PILOT ACTION LOWER SILESIA POLAND

OUTPUT O.T3.6

WORK PACKAGE T3 - IMPLEMENTATION AND FEEDBACK - TOOLBOX VERIFICATION

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1. Introduction

Testing the Toolbox beta version by project partners (PPs) in pilot actions (PAs) will provide:

documented learning experience, where PPs from different countries and disciplines will verify the Toolbox applicability and

an important communication tool where project results will enable important outreach and key post-project capitalization leverage supporting bottom-up participatory principles in water management planning processes, generally drafted by the Common Implementation Strategy for the Water Framework Directive (WFD CIS No.11).

The Toolbox will also be tested by stakeholders during training workshops and in the post-training implementation phase, when strategies will be discussed. These stakeholder interactions will enable clarification of needs and provide recommendations for Toolbox improvements (bottom-up approach) and for direct local and regional implementation of the Toolbox.

Pilot Action Lower Silesia activities focus mainly on risk reduction measures concerning low and high-water conditions. They are especially related to recommendations and proposals for water management and spatial planning.

During workshops, specific problems will be discussed with local stakeholders in order to receive feedback about cross-sectoral cooperation and conflicts between sectors.

One of the most significant issues will be testing and development of integrated toolbox. This will be carried out in order to improve spatial planning and land use recommendations for water management at a local level. Developed toolbox will be tested in the transboundary catchment of Lusatian Neisse River basin.

Activities planned within PA will contribute to achieve good status of water-related issues in the Lusatian Neisse River basin which should be in accordance to WFD. In the project of RAINMAN, recommendations on how to include pluvial floods in the FD were carried out. Therefore, the pilot activities concern the actions related to promotion of tools focused on increasing catchment retention to reduce the flood wave and consequently to mitigate the risk of flooding caused especially by heavy rains.

2. Basic data about pilot action

2.1. Geographical description

The Lusatian Neisse river basin is located in Central Europe, in south-west Poland - on the border of three countries, namely the Republic of Poland, the Federal Republic of Germany and the Czech Republic. The area of the river basin is 4 398,6 km^2, including 637,8 km^2 (14,5%) in the territory of the Czech Republic, 1 451,5 km^2 (33%) in Germany and 2 309,3 km^2 (52,5%) in Poland. The total length of the river Lusatian Neisse is 248,2 km. The upper section of the river (in the Czech Republic) is 48,4 km long. The remaining section up to the river mouth to the Oder river is within the boundaries of the Federal Republic of Germany and the Republic of Poland.

The region Lusatian Neisse river basin is characterized by significant variability in terms of altitude, relief and land use. The southern part of the basin is located in a mountainous area (Western Sudetes and their foreland), while the lowlands form the northern part. Total hypsometric differentiation of the region varies from 100 m a.s.l. (above sea level) in the north to over 1000 m a.s.l. in the south. This is due to the proximity of different physical and geographical units: the Czech Massif and the Central European Lowlands.

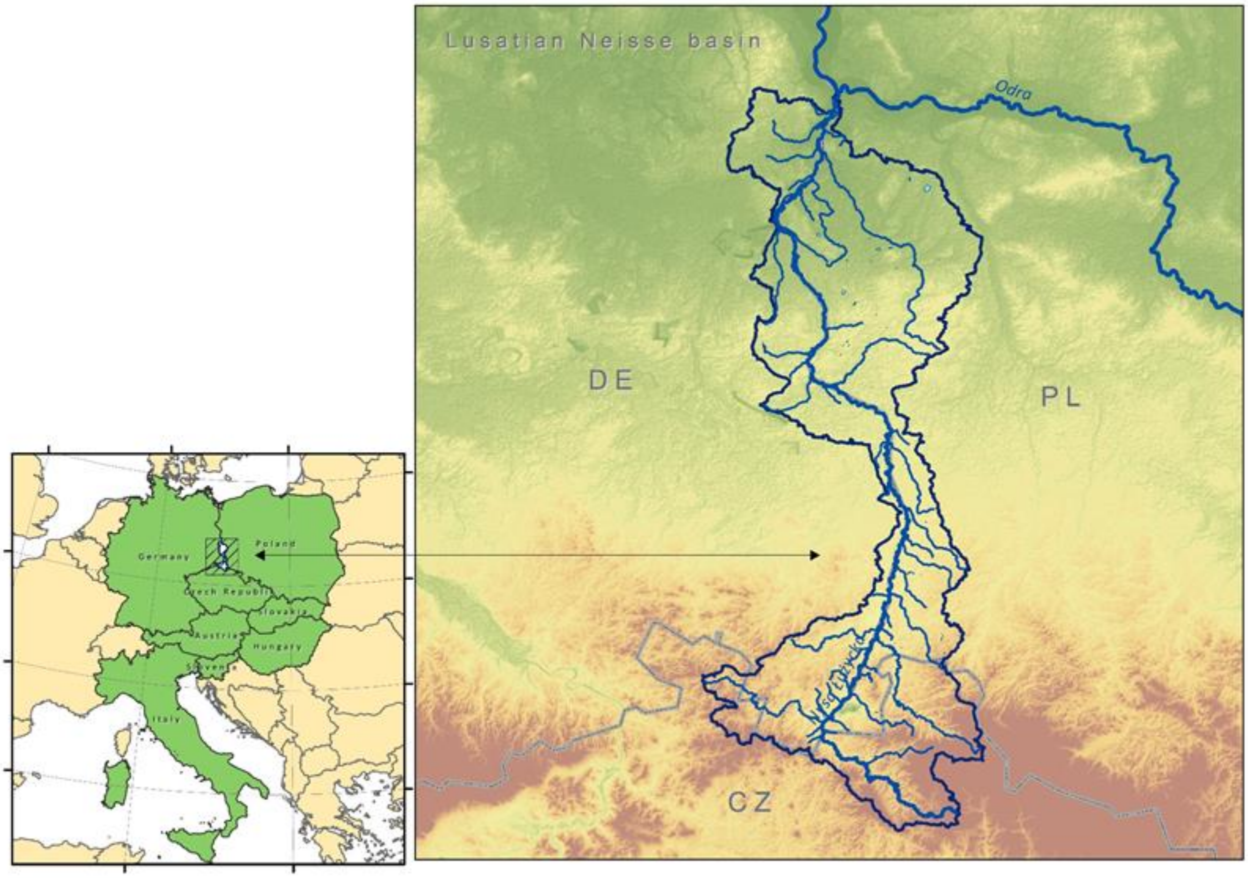


Fig. 1 Physical map and location of the Lusatian Neisse basin

2.2. Climate characteristics

Climate conditions of the pilot region of the Lusatian Neisse River basin are typical for moderate latitudes and are comparable to other areas of Poland representing the lowlands or mountain foreland. According to Koppen's climate classification, the region belongs to Cfb zone, characterized by mean air temperature of the coolest month higher than -3^{o}C and balanced annual course of precipitation totals. Circulation conditions are usually related to western advection of marine polar air masses that are predominant in this part of Europe. Because of significant geographical variability, altitude is the main factor determining distribution of various meteorological variables. This is noticeable especially in the context of thermal conditions. In the regions located lower down, mean annual air temperature varies within 8-9^{o}C. In Zgorzelec (the main municipality of the region), it is equal to 8,4^{o}C. In the higher altitudes of the region, it decreases with an average rate of 0,55-0,60^{o}C per 100 m. July is the warmest month while the lowest air temperature is observed in January. However, in the highest parts of the region, annual maximum and minimum can be shifted to August and February respectively. Because of significant hypsometric and morphologic variability, air temperature can be modified by altitude and terrain relief. Concave forms are characterized by significantly higher daily amplitudes of air temperature, resulting from relatively high maxima during the daytime and low minimum values at night. Such a course also causes increased frequency of frost in these terrain forms. On the other hand, low thermal amplitudes characterize convex forms. In this case, lower maximum values are observed during daytime while in the night air temperature is relatively high because of cool air masses flowing down the slopes towards lower hypsometric zones. It should be emphasized that local climate conditions can be also modified by other factors, such as vegetation, soils, anthropogenic activity, slopes exposition, etc.

In the context of the influence of thermal conditions on various environmental and economic sectors, information on characteristic days is very important. Mean annual number of days with maximum air temperature exceeding 30°C (heat days) and 25°C (summer days) in Zgorzelec amounts to 6 days and 35 days respectively. In terms of cold conditions, the frequency of frosty (T_{min}<0°C) and icy (T_{max}<0°C) days is equal to 88 days and 27 days. In the higher part of the region, the number of such days changes in favor of increase in frosty and icy days and decrease in heat and summer days frequency. In this case, mean annual number of frosty and icy days can exceed 130 days and 25 days, while for the heat and summer days can be equal to about 4 days and 30 days.

Precipitation is an element of climate that is characterized by very high temporal and spatial variability (Fig. 2). The amount of precipitation depends mainly on altitude, terrain and exposure to the dominant wind from the west direction. The highest annual precipitation totals, approx. 750-800 mm, occur in the highest part of the Lusatian Neisse River basin, such as the southern and south-eastern part of the Western Sudetes Foothills (Bogatynia, Bierna). The lowest precipitation totals occur in the northern part of the region, representing mainly by lowlands (approx. 570 mm). The precipitation totals are characterized by a high range of changes in individual years. In the last decades, the highest annual totals occurred in 2010, reaching over 150% of the climatic norm. The most dry ones were: 1982 (60-52% of norm) and 2003 (60% of norm). In the pilot area, days with heavy precipitation (≥ 10 mm per day) occur on average 14-18 days annually. Days with very heavy precipitation (≥ 20 mm per day) are less frequent, on average 3-4 days. Heavy and very heavy precipitation occur mainly in the summer months. In the last decades, the highest daily precipitation totals exceeded 100 mm and were recorded in the summer months (July-August). The highest rainfall in the Zgorzelec district was recorded in August 2010. On 7th August 2010, daily precipitation totals at Bogatynia station reached 160,2 mm (14,7% of the annual precipitation norm). At Sieniawka station, they reached 110,8 mm (13,3% of the annual norm). The maximum totals of 5-day precipitation can reach 200 mm, e.g. at Bierna station in July 1981, the 5-day precipitation was equal to 199,7 mm.

Strong precipitations often accompany meteorological storms. Mean number of days with storms in the region amounts to 24-27 days a year. The highest number of stormy days is notices in the summer months when 16-18 such days are observed. In the spring and autumn, the frequency vary from 1-2 days in autumn to 6-7 days in spring, whereas in the winter seasons storm occur just occasionally. Storms occurrence is also often related to strong wind. Mean annual wind speed in the region amount usually to 2,5-3,5 m/s, however gusts can often be higher than 25 m/s. One of the most extreme wind even was noticed on 18 January 2007 (Cyclone Kyrill) when wind speed exceeded 35 m/s. In the annual course, the highest wind speed is noticed in the cold half-year.

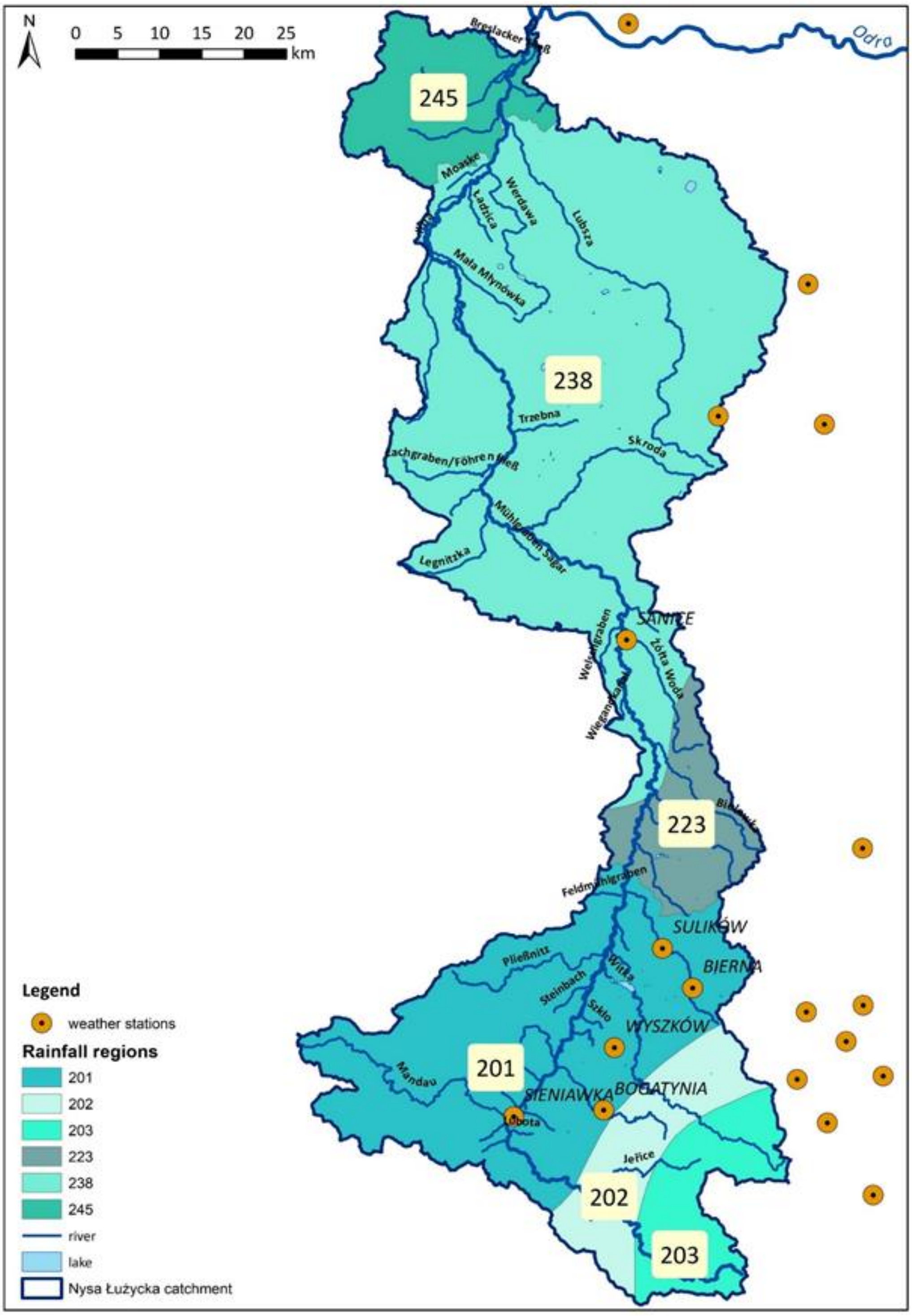


Fig. 2. Distribution of Polish meteorological stations and precipitation regions in the Lusatian Neisse River basin

2.3. Hydrology

2.3.1. Surface waters

The basin of the Lusatian Neisse River is a left tribuary to Odra River. The total length of the Lusatian Neisse is 248,2 km. The area of its basin A=4398,6 km^2 flows from the south-western slopes of the Isera Mountains at the height of 765 m above sea level in the vicinity of Budrichov city in the Czech Republic. The mean slope reduction in the river basin varies from approx. 3,3 % in the upper course of the river to 1,3% in the lower course. It flows to the Oder river at the kilometer of 542+400. In the west, the Lusatian Neisse river basin is surrounded by a watershed of the Elbe and Oder river basins, whereas in the east, it is surrounded by the watershed of the Bóbr river. In the south, it is surrounded by the Lusatian Mountains.

The main tributaries in the territory of Poland are as follows: the Miedzianka, the Witka, the Czerwona Woda, the Jędrzychowicki Potok, the Bielawka, the Żółta Woda, the Skroda, the Wodra, the Lubsza whereas in the territory of Germany these include: the Mandau, the Pließnitz, the Floßgraben, the Föhrenfließ, the Malxe, the Schwarze Fließ and the Buderoser Mühlenfließ (Fig. 3). Characteristic discharges for Lusatian Neisse hydrometric stations for the period 1981-2010 are presented in table 1.

Table 1. Characteristic discharges for Lusatian Neisse hydrometric stations for the period 1981-2010

Hydrometric station	Area [km²]	Average discharge [m³/s]	Medium discharge based on the yearly lowest values [m³/s]	Medium high discharge based on the yearly highest values [m³/s]
Hartau	378	5,99	1,68	68,7
Porajów	388	6,06	1,28	71
Zittau 1	694	9,03	2,31	128
Sieniawka	693	8,94	2,06	137
Rosenthal	879	10,6	3,08	123
Görlitz	1633	17,2	4,92	181
Zgorzelec	1630	15,5	3,47	180
Podrosche 2	2074	17,4	5,27	154
Przewóz	2108	19,3	5,43	185
Gubin	4080	28,8	9,27	179

There are numerous small reservoirs and ponds in the basin area with an area of 0.0007 to 1.62 km^2. Total area amounts to 15.69 km^2. In the recent years, after periods of drought, some of them have disappeared. The largest lakes are: Jańsko Lake with an area of 98 ha, Brody Lake with an area of 68 ha, Suchodół Lake with an area of 31.18 ha, and Wełnickie Lake with an area of 21 ha. The biggest one is the artificial Niedów Lake (Witka) with an area of 161.9 ha. On the German side, some of the former open casts were flooded and therefore artificial reservoirs were created. The lake of Berzdrof and Obersdorf (Berzdorfer See, Olbersdorfer See) can be examples of such actions. Additionally, in the German part (near Forst), pond complexes with an area of almost 200 ha were created as a result of mining activities and changes caused by the shift of the upper section of the Malxe River.

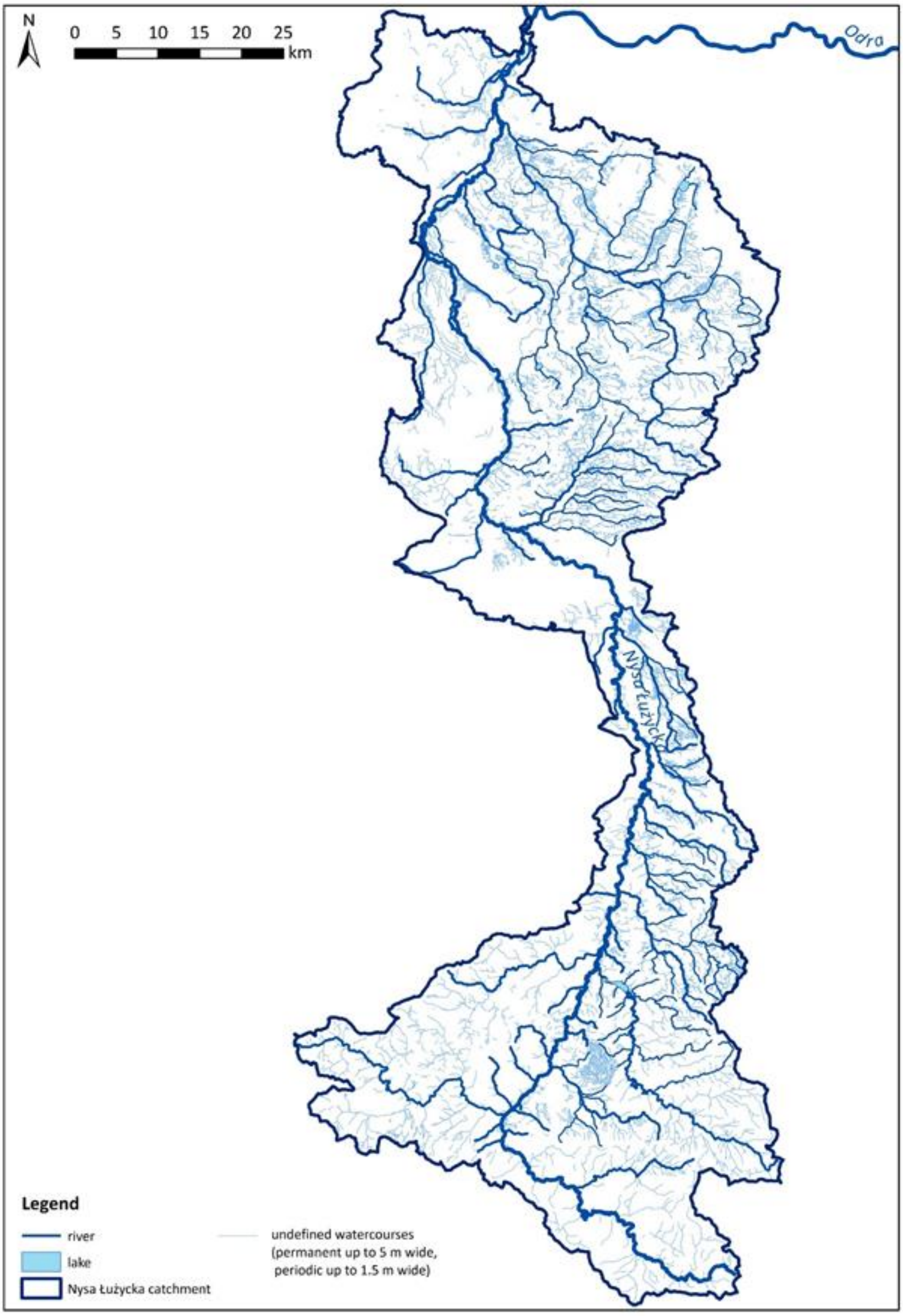


Fig. 3. Hydrographic network of the Lusatian Neisse basin.

2.3.2. Flooding

Floods in the Lusatian Neisse basin were mainly observed during the summer months (from June to August) after torrential rain. The largest floods were recorded in the following years: 1897, 1926, 1958, 1975, 1981, 2010.

The upper part of the Lusatian Neisse river basin is a dynamic flood risk area due to its mountain and sub-mountain character.

In the lower course of the Lusatian Neisse, there is also a risk of a longer flooding of the flood plain.

The following cities are particularly endangered by the flood on the Lusatian Neisse river:

- Liberec (CZ),
- Jablonec nad Nisou (CZ),
- Zgorzelec/Görlitz (PL/DE)
- Forst (DE)
- Guben/Gubin (DE/PL).

Flood hazard maps and flood risk maps are prepared basing on the Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (Flood Directive) and Polish Water Law Act (Journal of Laws of 2017 item 1566) and Regulation of the Minister of Marine Economy and Inland Navigation of 4 October 2018 on the development of flood hazard maps and flood risk maps (Journal of Laws of 2018, item 2031).

The flood hazard maps and flood risk maps should be reviewed and updated (if necessary) every water planning cycle (every 6 years).

Flood hazard and risk maps Flood hazard maps cover the areas with three probability levels of flooding:

areas where the probability of flooding is low (0.2%);

areas where the probability of flooding is medium (1%);

areas where the probability of flooding is high (10%).

The flood hazard and risk maps for the Lusatian Neisse and its tributaries were prepared in the first (2010-2015) and the second cycle (2016-2021) of preparation of Flood Risk Management Plans. Within the 2^{nd} cycle, maps for Lusatian Neisse and its 6 tributaries: Lubsza, Skroda, Czerwona Woda, Witka i Miedzianka were developed (Fig. 4 -5).

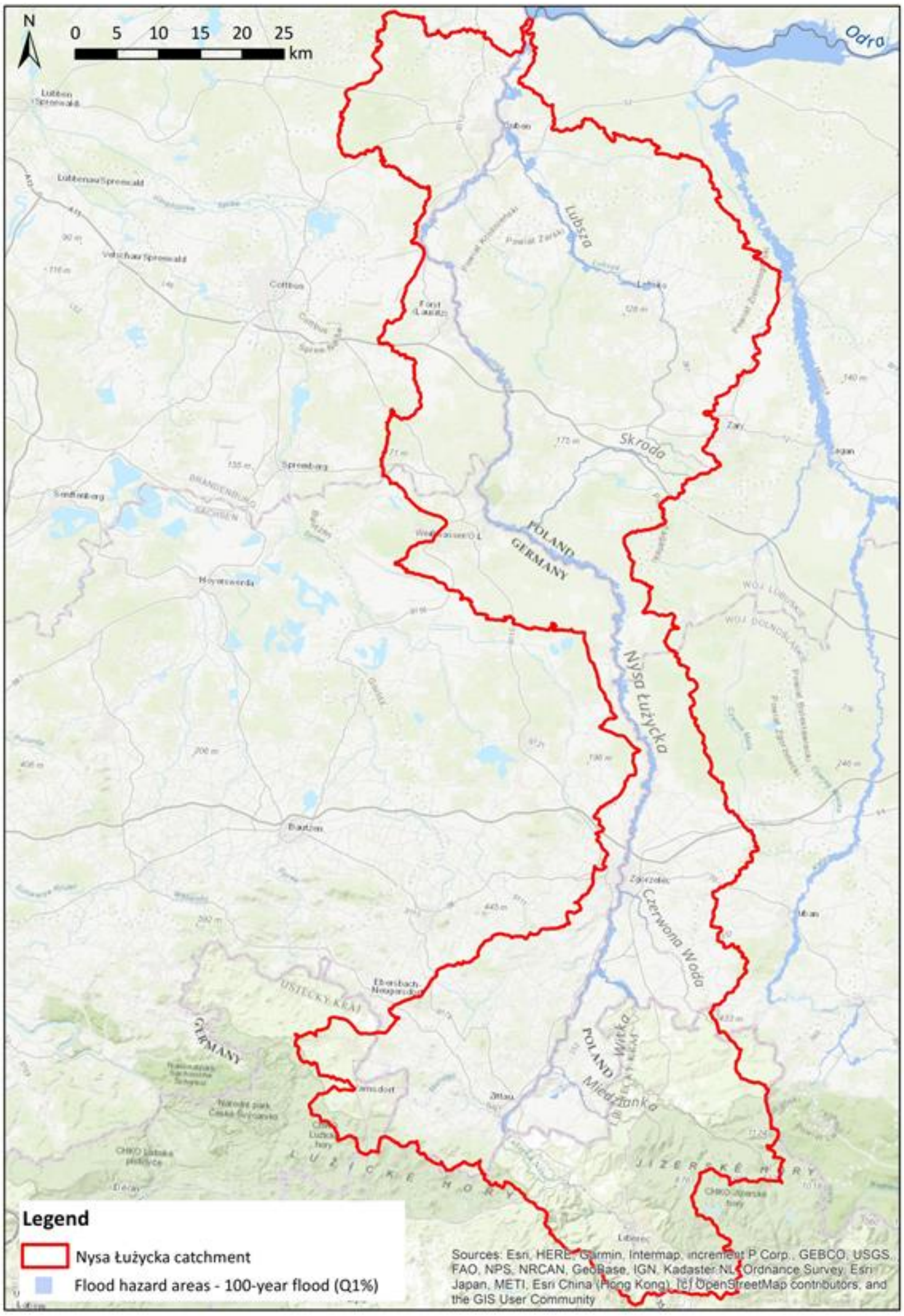


Fig. 4. Flood hazard areas where the probability of flooding is medium (1%) within Lusatian Neisse river basin

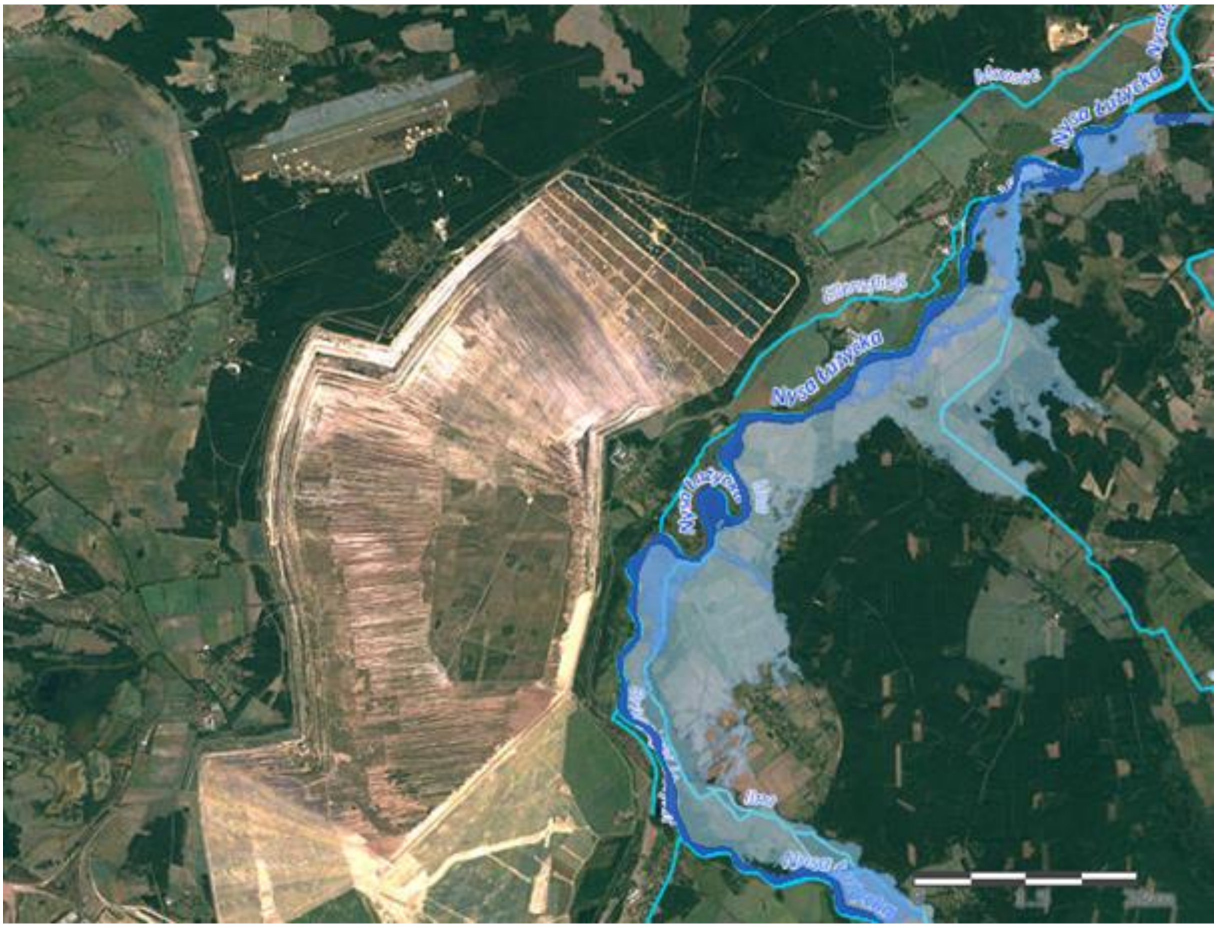


Fig. 5. Flood risk area for Lusatian Neisse section near the lignite opencast mine of Jänschwalde. Dark blue – flood probability 10%, blue – 1%, light blue - 0,2%. (wody.isok.gov.pl)

2.3.3. Heavy rain

Heavy rainfall often results in flash floods that are a major natural hazard in Central Europe. Figure 6 presents the meteorological stations that recorded heavy rain events in Lusatian Neisse basin in the recent decades (1971-2010). However heavy rain may hit any location due to local character of the events. For that reason, in many cases, meteorological network do not record heavy rain events. Their occurrence is often evidenced by the consequences observed in the environment and public infrastructure.

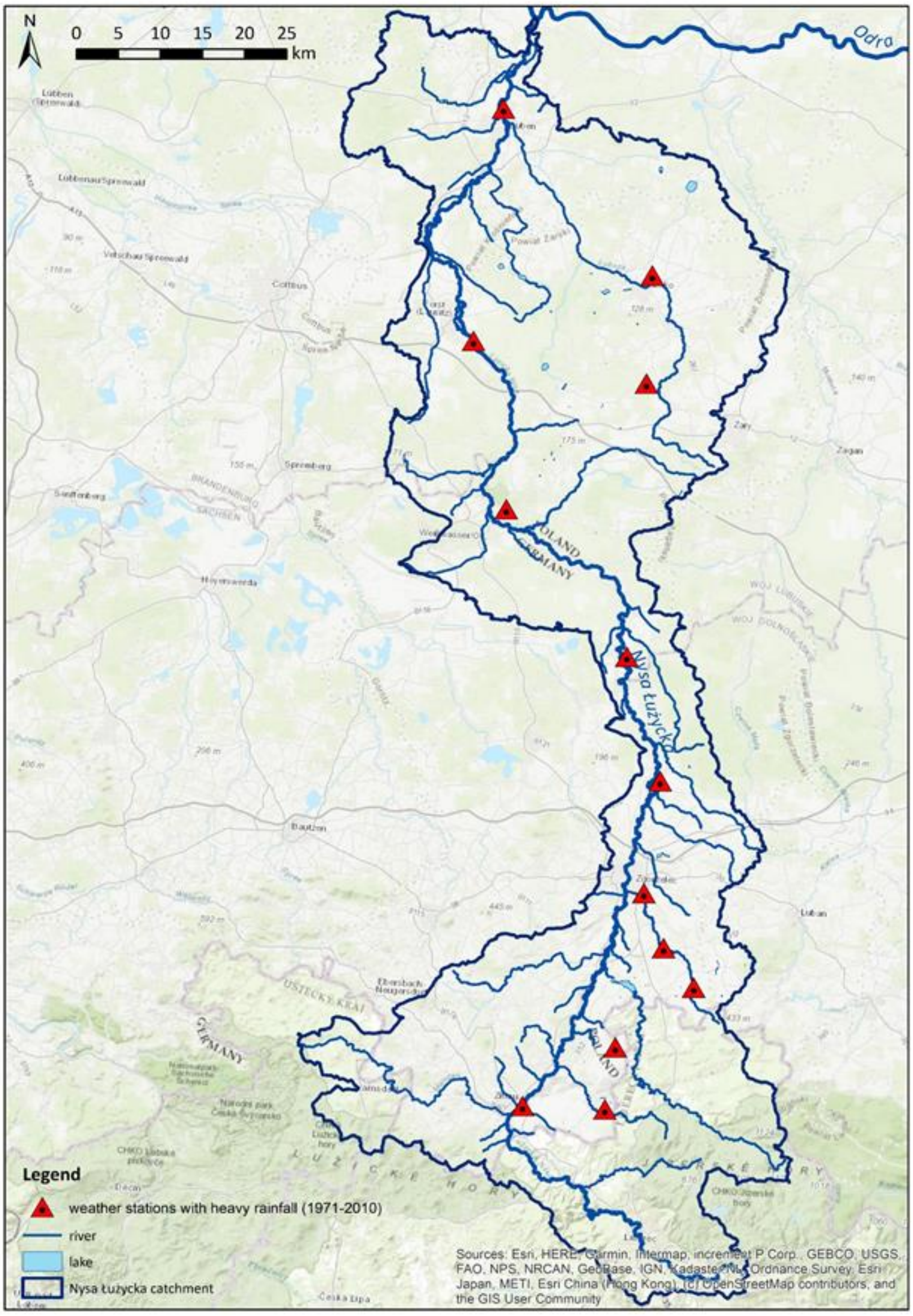


Fig. 6. Stations located within Lusatian Neisse basin where heavy rainfall events were recorded (1971-2010).

In the recent years, the most serious event of heavy rainfall resulted in flash flood that occurred in the Lusatian Neisse river basin took place in August 2010. Continuous rainfall was observed from the morning on 6th August to the evening on 7th August. The most intensive rainfall occurred at night on 6/7 August and in the morning on 7th August. The highest rainfall intensity at some meteorological stations reached almost 60 mm/hour. Daily totals of precipitation reached up to 180 mm. Water gauges in the upper Lusatian Neisse river recorded almost 3 m higher levels than the previously noticed maximal values. Heavy rainfall caused a rapid surface runoff and triggered destruction of the Niedów dam on the Witka river (tributary of Lusatian Neisse). Flash flood seriously affected citizens, destroyed buildings and technical infrastructure, crops etc. The material losses exceeded 225 mln PLN in Bogatynia community (Fig.7).

Other event of heavy rains, that resulted in local pluvial flood, took place in July 2013. In the evening on 29 July 2013, the part of Lusatian Neisse river basin located in Zgorzelec county was affected by thunderstorms and heavy rainfall. 40 mm (40 liters per m2) of water during one hour was recorded at the meteorological station of Bogatynia. A lot of basements, courtyards, garages and streets were inundated. The fire brigades had to tackle with a local pluvial flood in nearly entire county.

Fig. 7. Losses caused by flash flood in the Lusatian Neisse river basin in August 2010 (photo: IMGW-PIB).

2.4. Hydrologeology

The Lusatian Neisse river basin is situated in the area of the Czech Massif and the Central European Lowlands. There are four subprovinces within the boundaries of the river basin namely: the Sudetes with the Sudeten Foothills, the Central Polish Lowlands, the Saxonian-Lusatian Lowlands and the Southern Baltic Lake District.

Because the geological structure of the Lusatian Neisse river basin, variability in its course can be noticed: crystalline and metamorphic rocks are characteristic for the upper course of the river, tertiary deposits including lignite are characteristic for the middle course of the river whereas Quaternary formations coming from the glacial period dominate in the lower course of the river. They are accompanied by aquifers. The Quaternary multiaquifer formation in the Lusatian Neisse river basin consists of up to three aquifers. They are formed in as sand and gravel filling fossil river valleys and fragments of proglacial stream valleys. Their thickness reaches 30-40 m, locally within the fossil valleys up to 80 m.

Fluvioglacial tertiary sediments of variable thickness are also aquiferous. Such a large genetic diversity of aquifers affects the range of hydrogeological parameters, especially water conductivity, varying from a few m^2/day in the southern part of the catchment to over 1000 m^2/day in the northern part. This also has an impact on the efficiency of wells (10-30 m^3/h) [Marszałek, Wąsik 2004]. In the Lusatian Neisse river basin, groundwater is mainly concentrated in the Cenozoic formations, hence they are under a strong pressure caused by the activity of opencast lignite mines. For this reason, groundwater body no 105 is at risk of failing to achieve the environmental goals defined by law (Fig. 8).

In Poland, the main source of drinking water for the population are groundwater intakes, therefore one of the priorities of water management is the protection of groundwater. Many activities are undertaken to protect these resources in order to ensure the water supply for future generations.

There are 3 Main Groundwater Reservoirs (GWR) in the Lusatian Neisse catchment (Fig. 8). They are the most valuable fragments of hydrostructural units and aquifers. The potential efficiency of the well must be above 70 m3/h, the intake efficiency above 10,000 m3 /d, while water conductivity above 10 m2 / h (240 m² / d). Regarding water quality, water must be suitable for supplying the population in a raw state or after possible simple treatment. They require special protection in terms of quantity and quality. In order to protect GWR from degradation, there may be bans, orders and restrictions on land use or water use [Mikołajków, Sadurski, Red., 2017].

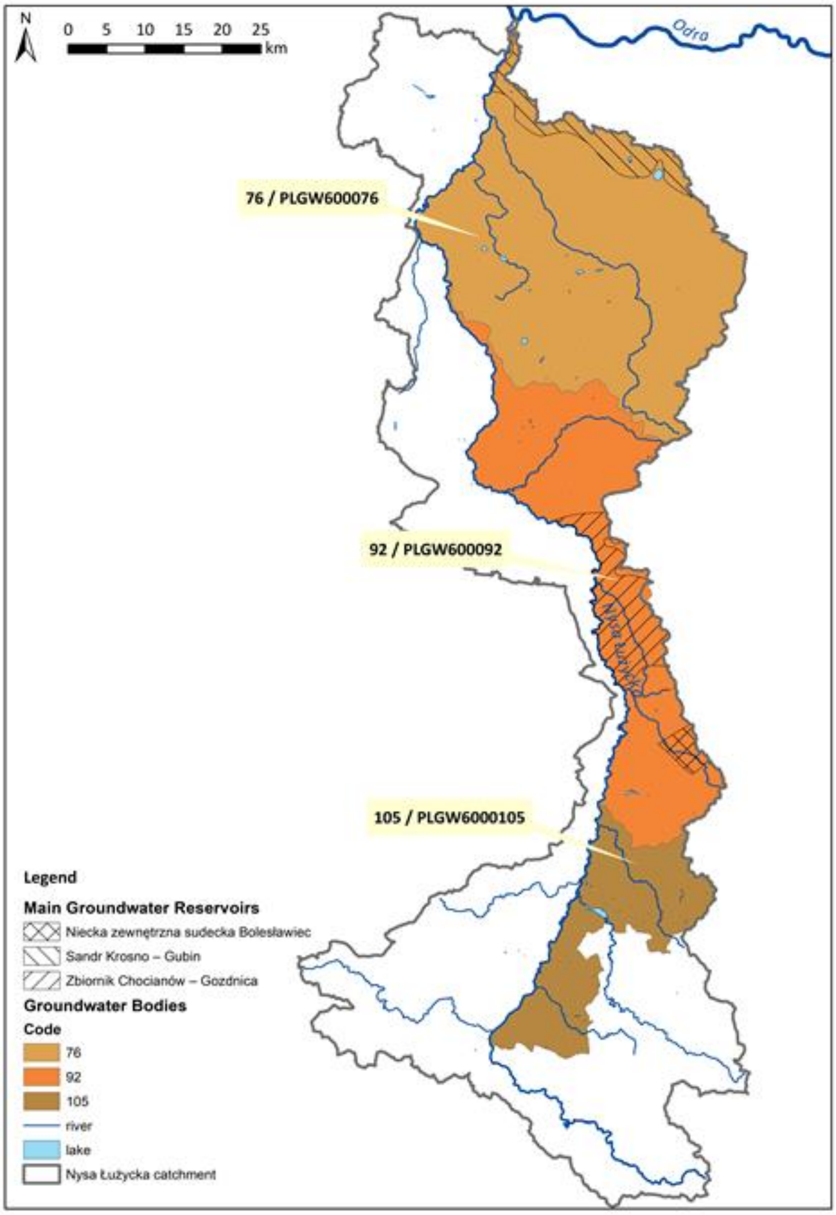


Fig. 8 Groundwater bodies and Main Groundwater Reservoirs at the Polish part of Lusatian Neisse basin.

2.5. Land use

The Lusatian Neisse river basin is currently dominated by forestland and agricultural land along with locally situated areas which have been subject to anthropogenic transformations. Agriculture (together 41,45%) and artificial surfaces (together 8,5%) dominate in the southern part of the area (Fig. 9). In the area of the Lusatian Neisse river basin, the industrial sector of open cast lignite mining plays a crucial role. In the German part of the Lusatian Neisse river basin, basically the impact of the Nochten open cast mine, Reichwalde open cast mine and Jänschwalde open cast mine can be registered while in Poland such a situation is observed for the Turów. Forest areas (together 48,7%) dominate in the central and northern parts. Water areas account for a small share of wetlands (0,11%) and water bodies (0,64%).

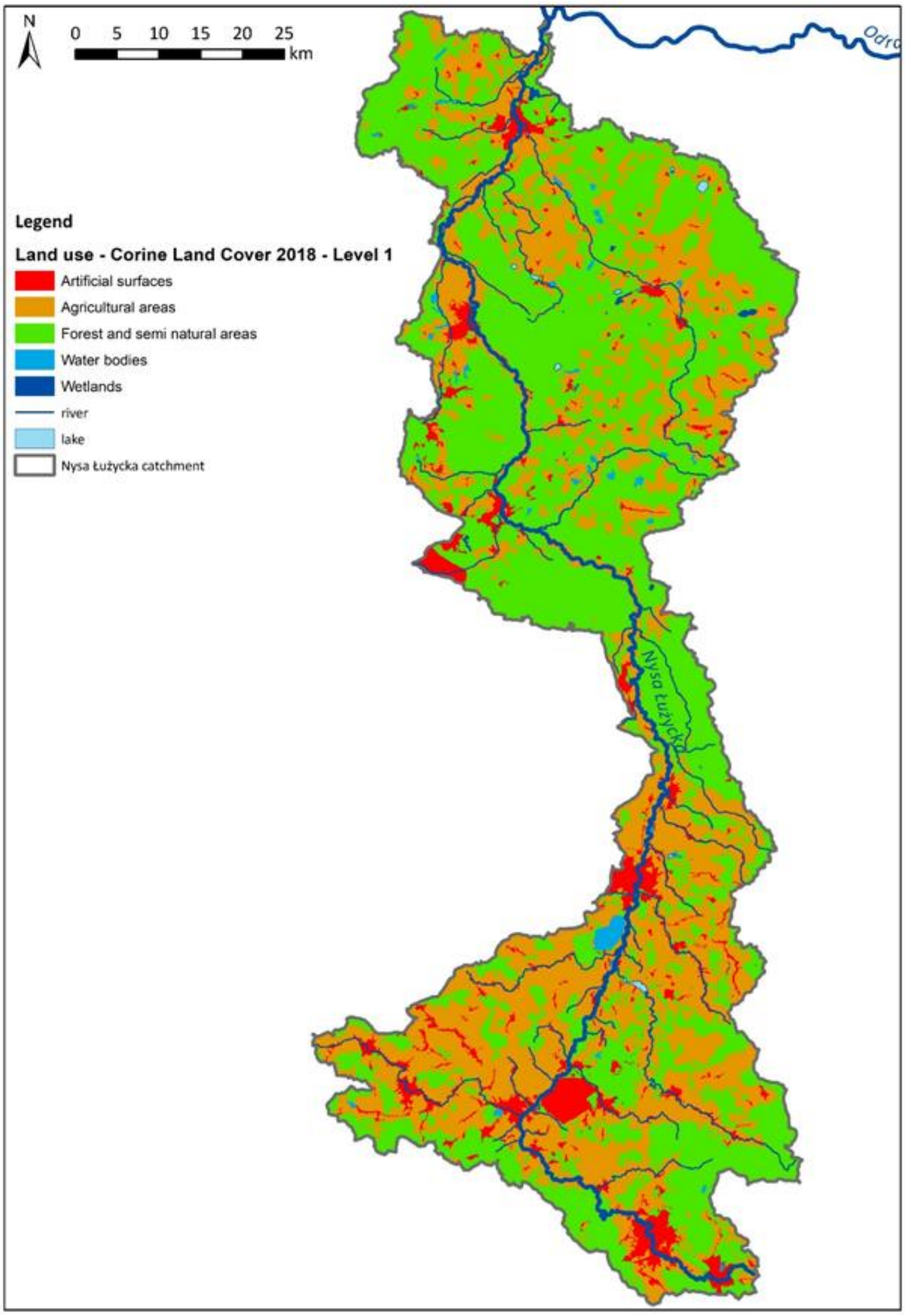


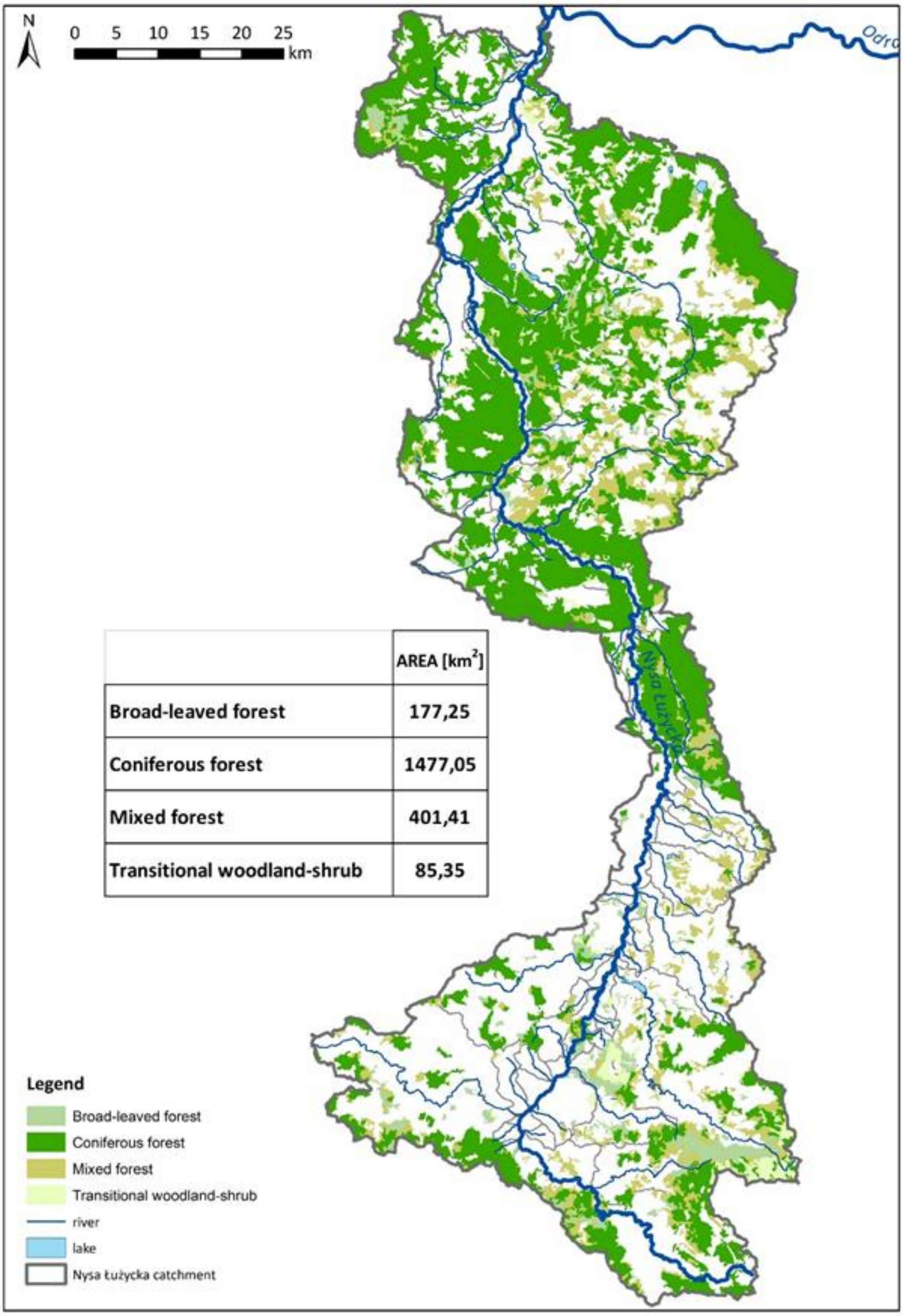
Fig. 9 Land use of Lusatian Neisse basin according to Corine Land Cover 2018 (Level 1)

2.5.1. Forestry

Forests in the analysed area of the Polish-German border area cover a significant part of land (48.7%). This value is higher than the European average (33.2% Eurostat data). In terms of forest types, coniferous forests are dominant, with a smaller share of mixed and broad-leaved forests (their fraction amounts to 68%, 19% and 8% of forest areas respectively). About 5% is covered by the areas with transitional woodland-shrubs (Fig. 10). Some forests are considered as various forms of protection areas (e.g., Natura 2000 areas, landscape parks or nature reserves). In addition, forests perform many functions - soil, water resource and biodiversity protection, source of timber and recreation site.

The research area, in terms of potential habitat conditions, includes both coniferous and other forest habitats (including upland and mountain forest habitats). The largest forest (coniferous type) complex in the Lusatian Neisse catchment is the Lower Silesian Forest (Bory Dolnośląskie). The structure of forest habitats contains fewer broad-leaved trees than the potential natural state of these habitats, which is a disadvantage for them. This is due to the historical forest policy that led to the creation of conifers monocultures which are very sensitive to the influence of various factors (unfavorable weather conditions, air pollution, etc.). The forests with the predominance of coniferous trees are located mainly in the western and northern part of the area as well as in some communes in the Sudetes.

Some of these areas are single-species (monocultures) - Scots pine (*Pinus sylvestris*) was planted in the lowlands, while Norway spruce (*Picea abies*) in the mountain areas after the World War II. In the recent years, adaptation works have been carried out to enrich these monocultures with other species. Additionally to the mentioned two dominant species (pine, spruce), sessile oak (*Quercus petrea)*, European beech (*Fagus sylvatica)* and other broad-leaved trees cover also minor areas.



	AREA [km²]
Broad-leaved forest	**177,25**
Coniferous forest	**1477,05**
Mixed forest	**401,41**
Transitional woodland-shrub	**85,35**

Fig. 10 Distribution and type of forests in the Lusatian Neisse basin

2.6. Protected areas

Within the Lusatian Neisse catchment, in the case of both the Polish and German sides, numerous areas of nature protection were created. Two landscape parks have the highest rank in the Polish part of the basin - the Łuk Mużakowa Landscape Park (which includes a bilateral Łuk Mużakowa Geopark) and a fragment of the Krzesinski Landscape Park, in the estuary section of the Lusatian Neisse. In addition, there are (as a whole or a part) numerous Natura 2000 areas, designated for the purposes of the Habitats Directive and the Birds Directive (Fig. 11). Within the already mentioned protected areas there are nature reserves. They are small areas characterized by a significant value for scientific, natural, cultural or landscape issues, designated for higher protection. It should be also emphasized that because of geographical variability, the region is characterized by a high biodiversity that improves the ecological value of this area.

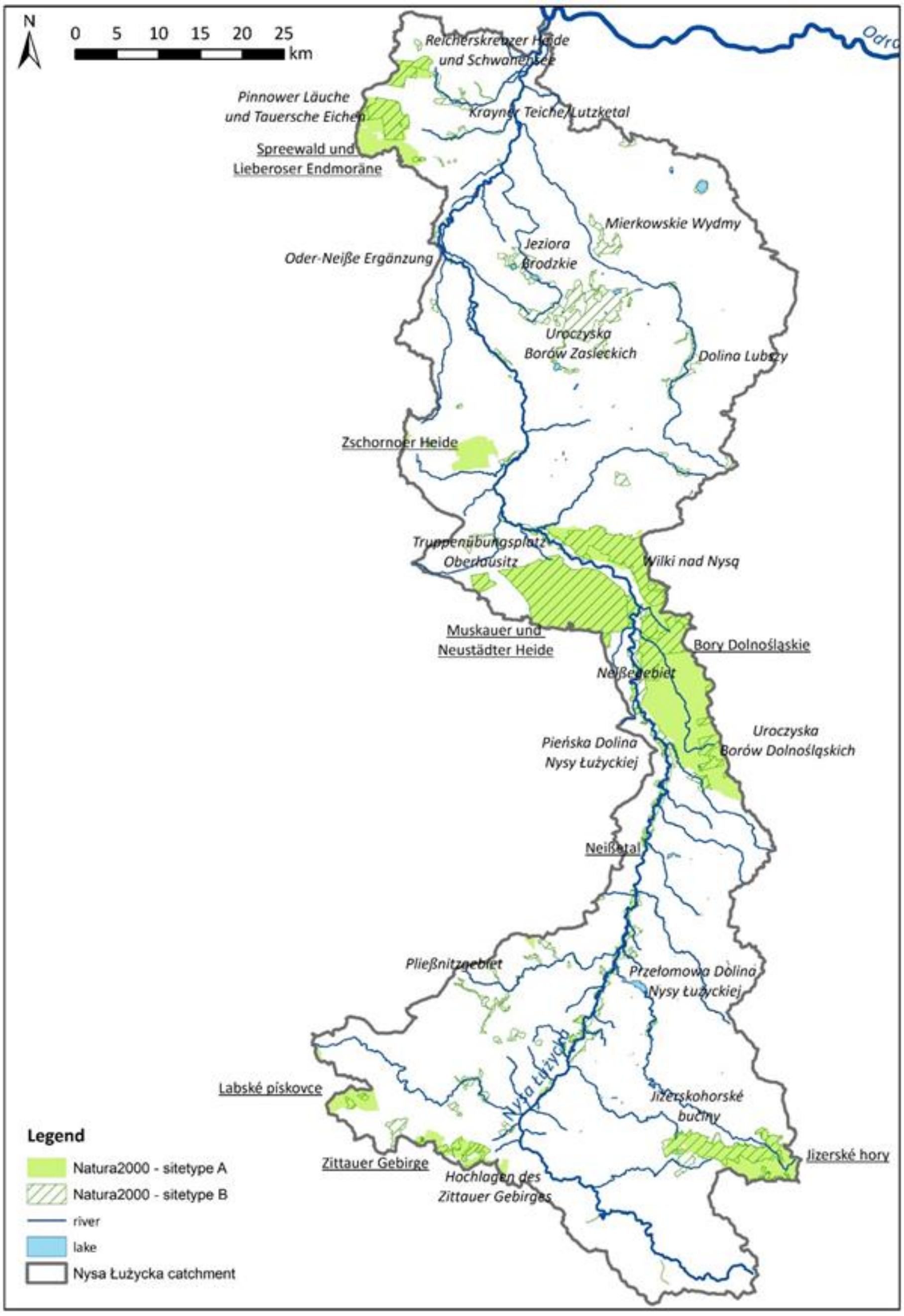


Fig. 11 Natura 2000 areas, type A – Special Protection Areas (SPA), type B – Special Areas of Conservation (SAC)

2.7. Drinking water sources and protection

Lusatian Neisse River is used for irrigation in agriculture sector, as this is a source of water for industry, fishery, as well as tourist and (in a minor level) for shipping purposes. Furthermore, the water is also used as a source of drinking water. In this case, groundwater is mainly used (29 water abstraction sites), while surface water is collected on a minor scale (2 water abstraction sites, Fig. 13, Table 2). The existing groundwater intakes are usually built within gravel and pebble river alluvia.

From 1 January 2018, after the implementation of the new Water Law in Poland, water intakes owners will be obliged to establish protection zones covering the area of direct protection for all water intakes for which no such zones have been established so far. Additionally, a risk analysis should be carried out. There are some prohibitions and restrictions in these zones. There are two types of protection zones: (1) direct protection area only (Fig. 12), and (2) a both direct and indirect protection areas. The 1st one is established by an office decision. The indirect protection zone is designated on request (in exceptional circumstances, ex officio) by acts of local law. The need to designate an indirect protection zone results from the risk analysis carried out by the owner of the water intake. The analysis includes the assessment of health hazards to the abstracted water, considering factors that may have a negative impact on its quality. Therefore, if the risk analysis shows the necessity to establish a zone and the catchment owner does not apply for it himself, the zone will be designated ex officio.

Fig. 12 Direct protection area for water intake in Bogatynia (Lusatian Neisse basin, photo: IMGW-PIB)

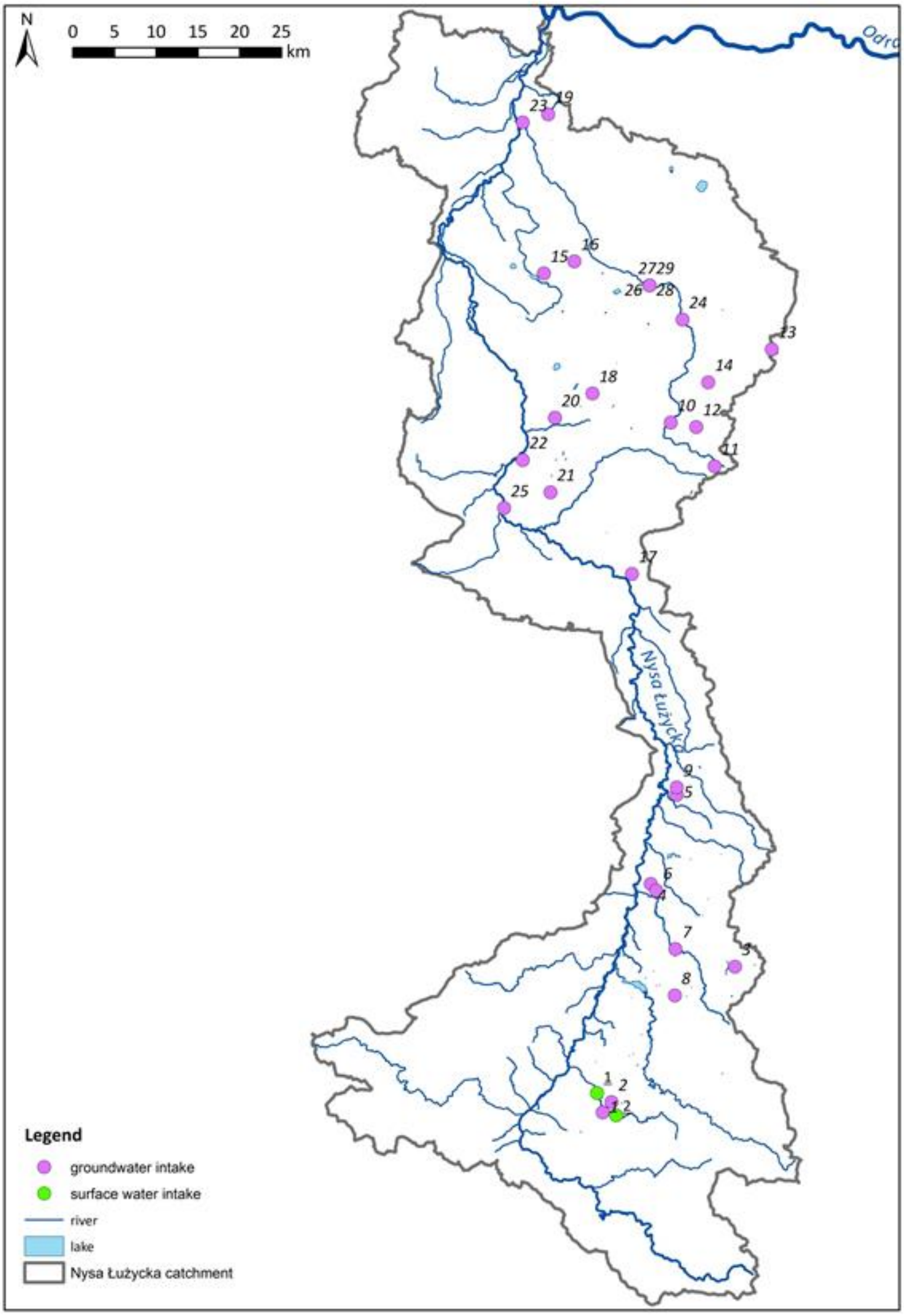


Fig. 13 Location of surface and groundwater intakes for drinking water purposes in the Lusatian Neisse river basin

Table 2. List of surface and groundwater intakes for drinking water purposes in the Lusatian Neisse river basin.

No	surface water intake location - name
1	BOT Elektrownia Turów S.A. ul. Młodych Energetyków 12, 59-920 Bogatynia
2	Bogatyńskie Wodociągi i Oczyszczalnia S.A. II Armii Wojska Polskiego 20, 59-920 Bogatynia

No	groundwater intake location - name
1	BOT Kopalnia Węgla Brunatnego "Turów" S.A. 59-916 Bogatynia 10
2	BOT Elektrownia Turów S.A. ul. Młodych Energetyków 12, 59-920 Bogatynia
3	Urząd Gminy w Platerówce 59-816 Platerówka
4	PW "COMFORT" Sp. z o. o. Reymonta 36, 59-901 Zgorzelec
5	Zakład Usług Komunalnych w Pieńsku Kościuszki 4, 59-930 Pieńsk
6	PWiK "NYSA" Sp. z o. o. w Zgorzelcu ul. Bohaterów Getta 1a, 59-900 Zgorzelec
7	Gminny Zakład Komunalny w Sulikowie ul. Dworcowa 5, 59-975 Sulików
8	Przedsiębiorstwo Usług Komunalnych Sp. z o. o. w Zawidowie ul. Grunwaldzka 4, 59-970 Zawidów
9	P.P.H.U. Dawid Nowakowski - Zakład w Pieńsku ul. Dąbrowskiego 44, 59-930 Pieńsk
10	UG Lipinki Łużyckie ujęcie wody
11	Urząd Gminy Żary ujęcie Olbrachtów
12	Urząd Gminy Żary ujęcie Sieniawa Żarska
13	Urząd Gminy Żary ujęcie Bieniów
14	Urząd Gminy Żary ujęcie Drożków
15	ZGKiM Brody ujęcie Brody
16	ZGKiM Brody ujęcie Biecz
17	ZGK Przewóz ujęcie Przewóz
18	ZGK Tuplice ujęcie Rytwiny
19	PUM Gubin ujęcie Komorów
20	ZGKiM Trzebiel ujęcie Trzebiel
21	ZGKiM Trzebiel ujęcie Czaple
22	ZGKiM Trzebiel ujęcie Żarki Wielkie
23	ZGKiM Krosno Odrzańskie ujęcie "Gubińska"
24	ZK Jasień ujęcie Jasień
25	MZK Łęknica ujęcie wody w Łęknicy
26	PGKiM Lubsko ujęcie Białków
27	PGKiM Lubsko ujęcie Dłużek
28	PGKiM Lubsko ujęcie Gozdno
29	PGKiM Lubsko ujęcie Górna Glinka

3. PA issues concerning TEACHER-CE topics

3.1. Heavy rain

In the pilot area, heavy rainfall mainly leads to rising water levels or flooding and may also cause other negative effects, such as soil erosion. However, numerous factors are critical for the effects of heavy rainfall, including topography (e.g., local depressions, slope gradient), land use, the kind of soil and percentage of sealed area are important features that determine the effects of heavy rainfall.

In the pilot area, days with moderate precipitation (≥ 10 mm per day) occur on average 14-18 days annually. Days with moderate heavy precipitation (≥ 20 mm per day) are less frequent, on average 3-4 days with precipitation ≥ 20 mm per day are observed. Moderate heavy precipitation occurs mainly in the summer months. However, the highest daily precipitation totals may exceed 100 mm. The highest rainfall was recorded in August 2010. On 7th August 2010, the daily precipitation total at Bogatynia station reached 160.2 mm (14.7% of the annual precipitation norm), at Sieniawka station reached 110.8 mm (13.3% of the annual norm). However, heavy rainfall may occur in any location in the pilot area, often only locally.

The early warning and weather monitoring systems are an important measure for reducing the effects of heavy rain. Institute of Meteorology and Water Management – National Research Institute (IMGW-PIB) provides a warning system against meteorological hazards and weather extremes. Weather forecast for the coming days, meteorological warnings, temperature, cloudy, precipitation, radar and satellite imagery are available on www.meteo.imgw.pl. Warnings issued by IMGW-PIB provide important weather information according to the criteria for different alert levels (moderate, high, very high). Warning against storm with heavy rainfall is issued when it is forecasting that the following threshold values will be exceeded:

Storm with rainfall (R); 20 mm<R≤ 30 mm and possible rainfall up to 40 mm during storm events (yellow weather warning, the weather can be potentially dangerous),

Storm with rainfall (R); 30 mm<R≤ 50 mm possible rainfall up to 60 mm during storm events (orange weather warning, the weather is dangerous, damages likely to happen),

Storm with rainfall (R); >50 mm of rainfall during storm phenomena (red weather warning, the weather is very dangerous that cause major damage and threat to human life).

Issuing warning means that the probability of the phenomenon occurring is very high and its intensity will threaten the safety or life of the people and causes property damages. The issue of a meteorological warning is crucial information for crisis management services. When they receive a meteorological warning, they take additional actions to protect health and human life and property. In case of high (orange) and very high (red) meteorological warnings, the citizens receive warnings (i.e., alert sending by the Government Centre for Security) as text messages (SMS) about hazards related to natural phenomena for a specific area interest of the user.

The new Polish Water Law (implemented in 2018), involves new aspects related to the introduction of green and blue infrastructure and proper development of urban areas with a consideration of minimization of rainwater discharges. Therefore, in the pilot region, development of green and blue infrastructure in urban area is the one of the measures of mitigation of heavy rainfall effects. This aspect should be considered in the updated studies of conditions and directions of spatial development of the commune and local spatial development plans.

3.2. Floods

By implementing the Water and Flood Directives, countries undertake the preparation of flood risk management plans (FRMPs). The plans prepared in the previous implementation cycle of the directive are currently under update stage. FRMPs contain crucial elements pointed by the Floods Directive, i.e. a description of the objectives and a catalog of measures aimed at achieving the objectives of flood risk management. These activities are used to minimize the risk of flooding and reduce flood losses. Not only structural measures are planned, such as the construction of embankment and retention reservoirs, but also non-technical measures in the field of spatial planning and legal regulations, and finally educational activities aimed at increasing awareness of floods.

The technical measures recommended in the plans concern mainly embankments within Lusatian Neisse river basin:

-maintaining embankments in Porajów

- flood protection - Krzewina Zgorzelecka / Ostritz

- flood protection of the town Gubin, km 14 + 900 - 16 + 000 of the Lusatian Neisse river with the mouth section of the Lubsza River.

- increasing the spacing of the Lusatian Neisse river embankments above Gubin (section Sekowice-Gubinek).

Other recommended activities:

- Modernization and implementation of ICT systems supporting the work of the operations center.

- Measures indicated in the study "Reconstruction of the Miedzianka and Witka watercourses after flood”.

- Concept of flood protection for the town Zgorzelec- Lusatian Neisse river together with the mouth of the Czerwona Woda river [Projekt aktualizacji… 2020].

3.3. Drought

Drought events are one of the natural hazards that affect the Lusatian Neisse river basin and its surroundings. Drought is an irregular phenomenon, the short-time drought (1-3 months) events occurs the most frequently, however long-term (6 months and longer) drought also can be observed. In 1981-2019, basing on drought index, i.e. Standardized Precipitation Index (SPI), 14 years were categorized as dry. The years of: 1982, 2003 and 2018 were classified as extremely dry (SPI≤ -2,0). In case of growing season (April-September), precipitation deficit may strongly affect agriculture production that plays an important role in the economy of the region. Within 1981-2019, 10 growing seasons (April-September) were characterized by precipitation deficit, 2 seasons (1982 and 2018) were classed as extremely dry (SPI≤ -2,0), while 2 another were very dry (1992 and 2003).

Recently, long-lasting and severe droughts in the Lusatian Neisse catchment occurred in the years of: 2015, and 2018-2019. Meteorological conditions, i.e., rainfall deficit, anomaly high air temperature and high insolation, contributed to the development of droughts. Meteorological conditions in winter seasons have also influence on development of drought: higher air temperature (if compared to the mean value), lack of snow cover and higher evaporation affect the reconstruction of the water supply in the soil. Therefore, especially in 2018, after warm and dry winter of 2017/2018, at the beginning of the growing season, conditions were favourable for the development of soil drought. As a result, meteorological drought in 2018 already occurred in spring. In the following months, meteorological drought became more intensive. The drought index of SPI showed the conditions of strong and locally even extreme drought. In autumn 2018, the drought became less intensive. However, in 2019 drought condition still lasted. Wet winter months (December 2018 and January 2019) did not compensate such a large water deficit. Therefore, a combination of shortage of precipitation and sustained above-average temperatures (including heat waves) contributed for the occurrence of another drought event in 2019. In the Lusatian Neisse river basin, low-flow periods occurred from May 2018 to the middle of December 2018 and from June 2019 to November or even December 2019. They were still observed in the beginning of 2020.

The droughts of 2018-2019 had various environmental, economic and social effects in the region. In the agricultural sector, losses in some crops exceeded 30% in 2018 and 25% in 2019 if compared to long-term yields. As an example for economic losses, hydropower production was reduced by more than 30%. Water withdrawal from surface water bodies was partly restricted (Report project Neymo-NW, 2020).

Drought is a natural phenomenon, therefore it is impossible to prevent from its occurrence. However, it is possible to reduce the risk of drought, i.e. to limit its negative impact on the economy, environment and society of the region.

The early warning and drought monitoring systems are important measure for reducing the effects of drought. They aim to identify, track, assess and deliver relevant information concerning meteorological, hydrological and water supply conditions. Drought monitoring websites provide up-to-date information on the hydro-meteorological conditions, drought hazard forecasts and historical drought data. In Poland, early warning and drought monitoring is carried out at national levels, therefore drought monitoring for the area of Lusatian Neisse river basin is available on the following websites:

http://stopsuszy.imgw.pl/ provide by the Ministry of Infrastructure, PGW Wody Polskie and the Institute of Meteorology and Water Management - National Research Institute.

Agricultural Drought Monitoring System (ADMS) http://www.iung.pulawy.pl provided by the

Institute of Soil Science and Plant Cultivation – National Research Institute (IUNG-PIB) on behalf of the Ministry of Agriculture and Rural Development

Monitoring of agricultural drought http://www.igik.edu.pl/pl/monitorowanie-suszy-rolniczej provided by The Remote Sensing Center of the Institute of Geodesy and Cartography

Ground Water Monitoring https://www.pgi.gov.pl/psh/sluzba-hydrogeologiczna provided by Polish Geological Institute – National Research Institute that carries out the national hydrogeological service.

In Poland, mitigation and prevention against drought effects is regulated by Water Law (act from 20.07.2017, DzU. 2017, pos. 1566 with further changes). Water Law (art. 183) indicates that prevention against droughts is a task of local and national authorities and the *Polish Waters* National *Water* Management Holding (PGW WP). In Poland prevention against drought effects is run accordingly to the Drought Effects Counteracting Plan (DECP) in river basin.

The main goal of the DECP is clarified by four specific objectives:

effective water resources management to increase available water resources,

increasing water retention (storage),

drought education and coordination of drought related activities,

creation of implementation and funding mechanisms for actions counteracting drought effects.

An important element of DECP is the catalogue of activities (measures), which has a practical aspect. It is a set of actions (measures) aimed at achieving the DECP goal, i.e., limiting and preventing the effects of drought. Activities (measures) included in the catalogue are addressed to various groups of users and concern all sectors of the economy (agriculture, energy, industry, forestry), as well as various areas (urban, forest). The education and public awareness in this area play a very important role. Therefore, number of activities related to education are planned, like including the topic of drought in the core curricula of primary and secondary schools, as well as the promotion of activities aimed at economical and rational water management. Activities planned in DECP are measurable and possible to implement in the scope of reducing the effects of drought (based on Draft of DECP available on https://stopsuszy.pl/projekt-planu-przeciwdzialania-skutkom-suszy).

3.4. Forest management

In the Polish part of the river basin, in numerous forest districts (designated forest management areas), due to climate change, some projects aimed to the increase in the ability to retain rainwater were implemented. They were focused on improving water relations in forests. Natural water retention measures (NWRM) are used for these purposes (valves, small reservoirs, reconstructed wetlands). Natural water retention facilities have been built of stones, ground, wood or fascine. The amount of water retained in the State Forests by 2015 is estimated at 52.7 million m^3.

In 2007-2014, two projects were implemented: "Increasing the retention capacity and counteracting droughts and floods in forest ecosystems in lowlands (179 Forest Divisions) and "Counteracting the effects of rainwater runoff in mountain areas. Increase in retention and maintenance of streams and related infrastructure in good condition " (54 Forest District).

The following projects are currently implemented (until 2022) by the State Forests National Forests: "Comprehensive project for adapting forests and forestry to climate change – natural water retention and counteracting water erosion in lowlands" and "Comprehensive project for adapting forests and forestry to climate change - natural water retention and preventing water erosion in mountain areas ".

In the pilot area, the implementation of activities as a part of the implementation of the both mentioned projects is also planned.

3.5. Drinking water sources protection

Not relevant for PA6.

4. Testing of the TEACHER-CE toolbox CC-ARP-CE

Testing of the toolbox CC-ARP-CE Beta Version led by PP11 (IMGW-PIB) took place from 6 to 12 July 2021. The participants were the representatives of the Focus Group from AP and other institutions.

The part connected with the gathering and insertion of issues on the toolbox map proved to be an easy task for the testers. This step of testing turned out to be the most accessible and clear for testing persons. The comments mainly concerned the possibility of editing an already entered record.

During testing of the toolbox beta version, 17 new issues have been added in the toolbox application. The focus of PA 4 was on issues related to the Fields of Action: "Fluvial Flood Risk (Management)" and "Pluvial Flood Risk (Management)".

The most entries concerned FoA "Fluvial Flood Risk (Management) 7", followed by "Pluvial Flood Risk (Management)" in terms of quantity - 4, and then "Management of Water-Dependent Ecosystems" - 3, "Drinking Water Supply (Management)" – 2, "Water Scarcity & Drought Risk (Management)" - 1. No records have been entered for "Ground Water Management" and "Irrigation Water (Management)"

In relation to the commenting on the issues, the testers focused only on the ones they already introduced and didn't leave comments for other PAs.

Reviewing the process of ranking the measures proved to be the most problematic stage for the testers, who sometimes skipped this stage in their testing process. After inserting issues into the map, testers considered the process completed. After adding the issue, a dialog box with the ranking module and the catalog of measures should appear immediately. Few people left their opinions on this issue after testing, which is probably related to the misunderstanding of the idea of the process and the diminishing importance of this stage in the testing process. The testers showed the need to supplement the toolbox with a manual containing materials explaining the principles of the AHP method along with the descriptions of the criteria and scoring rules.

The testers positively received the contents of the toolbox and were willing to test the tool. They made some comments about the overall functionality and usability of the tool. The most persons reported in their comments that it was not possible to edit already inserted issue. The testers also expected the system to confirm the correctness of the inserted records. To facilitate the testing and subsequent use of the TEACHER-CE toolbox, it would also be necessary to translate the content of the http://teacher.apps.vokas.si/catalogue into national languages. Testers reported a need and increased usability of the TOOLBOX after breaking the language barrier.

5. Synthesis of the National Stakeholder Workshop

The 2nd National Stakeholder Workshop took place online on 28.10.2021. The invitation was addressed to the participants represented institutions located within PA4 or authorities which range of responsibilities and influence concerns water management of PA4 region. They represented local and regional authority including Polish Waters - Regional Water Management Board in Wrocław, Institute of Regional Development, higher education and research (Wroclaw University of Science and Technology, Wroclaw University of Environmental and Life Sciences), NGO's, and catchment inhabitants. The total number of participants in the workshops was 34 persons.

After introducing and familiarizing the participants with TOOLBOX CC-ARP-CE, efforts were made to obtain feedback on the evaluation of this tool. It was generally established that this tool is:

- useful and functional, has a clear and understandable layout, a comfortable structure, which gathers a lot of information in one place;

- the part presenting climate indicators was appreciated because of their diversity, scope and visualization method for NUTS areas;

- a lists of FoA and adaptation measures have been approved;

- similarly, links to other projects and developed tools, as well as links to EU and national GIS tools and databases were well rated.

Generally, the Toolbox was considered as useful, interesting and valuable platform that allows users to identify problems in each area of CE and select the most appropriate adaptation measures for them. Most of the participants emphasized the need of downscaling the existing strategies to the local level. They also indicated that the problem of climate changes in strategy documents is not considered properly. In this case, intensive measures should be undertaken as there are no new strategies or updates planned in the institutions represented by the participants. Most of the participants mentioned, that they do not know the sources of fundings related to the strategies considering climate changes aspects. Generally, participants see the possibility of using the Toolbox as an additional tool, but simultaneously are obliged to use their own internal official guidelines. The final conclusion of the workshop is: in order to make the tool widely used among end users, it is necessary to prepare its Polish version.

6. Conclusions

The pilot catchment area of the Lusatian Neisse has a complicated water management situation. This is due to the varied topography (lowland, upland and mountain areas), land use (a significant share of agriculture, forests or brown coal mining areas) and the occurrence of extreme phenomena such as drought or flood (both types – pluvial and fluvial). Therefore, it is necessary to focus on the problem of needed adaptation and mitigation measures as soon as possible, considering projected climate changes.

The TOOLBOX CC-ARP-CE developed and presented at the 2nd workshop may be used to initiate or intensify consultations and work on the introduction and selection of necessary adaptation measures to local strategic documents. The suggested adaptation measures, after being discussed and approved by local authorities, influencing their further procedure and implementation, may enable the improvement of the situation in the Lusatian Neisse catchment area within the scope of broadly understood water management. This includes drinking water supply, flood protection and issues related to water in forest or agricultural areas. Such a broad approach was ensured by the works carried out in the TECHER-CE project, including the main product TOOLBOX CC-ARP-CE.

7. Literature

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