

IMPLEMENTATION OF MUNICIPAL ADAPTATION PLANS TO CLIMATE CHANGES: CASE STUDY OF POZNAŃ

Eliza Kalbarczyk¹✉, Michalina Piegat²✉

¹ ORCID: 0000-0002-4871-2483

^{1, 2} Adam Mickiewicz University in Poznań,
10 Krygowskiego street, 61-680 Poznań, Poland

ABSTRACT

The adaptation of cities to climate change is becoming an increasingly pressing need. The choice of optimal adaptation solutions for cities is difficult as it requires an individual approach. One way of avoiding poor decisions is to use the experience of cities which have already implemented adaptation solutions. The aim of the work was to identify measures conducted as part of implementation of the municipal plan of adaptation to climate change for Poznań and to evaluate if the conducted measures complied with the adopted strategic goals specific for the research area. It was found that Poznań undertakes measures on each of the four specified strategic goals, but to a different degree. Hard measures and measures of the types: mitigation, physical infrastructure, and green infrastructure prevail. Most measures are performed in the sectors of transport and biodiversity. In addition, single cases of actions which have a negative impact on the natural environment have been identified.

Keywords: city, measures, midwestern Poland, mitigation, strategic goal, vulnerable sector

INTRODUCTION

Cities as open systems are exposed to both external and internal negative phenomena. In the face of new climatic challenges, attempts at the development of resistance are made, including city adaptation to climate change [Leichenko, 2011; Szewrański et al., 2018; Wieteska-Rosiak, 2018]. Growing interest in adaptation to climate change in cities has been observed in the world since the beginning of the 21st century [Gill et al., 2007; Charlesworth, 2010; Reckien et al., 2018]. Main research topics focus on strategies for adaptation planning, and the advancement of climate action plans in particular countries [Carter, 2011; Reckien et al., 2014, 2015; Hughes, 2015; Araos et al., 2016; Karunathilake et al. 2020]. The latest challenge

is to search for solutions for the post-pandemic time [Moraci et al., 2020].

Additionally, the research focuses on determining a specific character or typology of planned actions [Tompkins et al., 2010; Fidelman et al., 2013; Biagini et al., 2014; Kalbarczyk & Kalbarczyk, 2020]. On the other hand, studies on the advancement of adaptation implementation, due to a relatively early stage of adaptation planning in most cities, are comparatively rare [Heidrich et al., 2013; Olazabal & Gopegui, 2021].

In Poland, an increased interest in urban adaptation to climate change has been witnessed only recently. The first national planning documents directly addressing adaptation to climate change were created at the beginning of the 2010s [A strategic plan for the adaptation, 2013]. Thanks to the project

✉ ekalb@amu.edu.pl, ✉ micpie@st.amu.edu.pl

coordinated by the Ministry of Environment, “Development of plans of adaptation to climate change in cities of population of more than 100 thousand” (www.44mpa.pl), until 2020 a total of 37 Polish cities of population of more than 100 thousand and 7 cities of a lower population prepared their own plans of adaptation.

Poznań started to prepare its municipal plan of adaptation to climate change in 2017 [Climate adaptation plan, 2019]. This document indicates necessary actions in response to forecast negative weather phenomena such as: heavy rains, floods, and droughts. Adaptation measures are planned to be implemented by 2030. The plan also takes into account the need of verifying the effectiveness of the implemented changes and a possible modification of the existing plan of adaptation while the document remains in force.

Information on the implemented measures can be useful not only in the determination of new directions of current activities, but also may be used to develop a catalogue of good adaptation practices. It is assumed that in the case of urban adaptation to climate change there are no ready-made solutions and each city by itself has to search for optimal actions. An important role is played here by the exchange of experiences [Guide for cities to adapt, 2015; EEA, 2016; Nowak et al., 2020]. One of the ways of avoiding wrong decisions is taking advantage of the experiences of the cities which have already implemented adaptation solutions. Therefore, there is a need of filling the gaps in the knowledge about adaptation planning and, when it is already possible, about the progress of implementation of the planned adaptation measures [EEA, 2016]. The need of tracking the progress of climate change adaptation does not raise any doubts. However, there are no adopted indices that could be used to evaluate if and how adaptation occurs [Ford et al., 2013].

The aim of the work is to identify measures conducted as part of implementation of the municipal plan of adaptation to climate change for Poznań and to evaluate if the conducted measures complied with the adopted strategic goals specific for the research area.

MATERIALS AND METHODS

Research material included the document “Climate adaptation plan for the City of Poznań until 2030” [Climate adaptation plan, 2019], approved by the City Council of Poznań in a resolution of 16th April 2019 (<https://bip.poznan.pl/>), as well as the content of local websites devoted to municipal investments.

The research was based on the monographic method and a review of publications in local websites: “Codzienny Poznań” (<https://codziennypoznan.pl/>) and “Poznańskie Inwestycje Miejskie” (PIM) (<https://pim.poznan.pl/>) in the period of 1st Sep. 2020 – 31st Mar. 2021, supplemented with a field inventory performed in the period from the 4th quarter 2020 to the 1st quarter 2021. The full list of identified actions is available from the corresponding author. Information about investments obtained by means of field observation was later confirmed through a thematic search of websites, which was reflected in the list of websites being a part of the list of identified measures.

The character of the planned and implemented adaptation measures was first determined based on a general division into hard and soft measures (<http://www.future-cities.eu/>). Soft adaptation measures include such ones which do not require big financial outlays and which relate to the development of skills and policies, behavior, education and planning, etc. [Ford et al., 2013]. Hard measures include mainly technological actions, such as infrastructural investments. In the next step, the planned and implemented measures were classified in accordance with the typology proposed by Biagini et al. [2014], later modified by Kalbarczyk & Kalbarczyk [2020]. According to this classification, planned actions can be assigned to the following types: Capacity building, Management and planning, Practice or behavior, Policy, Information, Physical infrastructure, Warning or observing systems, Green infrastructure, Financing, Technology, Health programs and Mitigation.

Moreover, being part of sectors vulnerable to climate change was determined according to the catalogue of vulnerable sectors and areas specified in the

document of the Ministry of Environment [A strategic plan for the adaptation, 2013]. The document indicates sensitive sectors such as: Water management (WM), Biodiversity (B), Forestry, Energetics (E), Agriculture, Transport (T), Spatial Management (SM), Construction (C), Health (H) and areas: the coastal zone and mountain regions.

The identified implemented measures were then assigned to particular strategic goals mentioned in the document “Climate adaptation plan for the City of Poznań until 2030” [Climate adaptation plan, 2019]: Mitigating the negative impact of extreme thermal phenomena, including concentration of pollutants; limiting the effects of heavy rainfall and urban flooding, drought, storms and strong winds; informing about and raising awareness among urban communities of the effects of climate change; institutional and organisational improvement of urban resilience to climate change or extreme climatic phenomena.

Each of the actions was identified individually by each of the researchers and next, after comparison of the results, it was ultimately decided how to assign them to the examined types of actions, sensitive sectors, and strategic goals.

RESULTS

The progress of planning for adaptation to climate change in Poznań

The City of Poznań officially joined the project “Development of plans of adaptation to climate change in cities of population of more than 100 thousand” by the Ministry of Environment on 30th June 2015 by virtue of an agreement signed by the President of Poznań and the Minister of Environment (<https://www.poznan.pl/mim/main/>). Formal works began in January 2017 [Climate adaptation plan, 2019]. The City Team was appointed to work on the project. It consisted of 24 members, including representatives of the City Hall responsible for particular municipal sectors and representatives of city residents, NGOs, academic bodies, and universities, non-combined administration (e.g., RDOŚ, PGW Wody Polskie) and combined administration (WIOŚ, KM PSP).

The works of the City Team were supported by a 12-member team of experts. During work on the adaptation plan, in the period from 23rd February 2017 to 17th September 2018, 8 consultation meetings and workshops occurred. The final project of the document was subjected to an open public consultation which occurred in the period of 7th – 28th December 2018. As part of the consultation, 14 residents of Poznań and two community organizations submitted comments and proposals [Report on public consultations, 2019]. The document was adopted by way of resolution of the City Council on 16th April 2019 [Resolution No. X/144/VIII/2019 of the Poznań City Council]. It can be assumed that that moment started the period of implementation of the planned measures.

Strategic goals and planned adaptation measures

The plan of adaptation to climate change for Poznań [Climate adaptation plan, 2019] aims to conduct 32 measures divided into technical, organizational, and informational educational by 2030. These measures are intended to serve the main goal, specified as “consistent implementation of the assumptions of the adaptation plan for a continuous increase in awareness, safety, and quality of life of city residents, in the conditions of climate change” and four strategic goals, described in detail later in the text.

Based on the analysis of the measures from Climate adaptation plan [2019], it was found that out of 32 planned measures, 52% could be regarded as hard; soft measures constituted 48% respectively. In the analysed document, the planned actions were classified as follows: organizational (7), informational-educational (1), technical (7), and organizational-technical (12) and educational-organizational (5).

According to the modified typology of adaptation measures [Biagini et al., 2014, Kalbarczyk & Kalbarczyk, 2020], the measures of Climate adaptation plan [2019] are concerned: capacity building (4 measures), management and planning (1), practice or behavior (0,5), policy (2), information (2), physical infrastructure (6), warning or observing systems (2), green infrastructure (4,5), health programs (5) and mitigation (5).

Identification of implemented measures

Based on a review of local news websites, it was stated that from 1st September 2020 to 30th March 2021, reports on the actions which fit into the scope of the planned adaptation measures occurred nearly 190 times. It is noteworthy that a direct reference to adaptation to climate change could be found in four articles, a general reference to climate change in 10. The largest share (40%) among the analysed reports was that of information about work related to the mitigation of climate change. They included: construction of a tramway, bike path, and park-and-ride car park, and a change of traffic management. Next in terms of frequency (approx. 20% each) were the actions for green and physical infrastructure. The reports mainly concerned new tree plantations along Poznań's streets, regeneration of parks, greenery maintenance, and reconstruction or extension of water supply, sewage, and storm water drainage systems, construction of storage reservoirs and pavements, etc. Finally, among the most frequently reported actions, there were "capacity building" (approx. 7%). Such measures as practice or behavior, health programs, financing, information, management, and planning were referred to sporadically. Moreover, two reports concerned issues which could be classified as environmental maladaptation [Magnan, 2014] – interventionist articles about damage to trees during performed investments.

Evaluation of the progress of measures implementation in relation to the plans was made by comparing the structure of planned and implemented measures in different categories. The analysis of the structure of soft and hard measures showed a clear prevalence of infrastructural measures (76%), that were the hard ones. Moreover, the analysis of the types of planned and implemented measures revealed that the first works to be performed in the city were the ones related to climate change mitigation and green infrastructure (Tab. 1). The least advanced in relation to the plan were measures: information, warning or observing systems, policy, practice or behavior, and health programs.

Table 1. Types of planned and implemented measures in Poznań as part of municipal adaptation to climate change

Type of measures	Planned measures (in %)	Identified implementations (in %)*
Capacity building	12,5	8,2
Management and planning	3,1	1,6
Practice or behavior	1,6	0,8
Policy	6,2	0,5
Information	6,2	0,8
Physical infrastructure	18,8	19,8
Warning or observing systems	6,3	0,0
Green infrastructure	14,1	23,6
Financing	0,0	3,7
Technology	0,0	0,0
Health programs	15,6	1,3
Mitigation	15,6	38,1

* 1,6% measures were identified as maladaptation (not listed)
 Source: own preparation, types of measures based on Kalbarczyk & Kalbarczyk [2020].

The comparison of the structure of planned and implemented adaptation measures in Poznań by sectors vulnerable to climate change (Tab. 2) showed that the tasks in such sectors as transport and biodiversity were performed first, and in such sectors as water management and health implementation was relatively slow.

Table 2. The structure of planned and implemented adaptation measures in Poznań by sectors vulnerable to climate change

Vulnerable sector (symbol)	Planned measures (in %)	Identified implementations (in %)
Water management (WM)	34,6	7,1
Biodiversity (B)	15,4	26,1
Energetics (E)	9,6	7,6
Transport (T)	11,6	43,4
Spatial Management (SM)	3,8	7,6
Construction (C)	1,9	0,0
Health (H)	23,1	8,2

Source: own preparation, vulnerable sectors based on A strategic plan for the adaptation [2013].

Implementation of strategic goals

The analysis of the content of local websites and field observations confirmed the implementation of measures for the four strategic goals of the adopted Climate adaptation plan [2019] (Tab. 3).

Measures implemented under Goal 1 are among the most frequently observed in the city. Goal 1 encompasses 10 groups of measures, including 3 groups in the transport sector, 3 groups of the power sector, and 4 groups of the biodiversity sector. Transport sector tasks are implemented, e.g., through construction of bus lanes, development of intelligent transportation systems, construction

of integrated transportation interchange points, further development of P+R and P+G car parks, public transport fleet replacement for higher comfort vehicles, modernization of interchange infrastructure through introduction of facilities for waiting passengers, extension of tramways, development of the metropolitan railway, introduction of solutions reducing car traffic. Another group of measures fitting into Goal 1 but referring to the power sector is represented by the continuation of the exchange of cooling and heating systems for more efficient and nonemission solutions, connecting buildings to district heating networks and reducing urban low emission, and thermal insulation of buildings. The final group

Table 3. Examples of implementation of adaptation measures corresponding to the adopted strategic goals in Climate adaptation plan for the City of Poznań [Climate adaptation plan, 2019]

Strategic goal	The number and name of an measure in Adaptation plan: – an example of implementation	Sector*
1	2	3
I. Mitigation of the negative impact of extreme thermal phenomena, including the concentration of pollutants	1.1 Introducing solutions in the organization of traffic to increase its flow: – implementation of bus lanes, https://www.poznan.pl/mim/info/news/dwa-nowe-buspasy,153133.html [18.09.2020]; https://tenpoznan.pl/poznan-nowe-buspasy-i-nowa-jakosc-transportu-publicznego-mariusz-wisniewski-chcemy-zeby-poznanska-komunikacja-byla-najlepsza-w-polsce/ [23.05.2021]	T
	1.2 Introducing solutions to improve the functioning of public transport: – construction of new connections for tram lines, https://codziennypoznan.pl/arttykul/2021-01-29/tramwaj-na-os-kopernika-coraz-blizej-jest-decyzja-rdos/ [29.01.2021] – expansion of P+R and P+G car parks, https://www.poznan.pl/mim/komunikacja/news,1185/nowe-parkingi-park-ride,160307.html [04.03.2021]; http://metropoliapoznan.pl/aktualnosci,2579,jak-korzystac-z-parkingow-parkuj-i-jedz-(p&r).html [06.05.2021] – construction of integrated transfer junctions, https://www.transport-publiczny.pl/wiadomosci/poznan-budimex-zbuduje-wezel-grunwaldzka-przy-przystanku-kolejowym-junikowo-jest-umowa-67953.html [11.03.2021] – construction of green stops, https://www.mtp.pl/pl/aktualno%C5%9Bci/zielone-przystanki-w-poznaniu/ [23.05.2021] – fleet replacement, https://www.transport-publiczny.pl/mobile/poznan-kupuje-piec-autobusow-klasy-mini-67912.html [08.03.2021] – development of the metropolitan railway, https://koleje-wielkopolskie.com.pl/od-stycznia-2021-r-poznanska-kolej-metropolitalna-na-linii-poznan-koscian/ [23.05.2021]	T
	1.3 Continuation of changes in heating and cooling systems to be more efficient and less – or emission-free: – furnace replacement program, https://powiat.poznan.pl/dotacja-na-wymiane-piecow/ [18.01.2021] – expansion of the heating network, https://zdm.poznan.pl/pl/web/aktualnosci/view/id/budowa-sieci-cieplnej-i-zwezenia-na-gorczyynie [05.03.2021]	E
	1.4 Creation of a coordinated energy management system in public utility buildings; continuation of thermo-modernization of buildings: – thermo-modernization of buildings in Poznań, https://puls.edu.pl/projekty-ue/termomodernizacja-budynku-wtd [23.05.2021] – modernization works – raising the standard of nursery buildings, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/prace-modernizacyjne-podniesienie-standardu-budynkow-zlobkow [11.05.2021]	E

cont. Table 3

1	2	3
2. Limiting the effects of heavy rains and urban floods, droughts, storms and strong winds	1.5 Increasing energetic safety (modernization of the power grid, diversification of energy sources) – the program ‘Słoneczne Dachy (Solar Roofs)’, https://globenergia.pl/program-sloneczne-dachy-winogrody-oze-fotowoltaika-energetyka/ [28.01.2021] – modernization of the kindergarten, https://www.poznan.pl/mim/oswiata/news/energetyczna-metamorfoza-przedszkola,153931.html [06.10.2020]	E
	1.6 Development and implementation of the concept of introducing green and blue infrastructure to urban space: – https://zdm.poznan.pl/pl/web/aktualnosci/view/id/zielen-na-chwaliszewie-i-nie-tylko [01.12.2020]	B
	1.7 Introducing solutions reducing car traffic in Śródmieście: – construction of new pedestrian and bicycle routes and bicycle paths, [02.03.2021] – reorganization of traffic in terms of limiting and calming car traffic in Śródmieście, https://mapadotacji.gov.pl/projekty/746909/ [23.05.2021]	T
	1.8 Revalorization of park greenery in the city; creating new parks: – restoration of the Tysiąclecia Park, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/rewaloryzacja-parku-tysiaclecia [08.04.2021]	B
	1.9 Recreating street trees: – revalorization of the existing ones and creation of new squares in degraded places, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/przebudowa-ul-kwiatowej-na-odcinku-od-ul-polwiejskiej-do-ul-rybaki [02.11.2020] – reconstruction of Jarochowskiego Street, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/przebudowa-ul-jarochowskiego-na-odcinku-od-ul-chociszewskiego-do-ul [02.03.2021]	B
	1.10 Development of a strategy for the development of green areas – not inventoried (n.i.)	B
	2.1 Preservation and revalorization of existing watercourses and reservoirs: – reconstruction of the Górczynka watercourse, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/przebudowa-cieku-gorczyzna [23.05.2021]	WM
	2.2 Undertaking joint actions to protect the catchment area of urban watercourses and lakes within the Poznań metropolis – n. i.	WM
	2.3 “In situ” rainwater management in the city; use of “clean” rainwater on the property – n. i.	WM
	2.4 Creating a system of retention and pre-treatment reservoirs: – construction of a retention reservoir in Łacina, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/budowa-zbiornika-retencyjnego-na-lacinie [18.01.2021] – construction of a retention reservoir in the Kiekrz estate, https://pim.poznan.pl/inwestycje/wspolfinansowane-ze-srodkow-ue/budowa-zbiornika-retencyjnego-na-osiedlu-kiekrz [18.01.2021]	WM
	2.5 Installation of sedimentation and flotation devices, settling tanks and separators for rainwater flowing from facilities and areas with high pollution – n. i.	WM
	2.6 Development and promotion of municipal drainage system standards; preparation of a catalog / guidelines of good practices in rainwater management: – program ‘Moja Woda (My Water)’, https://codziennypoznan.pl/artykul/2021-03-22/mozna-juz-skladac-wnioski-w-ramach-ii-edycji-programu-moja-woda/ [22.03.2021]	WM
	2.7 Creation of surface drainage of rainwater from the roadway to the belts of infiltrating areas, in areas with less intensive development: – construction of a rainwater drainage system in Miastkowska Street, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/budowa-jezdni-i-chodnika-w-ul-gryfinskiej-i-wyszomierskiej-oraz [28.04.2021] – extension of the Moraski Collector, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/budowa-ulicy-nadwarcianskiej-rozbudowa-kolektora-moraskiego [18.01.2021]	WM
	2.8 Reconstruction of surface water systems, including the construction of a comprehensive municipal drainage system for 20 catchments using, inter alia, natural retention methods, in particular in the “Bogdanka” catchment: – reconstruction of the Bogdanka watercourse, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/przebudowa-cieku-bogdanka [22.04.2021]	WM

cont. Table 3

1	2	3
	2.9 Development of a hydraulic model and creation of an automatic monitoring / control system for the operation of the rainwater sewage system – n. i.	WM
	2.10 Program of inventory and assessment of the condition of tree stands in terms of their threat in the event of strong winds, gradual removal of trees that pose a threat in the event of strong winds – trees removal, https://poznan.naszemiasto.pl/wycieto-kilkadziesiat-sosen-w-poznaniu-wiekszosc-z-nich/ar/c1-8143793 [18.02.2021]	H
3. Informing the local urban community and awareness raising on the effects of climate change	3.1 Conducting a social campaign promoting good adaptation practices: – ‘Moja Woda (My Water)’ program, https://codziennypoznan.pl/artykul/2021-03-22/mozna-juz-skladac-wnioski-w-ramach-ii-edycji-programu-moja-woda/ [22.03.2021]; ‘Odmień swoje podwórko (Change your yard)’ program, https://codziennypoznan.pl/artykul/2021-03-20/ostatnie-dni-na-zgloszenie-dok akcji-odmien-swoje-podworko/ [20.03.2021]	
	3.2 Conducting educational activities on legal regulations in the field of environmental protection – n. i.	
	3.3 Improving and extending the system of warning residents against climate hazards – n. i.	
	3.4 Building and maintaining a platform for the exchange of knowledge about good practices in adaptation to climate change: – Poznań citizens’ assembly, https://www.poznan.pl/mim/wos/news/poznanski-panel-obywatelski-zanami-pierwsze-spotkanie-edukacyjne,160469.html [08.03.2021]; https://www.poznan.pl/mim/main/temat-panelu,p,51691,51696.html?wo_id=344 [23.05.2021]	
	3.5 Strengthening and expanding cooperation with the Technology Park, universities, other research institutions in Poznań, and non-governmental organizations – n. i.	
	3.6 Creation and management of a database of threats and effects of extreme climate phenomena – n. i.	
4. Institutional and organisational strengthening of city’s resistance to climate change or extreme climatic phenomena	4.1 Modernization of the infrastructure of social welfare facilities: – comprehensive modernization along with the expansion of the MOPR headquarters, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/kompleksowa-modernizacja-wraz-z-rozbudowa-siedziby-mopr [14.04.2021] – the new seat of the Nursing Home at Bukowska Street in Poznań, https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/dom-pomocy-spoecznej-przy-ul-bukowskiej-w-poznaniu-nowa-siedziba [02.11.2021]	H
	4.2 Organizing systemic care for seniors – creating day homes for seniors and extending the scope of their activities – n. i.	H
	4.3 Successive improvement of the standard of medical services in health care facilities in the city: – modernization of the building of the Poznań Center for Specialist Medical Services https://pim.poznan.pl/inwestycje/w-trakcie-realizacji/modernizacja-budynku-poznanskiiego-osrodka-specjalistycznych-uslug [29.01.2021]	H
	4.4 Construction of watchtowers and retrofitting of equipment for the State Fire Service (SFS) and Volunteer Fire Brigade (VFB), https://pim.poznan.pl/inwestycje/zrealizowane/budowa-budynkow-na-potrzeby-miejskiego-magazynu-przeciwowo-dziowego-oraz [23.05.2021]	H
	4.5 Organizing and conducting joint training of services as part of the cooperation of the SFS and the VFS – n. i.	H
	4.6 Preparation of spatial development guidelines in planning documents, concepts, projects, etc. Successive preparation of local plans to increase the city’s resilience – n. i.	SM

* marking of sectors vulnerable to climate change as in Tab. 2, n. i. – not inventoried.

Source: own preparation.

of strategic Goal 1 is a group of biodiversity development measures. It includes regeneration of park greenery, recreation of street greenery, and development of new garden squares. No information was noted about the concepts of introducing blue-

green infrastructure to urban space or strategies for development of green areas.

Strategic Goal 2 includes 10 groups of measures; 9 out of 10 are connected with the water management sector. The most often recorded tasks encompass:

construction of storm water drainage systems, water collection systems and a storage reservoir, and redevelopment of watercourses. No actions regarding the development of standards for drainage systems, a catalogue of good practices, cooperation within the metropolis, or development of a hydrological model were recorded. The last of the measures of Goal 2 is related to the biodiversity sector. It encompasses greenery maintenance works and removal of trees posing a threat to pedestrians. For the 4 groups of actions (assigned to the water management sector), information about the start of implementation was not recorded.

Goal 3 primarily covers informational, educational, and promotional actions in 6 groups of multi-sector measures. In this regard, the Citizens Panel devoted to adaptation to climate change was launched. Furthermore, information about programs which promote water retention and green courtyards was distributed. Compared to the previous goals, a shortage of actions for Goal 3 is noticeable. In the case of as many as 4 out of the 6 considered groups, information about the start of implementation was not recorded.

The final strategic goal, Goal 4, includes the implementation of 6 groups of measures. Most of them, namely, 5 out of 6, are connected with the health sector; one of the groups of measures relates to spatial management. The health sector measures concern, e.g., modernization and construction of social services and health care centers, construction of warehouses, and provision of equipment for the needs of emergency services. To date, there have been no records of construction of new daycare centers, organization of joint training courses for emergency services (measures from the health sector), or development of spatial management guidelines (a measure from the spatial management sector).

DISCUSSION

The conducted analysis of implemented adaptation measures in Poznań showed a prevalence of measures in the transport and biodiversity sectors. It results from the research by Reckien et al. [2014] those

tasks of adaptation plans for European cities most frequently come from the following sectors: urban planning and development, water management, health, flood protection, forestry and agriculture. A significant proportion of measures related to transport, in addition to urban infrastructure and natural environment measures, was noted in the research covering 100 cities worldwide carried out by Castán Broto and Bulkeley [2013]. In the study by Reckien et al. [2014] for European cities, transport was most often considered in mitigation plans, right after efficient energy use and renewable energy. Concentration of action on the transport sector was typical of the cities of Central and South America [Hardoy & Lankao, 2011].

Out of the types of measures implemented in Poznań, the most prevalent are the following: mitigation, green, and physical infrastructure. Co-occurrence of mitigation and adaptation measures in cities was noticed, e.g., by Charlesworth [2010], Reckien et al. [2014], and the necessity of integrating both types of measures was highlighted, e.g., by Walsh et al. [2011], Ayers et al. [2014]. Planned measures are marked by a bigger balance between the types, as in five types of measures they are planned in the proportion of 12–19% each, in another five – 2–6%; the two types were not included in the plans. The planned soft and hard measures are almost balanced. It is recommended that measures of different character (mitigation and adaptation) be balanced and complement each other [Rosenzweig et al., 2015; EEA, 2016; Gajewska et al., 2019]. Planned measures should be adjusted to the needs and conditions of a particular city [Implementing climate change, 2012]. Therefore, each city may have a different structure of planned and implemented measures. In the study by Biagini et al. [2014], adaptation measures were most frequently classified as the types: capacity building, management and planning, and practice or behavior. According to Hunt and Watkiss [2011], most of the undertaken adaptation measures could be included in the “awareness-raising” type. In Poznań, the majority of measures included the following types: physical infrastructure, green infrastructure, health

programs, and mitigation, which slightly differed from the average structure of planned adaptation measures in other Polish big cities [Kalbarczyk & Kalbarczyk, 2020]. There were reports about damaged trees during the conducted investments. They occurred sporadically, but indicated a real threat of environmental maladaptation [Ford et al., 2013]. Damage to and removal of trees in Polish cities are not always balanced by replacement plantings [Ziemiańska et al., 2019]. It would be advisable to recognize that a badly planned and performed adaptation of one system may result in negative results in other systems [Ford et al., 2013].

According to the guidebook of adaptation [Guide for cities to adapt, 2015], each of the municipal adaptation plans should undergo verification and the planned measures should be modified depending on the speed of implementation and changing climatic conditions. Evaluation of the progress of implementation of planned tasks in Great Britain was a subject of research by Heidrich et al. [2013]. The authors showed that despite a widespread occurrence of adaptation and mitigation plans, the degree of implementation is highly diverse. Based on the analysis of the recorded actions undertaken to implement particular strategic goals, it can be noticed that the implementations of Goal 3, connected with information, education, and promotion regarding adaptation to climate change, are the least advanced. The second of the least frequent goals is Goal 4, related to institutional and organisational improvement of urban resilience to climate change. Actions undertaken to implement Goals 3 and 4 can be classified as soft, which as a rule generate lower costs than hard measures. Their relatively low advancement is fairly surprising.

According to the Climate adaptation plan [2019], the commune self-government is responsible for the implementation of adaptation measures in Poznań [Climate adaptation plan, 2019]. In the Climate adaptation plan [2019], the importance of Poznań residents' participation is also highlighted as well as the involvement of community organizations, infrastructure management units, and entrepreneurs.

In some plans of the Polish cities, the entity responsible for the implementation of planned actions is not clearly indicated [www.44mpa.pl]. Such a wide and diverse group of responsible entities causes that the evaluation of the progress and, above all, the effectiveness of implementation may be a difficult task. To date, the research on the implementation of adaptation to climate change has mainly used the method of interview with the entities responsible for planned actions in a given unit [Dannevig et al., 2012; Implementing climate change, 2012].

CONCLUSIONS

The conducted research on Poznań allows confirming the implementation of measures connected with four strategic goals of the adopted Climate adaptation plan [2019]. The biggest advancement can be observed in the actions reflected in Goal 1: "Mitigation of the negative impact of extreme thermal phenomena, including the concentration of pollutants". A considerable number of implementations were also recorded regarding the actions of Goal 2: "Limiting the effects of heavy rains and urban floods, droughts, storms, and strong winds". There is a prevalence of implementation of hard measures as well as of actions of the types: mitigation, physical infrastructure, and green infrastructure, in the transport and biodiversity sectors. Among the recorded works, there are both actions which continue tasks from earlier years, that is, from before the adoption of the plan of city adaptation to climate change, and new measures which respond to the challenges caused by climate change. Single cases of action resulting in environmental maladaptation have also been identified. The conducted review of thematic and city websites does not exhaust the list of all introduced actions. However, it may point to these measures which are most visible in the urban fabric, arouse the biggest interest of residents, and/or constitute a reflection of the communication policy of Poznań's authorities. The presented method evaluating implementation of adaptation plans enables the recording of actions performed by very diverse entities. While the identi-

fication of measures fitting into the planned strategic goals may be satisfactory, a real evaluation of the effectiveness of implementation remains a big challenge for future researchers. The presented research results may contribute to creating improved methods which verify the implementation of plans of adaptation to climate change. Assessment of implementation of particular types of actions and sensitive sectors is important in terms of effective coordination while implementing urban adaptation plans.

Author contributions: the authors have given approval to the final version of the article. Authors contributed to this work as follows: E.K. developed the concept and designed the study, E.K., M.P. collected the data, E.K., M.P. analysed and interpreted the data, M.P. prepared the draft of the article, E.K. revised the article critically for important intellectual content.

REFERENCES

- Araos, M., Berrang-Ford, L., Ford, J.D., Austin, S.E., Biesbroek, R., Lesnikowski, A. (2016). Climate change adaptation planning in large cities: A systematic global assessment. *Environmental Science and Policy*, 66, pp. 375–382. doi:10.1016/j.envsci.2016.06.009.
- Ayers, J., Huq, S., Wright, H., Faisal, A.M., Hussain, S.T. (2014). Mainstreaming climate change adaptation into development in Bangladesh. *Climate and Development*, 6(4), pp. 293–305. doi:10.1080/17565529.2014.977761.
- Biagini, B., Bierbaum, R., Stults, M., Dobardzic, S., McNeeley, S.M. (2014). A typology of adaptation actions: A global look at climate adaptation actions financed through the Global Environment Facility. *Global Environmental Change*, 25, pp. 97–108. doi:10.1016/j.gloenvcha.2014.01.003.
- Carter, J.G. (2011). Climate change adaptation in European cities. *Current Opinion in Environmental Sustainability*, 3(3), pp. 193–198. doi:10.1016/j.cosust.2010.12.015.
- Castán Broto, V., Bulkeley, H. (2013). A survey of urban climate change experiments in 100 cities. *Global Environmental Change*, 23, pp. 92–102. doi:10.1016/j.gloenvcha.2012.07.005.
- Charlesworth, S.M. (2010). A review of the adaptation and mitigation of global climate change using sustainable drainage in cities. *Journal of Water and Climate Change*, 1(3), pp. 165–180. doi:10.2166/wcc.2010.035.
- Dannevig, H., Rauken, T., Hovelsrud, G.K. (2012). Implementing adaptation to climate change at the local level. *Local Environment*, 17(6–7), pp. 597–611. doi:10.1080/13549839.2012.678317.
- EEA. (2016). Urban adaptation to climate change in Europe. Transforming cities in a changing climate. Report 12/2016, Luxembourg: Publications Office of the European Union. doi:10.2800/021466.
- Fidelman, P.I.J., Leitch, A.M., Nelson, D.R. (2013). Unpacking multilevel adaptation to climate change in the Great Barrier Reef, Australia. *Global Environmental Change*, 23(4), pp. 800–812. doi:10.1016/j.gloenvcha.2013.02.016.
- Ford, J.D., Berrang-Ford, L., Lesnikowski, A., Barrera, M., Heymann S.J. (2013). How to track adaptation to climate change: a typology of approaches for national-level application. *Ecology and Society*, 18(3), art. 40. doi:10.5751/ES-05732-180340.
- Gajewska, M., Rayss, J., Szpakowski, W., Wojciechowska, E., Wróblewska, D. (2019). *System powierzchniowej retencji miejskiej w adaptacji miast do zmian klimatu – od wizji do wdrożenia [Urban surface retention system in adapting cities to climate change – from vision to implementation]*. Gdańsk, Wydawnictwo Politechniki Gdańskiej.
- Gill, S.E., Handley, J.F., Ennos, A.R., Pauleit, S. (2007). Adapting cities for climate change: the role of the green infrastructure. *Built Environment*, 33(1), pp. 115–133. doi:10.2148/benv.33.1.115.
- Hardoy, J., Lankao, P.R. (2011). Latin American cities and climate change: challenges and options to mitigation and adaptation responses. *Current Opinion in Environmental Sustainability*, 3, pp. 158–163. doi:10.1016/j.cosust.2011.01.004.
- Heidrich, O., Dawson, J.R., Reckien, D., Walsh, C.L. (2013). Assessment of the climate preparedness of 30 urban areas in the UK. *Climatic Change*, 120, pp. 771–784. doi:10.1007/s10584-013-0846-9.
- <https://bip.poznan.pl/bip/uchwaly/uchwala-nr-x-144-viii-2019-z-dnia-2019-04-16,78779>, date: 12.05.2021.
- <https://codziennypoznan.pl/>, date: 12.05.2021.
- [http://metropoliapoznan.pl/aktualnosci,2579,jak-korzystac-z-parkingow-parkuj-i-jedz-\(p&r\).html](http://metropoliapoznan.pl/aktualnosci,2579,jak-korzystac-z-parkingow-parkuj-i-jedz-(p&r).html), date: 12.05.2021.
- <https://pim.poznan.pl/inwestycje/w-trakcie-realizacji>, date: 12.05.2021.

- <https://powiat.poznan.pl/dotacja-na-wymiane-pieczow/>, date: 12.05.2021.
- <http://www.future-cities.eu/project/adaptation-compass/>, date: 12.05.2021.
- https://www.mpk.poznan.pl/index.php?option=com_content&view=article&id=228, date: 12.05.2021.
- <https://www.poznan.pl/mim/komunikacja/news,1185/tramwaj-na-osiedle-kopernika-projekt-copernicus-gotowy-na-dofinansowanie,158748.html>, date: 12.05.2021.
- <https://www.poznan.pl/mim/main/-,p,46898,46908,51270.html>, date: 12.05.2021.
- <https://zdm.poznan.pl/pl/system-its-poznan>, date: 12.05.2021.
- <https://zdm.poznan.pl/pl/web/aktualnosci/view/id/zielen-na-chwaliszewie-i-nie-tylko>, date: 12.05.2021.
- <https://zdm.poznan.pl/pl/web/aktualnosci/view/id/zielony-most>, date: 12.05.2021.
- <http://44mpa.pl>, date: 12.05.2021.
- Hughes, S. (2015). A meta-analysis of urban climate change adaptation planning in the U.S. *Urban Climate*, 14, pp. 17–29. doi:10.1016/j.uclim.2015.06.003.
- Hunt, A., Watkiss, P. (2011). Climate change impacts and adaptation in cities: a review of the literature. *Climatic Change*, 104, pp. 13–49. doi:10.1007/s10584-010-9975-6.
- Implementing climate change adaptation. Lessons learned from ten examples. (2012). Headwaters Economics. Taos, USA. <https://headwaterseconomics.org/equity/climate-change/climate-adaptation-lessons-learned/>, date: 30.05.2021.
- Kalbarczyk, E., Kalbarczyk, R. (2020). Typology of climate change adaptation measures in Polish cities up to 2030. *Land*, 9(10), 351. doi:10.3390/land9100351.
- Karunathilake, H., Nahiduzzaman, K.M., Prabatha, T., Hewage, K., Sadiq, R., Alam, S., Shaw, P. (2020). The nexus of climate change and increasing demand for energy: a policy deliberation from the Canadian context. In: *Dynamics of Energy, Environment and Economy. Lecture Notes in Energy* 77. H., Quadrat-Ullah, M., Asif (eds.). doi:10.1007/978-3-030-43578-3_13.
- Leichenko, R. (2011). Climate change and urban resilience. *Current Opinion in Environmental Sustainability*, 3, pp. 164–168. doi:10.1016/j.cosust.2010.12.014.
- Magnan, A. (2014). Avoiding maladaptation to climate change: towards guiding principles. *S.A.P.I.E.N.S.*, 7(1). <http://journals.openedition.org/sapiens/1680>, date: 30.05.2021.
- Moraci, F., Errigo, M.F., Fazia, C., Campisi, T., Castelli, F. (2020). Cities under pressure: Strategies and tools to face climate change and pandemic. *Sustainability*, 12(18), 7743. doi:10.3390/su12187743.
- Nowak, M., Dawidowicz, A., Żróbek, R., Do Thi Tuyet, M. (2020). Identification of development determinants of Green Information System for urban areas – Polish case study. *Acta Scientiarum Polonorum, Administratio Locorum*, 19(1), pp. 45–60. doi:10.31648/aspal.4456.
- Olazabal, M., De Gopegui, M.R. (2021). Adaptation planning in large cities is unlikely to be effective. *Landscape and Urban Planning*, 206, 103974. doi:10.1016/j.landurbplan.2020.103974.
- Plan adaptacji do zmian klimatu Miasta Poznania do roku 2030 [Climate adaptation plan for the City of Poznań until 2030]. (2019). <https://www.poznan.pl/mim/main/-,p,46898,46908,51270.html>, date: 12.05.2021.
- Podręcznik adaptacji dla miast wytyczne do przygotowania Miejskiego Planu Adaptacji do zmian klimatu [Guide for cities to adapt the guidelines for the preparation of the Municipal Plan for Adaptation to Climate Change]. (2015). Warszawa, Ministerstwo Środowiska, http://www.rpo.wzp.pl/sites/default/files/podrecznik_adaptacji_dla_miast_20191126.pdf, date: 12.10.2021.
- Raport z konsultacji społecznych projektu Planu adaptacji do zmian klimatu Miasta Poznania do 2030 [Report on public consultations on the draft Climate adaptation plan for the City of Poznań until 2030]. (2019). <https://www.poznan.pl/mim/konsultujemy/-,p,38117,38125,45266.html>, date: 23.05.2021.
- Reckien, D., Flacke, J., Dawson, R.J., Heidrich, O., Olazabal, M., Foley, A., Hamann, J.J.-P., Orru, H., Salvia, M., De Gregorio Hurtado, S., Geneletti, D., Pietrapertosa, F. (2014). Climate change response in Europe: what's the reality? Analysis of adaptation and mitigation plans from 200 urban areas in 11 countries. *Climatic Change*, 122, pp. 331–340. doi:10.1007/s10584-013-0989-8.
- Reckien, D., Flacke, J., Olazabal, M., Heidrich, O. (2015). The influence of drivers and barriers on urban adaptation and mitigation plans – an empirical analysis of European cities. *PLoS ONE* 10(8), e0135597. doi:10.1371/journal.pone.0135597.
- Reckien, D., Salvia, M., Heidrich, O., Church, J.M., Pietrapertosa, F., De Gregorio-Hurtado, S., D'Alonzo, V., Foley, A., Simoes, S.G., Krkoška Lorencova, E., et al. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *Journal of Cleaner Production*, 191, pp. 207–219. doi:10.1016/j.jclepro.2018.03.220.

- Rosenzweig, C., Solecki, W., Romero-Lankao, P., Mehrotra, S., Dhakal, S., Bowman, T., Ibrahim, S.A. (2015). *ARC3.2 Summary for city leaders. Urban Climate Change Research Network*. New York, Columbia University.
- Strategiczny plan adaptacji dla sektorów i obszarów wrażliwych na zmiany klimatu do roku 2020 z perspektywą do roku 2030 [A strategic plan for the adaptation of areas and sectors vulnerable to climate change by 2020, with the prospect of 2030]. (2013). Warszawa, Ministerstwo Środowiska. <https://klimada.mos.gov.pl/wp-content/uploads/2013/11/SPA-2020.pdf>, date: 12.05.2021.
- Szewrański, S., Chruściński, J., Kazak, J., Świąder, M., Tokarczyk-Dorociak, K., Żmuda, R. (2018). Pluvial Flood Risk Assessment Tool (PFRA) for rainwater management and adaptation to climate change in newly urbanised areas. *Water*, 10, 386. doi:10.3390/w10040386.
- Tompkins, E.L., Adger, W.N., Boyd, E., Nicholson-Cole, S., Weatherhead, K., Arnell, N. (2010). Observed adaptation to climate change: UK evidence of transition to a well-adapting society. *Global Environmental Change*, 20(4), pp. 627–635. doi:10.1016/j.gloenvcha.2010.05.001.
- Uchwała Nr X/144/VIII/2019 Rady Miasta Poznania z dnia 16.04.2019 w sprawie przyjęcia Miejskiego Planu Adaptacji do zmian klimatu dla Miasta Poznania [Resolution No. X/144/VIII/2019 of the Poznań City Council of 16.04.2019 on the adoption of the Municipal Plan for Adaptation to Climate Change for the City of Poznań]. <https://bip.poznan.pl/bip/uchwaly/uchwala-nr-x-144-viii-2019-z-dnia-2019-04-16,78779>, date: 23.05.2021.
- Walsh, C.L., Dawson, R.J., Hall, J.W., Barr, S.L., Batty, M., Bristow, A.L., Carney, S., Dagoumas, A.S., Ford, A.C., Harpham, C., Tight, M.R., Watters, H., Zanni, A.M. (2011). Assessment of climate change mitigation and adaptation in cities. *Urban Design and Planning*, 164 (DP2), pp. 75–84. doi:10.1680/udap.2011.164.2.75.
- Wieteska-Rosiak, B. (2018). Hybridyzacja przestrzeni publicznej miast w kontekście adaptacji do zmian klimatu [Hybridization of urban public space in the context of adaptation to climate change]. *Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach*, 365, pp. 30–44.
- Ziemiańska, M., Kalbarczyk, R., Sobota, M. (2019). Replacement planting in the light of the Polish law – an effective or token tool of environmental compensation? *Acta Scientiarum Polonorum. Administratio Locorum*, 18(3), pp. 323–333. doi:10.31648/aspal.4188.