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ADAPTATION PLANS TO CLIMATE CHANGE – RANGE AND QUALITY OF INPUT DATA

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ABSTRACT: One of the most important elements of the process of developing the urban plans for adaptation to climate change is a gathering proper data. It will have an influence on the quality of the final work, its accuracy, reliability, determining the adaptation option and decide on its success. In the first part of the paper the experience in collecting data from the English-language literature which were published between 1999-2016 has been presented. A search was carried via scopus.com, webofknowledge.com and springer.com or sciencedirect.com. In the next part of the paper the main information sources which will be referred to when developing MPAs (Miejskie Plany Adaptacji – Urban Adaptation Plan) in Polish cities have been identified. At the end, the requirements for conducting proper and reliable geostatistical analyses have been presented. In the article the main framework of resources required for MPAs was established. This will allow maintaining the level of quality of documents received and avoid the mistakes.

KEY WORDS: urban adaptation plans, climate change, data collection

Introduction

The issues of urban sensitivity to climate change are addressed in numerous expert studies and strategic documents of the European Union (Gorgoń et al., 2014b). They are of various forms and the first time they appeared was in 2007, when during the COP16 conference the framework for adaptation activities was established. In Poland these activities started almost simultaneously, i.e. in 2009 with the implementation of the KLIMADA project. Works carried out in the previous years resulted in the adoption of a „Strategic Adaptation Plan for Sectors and Areas Sensitive to Climate Change by 2020" in 2013 ('SPA', 2013). This most important Polish document points out to the necessity of preparing adaptation plans or strategies addressed to Polish cities. These documents have been referred to by the Ministry of the Environment as Urban Adaptation Plans (MPAs).

In Poland the process of developing Urban Adaptation Plans (MPAs) to climate change in large cities (i.e. cities with more than 100 thousand inhabitants) was launched in 2017. This is the first such a large project covering 44 Polish cities. The aim of these plans is to prepare urban areas for potential impacts related to climate change. This is the result of the European Union's policy, which points out the need to implement adaptation measures at an urban level (Perks, 2013).

The basis for the development of adaptation plans is the analysis of the vulnerability of a given city to potential impacts resulting from climate change. A characteristic of potential impacts to Polish cities was worked out by the Institute for Ecology of Industrial Areas in the document entitled „*Assessment of the sensitivity of urban areas to potential threats posed by climate change*" (Gorgoń et al., 2014b). Together with the above-mentioned assessment „Guidelines for the development of an urban adaptation strategy for cities with more than 100 thousand inhabitants" (Gorgoń et al., 2014a) were prepared. On the basis of this the "Urban adaptation handbook – guidelines for the development of urban adaptation plan to climate change" ('Podręcznik MPA', 2015) was developed. The aim of these documents is to support the process of establishing MPAs in Polish cities.

Although the aforementioned documents have been developed, there is still an urgent need to continue and expand the activities that could significantly influence the effectiveness of the MPA process. One of the very important elements of such activities is to determine the range of data and information necessary for developing MPAs. Their aim is to support the process of raising the awareness and understanding of the potential impact of climate change and the possible adaptation options. The collected data and information will constitute the basis for further analyses related to MPAs. Therefore,

the quality of work, its accuracy and reliability will depend on the proper selection of data. In addition, it may influence the choice of the adaptation options at the final stage of the process, and ultimately its final success.

The main aims of the paper is establish the minimum requirement for gathering data to allow some level of quality of MPAs and to avoid the mistakes.

Material and Method

This section sets out the methods for reviewing literature and conducting research.

Research related to the data collection process was initiated during statutory work titled "Methods of identifying areas of the city's sensitivity to climate change and preliminary assessment of the effectiveness of measures aimed at reducing the city's sensitivity to the above-mentioned changes". The statutory was conducted in 2016. These studies have led to the conclusion that the first step to conduct the sensitivity analysis is to collect and verify the necessary climate data and information. This stage of work on adaptation plans is of great importance to their result.

Than the research about this issue was began. A literature search was carried out using the terms "input data", "climate change", "adaptation plans" via scopus.com, webofknowledge.com and springer.com or sciencedirect.com. The research was conducted in peer-reviewed journals, books, and conference proceedings which were published in English between 1999-2016 mainly. This literature included a European policy, guidelines, methodological papers, best-practice examples and adaptation plans reviews issued by international organizations, donors and development cooperation agencies. The resulting citations were screened in order to isolate 'input data' that pertained to European and urban/cities adaptation plans. In this stage of work The EU-ClimateAdapt (http://climate-adapt.eea.europa.eu) portal was searched for items tagged "urban adaptation plans" and "data collection" also.

The next step was to review Polish experiences in this area. Two items were helpful in creating the data list of source for adaptation plans of polish cities:

- Wytyczne do przygotowania miejskiej strategii adaptacyjnej dla miast powyżej 100 tys. mieszkańców (Gorgoń et al., 2014a),
- Podręcznik adaptacji dla miast wytyczne do przygotowania Miejskiego Planu Adaptacji do zmian klimatu ('Podręcznik MPA', 2015).

As for Polish experience in collecting and using data for adaptation plans, it was in that stage of work rather poor.

In the text was used abbreviation MPA which means Miejskie Plany Adaptacji in Polish language and Urban Adaptation Plan in English.

What data should be collected? Review of English-language literature

The key element is collecting and reviewing the necessary data concerning climate change and the related hazards of potential impacts within the city area. The data obtained will constitute the basis for all further analyses aimed at the city adaptation (Gorgoń et al., 2014a; 'Podręcznik MPA', 2015; Snover et al., 2007). The problem of data collection, selection of their sources and quality control has so far been discussed mainly in foreign language literature. The largest in this area is the experience of American and European countries, regions or cities which have initiated the process of creating documents related to the adaptation of cities. Taking this into account, it is extremely important to use the acquired knowledge and expertise while starting work with the cities (Giordano, Capriolo, Mascolo, 2013). The analysis of the available materials concerning preparation for urban adaptation or the adaptation itself may be the useful step, especially if it is accompanied by similar climate change experiences. However, it should be emphasized here that solutions which are good in one city do not necessarily work in another (Cortekar et al., 2016).

It is obvious that while collecting the data the existing resources will be used (Basher, 1999; Giordano et al., 2013). It is not expected that new databases will be developed because it is a time-consuming and cost-intensive process. It should also be stressed here that the amount of data required for the development of MPAs may have some limitations, i.e. lack of data, their unavailability, low quality or invalidity. It should also be borne in mind that during the work the state-of-the-art should be monitored for new information to supplement those previously collected.

Quoting Snover et al. (2007), the process of collecting data and information will be connected with finding an answer to the following question: how does climate change affect the region and does it pose an impact to the local community? Van de Ven (van de Ven, Buma, Vos, 2014), on the other hand, addresses the issue in the form of four questions:

1. What can be vulnerable to climate change and where (facilities, networks and groups)?
2. What climatic risks appear, where, and to what extent? Where is the highest risk?
3. Where can you find opportunities connected with climate change?

4. Which of the recent extreme weather conditions may be the benchmark in the research analysis?

Adaptation of cities to future climate change will depend on a number of factors, independent or interacting with each other. However, as already mentioned above, the key element in the adaptation of cities to future climate change is to understand and manage the current climate fluctuations so as to make them predictable (Basher, 1999). For this purpose, relevant data and information will be required. They can be divided into several categories (according to Basher, 1999; Burton, Malone, Huq, 2005; Giordano et al., 2013):

- climatic factors (temperature, precipitation, wind, etc.),
- non-climatic factors (environmental and socio-economic conditions i.e. population, land
- use, ecosystem data, etc.),
- sector vulnerability to present climate change and other changes, and their impacts,
- interactions between the various elements of the system and the result of these interactions,
- adaptation actions, plans and policies.

Climate phenomena and their derivatives, which are, in some way, a causative factor that can affect particular sectors of the city and its components. These, are the first from the above-mentioned data categories. Generally, most of foreign language literature focuses on collecting information related to: air temperature, atmospheric precipitation, solar radiation, wind speed and humidity. The availability and quality of this data is relatively better than, for example, than those relating to the environment or socio-economic factors. They have been gathered for many years, if not decades, as this is popular data, which constitutes the basis for many processes and is used in many sites. In addition, their measurement is relatively simple. Monitoring and collection of data related to climatic issues factors is conducted on a global scale, with the cooperation of international and regional centers. Problems connected with meteorology, operational climatology and hydrology are dealt with by the World Meteorological Organization (WMO). It was established, among others, to coordinate the network of meteorological and hydrological stations and to ensure data consistency. In turn, the Global Climate Observing System (GCOS) is responsible for systematic data collection for global monitoring system, prediction and monitoring of the climate change effects.

Collection of data is just the beginning of the process of gaining knowledge on the climatic phenomena. Based on the obtained data, climate trends are identified and estimated. This can be done using statistical methods, i.e.

analysis of time series from meteorological monitoring stations. Such data should meet the following criteria: the data series should cover a longer period of time (at least 40-50 years), should be continuous over time, and tested for completeness and quality. In addition, the series of data is subjected to homogenisation (Aguilar et al., 2003; Kuglitsch et al., 2009) and statistical processing, including the recognition of linear and nonlinear trends (Seidel, Lanzante, 2004; Tomé, Miranda, 2004) in order to provide reliable results. Subsequently, properly prepared data is interpolated in a regular grid to a larger area using geostatistical methods (Giordano et al., 2013).

Another very important step in the development of the database is the review of environmental and socio-economic conditions as they may include elements sensitive to climate change. Proper identification of impacts will contribute to the selection of the best adaptation option. Nowadays, it can be observed that there are cities which have already been struggling with some environmental or socio-economic problems which are not related to climate change. These problems are sometimes so serious that the cities are not willing to solve any other problems. However, it must be borne in mind that the potential climate change may exacerbate the existing „non-climatic" problems or generate new ones. At this stage of research areas systematically exposed to climatic hazards and showing the highest exposure level should be identified. There is also another factor that raises the level of uncertainty, namely the fact that volatility of the so called „non-climatic" data is sometimes much higher than the observed climate change (Basher, 1999).

In most cases at this stage a list of indicators, i.e. parameters characterise a given receptor (sector of the city) (Burton et al., 2005), is prepared. They will help define the sector sensitivity level. The indicators should meet three criteria – they should: a) aggregate, calculate and simplify relevant information, b) capture the key problem, and c) provide relevant information. They may be qualitative, quantitative or mixed. An ideal situation is when the indicators characterise a given receptor in a qualitative manner. There are many publications and there are adaptation tools that offer ready-made lists of indicators, such as, for example THE FUTURE CITIES ADAPTATION COMPASS. Below, an exemplary fragment of the table from the above-mentioned tool is presented (table 1).

When selecting the indicators, one should also refer to the manual: "The Vulnerability Sourcebook. Concept and guidelines for standardized vulnerability assessments", which describes how to identify and select the indicators ('GIZ', 2014).

Table 1. Sample list of indicators for population-related receptors. Fragment of the table from THE FUTURE CITIES ADAPTATION COMPASS tool

	Receptors	Indicators Select one/or more indicators per receptor to describe core areas
Population	Public health/vulnerable groups*	Spatial distribution of vulnerable groups
		Age structure of different groups in the city
		Population density
		Capacity of medical system
		Capacity of emergency system
		Amount of green spaces
		Distribution of air corridors
		Degree of air quality

* (Smit, Wandel, 2006) According to this authors, vulnerability is a function of sensitivity and exposure of a receptor to the hazardous conditions/climate or weather impact and the capacity to adapt towards those conditions. This definition is different than in the IPCC is, which refers to climate change impacts instead of integrating actual and observed climatic or weather related impacts (compare IPCC, 2007)

Source: The future cities..., 2013.

Another very important element of the above-mentioned list of data categories is to understand the impact of current climate changes on the sectors and their vulnerability to these changes. In literature there are a number of variants which propose a proper course of action. In the tool "THE FUTURE CITIES ADAPTATION COMPASS. A guidance tool for developing climate-proof city regions" ('THE FUTURE CITIES...', 2013), starting from the list of receptors, which are a set of local physical properties and socio-economic conditions, their current sensitivity to weather events and their distribution can be investigated. This is one of the methods, and there is not one tried and tested course of action in this case.

Interactions between the various elements of the system and the resultant of these interactions is a category of data that is much more difficult to put into any frame. It requires understanding and combining many scientific disciplines and data (Basher, 1999). It would be advisable here to refer to the IPCC reports (Pachauri, Mayer, Intergovernmental Panel on Climate Change, 2015).

The last step is to review the existing adaptation measures, plans and policies which operate within or on the part of the investigated area, as well as the effects of the actions already taken. The range of the data is limited to the region or city. It largely depends on funds and local policy. Conducting the data analysis on a local scale will be helpful in taking further actions.

Proposed range of data for adaptation of Polish cities

The presented thematic range and principles of procedure at the stage of spatial data collection was developed on the basis of research and development works (including expertise and studies for the Ministry of the Environment), which have been carried out in the Institute for Ecology of Industrial Areas since 2014.

Currently, a lot of information on the environment, urban structure, climate and its influence is available in Poland and worldwide. It can be obtained from various sources, such as:

1. Publicly available web portals, such as those of the European Environment Agency: http://climate-adapt.eea.europa.eu/, https://www.eea.europa.eu/data-and-maps.
2. Institutions dealing with the collection and dissemination of such data, in particular: Geodesic and Cartographic Documentation Center (CODGiK), National Water Management Authority (KZGW), The General Directorate for Environmental Protection (GDOŚ), Chief Inspectorate of Environmental Protection (GIOŚ), and regional representatives of these institutions.
3. City resources, which are an essential element of the knowledge about the city due to their accuracy of details and adequacy (of course, provided that they are updated).

The above mentioned institutions have databases and information which are also available on their web portals. An example may be the KZGW hydroportal where, for example, under the project: "National Information System for Protection against Extreme Hazards (ISOK)" flood hazard and risk maps as well as Flood Risk Management Plans for the Odra and Vistula River Basins have been published. The maps are available on the portal in pdf format, but they are also in the possession of the administrative units.

When collecting data for MPAs, particular attention should be drawn to a few details. The first important thing in creating the MPA document, especially in analyses of the sensitivity of city sectors and their vulnerability, is the data collection date and data quality. The collection date does not, of course, relate to historical data and studies. The validity of data collected nowadays is often different. It is important, especially when dealing with, for example, models related to future climate change. Current data and information take into account the state-of-the-art on climate change in many areas, as well as adaptation methods or complex systems and interactions between particular elements. This knowledge is dynamic and based on the experience gained in this field. As mentioned before, the validity of data can significantly affect the final outcome of the analyses. Data obtained under international projects are generally updated and also reviewed.

Thus, it can be assumed that the quality of both input and output data is quite good. In many cases this quality is determined and known to the user. It should be remembered, however, that they do not always translate into real problems in the city. The situation is different in terms of data coming from the city resources. Planning documents, which are one of the main sources of information about the city, show different validity, and what may become even a bigger problem – they may be of various quality. It depends on the period in which the document was developed and on the applied cartographic tools. Cities updated or created such documents, depending on the needs or changes of the law.

Another important thing to pay attention to in creating the MPA document is the scale and coverage of data and information. Regardless of whether they are statistical, mapping or descriptive, the data usually have a specific coverage and scale. Most often, those from international portals represent a global scale (world, continent or country). The rest are regional (voivodeship) or local (county, municipality, city). For broader context analyses, less accurate global or regional data will be used. However, this will be rather rare and used to support the work, the overwhelming majority of which will concerns the city, i.e. the local scale.

In order to systematize the data and information on urban adaptation to climate change, they were divided into groups. A similar situation is in the case of English-language literature – Basher et al. (1999) Burton et al. (2005) and Giordano et al. (2013) cited above, where the collected data and information are assigned to different categories (groups). As far as MPAs for Polish cities are concerned the following groups of data and information are proposed:

- elements of urban structure and the environment,
- causative factors, i.e. natural climatic phenomena and their derivatives,
- Internet portals, which are a good source of knowledge or basic and complementary information on both climate change and adaptation methods,
- manuals, good practices, and plans for the applied world-wide examples of urban adaptation to climate change,
- own, strategic, spatial planning and other studies developed at a city or municipal level, and other data collected by local or regional institutions,
- reports developed under bilateral and / or international projects,
- research projects and studies.

The first group of data includes information about the elements of the urban structure and the environment, which constitute the receptors potentially vulnerable to natural hazards, exacerbated by climate change. They can be further systematised by dividing into the following thematic subgroups:

- land use pattern,
- administrative units and special borders,
- digital terrain model (DTM),
- hydrography / hydrology,
- technical infrastructure of the city,
- functional structure of the city including development and its structure,
- division of the city into districts, area of the city,
- share of biologically active areas,
- soil sealing degree,
- functional-spatial relationships with the surrounding,
- demography, health and safety of the population,
- habitats and natural areas, protected areas and species,
- historical background,
- natural hazard zones including flood plains,
- soil.

The second group includes data on causative factors, defined as stressors, i.e. natural climatic phenomena and their derivatives, which have a particular influence on the elements of the urban structure and the environment. These phenomena are related to three areas that may pose a potential threat to the city. These are:

- water,
- temperature,
- wind.

The third group covers Internet portals. They are a good source of knowledge, basic and additional information on both climate change and adaptation methods. This group is so large and dynamic that it is difficult to gather all the available portals. However, when using this information to avoid misunderstandings and ambiguities, it is important to pay attention to the purpose for which it was created, who is the recipient and what is the source of funding.

The fourth group of data and information sources includes manuals, good practices and examples of urban adaptation to climate change. It is also a very broad and dynamically developing group. Many cities, especially European and American ones, have already implemented urban adaptation plans. This enables the exchange of experience in adaptation of cities located in different climatic zones in the world.

The fifth, but very important group, consists of the data collected by individual cities, including those which are publicly available but also studies and documents of the municipality. These are their own, strategic, spatial planning and other works developed at the city or municipal level. This group also includes supra-municipal documents, such as city functional areas or studies on a voivodship scale.

A good source of data may also be reports prepared under bilateral and/or international projects. They may address issues related to climate change or urban adaptation. Such projects are often carried out by the municipal offices and other municipal entities. Many studies on urban adaptation to climate change emerged in scientific circles under various research projects and studies. They were developed by universities, scientific and research institutes and state environmental protection institutions. They contribute a lot to the development of the state-of-the art in this field.

As it has already been mentioned at the beginning of this paper, the list of sources should be updated during the work on MPAs immediately after a new document appears. Within the city, however, the list should include additional documents depending on the city specificity. During the work on the MPAs ready and standardised list of data necessary for carrying out analytical and diagnostic work should be used. This can ensure correct and uniform analytical procedure in the carried out city sensitivity and vulnerability assessment. In addition, the use of similar data sources allows obtaining a result of comparable quality and value. It is also important to use adaptive solutions tested in a specific city to avoid errors. This is why it is so important to refer to the experience of other cities having similar problems connected with the urban adaptation.

Conditions ensuring correctness of geostatistical analyzes

In order to ensure that the above-mentioned data provide measurable effects, the method of their processing is also very important. For this purpose, calculations and statistical inference in these research methods should be performed at the significance level of $\alpha = 0.05$ and in the case of short measurement series at $\alpha = 0.01$. Calculations and inferences will take into account the nature of the statistical distribution, and depending on this distribution parametric and / or nonparametric methods will be used. The analyses will cover the latest data collected from the official holders of such data, e.g. Chief Inspectorate for Environmental Protection, Institute of Meteorology and Water Management, Central Statistical Office, etc. In the case of multi-criteria analyses, the correctness of the results should be ensured by conducting the sensitivity analysis.

In the case of map and computational data obtained from various reliable sources, the consistency analysis should be performed. If there is a lack of consistency, the data which are more reliable (i.e. those the accuracy of which is the highest, data error is known and represents the lowest value) should be taken into account. Spatial analyses should be performed wherever possible on large scale materials (local scale) e.g. 1:10 000.

An important element that will improve the transparency of results is "enclosing" the result maps with metadata in a format consistent with the INSPIRE Directive. In the case of Internet portals providing statistical and spatial data (e.g. the European Environment Agency portal), the following data should be taken into account (if possible): data that are reviewed, reliable, possibly the most recent ones, worked out by renowned institutions, foundations or experts and originating from sources recognized by experts. The last element to be highlighted in the case of information sources or tools is the applied methods, which should take into account the current state-of the-art.

Results and Discussion

The article shows haw to develop data base for adaptation plans of polish cities. The knowledge how data we need for adaptation plans has a decisive impact on the result. In the Poland large project covering 44 has just been completed. Therefore, we have some experience in this area but growing knowledge is very desired. It is extremely important to use the experience and knowledge of other countries. In this range, the available literature is impressive. Using this knowledge one should, however, remember about the specificity of Polish cities. In Poland we have a slightly different data resource than it is, for example, in America or in Europe. Largely, of course we can use the data collected by the European Union especially if were created for adaptation purposes, but one should remember that the basic source of data are gathering from Polish institutions and cities.

In this article, we organize knowledge about the collection of data, indicate the source of which to use and on what we should pay special attention to. The information provided in the article will contribute to broadening the knowledge on the data needed to create plans for adapting to climate change in Poland. The purpose of this article is also to draw attention to the aspect of data collection for the plans for adapting Polish cities. Therefore, it aims is not only to systematize knowledge about data collection but also the correctness of data selection and their range. This is one of the key elements in creating such a plans and can not be belittle.

Conclusions

In the first part of this paper experiences in collecting data described in English-language literature have been presented. The topic has been addressed

in a very general way in order to demonstrate the most important branches of knowledge concerning the adaptation of cities to climate change. A set of questions supporting the collection of data has been developed. In addition, the provided data have been presented according to thematic categories. In the case of climatic data, the way in which they are processed before they reach the final user has been described. This method is very important. It helps realize that climate scenarios are based on data already processed in some way in order to eliminate measurement errors. The English-language literature referred to in this paper brings the whole process of data collection together and should be very helpful in the development of MPAs.

In the next part of the paper the sources from which data and information on urban adaptation will come from have been identified. There are also groups that define the thematic range of data and information necessary for the adaptation of Polish cities. The development of a fixed list of sources, defined for cities at the beginning of the document creation process, should ensure high quality and uniformity. This data may be of different character, e.g., statistical, map or descriptive. Their validity may also vary. Particular attention should be paid to the date of their creation, the latest literature and to the current data. Obviously, this does not apply to historical data, which also affects the understanding of future climate change. Their quality, however, may vary. It may also happen that due to their doubtful reliability they will become useless. When new research results on information appear during the studies the data should be updated on a regular basis. Such a "monitoring" of the latest data or information should be carried out until the final stage of the MPA development process.

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The contribution of the authors

Magdalena Głogowska – 90% (concept, research, literature review, all article except chapter "Conditions ensuring correctness of geostatistical analyzes").

Joachim Bronder – 10% (chapter "Conditions ensuring correctness of geostatistical analyzes" and consultations).

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