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and the National Fund for Environmental Protection and Water Management

NFOŚiGW

LIFE14 CCA/PL/000101

RadomKlima

LIFERADOMKLIMA-PL

LAYMAN'S REPORT of the project

Adaptation to climate change through sustainable management of water of the urban area in Radom City

radom siła w precyzji

wodociągi miejskie

UNIWERSYTET ŁÓDZKI

FPP ENVIRO

RadomKlima

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1. Project LIFE in Radom

1.1. Project data

Project No: LIFE14CCA/PL/000101

Title: Adaptation to climate change through sustainable management of water of the urban area in Radom City.

Acronym: LIFERADOMKLIMA-PL

Applicant and Coordinating Beneficiary:
Municipality of the City of Radom

Co-beneficiaries:
Municipal Waterworks in Radom Ltd.
University of Łódź
FPP Enviro Ltd.

Project location:
Municipality of the City of Radom, Masovian Province, Poland

Project implementation period:
16/07/2015 – 31/12/2022

Project budget: PLN 24 291 746

Co-financing from the European Commission: PLN 12 207 760

Co-financing from the National Fund for Environmental Protection and Water Management:
6 494 305 PLN

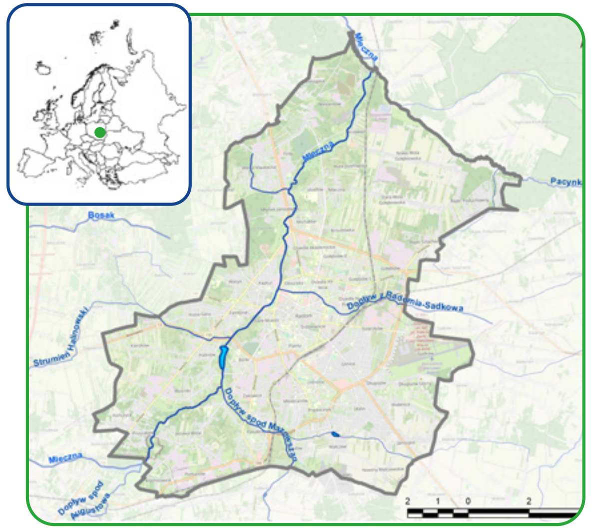
www.life.radom.pl/pl

Project objectives:

- Increasing climate resistance of the City of Radom by construction of demonstration "blue and green infrastructure"
- Improving the quality of life of Radom inhabitants by generating a favourable microclimate in the urban space
- Integrating and enhancing biodiversity in all project activities.
- Including the adaptation to the climate change into the Area Development and Planning
- Raising awareness and building capacity for climate change adaptation through rainwater management
- Exchange of experience and expert knowledge on the role of blue-green infrastructure in the urban space and in the adaptation to climate change.

2. Radom – city characteristics

Radom is a city county located in Central-Eastern Poland on the River Mleczna. It is the second largest city of the Mazowieckie Voivodeship. In 2020 the number of its inhabitants exceeded 209 thousand. The Municipality of the City of Radom is a dynamically developing one in accordance with the slogan „Radom - strength in precision". Radom is one of the first cities in Poland to comprehensively implement solutions in the field of integrated water management and blue-green infrastructure as a method of adapting to climate change, in form of the LIFEARDOMKLIMA-PL project executed in 2015–2022. This is the first demonstration project in Poland implementing adaptation measures comprehensively, systematically and on a city-wide scale.



3. Why Radom needs adaptation activities

High temperatures and a lack of precipitations lead to drying of plants, especially urban vegetation areas - in parks, squares, and gardens. Furthermore, scarce ponds dry out, the water level in rivers and streams goes down, and the quality of water and the nature deteriorate. During the summer, cyanobacteria bloom frequently affects the Borki reservoir, used for recreational purposes by inhabitants of Radom and its area, so swimming in it is not possible. Heat waves are increasingly more difficult to endure for people. This effect is emphasised by concrete surfaces and heavily built-up areas of the urban space. On the other hand, the climate change results in greater intensity of extreme weather conditions, such as heavy rainfalls and strong winds, resulting in floodings and damage to trees, buildings, or vehicles. Regulated, straightened watercourses with build-over valleys, such as the River Mleczna or Potok Północny, react quickly to rainfall and flood developed areas of the city in an uncontrolled way, resulting in damage to the property. During extreme rainfalls, the stormwater system is overloaded.

Floodings by rivers by Radom (Photo by Municipal Waterworks in Radom)

Dried bed of the River Mleczna (Photo by Municipal Waterworks in Radom)

4. Cities and the climate change

In the last decade (2011–2020), the global temperature of the Earth surface was about 1.1°C higher than one hundred–one hundred and fifty years ago. This seemingly small warming is the cause of the intensification of many catastrophic phenomena, such as extreme heat, heavy rainfall, droughts, floods and others. If the process of global warming continues to intensify, catastrophic phenomena will occur more often and with increasing intensity.

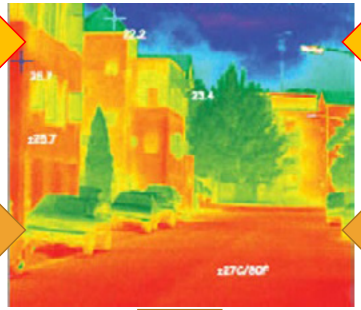
The specific urban climate, formed when the natural landscape is replaced with urban developments, additionally exacerbates consequences of the climate change. The increasing area of sealed surfaces (streets, pavements, etc.) and the decreasing share of biologically active terrains (various forms of green areas, rivers, etc.) lead to rising of temperatures in the city (the so-called urban heat island) and a risk of floodings and floods.

URBANIZATION
Sealed surfaces and a smaller share of greenery and water ecosystems in the city

CLIMATE
Anthropogenic climate change

Temperature

Urban Surface Heat Island
The temperature of built-up areas can be a dozen or more degrees higher than in green areas



Rise of temperature
The global temperature is rising. The last 10 years have been the warmest years in the history of temperature measurements on earth

Water

Urban flash floods
In highly sealed areas, even more than 90% of rainfall runs off the surface, causing flooding (up to 10 times more than in the natural landscape)

Increase in rainfall
Frequent and more intense rainfall is forecast in the future - the amount of rainfall will increase by up to 30-50%

RESULT

• heat in cities • deterioration of the quality of life in cities
• respiratory and cardiovascular diseases • more frequent floods
• economic losses • weakening of the urban natural system
• health and life hazard

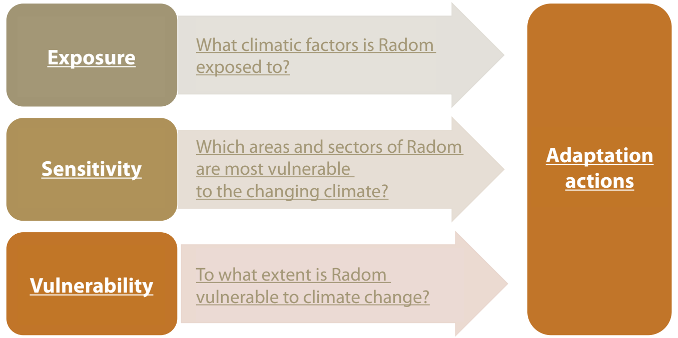
5. Assessment of vulnerability to the climate change

The negative impact of global warming is felt in all cities, including Radom.

To assess the extent to which a particular city is exposed to the effects of catastrophic events, the so-called vulnerability assessment is conducted. The vulnerability assessment informs which economic sectors or spatial areas of the city are particularly vulnerable to the negative impact of climate change. At a later stage, it is also the basis for effective planning of adaptation measures.

The vulnerability assessment for Radom was performed in accordance with the guidelines of the Ministry of the Environment.

The document asks the following questions:



The results of the vulnerability assessment for Radom carried out as part of the LIFERADOMKLIMA-PL project are available on the project website in the form of an interactive platform:

gis.umradom.pl/life_radom_mapy.html

Two emission scenarios were used in the vulnerability assessment for Radom: the moderate RCP4.5 scenario assuming that actions to reduce CO2 emissions are undertaken, and the pessimistic RCP8.5 scenario assuming high emissions and the largest changes in the average Earth surface temperature.

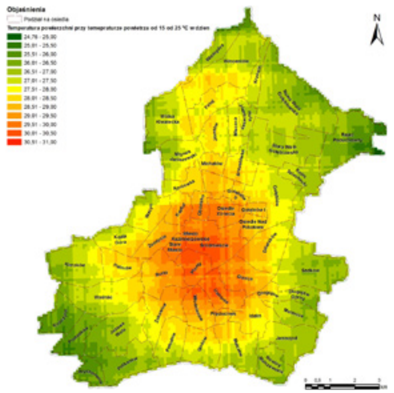
All forecasts made for Radom point to:

- further climate warming, with the increase in average air temperatures in summer and winter, an increase in extreme temperatures, and a growth in the number, length and frequency of warmth and heat waves;
- change in the distribution of rainfall - an increase in the amount of rainfall, especially in the winter, and an increase in the intensity of rainfall and the frequency of heavy rainfall, especially in the summer,
- greater risk of drought - especially in the summer,
- less snow and cold days - reducing the number of days with snowfall and the number of days with snow cover during the year.

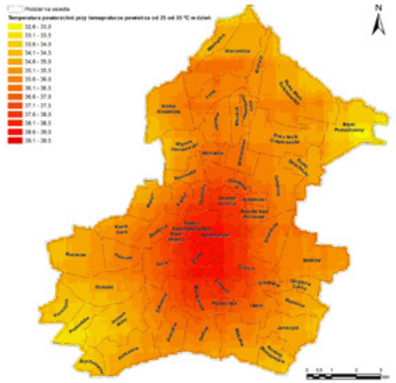
In the case of the implementation of the pessimistic RCP8.5 emission scenario, more intense changes should be expected than in the case of the RCP4.5 scenario.

The crucial climate challenges for Radom include rising temperatures and floodings caused by heavy rainfalls.

Analyses of satellite images showed that the highest surface temperatures in Radom occur in the city centre, where the buildings are the most compact, while areas associated with water and greenery are most limited. This phenomenon is called the urban surface heat island.



Surface temperature at average daily air temperature from 15°C to 25°C (data collected from June 2015 to June 2016).



Surface temperature at average daily air temperature from 15°C to 25°C (data collected from June 2015 to June 2016).

High temperatures have a negative impact on city dwellers. During heat waves, the risk of overheating and dehydration increases, fatigue and a decrease in well-being may occur. In people from particularly vulnerable groups, especially those with cardiovascular diseases and the elderly, the symptoms may worsen. Dry city air, especially at high temperatures, can exacerbate the symptoms of bronchial asthma and allergies. Particular attention should be paid to children and single people who may not be aware of or able to cope with the symptoms of overheating on their own.

On the other hand, heavy rainfalls may lead to an increased risk of river floods. The analyses carried out in the vulnerability assessment indicate that approx. 430 ha were flooded in Radom in 2016. In 2050, this area for the same probability and duration of rainfall may increase by more than half as a result of climate change and amount to 682 ha.

In Radom, the areas located along the Mleczna River and its tributaries: Potok Północny, Strumień Halinowski, Potok Malczewski, Potok Gołębiowski and Strumień Godowski should be considered the most vulnerable to flooding.

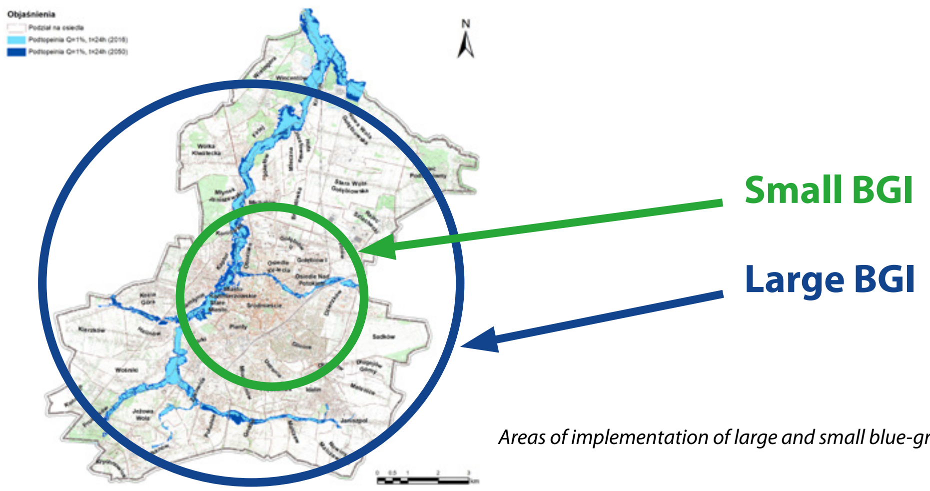
Persistently high temperature and lack of rainfall cause drying up of vegetation in cities, especially decorative vegetation. This negative impact can be mitigated to some extent by local retention of rainwater in green areas.

Jagielloński Square in Radom - heat waves in July 2019 (Photo by FPP Enviro)

6. Blue-green infrastructure (BGI)

The basis for the adaptation of the urban space to the climate change is the proper functioning of the so-called blue-green infrastructure (BGI). It consists of all areas related to urban greenery, surface water and various solutions to retain rainwater where rainfall occurs.

The project developed and implemented a demonstrative blue-green infrastructure at two levels of the city: at the catchment level of the rivers supplying water to the city (large blue-green infrastructure - large BGI) where the retention capacity of river valleys was increased, to mitigate extreme flows while creating habitats for biodiversity, and in central areas of the city (small blue-green infrastructure - small BGI), where rainwater was retained and managed to mitigate flooding from sealed areas of the city, thus alleviating the effects of urban drought.



Areas of implementation of large and small blue-green infrastructure (BZI).

Implementations conducted in Radom under the IFERADOMKLIMA-PL project show how to reduce the problem of floods by increasing valley retention of rainwaters brought into the city by systems of rivers. The Borki Reservoir together with the colmatation ponds retain almost 30,000 m^3 of water flowing in the Mleczna River to Radom after rainfall. In turn, the floodplain polder constructed on the Cerekwianka River has the capacity to take over up to 17,000 m3 of water carried by the river into the city after heavy rainfall. The multifunctional area created on Potok Północny enables retaining 11,000 m3 of rainwater carried by the river.

In total, the implemented systems can reduce the quantity of water brought to the city centre by nearly 60 thousand m3, preventing flooding in many of its parts. Re-meandering of the River Mleczna performed in the city centre, together with stone covers slows the water flow and increases its retention in the valley. The measures used to alleviate consequences of the climate change are supplemented with "Small BGI" implemented in the developed city centre. They are to stop rainwaters at a place where the rainfall occurred. The map of all investments is provided on the last page of this report.

Large BGI RadomKlima project actions:

- Adaptation of the Borki reservoir and colmatation ponds to the climate change
- Modification of the stormwater sewer A0
- Construction of a multifunctional reservoir on the Potok Północny River
- Renaturation and adaptation to the climate change of the River Mleczna
- Construction of a floodplain polder on the Cerekwianka River.

LARGE BGI - ADAPTATION OF THE BORKI RESERVOIR AND COLMATATION PONDS TO THE CLIMATE CHANGE

The Borki Reservoir is a place of recreation for inhabitants of Radom and its area. A beach and a pier are located in its north-east part. The remaining part of the reservoir's shoreline is covered by aquatic plants, mainly reeds, bulrushes, and club-rushes. Due to its relatively large surface area, numerous species of water and marsh birds can be found here. Due to a deteriorating quality of the water, mainly caused by an inflow of untreated stormwater runoff from Radom, cyanobacteria blooms are frequently observed here during the summer. They may cause poisoning, and transient gastrointestinal and liver problems. Additionally, a temporary low water level makes the use of the reservoir impossible and intensifies problems with its quality.

The modification of **colmatation ponds** of the Borki reservoir was to ensure efficient additional treatment of water by using natural sedimentation processes of suspended solids transported by the river, extending the flow distance, and the use of natural filtration and adsorption processes due to the use of dolomite structures. They increase the effectiveness of phosphorus removal from water and improve physical properties of water in consequence of its aeration.

The Borki reservoir and colmatation ponds (photo from the Project file)

Project objectives:

- providing a habitat corridor for migration of aquatic organisms, through a construction of a fish ladder,
- removal of sediments from the Borki reservoir bottom,
- improvement in the quality of water supplier to the reservoir by increasing the pretreatment capacity of the colmatation ponds, to reduce nitrogen and phosphorus levels responsible for algal and cyanobacteria growth in the water,
- increasing the retention capacity of the colmatation ponds by removing bottom sediments and modernisation of the stake weir,
- maintaining of habitats for organisms living in the colmatation ponds,
- regulation of the water flow to the Borki reservoir to reduce the hazard of the flood.

Completed works:

- modernisation of the main weir, which ensured additional 20 centimetres for stormwater retention in the reservoir bowl, so the amount of water carried by the River Mleczna to lower parts of the city during heavy rainfalls was reduced,
- construction of a slot fish ladder for migration of fish and other aquatic organisms in two directions,
- installation of devices for water aeration and mixing (fountains and diffusers) improving its physical properties and reducing algal and cyanobacteria blooms in water,
- installation of renewable energy devices (wind turbines, photovoltaics) to provide power supply for the above devices,
- a system raising excess stormwaters in the colmatation ponds,
- a sequential system for treatment of stormwaters supplied into the colmatation ponds, taking into account the suspended solids sedimentation zone, dolomite structures for removal of phosphorus compounds, an aquatic vegetation zone to reduce nitrogen compounds, and aeration limiting phosphorus transfer from the sediments to the water,
- removal of sediments accumulated on the ponds bottom, which in the summer were a source of pollutants, mainly phosphorus compounds, moving into the water.

photo on the left - The weir and the fish ladder on the Borki reservoir (Photo from the Project file)

photo on the right - installation of renewable energy devices at Borki reservoir (Photo by Marek Miłkowski)

LARGE BGI - MODERNISATION OF THE STORMWATER SEWER A0

Sealing of the A0 sewer was crucial for preventing penetration of groundwater contaminated with iron compounds into it. Additionally, to ensure water supply to the Borki reservoir during summer rainless periods, the existing system transporting water from the A0 sewer to the River Mleczna upstream from the reservoir was adapted. This ensured effective treatment of stormwaters pumped from the underground A0 sewer supplying the Borki reservoir. The solution involves the use of natural sorbents, like lime and dolomite stone, BioKer and a vegetation zone at the outflow from the drainage ditch. This solution eliminates biogenic compounds. Therefore, this solution not only restricts the transfer of pollutants, but also provides an additional source of water for the Borki reservoir during periods of draught, reducing the amount of water transported to the city centre in the stormwater sewer.

plantings by the stormwater ditch estuary

uderground A0 sewer

pumping station

stormwater draining ditch

Project objectives:

- reduction of water flow in the A0 sewer during a dry period,
- improvement in the water quality in the stormwater sewer.

Completed works:

- sealing of the 679 m of the sewer, from Starokrakowska Street to the pumping station at Sucha Street,
- modernisation of water supply from the A0 sewer to the stormwater pumping station at Sucha Street,
- adaptation of the existing stormwater draining ditch from the pumping station of the A0 sewer into a sequential sedimentation and biofiltration system,
- planting plants with nutrient-reducing properties.

LARGE BGI - CONSTRUCTION OF A MULTIFUNCTIONAL RESERVOIR ON THE POTOK PÓŁNOCNY RIVER

Potok Północny is the right tributary of the River Mleczna flowing through the centre of Radom, with its beginnings in the Lasowice area. In its upstream part, stormwaters from the Sadkowo airport and a runoff from the allotments are drained into it.

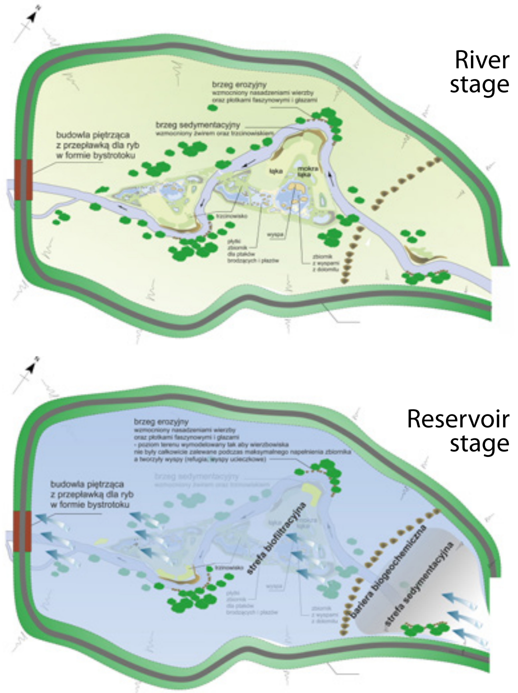
Project objectives:

- adaptation of a floodplain area on Potok Północny, transforming it into a multifuctional area improving the quality of water, increasing biodiversity, adaptation to the climate change, and creation of social and educational functions,
- decreasing extreme water flows reaching the Radom centre with the River Potok Północny, by retaining it in a multifunctional area of ca. 2 ha,
- creating a habitat for animals, including various species of amphibians and birds,
- improvement in the inhabitants quality of life.

A floodplain polder on Potok Północny (Photo from the Project file)

Completed works:

- the terrain adaptation, including dykes, to retain rainwaters,
- constructions on river inlet and outlet, to regulate the level of the retained water,
- meandering of the Potok Północny bed in the system bowl,
- numerous pond zones, to improve biodiversity and create habitats,
- a sedimentation and floatation zone improving the process of pollutants sedimentation, and biofiltration zones increasing water auto-purification capacity.



Adaptation of a floodplain on Potok Północny for retaining of rainwaters, using a sequential sedimentation and biofiltration system (SSBS)

LARGE GBI - RENATURATION AND ADAPTATION TO THE CLIMATE CHANGE OF THE RIVER MLECZNA

The River Mleczna, a right tributary of the River Radomka, is the main watercourse in Radom. It is also supplied by rainwaters from stormwater sewers from individual city districts, resulting in a risk of flooding and a decrease in water quality. In the summer, the river is susceptible to drying, due to its straightened bed of a limited retention capacity. The regulation also leads to a loss in biodiversity and a reduction in water purification capacity.

Restored meandering of the River Mleczna - on the left (photo from the Project file)

High water bed - on the right (photo from the Project file)

Project objectives:

- increasing flood security in changing climate conditions,
- improvement in water quality,
- improvement in biodiversity - restoring of habitats of birds, amphibia, fish, invertebrates, and other organisms,
- restoration of a habitat corridor in the river valley,
- improving of landscape and recreation values.

Completed works:

- restoring of meanders of the River Mleczna bed at a length of 315 m, to slow the water flow and enable its spreading in the valley,
- 4 marginal bays increasing the retention of flood waters and creating habitats for aquatic organisms,
- 10 systems acting as riffles (shallows) and stream pools (deeps) in the riverbed, improving the riverbed structure and water quality,
- high water bed to retain floodwaters in a floodplain area,
- reconstruction of the outlet of the rainwater sewer to the river into a purifying system using aquatic vegetation,
- gravel heaps in the bed to raise the river bottom, and thus to increase water retention in the landscape and its availability to the plants.

In the longer term, restoration of degraded natural and semi-natural hydrological habitats, and restoration of the habitat corridor of the river valley will contribute to the improvement in the quality of habitats of birds, amphibia, invertebrates, and other organisms.

LARGE GBI - CONSTRUCTION OF A FLOODPLAIN POLDER ON THE RIVER CEREKWIANK

The River Cerekwianka, also known as Strumień Halinowski, is the left tributary of the River Mleczna, representing a small but important habitat corridor (a route for animals migrations) in Radom. This river caused regular local floods, and nearby streets were frequently flooded during heavy rainfalls.

Floodplain polder on the River Cerekwianka (photo from the Project file)

Project objectives:

- accumulation of the excess rainwater and preventing flooding of nearby roads,
- use of processes of natural succession to expand the vegetation structure and improve the water quality,
- increase in the biodiversity of the area by creating a mosaic of land and marsh habitats,
- maintaining the habitat corridor for migration of aquatic organisms, spawning grounds for fish, and habitats for water birds and amphibians,
- maintaining the River Cerekwianka waters in a good condition.

Completed works:

- a 0.5–1 m deep floodplain polder of 1.7 ha, by adaptation of the existing depressed area of former fish ponds on the right bank of the River Cerekwianka,
- a system directing excess rainwaters to the polder and increasing its retention,
- a sequential pretreatment system consisting of a sediment section and two biofiltration sections with natural aquatic vegetation,
- increasing the self-purification capacity of waters.

Small BGI - these are solutions that retain rainwater at the point of rainfall in those parts of the city where the risk of overflowing the stormwater drainage system and flooding resulting from urban flash floods is the greatest. Thanks to their construction, attractive places are created for residents as well as biodiversity enclaves.

Over 30 small BGI systems were constructed under the RadomKlima project:

5 Climapond, 8 overground Climabox, 1 permeable surface, 17 rain gardens and absorption hollows, and 5 bus shelters and bicycle sheds.

Furthermore, an architectonic conceptual design of an educational square, focusing on adaptation to the climate change, was prepared for the Complex of Leather and Clothing, Styling and Services Schools at Śniadeckich 5.

SMALL GBI – CLIMAPOND - A BIOLOGICAL POND COLLECTING RAINWATER FROM ROOFS

5 small ponds were constructed in total, collecting rainwater from roofs of educational institutions. Water is drained into them through downpipes and a system of troughs, or so-called dry streams. The reservoirs were designed to accumulate inflowing water during a rainfall, and then gradually filtrate the excess water into the ground on subsequent days. When all water is transferred, the reservoir is ready to receive another portion of rainwater. Aquatic and wetland plants were planted in the reservoirs and around them, also in additional wooden pots. All locations are provided with educational boards, and secured with a fence.

Climapond - State Kindergarten No. 16

On reaching the reservoir, water drained from gutters gets into a ca. 3 m long concrete overflow gutter, which dissipates too strong water stream that could wash out bedding of acquatic plants or destroy delicate plant species. The Climapond surface area is 16.9 m^2 and its maximum retention capacity is ca. 3.67 m^3. The excess water from the pool is drained to a water playground with a water pump, and then to an absorption hollow with an emergency overflow.

Climapond - State Primary School No. 11

The Climapond surface area is 30 m^2 and its capacity is ca. 10.80 m^3. The reservoir component, i.e., a gutter for distribution of rainwater, forms a base of a wooden bench. Two functional zones are formed in the reservoir: the rainwater infiltration zone around its edges, about 35 cm deep, and the sealed one, ca. 65 cm deep. Additionally, a well was installed to maintain biological life during a drought.

SMALL BGI – CLIMABOX – BIOLOGICAL RESERVOIR COLLECTING RAINWATER FROM ROOFS

Climaboxes are a type of specific rain gardens installed in overground containers that can be made of various materials. It is an ideal solution at locations where a Climapond cannot be constructed. Because they are tightly sealed, they can be placed directly at a building wall. Tanks, similarly as other small BGI structures, retain water, provide option for watering plants during a drought, and are a place of rest for users of a given facility, both children and adults. The excess rainwater is drained trough a system of dry beds to absorption hollows planted with hydrophytic vegetation. Each of the sites is supplemented with educational and safety boards.

Concrete ClimaBox

A modular water reservoir with acquatic and wet meadow vegetation, made of concrete, and having an additional role of a bench. It consists of three parts: a 153 L tank with a substrate and aquatic plants, a 991 L tank filled with water, with aquatic plants in special baskets, and a 413 L tank with a bench, for water storage. It can contain ca. 1.6 m³ of water in total.

Wooden and metal ClimaBox

A two-chamber 1256 L metal tank with a wooden cladding. Each chamber contains a different set of plants, including aquatic plants on floating islands.

Brick ClimaBox

Two tanks of different capacity, 785 L and 1366 L were constructed of clinker brick, sealed on the inner side of the tank. Each tank is divided into two chambers with diverse vegetation, including aquatic plants on floating islands.

The excess rainwater from wooden and metal, and brick ClimaBoxes is drained through a system of naturally looking so-called dry streams to absorption hollows plated with vegetation.

SMALL BGI – RAIN GARDENS AND ABSORPTION HOLLOWS – VARIOUS FORMS OF LANDSCAPE ARCHITECTURE COLLECTING RAINWATER

The main function of rain gardens is to use rainwater for plant development. One of their forms can be absorption hollows, which are also usually covered with vegetation, but their task is to filter water deep into the ground. They are frequently combined with other BGI elements, like ClimaPonds, ClimaBoxes or green shelters, where the excess of water could form unwanted puddles or floodings.

Kindergarten No. 11

The investment covers construction of a cascade rain garden with an emergency overflow. The garden is to receive and use the rainwater from the kindergarten building roof of ca. 162 m² and the paved surface (pavement) of ca. 33 m². The garden was divided into three parts of 4.8 m², 4.3 m² and 18.5 m². It contains two functional zones: marsh (without rainwater infiltration) and moist (with rainwater infiltration). A water reservoir of ca. 4.36 m³ is located in its lowest part, forming a moist zone and equipped with the emergency overflow drained into the stormwater system. The garden area was planted with vegetation and secured with a fence.

A square between Bema, Jasińskiego and Sowińskiego Streets

A complex of three depressions collecting water from the square surface and acting as protective hollows, of a total area of 164.1 m². The hollow zones are separated by a system of gabions filled with stones for hydrotechnical constructions.

Tree-trench – Primary School No. 33

Rainwater can be used to water trees. Water from the 290 m² roof is drained with gutters and then with dry streams to the swale. A row of five trees of native species was planted in the hollow of ca. 39.6 m², which can receive nearly 8 m³ of water at one time. Nine benches were installed near the tree-planted hollow, in a way enabling conducting outdoor classes on the climate changes.

SMALL BGI - GREEN SHEDS

Top photo - Jagielloński Square, bottom left photo - State Primary School No. 33, photo on the right - RCS (Photo from the Project file)

Green sheds are formed by a reinforced steel structure enabling instalment of a Green Roof (of ca. 10 m^2) and a Green Wall (ca. 9 m^2). The Green roof provided with a system for retaining rainwater is a surface of 10 m2 planted with a mixture of stonecrops. The roof structure is designed to retain even 90% of the rainwater, which is used to water the Roof and plants planted around the shed. In normal conditions (outside periods of summer droughts) of the use, the Sheds do not require additional watering of the plants.

The vegetation planted within the structure produces 10 kg of oxygen a year. The steel structure planted with vegetation can reduce the temperature inside the shed even by 10°C versus the temperature outside, and this answers the problem of heat islands found in the cities.

7. Improving water quality

To determine the influence of project activities on water quality, its physical and chemical parameters were monitored, comparing the results of the post-investment (2021/2022) versus the pre-investment (2016) period. Additionally, the effectiveness of individual solutions was evaluated.

Adaptation of colmatation ponds and the needle weir at the Borki Reservoir had the strongest influence on the improvement in removal of the total suspended solids (by 39%), nitrogen (reduction of various nitrogen forms from 17% to 34%), phosphorus (from 1% to 12%) and iron (from 18% to 29%). Values of the remaining parameters (conductivity, oxygen level) remained at the same level. All this resulted in a significant improvement of the sanitary status of the Borki Reservoir in the summer months of 2022, especially in the vicinity of the bathing beach (no toxic cyanobacteria strains were detected), when compared to 2016, before the investments were implemented.

Noticeable improvement in the water quality in the Borki Reservoir (photo from the Project file)

Restored meandering of the River Mleczna, introduction of deflectors and gravel heaps slowed the water flow, and this translated into a noticeable reduction in the quantity of suspended solids transported with it (from 11% to 15%) and the total nitrogen (from 25% to 30%). The mean values for total suspended solids, ammonia nitrogen, and total phosphorus upstream from the renatured river section were also lower, and this may confirm a positive effect of the implementation of solutions in the upper part of the catchment, i.e., in the Borki reservoir, colmatation ponds and the River Cerekwianka. Sealing of the A0 sewer reduced contamination with iron compounds, which penetrated into it together with groundwater, with a reduction in its levels from 100% in 2016 to just 12% in 2022.

The effectiveness of the polder constructed on the River Cerekwianka in elimination of biogenic substances was 16% for ammonium nitrogen, 2% for ammonium nitrogen, and ca. 83% for phosphate phosphorus. The improvement in water quality will definitely be influenced by a construction of the multifunctional area on Potok Północny, although the effectiveness of this solution could not be monitored, because the investment was completed in September 2022.

Gravel heaps raise the water, slowing its flow, and this positively influences its quality (Photo from the Project file)

8. Increasing flood security and draught prevention

Metrological data from three stations created under the project show that the total rainfall decreases along with an increase in the temperature, and the number of days with extreme rainfalls is also increasing. This suggests that without implementing relevant adaptation measures, the risk of draught and floods in Radom will increase.

The ST3 station near the Borki Reservoir (photo from the Project file).

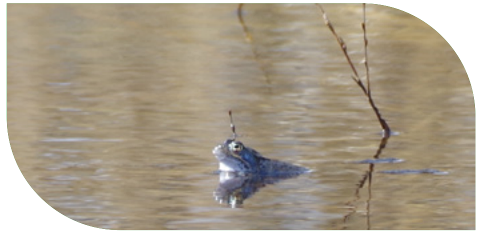
The increase in the quantity of water transported to the city centre by the River Mleczna and its tributaries during periods of rain led to numerous floodings. To increase options for rainwater retention, the existing infrastructure of the Borki Reservoir was modified. This contributed to gaining additional rainwater retention capacity in the reservoir of ca. 30 thousand m^3. This means that in the case of the extreme flow in the river following a heavy rainfall (so-called "centenary water-level") lasting for up to 45 minutes, all that water can be contained in the reservoir. In consequence, the conducted works improved flood safety of lands in the River Mleczna catchment downstream from the reservoir (the city centre). To prevent water shortages during droughts, a solution was implemented for taking water from the underground A0 sewage running along the Borki Reservoir. The functioning of the pumping station was optimised, and the sewage drainage was modified, so the reservoir receives additional pre-treated water.

Construction of floodplain polders on the River Cerekwianka and on Potok Północny contributes to a retention of further 27 thousand m^3 of rainwater in total. After passing of the rainfall wave, water retained in the polder can be drained, preparing the system for receiving the next wave, or can be retained and used for environmental purposes (an improvement in the microclimate and an increase in the landscape retention) during rainless periods. Therefore, the constructed solutions protect directly the River Mleczna, and indirectly the central part of the city, against floods and floodings.

The floodplain polder on Cerekwianka, before and after the rain (Photo from the Project file)

9. Biodiversity protection

An improvement in moisture conditions and creation of even the smallest water reservoirs, especially in conditions of "urban concrete deserts" always have an advantageous effect on the increase in the biodiversity, i.e., diverse life forms. Water is necessary for development of urban vegetation. It results in appearance of hydrophytic and aquatic plants and animals associated with the aquatic environment - invertebrates, amphibians, birds, and mammals. All these groups were monitored under the LIFERADOMKLIMA-PL project.



Male moor frog (Photo by Oskar Gross)

Male corncrake (Photo by Robert Tęcza)

Nine species of amphibians were found, including five species endangered in the European Union (listed in Annex IV of the Habitats Directive): the moor frog (photo), the pool frog, the European green toad, the common spadefoot, and the rarest of them, the northern crested newt (in the Potok Północny region). This last species was detected with the innovative method of analysing DNA from water samples, so-called environmental DNA (EDNA). During observations, presence of 124 bird species was found in the studied area, including 15 species listed in Annex I to the Birds Directive (as many as 13 of them were found in the "Borki" area), including: the kingfisher, the black stork, the corncrake (Photo), the syrian woodpecker, the peregrine falcon, and even a visitor from the far north, the black-throated loon.

Several valuable species of insects were found. The most interesting insect species discovered include the beetle Cucujus cinnaberinus and the butterfly large copper (photo). They are protected under the national and the European legislation. Furthermore, 23 species of dragonflies were found at the monitored sites. The scarce blue-tailed damselfly, a dragonfly previously not recorded in Radom, was observed for the first time. When compared to the period before starting the LIFE project, the number of fish species increased by eight. 26 species of fish were found in total, including also two species listed in Annex II to the Habitats Directive, the asp and the weatherfish.

Small BGI facilities play a very important role, among which the newly created ponds (Climaponds) were characterised by the greatest biodiversity. They were planted with aquatic plants, including alisma, the broad-leaf arrowhead, and the mare's-tail. In the urban environment, where the access to water is very limited, water reservoirs are used by birds for drinking, and for bathing in the summer. A blackbird made its nest in ivy covering one of the green bus shelters. The mammals also benefited - a hedgehog started to live near the Climapond at the State Kindergarten No. 16.

Male large copper (Photo by Marek Miłkowski)

Hedgehog (Photo by Paweł Wacławik)

10. Increased awareness

The LIFE RadomKlima project resulted in including activities adapting to the climate change into the main stream of the city spatial development planning and in an increase in the knowledge on informed decision-making at the local level through, among others, working groups. Two international conferences were held in Radom, and the experience was shared during numerous other meetings. Events concerning relevant subjects were organised, including "Feel the climate" 2019, "Family Picnic" 2019, or "Concert with the Climate" 2018, arts competitions, like "ECO CITY" 2020 or "Climate change consequences" 2019. Educational materials were prepared for classes at kindergartens, which were used during opening of the "Climatic kindergarten No. 16 in Radom".

ECOCITY conference in 2017 (Photo by Municipality of the City of Radom)

The project's solutions offer great replication capabilities. Such products as the vulnerability assessment, a comprehensive approach to multi-level territorial rainwater management, GIS tools, and a demonstrative blue-green infrastructure are made available to all interested parties. Visit www.life.radom.pl to see a gallery of 12 videos about the project and the small and large implementations of the Blue-Green Infrastructure.

Event "Feel the climate", 2019 r. (Photo by Municipality of the City of Radom)

The combination of the knowledge of engineers and ecologists helped to work out implementations thanks to which the city space, apart from functional aspects, gains a natural element, responsible for the quality of the functioning of an urbanized area, which is important in the era of climate change. In 2021 and 2022, the project representatives participated in Conferences organised by the Mazovian District Chamber of Civil Engineers, Field Office in Radom, including the conference dedicated to the LIFE project effects held in 2022.

The experience gained during the project executed in Radom were used in project MPA 44 of the Ministry of Climate and Environment, to develop plans for adaptation to the climate change in 44 cities with over 100 thousand inhabitants. In December 2022, due to the effects of the LIFERADOMKLIMA-PL projects, the city of Radom was recognised at the international level, by being included in the Global Network of Ecohydrology Demonstration Sites under the Intergovernmental Hydrological Programme (UNESCO-IHP).

A field visit of the Masovian District Chamber of Civil Engineers (Photo by Municipality of the City of Radom)

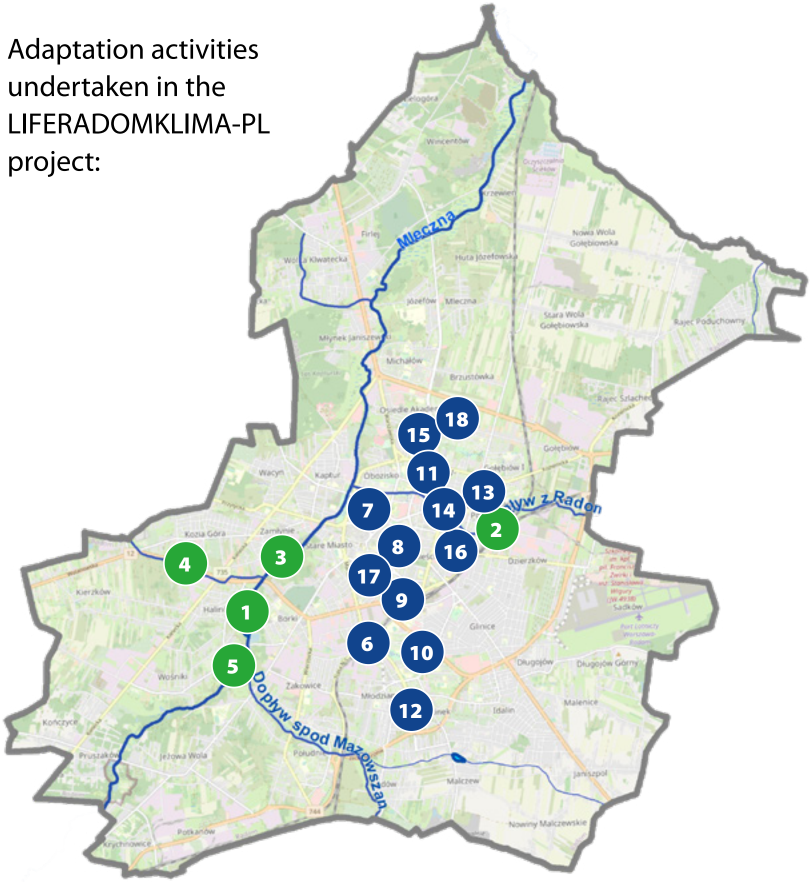
Illustration from Educational Materials

PROJEKT LIFERADOMKLIMA-PL

As the first city in Poland, Radom has been implementing a project on adapting the city to anthropogenic climate change since 2015. The project called „Adaptation to climate change through sustainable management of water of the urban area in Radom City” (LIFERADOMKLIMA-PL, LIFE14 CCA/PL/000101) is co-financed by the European Union under the LIFE Program and the National Fund for Environmental Protection and Water Management.

NFOŚiGW

Adaptation activities undertaken in the LIFERADOMKLIMA-PL project:



Map source: OpenStreetMap.org

Large BGI (blue-green infrastructure):

1. Adaptation of the Borki reservoir and colmatation ponds
2. Construction of a multifunctional reservoir on the Potok Północny river with a sequential sedimentation and biofiltration system (SSSB) (between Olsztyńska St and railway tracks)
3. Remeandering of the Mleczna river (at the boulevards over Mleczna)
4. Floodplain polders on the Cerekwianka river (at NSSZ Solidarności St. - behind Jana Łaskiego Roundabout)
5. Canal A0 and SSSB on the Mleczna river above the Borki reservoir (at Sucha St)

Small BGI (blue-green infrastructure):

6. Climapond Public Kindergarten No. 16 (3 Grenadierów St)
7. Green bus shelters (Struga St opposite Galeria Słoneczna)
8. Rain garden – Public Kindergarten No. 4 (23 Jana Kilińskiego St)
9. Rain Garden and Climapond - Public Kindergarten No. 11 (10 Kościuszki St)
10. Climapond – Public Primary School No. 11 (19 Gagarina St)
11. Absorptive basins (Square Bema St/Jasińskiego St)
12. Rain gardens - Nursing Home (16 Wyścigowa St)
13. Rain gardens - Nursing Home (88 Struga St)
14. Green bicycle shelter - RCS at (63 Struga St)
15. Rain Gardens and Climapond - XI LO (27 11 Listopada St)
16. Tree trench and Green bicycle shelter - Public Primary School No. 33 (5 Kolberga St)
17. Climapond and Green bicycle shelter - III LO (44 Traugutta St)
18. Climabox - Municipal Cultural Centre Amphitheatre (5 Daszyńskiego St)

The project is implemented by:

radom siła w precyzji

with partners:

wodociągi miejskie

UNIWERSYTET ŁÓDZKI

FPP ENVIRO

More about the project: **www.life.radom.pl**