or even creating new ecosystems (e.g., artificial ecosystems with new assemblages of organisms for green roofs and walls to mitigate city warming and clean polluted air).

Against this background, our approach combines elements of both these classifications, taking into account the type of activities within GI as well as their goals in facing urban challenges. Comparing our approach (see paragraph 2.3.) with classification presented by Eggermont et al. (2015), we can find some coincident categories, for example subgroup A1- Type 3, subgroup A2 -Type 2. We took into consideration also activities aimed at using and promoting existing GI – subgroup A3, and the potential of implementation of NbS in the provisions not specifying particular solutions (grey or green) – group B.

Our research shows that significant attention and a number of actions are targeting existing GI and focus on changes towards its multifunctionality and better quality (A2). This illustrates the significant role of NbS in urban regeneration and the revitalisation of existing urban spaces that improves spatial and environmental quality in cities. It also has to be highlighted that despite the already high share of GI in the city, intensive development and limitation in space availability, new green spaces are still planned to be created (A1). Relatively low attention is placed on the possibility to increase usage of green spaces by organising soft actions (A3). Moreover, the Poznań Case Study shows the disproportion between number of NbS-related provisions (group A) and more numerous provisions not specifying particular solutions (group B), which indicates not fully exploited potential for further implementation of NbS.

The urban policy documents express the intention of municipality governments and their awareness concerning sustainable development. Therefore, the presence of references to GI in the text can be recognised as important evidence testifying the extent to which city management perceive its potential to solve urban problems.

4.2. The role and potential of NbS in addressing urban challenges

4.2.1. NbS for resilience and climate change adaptation

In policy documents of Poznań, the emphasis is put on urban resilience, which is strengthened through the use of the existing structure of green space for:

- air quality - ventilation of the city, mainly areas particularly exposed to an accumulation of pollutants,
- water management - retention of rainwaters and meltwaters in a drainage area, reduction of rain and melting wastewaters carried to the rain drain system or watercourses, contributing to the protection of water resources,
- green space management - maintenance of environmental functions.

The role of GI in increasing resilience is well documented not only in Poznań. It was noticed in many cities that appropriate development of GI is important for the achievement of specific resilience goals (Groenewegen et al., 2006; Escobedo et al., 2011; van de Meene et al., 2011) and solving urban problems (Harrison et al., 2014).

Creative way of thinking about planning the structure of the city supporting its resilience should include GI and NbS. One of the most popular approach is a transition from grey to green infrastructure. An example is the city of Los Angeles where, as a part of the improvement of rainwater management, Los Angeles River was restored to its natural state through unsealing of the channel (Subramanian, 2016) and Green Alley program (Tayouga and Gagné, 2016) was implemented.

The concept of resilience is also used in the activities aimed at adaptation to climate change, but, as it was mentioned above, its application is broader (Davoudi et al., 2012). The adaptation to climate change combines social, economic, natural and spatial dimensions (Mizgajski and Zwierzchowska, 2015), which can adopt: coping, incremental and transformative approaches (EEA, 2016). In Poznań, the issue of adaptation to climate change is not a priority direction of the activities in the urban policy, similarly as in Europe several years ago (Carter, 2011). Only the Strategy of Development of the Warta River directly indicates the necessity of adaptation to climate change in order to improve flood safety. Although it is the only document referring to the issue of climate change, its provisions are innovative and based on nature. The provisions of the strategy within the scope of river safety are of transformational character, reaching beyond the current application of grey infrastructure and including, among others, the creation of more space for the water to absorb peak flows after mainly heavy rains; creation of the additional river channels and bringing back the historic river. Management of blue infrastructure is therefore seen as a Nature-based Solution towards the reduction of flood risk and a way of adaptation to climate change. Other remarks to climate change mitigation can be found in LCEP (2016) and PSDPT (2014) where the need for development of an alternative transportation is mentioned.

Although the issue of adaptation to climate change in the urban documents is not highlighted, it must be emphasised that adaptation plans are being prepared now for 44 cities in Poland (including Poznań).

The general urban policy provisions (group B) create a wider possibility for the inclusion of NbS-related actions toward urban resilience. In particular, they could promote nature-based engineered solutions that are currently used in building constructions and modernisation. Solutions such as green roofs provide thermal benefits (Wong et al., 2003) and reduce energy consumption (Niachou et al., 2001). It is particularly highly beneficial in retrofitting older buildings (Castleton et al., 2010). Also, vertical greenery systems may decrease ambient temperature; however, the effect depends on adopted solutions (Wong et al., 2010). Additionally, green roofs increase water storage capacities, reduce surface run-offs (Zölch et al., 2017) and can support air purification, contributing in this way, also, to the adaptation of cities to climate change (Bowler et al., 2010; Pérez et al., 2014; Jim, 2015). Introduction of such solutions is still not widespread, although they could be more ferquently used for example in thermo-modernisations.

The benefits of green roofs were noticed in the urban policy of London, where a part of the London Plan supports green roof development (GLA, 2016). Similarly, in Copenhagen, green roofs have become integrated into the Climate Plan (CCP, 2009), Strategy for Biodiversity (UNCS, 2015) as well as in the guidelines for Sustainability in constructions and Civil works (SCCW, 2010). In North America, it is Toronto where requirements and standards concerning the installation of green roofs on new commercial, institutional, and multifamily residential developments were set in municipal bylaw.

The next provisions with potential for NbS inclusion are those regarding the development and modernisation of road network that provide an opportunity to introduce sustainable water management such as bioswales and rain gardens (Pauleit et al., 2011; Katsifarakis et al., 2015). An example can also be the unsealing and greening tramway tracks with the lawns (Prokop et al., 2011; Brodowicz et al., 2015). The urban policy could more directly highlight the role of GI in water purification and flood protection as an attractive alternative for the grey infrastructure, which at a similar cost, provides additional benefits (wildlife support and recreation) (Liquete et al., 2016).

Documents devoted to air protection could more strongly refer to the importance of green spaces for air purification, climate regulation (Vieira et al., 2018) and noise reduction as well as shaping acoustic climate at the city level (Dimitrijević et al., 2017; Margaritis, Kang 2016).

The last area of urban policy in which potential for inclusion of NbS was identified is the development of the use of renewable energy sources and the reduction of landfill. Current provisions do not mention the opportunity to use green infrastructure's waste biomass for bioconversion and biofuel production (Raud et al., 2017), which simultaneously would contribute to green space multifunctional use, resource efficiency and could provide green jobs and economic benefits.

4.2.2. NbS for health and well-being

The results of the analysis of urban documents in Poznań showed that emphasis is put on improving the quality of life through the development of greenery and recreational infrastructure, but the presence of health goals is rare. However, the general provisions of the urban policy (Group B) referring to health have a huge potential for including NbS. The presence of GI and its usage may have a positive impact on physical or mental health (Hartig et al., 2014; Kabisch et al., 2017). Appropriate creation and arrangement of green spaces give possibilities for horticulture therapy that is recognised as a NbS for improving mental health that contribute to recuperation from stress, depression and anxiety (Vujcic et al., 2017). Therefore, it is crucial to emphasise currently unnoticed role of GI planning as a valuable tool in health policy. However, it has to be bear in mind that actions concerning the introduction of new green spaces are not sufficient activities at the policy level. The recent research shows that health is not among the main reasons for using public green (Zwierzchowska et al., 2018) and it requires soft actions to inform and encourage people in using it for health purposes. Although it is well recognised and proved that a systematic undertaking of physical activity has a positive effect on physical and mental health (Coon et al., 2011; Mitchell, 2013; Hunter et al., 2015; Lawton et al., 2017), physical inactivity is a global pandemic and one of the leading cause of death in the world (Sallis, 2011; Kohl et al., 2012). The awareness that constructing bicycle and pedestrian paths in the green areas indirectly contributes to the improvement of health of the inhabitants (Wang et al., 2004) through reducing the emission of car pollutants (Brodowicz et al., 2015; Johansson et al., 2017) and providing space for active outdoor activities should be stronger raised in urban policy documents. Similarly, provisions concerning creation of school gardens should highlight its contribution to children's health. In the context of insufficient attention put on educational and promotional actions in using GI, we therefore agree with Corburn et al. (2014) that

integrating health issues into the agendas of policymakers who have not previously identified health as their responsibility is a challenge. In cities Health in All Policies approach is increasingly seen as an solution that brings the health issue into policy outside the health sector (Corburn et al., 2014). The guidelines on the integration of public health and well-being into the implementation of NbS is proposed by van den Bosch and Sang (2017).

4.2.3. NbS for social cohesion

In the context of growing social and economic inequality in the urban communities (Schreiber and Carius, 2016), the challenge for urban policy is to strengthen social cohesion (Van Marissing et al., 2006). The case study of Poznań shows that although social cohesion is one of the urban policy areas it is rarely seen as an issue that can be solved or supported by GI and related NbS. Whereas, GI, apart from regulating ecosystem services often provides attractive and convivial meeting places (Hoang et al., 2016).

Green outdoor common spaces contribute to the strength of social ties and sense of community that, in particular, benefit older adults (Kweon et al., 1998). Moreover, GI could also be used for nature-based education that benefits citizens of all ages (Schweitzer and Gionfra, 2018). In this respect, the city of Poznań plans actions in creating school gardens but their social and educational benefits are not sufficiently emphasised in policy. What is missing in Poznań's urban policy are provisions supporting the creation of community or social gardens that are widely recognized as socially important (Hou, 2017).

In order not to limit the issues of strengthening social cohesion to single solutions, they must be included in the urban documents. Current policies rarely include the issues of a fair and equal greening urban areas to make them serve for the whole society, in all parts of the city. Despite recommendations for implementation of NbS within GI and in order to face various social challenges (COM, 2013; EU, 2015) and many examples showing that urban spaces poor in greenery deepen the feeling of social inequality and environmental injustice (Byrne, 2012; Wolch et al., 2014), GI and NbS are still insufficiently included in the urban policy. On the other hand, it has to be mentioned that the recent research of Haase et al. (2017) showed that the relations between greening and social integration are not unambiguous and social effects of developing GI and NbS still require thorough analysis. It refers both to the chances of improvement of the quality of life in the city and potential negative effects (e.g. social exclusion or relocations related to the growth of real estate prices).

The interesting part of Poznań urban policy is highlighting importance of society activation and the development of innovativeness. Those general provisions from group B, if included in planning and managing GI could contribute to participatory planning and governance that is one of 10 challenges identified by Expert Working Group on NbS to Promote Climate Resilience in Urban Areas (Raymond et al., 2017a).

4.2.4. NbS for economic development potential

The green spaces and related NbS are still rarely seen as contributing to economic development. The references to this issue were found only in 2 out of 10 analysed documents of Poznań.

It has to be highlighted that potential effects of incorporating NbS into the urban policy need to be recognised. According to Nesshöver et al. (2017), they may stimulate, but also inhibit economic development. In order to assess the impact of NbS on the economic development of the cities, the ecosystem services concept may be applied. Urban ecosystems provide the inhabitants with a wide spectrum of services (e.g. Sirakaya et al., 2017), including provisioning, regulating and cultural services (Haines-Young and Potschin, 2018). The benefits they bring to people can be attributed ecological, socio-cultural and economic value (de Groot et al., 2002; MEA, 2005; TEEB, 2010). For example, air purification and temperature regulating services of Beijing's forest ecosystems have been valued at 7.72 billion yuan annually (1.03 billion euro) based on avoided air pollution charges and electricity savings (Wu et al., 2010). The value of greenery in the city is also reflected in real estate prices that depend on the distance from various forms of green spaces (e.g. Sander and Haight, 2012; Łowicki and Piotrowska, 2015). The impact on the real estate market is undoubtedly the sign of the role of greenery in the quality of life in the city. On the other hand, potential limitations for economic development of the city connected with the development of NbS within GI may result from the provision of ecosystem disservices (Zhang et al., 2007; Shapiro and Baldi, 2014). The disservices can be, for example, damages caused by falling trees during storms, bio-emissions from trees, irrigation requirements (e.g. Conway and Yip, 2016; Liu et al., 2018).

NbS are also expected to create business opportunities (Nikolaidis et al., 2017). The connections between NbS and local economy can be emphasised in the urban policy, however it should be preceded by an intensification of research on the impact of NbS on the economic development of urban areas. Their results and good practices from other cities (the real-world case studies) should be popularised among stakeholders. The examples of good practices, including changes in policy, planning and society together with transition initiatives from Brighton, Budapest, Dresden, Genk and Stockholm are presented by Frantzeskaki et al. (2017). Convincing the stakeholders to implement NbS may happen through presenting real benefits resulting from appropriate problem or opportunity oriented planning, design and management of GI.

4.3. Study limitations and further research directions

The document analysis was limited to the Poznań city development directions and tasks expressing the role of actions within GI in selected urban documents. Yet, one has to keep in mind that those documents also include other (grey) solutions that may support solving urban problems. What's more, NbS that go beyond GI are not identified, and these are not included in the analysis. Importantly, the city also takes NbS-related actions and participates in bottom-up initiatives not directly included in urban policy documents. Therefore the results of conducted analysis should be seen as a piece of the city's involvement. Other actions undertaken in line with urban policies concerning NbS should be a subject for further research.

The identification of relevant document contents has required a thorough analysis, especially in the case of NbS influence areas. They have been expressed in the list of development directions or tasks, or document aims or conclusions of the city-state analysis. In each case, a direct reference to the urban challenges was taken into account.

The analysis of the urban policy document is hindered due to a diverse spatial scale, timeframes and different level of details of its contents. The general directions for the development of GI and detail tasks like the planting of street trees are difficult to compare. However, despite the limitations, both are illustrating the policymakers' awareness of GI potential to solve urban problems and NbS benefits.

Bearing in mind that consideration of NbS in urban documents does not guarantee their implementation, another challenge is monitoring of the urban policy effects. Daniel (2017) defines it as evaluating the extent of town planning policies implementation or impact. In this regard a systemic monitoring and evaluation of strategic and programming documents are conducted according to the law requirements or on decision makers request. However, the key question is how and to what extent evaluation results are implemented. The evaluation usually has a quantitative and a qualitative character. In the second aspect, it has to be underscored that as NbS often rely on a mixture of green and grey infrastructure, the balance between those components in tasks as well as development directions final execution will be one of the aspects that will show whether created solutions are nature-based. The evaluation practices in this field are understudied and their recognition should be develop. Monitoring and evaluation of policy efficiency are key parts of the planning cycle, also within the scope of NbS implementation (Raymond et al., 2017b) therefore they should be a subject for further

investigation.

5. Conclusions

Cities look for solutions to tackle contemporary challenges. Their striving for development is expressed in planning, strategic and programming urban policy documents. The case study of Poznań shows that urban policy documents contain a wide range of proposals for improvements using NbS-related actions. Nonetheless they are not expressed with this term.

The identified NbS-related contents includes mainly activities that lead to physical changes of existing GI elements, to the lesser extent creation of new GI elements and several activities that increase the usage of GI. However, the potential for NbS inclusion is not fully exploit.

The urban policy of Poznań, to a large extent, relies on the natural conditions in the city's development and treats it as a tool for building urban resilience. This aspect is also more and more promoted in politics and academia (Zölch et al., 2017). GI contribution to inhabitants' quality of life and related well-being is also clearly addressed in the documents, while climate change adaptation is just recently gaining more attention. The other urban challenges are expressed in the city's policy to the lesser extent. The main gaps were identified in the field of:

- supporting development of NbS in construction and transportation sector that could influence all four urban challenges;
- appropriate planning, design and management of GI towards building and strengthen social cohesion;
- consideration of NbS as aiming at supporting the citizens' health;
- the influence of NbS on the economic development potential.

In reducing these gaps, we find the potential to strengthen and develop the role of NbS in planning urban development. The recommendation that can be formulated to the next generation policy document focus on:

- supporting the development of nature-based engineered solutions such as green roofs in building constructions and sustainable urban drainage systems in the modernisation of roads;
- supporting co-creation of common multifunctional green spaces such as community or social gardens, pocket gardens and other local scale solutions, not only within open public spaces but also associated with institutions such as schools, kindergartens, senior centres, hospitals or cooperatives;
- actions activating and educating citizens to take advantage of the existing potential of GI and co-creation of NbS;
- acknowledging NbS business opportunities and its influence on the economic development potential.

The recommended NbS should be seen as an alternative or a supplement to other solutions. We agree with Eggermont et al. (2015) that NbS should not be considered as "the one and only" possible solution to urban challenges. However, it is crucial to embed NbS in urban policy in a comprehensive way. Since, in many cases, the same urban problems may be solved through grey or green solutions, it is crucial to raise awareness of multi-beneficial NbS. Although fostering NbS in urban areas receives more attention on the political agenda, realising them still faces political, economic and scientific challenges (Droste et al., 2017; Maes and Jacobs, 2017).

In this context, the willingness to apply solutions based on GI expressed in local urban policy documents can be seen as a driving force for accelerating the transformations of cities using Nature-based Solutions. Including NbS in city document contents is an essential signal that can facilitate the transition in the long-term perspective. It is also an evidence about the usefulness of such solutions for the awareness of policymakers.

We argue that to support large-scale, Nature-based Solutions implementation in cities, the crucial step is to bring them into the local urban agenda. Evaluation of urban policy documents based on the presented approach can serve as a guideline for identifying gaps and potentials for NbS inclusion. As a result, it can help the better organisation of urban policy and harmonisation of different sectors through NbS.

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