Capital City of Prague Climate Change Adaptation Strategy

Aim

Reducing vulnerability of the Capital City of Prague, the Czech Republic, to climate change effects aiming at improving the environment for its inhabitants in future

Vision

Enhancing a long-term resilience and reducing vulnerability of the Capital City of Prague to climate change effects by step-by-.step implementation of adaptive measures, preferably applying nature-based solutions combined with grey, *i.e.* technological and soft measures, to provide the city´s inhabitants with high well-being.

Content

Introduction

The Czech Republic, as well as its capital Prague, has during the last decades been facing increasing frequency in extreme weather events related to climate change. Mean annual air temperatures have been increasing: the increase has been approx. 0.3 ^{0}C per decade and by 2030 the further increase by 1 ^{0}C is projected for the Czech Republic´s territory. In addition, frequency, intensity and duration of extremely hot periods (heat waves) will possibly be increasing in Prague.

Hydrological cycle and rainfall distribution in time and space have also been changing: risk of torrential rains and consequent local floods have also been increasing, as well as discharge fluctuation (droughts v. floods). It is expected that winter precipitation totals will increase: on the other hand, summer precipitation totals will be decreasing. In addition, number of days in the period without precipitation shall be significantly increasing as well as risks in an occurrence of droughts. The climate models predict an increase in extreme weather events (windstorms, tornados, *etc*.) frequency.

The Capital City of Prague Climate Change Adaptation Strategy (hereinafter referred to as the Adaptation Strategy) is connected with the Strategy on Adaptation to Climate Change in the Czech Republic approved by the Government of the Czech Republic´s decision in 2015. It aims at reducing adverse climate change impacts trough nature-based solutions (*e.g*., green and blue infrastructures) using natural vegetation patterns which cools the environment by evaporation and providing shade in its vicinity. At the same time, vegetation allows to capture, retain and accumulate rainfalls in soil layers or as the case may be to infiltrate them in underground water. The Adaptation Strategy also deals with conservation of water, soil and biological natural and landscape components and conservation and restoration of ecosystems resilient to climate change, thus contributing to natural disaster prevention (the so-called ecosystem approach to climate change adaptations or nature-based solutions).

If nature-based solutions cannot be applied or are ineffective, suitable technological (also called grey) and soft measures, *e.g*. early warning systems or communication, education and public awareness/environmental education campaigns, will be used.

The strategy tries to take into account specific Capital City of Prague´s patterns as the urban landscape, being characterized by high proportion of built-up areas, economic, technological and transport infrastructure high accumulation and unevenly dispersed vegetation component distribution.

By Prague Council Decision No. 3213 of December 12, 2015 and submitting an application, the Capital City of Prague became a *Mayors Adapt Initiative* member, thus accepting a commitment to develop a climate change adaptation strategy and to monitor and assess the process and procedure of adaptation measures incl. risk assessment and elaborating biennial assessment reports. The Capital City of Prague Climate Change Adaptation Strategy shall be elaborated by the Implementation Plan for 2018 – 2019: the latter will provide specific adaptation measures and pilot projects which contribute to climate change mitigation, their monitoring and effectivity and effectiveness assessment.

1. Observed and projected climate change effects in Prague

1.1 Observed climate change patterns on the Capital City of Prague´s territory

1.1.1 Temperature

Prague, particularly its downtown, is among the warmest areas in the Czech Republic with mean annual temperature > 10 ^{0}C; the temperature has in the long term been increasing. The step-by-step increase in temperature can also be evidenced by mean annual temperatures, having been 9.1 ^{0}C in 1911-1960, 10.4 ^{0}C in 1961-2010 respectively (an increase by 1.3 ^{0}C). The increase in mean annual temperature is showed by measurements at the Prague Clementinum Observatory & Meteostation (see Fig. 1).

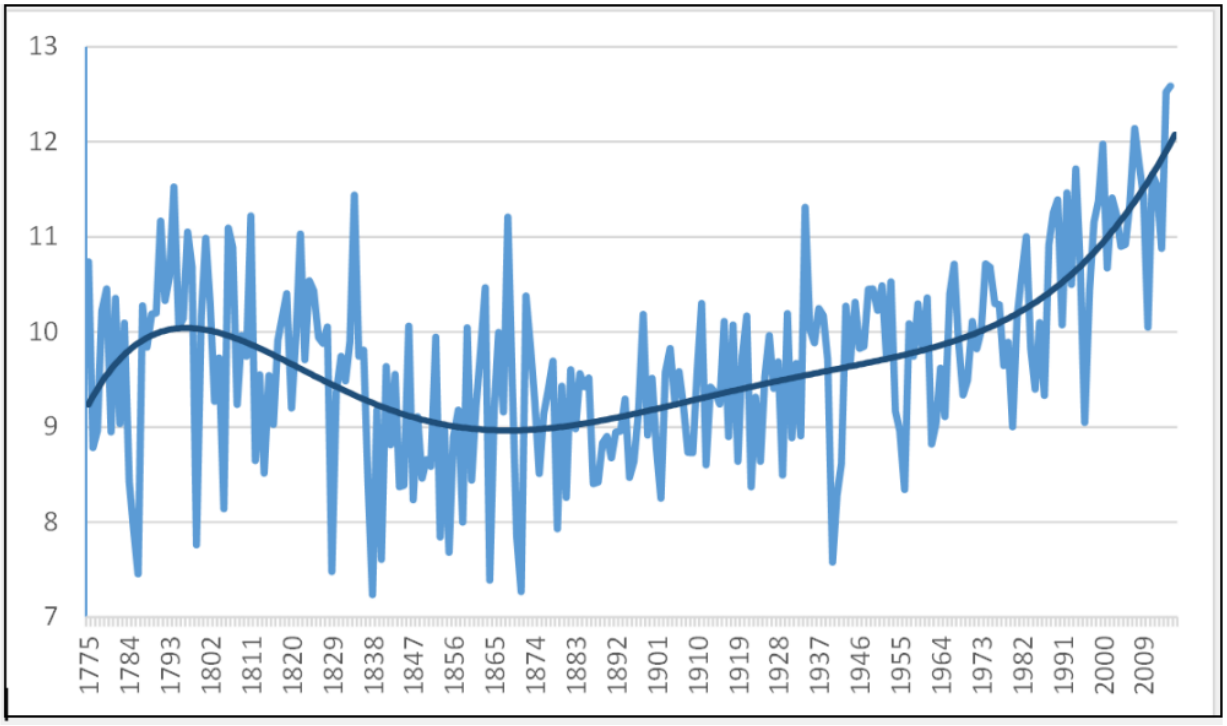

Fig. 1 Mean annual air temperatures (in ^{0}C) in 1775-2015 at the Prague Clementinum Observatory & Meteostation (Source: Czech Hydrometeorological Institute, 2016, portal.chmi.cz and infomet.cz)

In built-up areas of the city, there are many surfaces absorbing solar radiation and accumulating heat, *e.g.* asphalt and concrete. Under climatic conditions typical for Prague, the maximum day temperature of the surfaces, if they are not overshadowed, may even reach more than 50 ^{0}C during summer months. Compared with surfaces able to retain and release water may the difference can exceed dozens of centigrade (*e.g.* difference between water surface and asphalt parking surface temperatures).

Due to increased solar radiation absorption in built-up areas, heat is more accumulated there, thus forming an urban heat island. Heat accumulated in built-up areas during the day, is lost by radiation in the night and warms the surrounding. Thus, it amplifies the adverse effects caused by high to extremely high temperatures which consequently becoming longer and more intensive (Fig. 2).

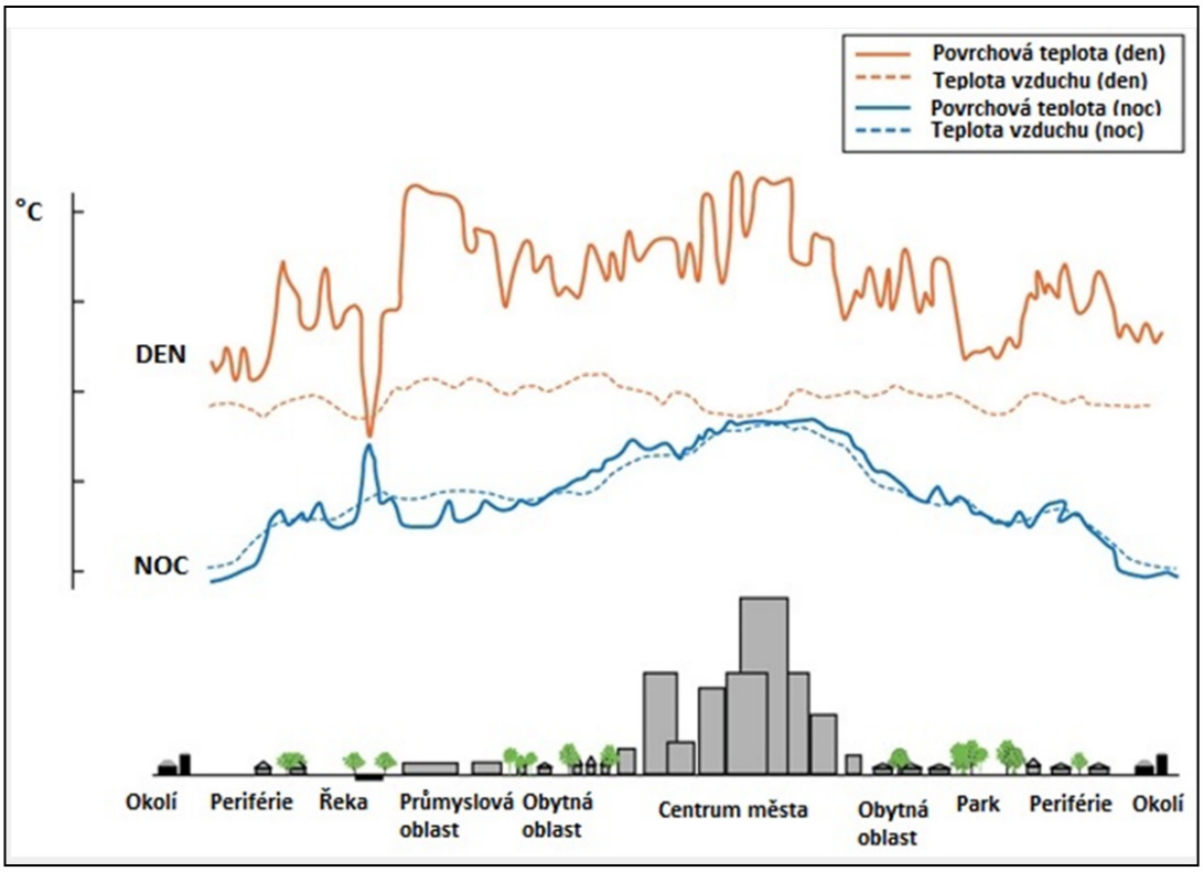

Fig. 2 Urban heat island – air temperature dynamics during the day and the night (Source: www.epa.gov.)

den - day; noc - night; povrchová teplota (den) – surface temperature (day); teplota vzduchu (den) – air temperature (day); povrchová teplota (noc) – surface temperature (night); teplota vzduchu (noc) – air temperature (night); okolí - vicinity; periférie – city´s outskirts; řeka - river; průmyslová oblast – industrial area; obytná oblast – residential area; centrum města – city´s downtown; park – park.

The Prague urban heat island reaches mean daily temperature intensity of 1.6 ^{0}C, while the highest one is just in the densely built-up downtown (Fig. 3). The highest difference in temperature between the centre of Prague and its surroundings has been experienced in the recent years and it has continuously been increasing during the last 50 years. The key drivers of the above pattern are spatial spreading of built-up areas and traffic intensification.

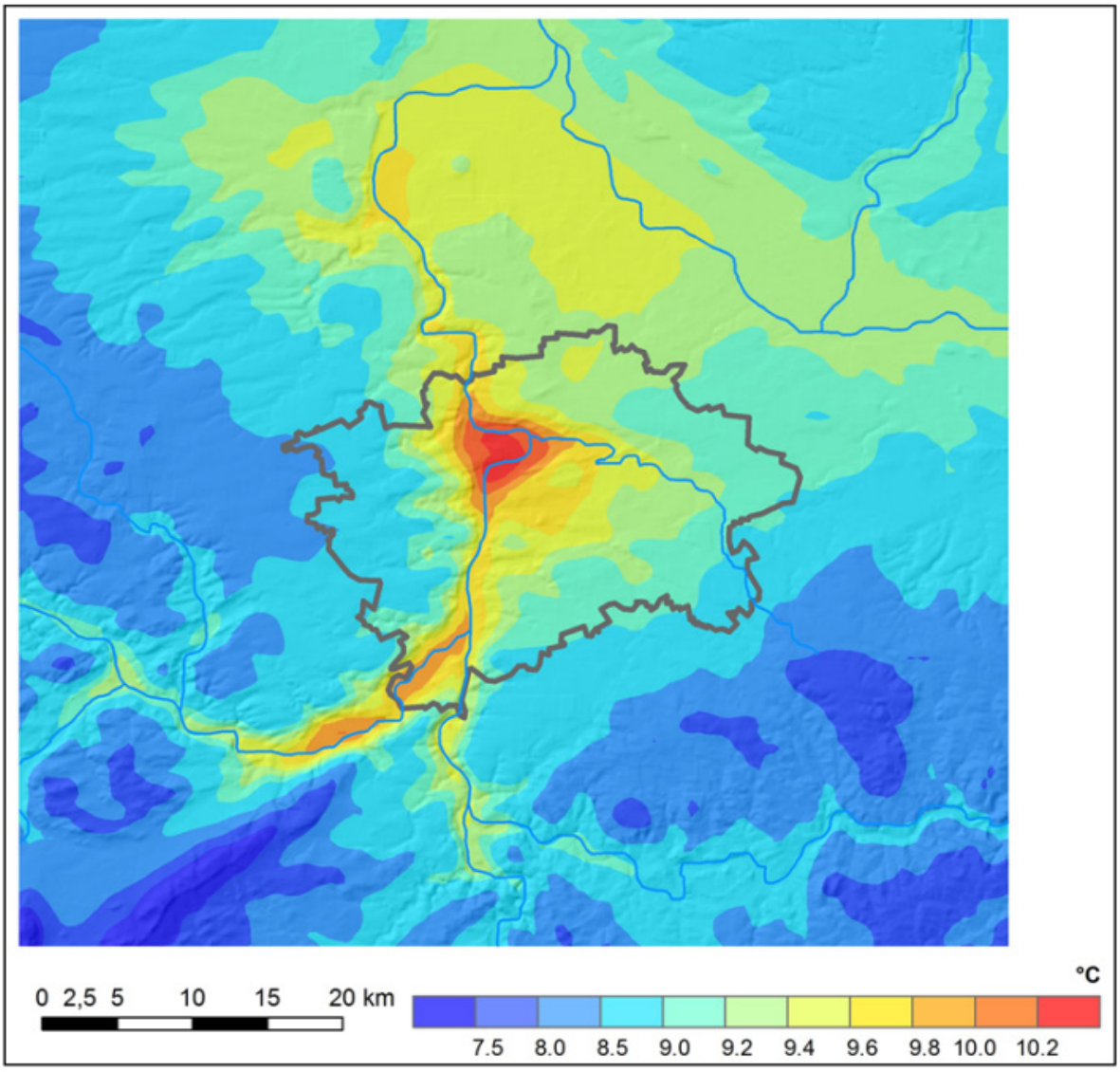

Fig. 3 Mean annual air temperature in Prague and its surroundings in 1961 – 2013 (Source Czech Hydrometeorological Institute, 2016)

1.1.2 Precipitation

Measuring precipitation shows keeping its mean annual totals, but also a sharp change in its temporal and spatial distribution. Both number and intensity of torrential rainfalls have been increasing and drought periods have been more frequent (see Fig 4). At the same time, frequency and intensity have also been increasing in other extreme weather events (*e.g.*, thunderstorms, hailstorms or strong winds). Generally, a trend in mean annual precipitation totals cannot be found, due to their sharp annual fluctuations and variability (*cf.* the highest annual precipitation total in 2002 and the lowest one in 2003). Number of days without precipitation as well as frequency in irregular drought periods has also been increasing in Prague.

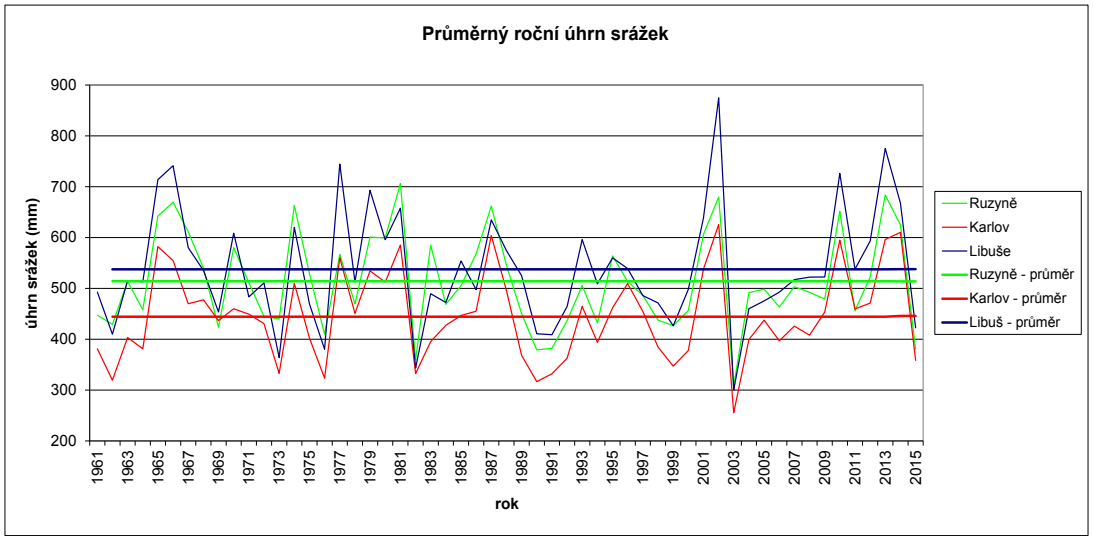

Fig. 4: Annual precipitation totals in 1961-2015 at the selected stations on the Capital City of Prague´s territory (Data source: Czech Hydrometeorological Institute, 2016)

průměr - average

1.2 Expected climate change manifestations on the City of Prague´s territory

1.2.1 Temperature

According to climate models, the Capital City of Prague shall face changing climate conditions, particularly increase in mean annual temperature for low (RCP 4,5) as well as high (RCP 8,5) scenarios. The fact will result in a highly significant increase in the tropical day number ($T_{max} > 30\ ^0C$), up to 38.6 days/year for RCP 8.5 in 2081-2100 compared with 11.5 days/year in the 1981 – 2010 reference period (+235 %). A high increase in the tropical night number ($T_{min} > 20\ ^0C$) and in heat wave numbers is also expected. The above days are considered as discomfort, threatening human health within the affected population.

Tab. 1: Modelled values in the selected temperature characteristics in the Capital City of Prague in 2021-2040, 2081-2100 and the 1981-2010 reference period.

Characteristics	**Baseline (1981–2010)**	**2021–2040**		**2081–2100**	
		RCP 4,5	RCP 8,5	RCP 4,5	RCP 8,5
Mean number of tropical days during the year	11.5	14.2	15.4	19.9	38.6
Mean number of tropical nights during the year	0.6	1,2	1.5	2.5	12.1
Mean number of heat waves during the year	5.2	8.3	8.4	11.9	28.1

Data source: CzechGlobe Brno.

1.2.2 Precipitation

Patterns in precipitation are more comprehensive, particularly from a point of view of high variability in annual precipitation totals. It is expected that mean annual precipitation totals shall not be changed, compared with a long-term average from 1981 – 2010. Nevertheless, when stabilizing the precipitation total, l, lower number of precipitation events, but displaying higher extremes is expected. A slight increase in winter precipitation has also been projected for Prague (Fig. 5).

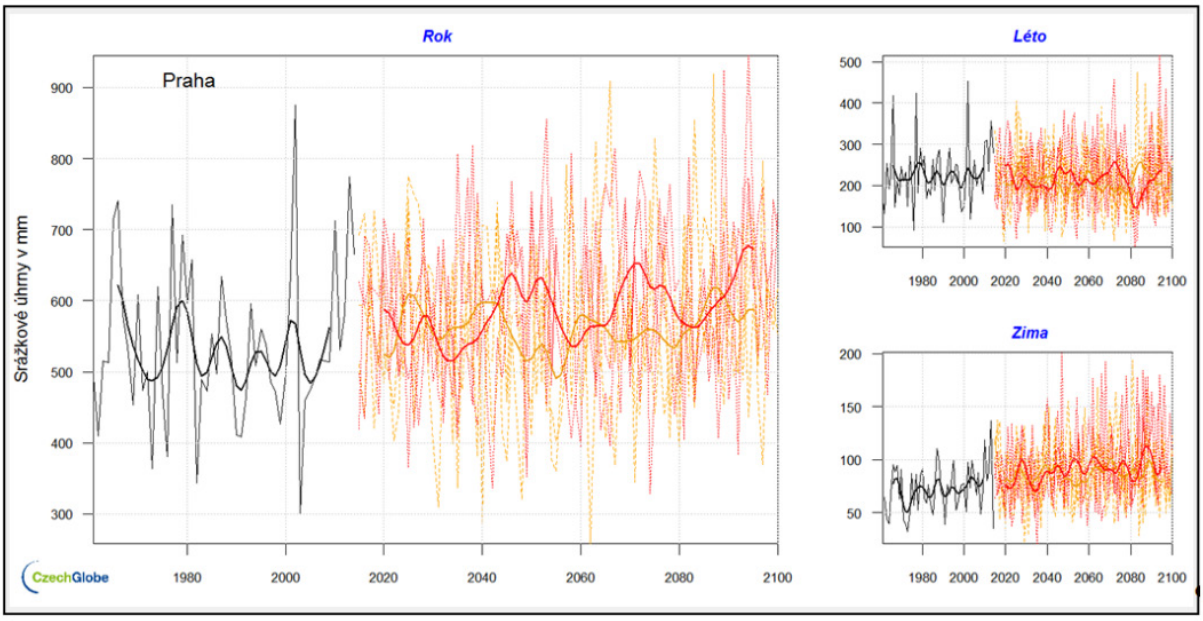

Fig. 5**:** Mean annual precipitation totals in Prague and a prognosis on their development based on EURO-CORDEX climate models (RCP 4,5 – orange colour; RCP 8,5 – red colour)(Source: www.klimatickazmena.cz)

srážkové úhrny v mm – precipitation totals in millimetres; léto - summer; zima – winter.

2. Assessment of vulnerability to climate change effects in Prague including the non-action option

2.1 Heat waves and urban heat island

High temperatures and heat waves clearly damage human health and extreme events can increase mortality within the human population. Increasing heat stress can cause health problems, higher sickness rate and mortality in sensitive groups of people, particularly elderly citizens, people suffering from cardiovascular and respiratory diseases and babies/small children.

Due to extreme temperatures labour efficiency has been decreasing and driver attention has also been declining; the latter can lead to higher accident rate. Extremely high temperatures might negatively affect economic performance and result in declining human well-being.

Future development scenarios show increase in vulnerability of citizens, particularly in the Prague downtown (*i.e.* Prague 1, Prague 2, Prague 3, Prague 4, Prague 7, Prague 10 and Prague 11 city districts). In the above city´s parts, people are more sensitive to heat wave severity affects: the fact is driven by higher proportion of the population older than 65 years and of built-up areas within the individual quarters (see Fig. 6). Analyses take into account future demographic development in the human population there. Generally, more significant heat wave impacts than at present are expected.

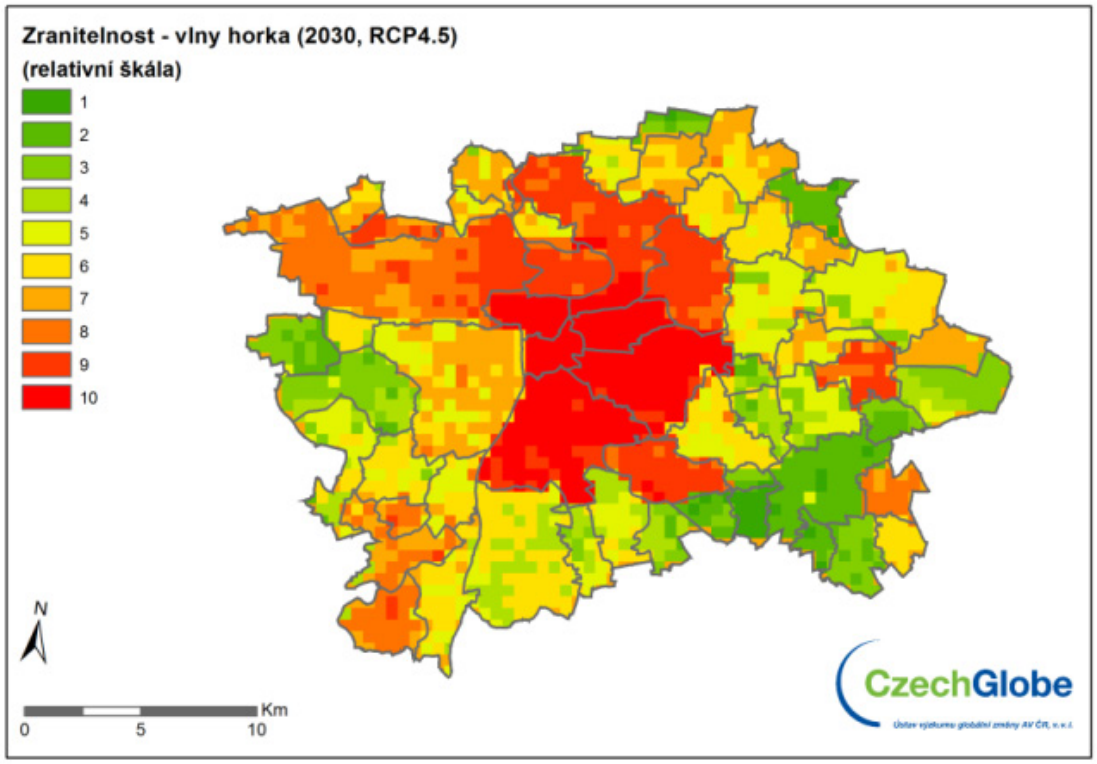

Fig. 6 Vulnerability of the Capital City of Prague inhabitants to heat wave impacts – the near future in 2030 according to RCP 4.5 scenario (stabilizing low CO_2 levels)

zranitelnost – vlny horka – vulnerability – heat waves; relativní škála – relative scale

2.2 Floods and insufficient rainfall water infiltration

The City of Prague has been threatened by two flood types:

- Floods caused by long-term regional rains in spring and summer, occurring mostly on the Vltava and Berounka rivers (the so-called river floods).
- Torrential floods on smaller watercourses in Prague caused by short-term highly intensive rainfalls affecting small areas (the so-called flash floods).

In the past, namely in 1830-2013, the City of Prague was affected by a lot of floods on the Vltava River (see Fig. 7). After the floods in 2002, the flood prevention and control facilities were built in Prague, helping to protect and save lives and properties of Prague citizens. In the future, stronger river flood impacts in West and Central Europe, thus in the Czech Republic, have been expected.

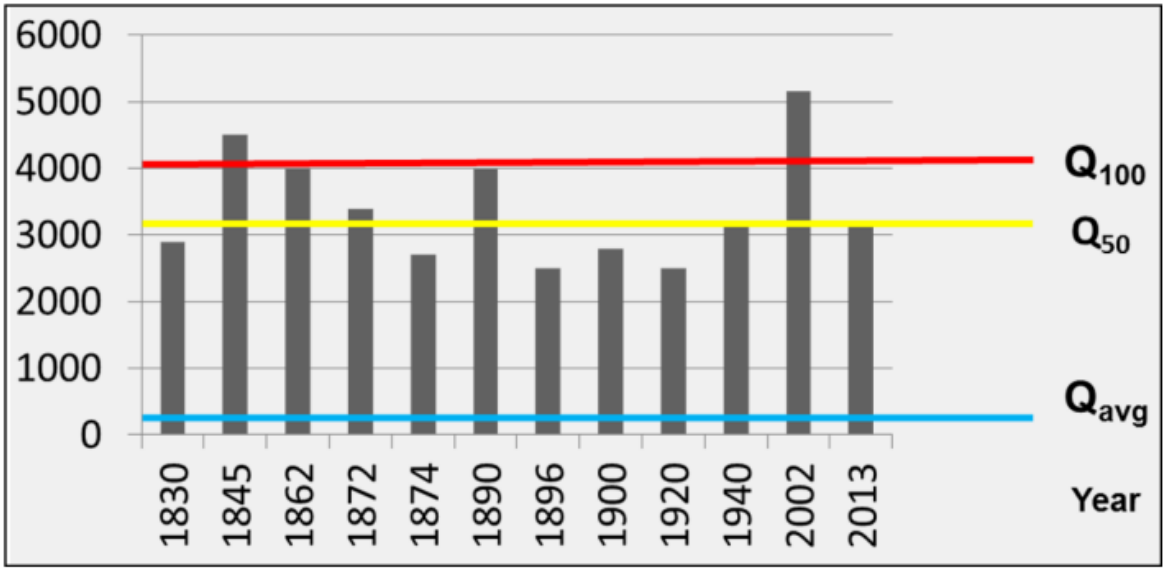

Fig. 7 Floods on the Vltava River in 1830-2013 (source: Department of Environmental Protection, Capital City of Prague Municipal Office)

Short-term highly intensive rains usually influencing small areas can cause torrential or flash summer floods. Insufficient water infiltration often results in flash floods, small watercourses can abruptly overflow or a sewage system can be filled and clogged, particularly in towns and cities: there is high proportion of surface displaying low water permeability there, causing a quick surface rainfall water runoff. Therefore, from the above point of view increasing in infiltration areas and polders is among the crucial measures in towns and cities.

Flash floods are characterized by a very quick increase in water level and consequently, by a very quick decrease in it. In addition to high intense rains, a current state of soil saturation by previous rainfalls, ability to infiltrate water and to capture and retain it and vegetation cover type play a very important role there. During flash floods, rainfall high intensity does not provide time necessary to infiltration of water

into the soil. Thus, almost immediately after beginning of rain a water runoff occurs. Flash flood impact is pronounced more in urban areas with high proportion of paved surfaces not being able to retain water and having been drained by a sewage system into small watercourses.

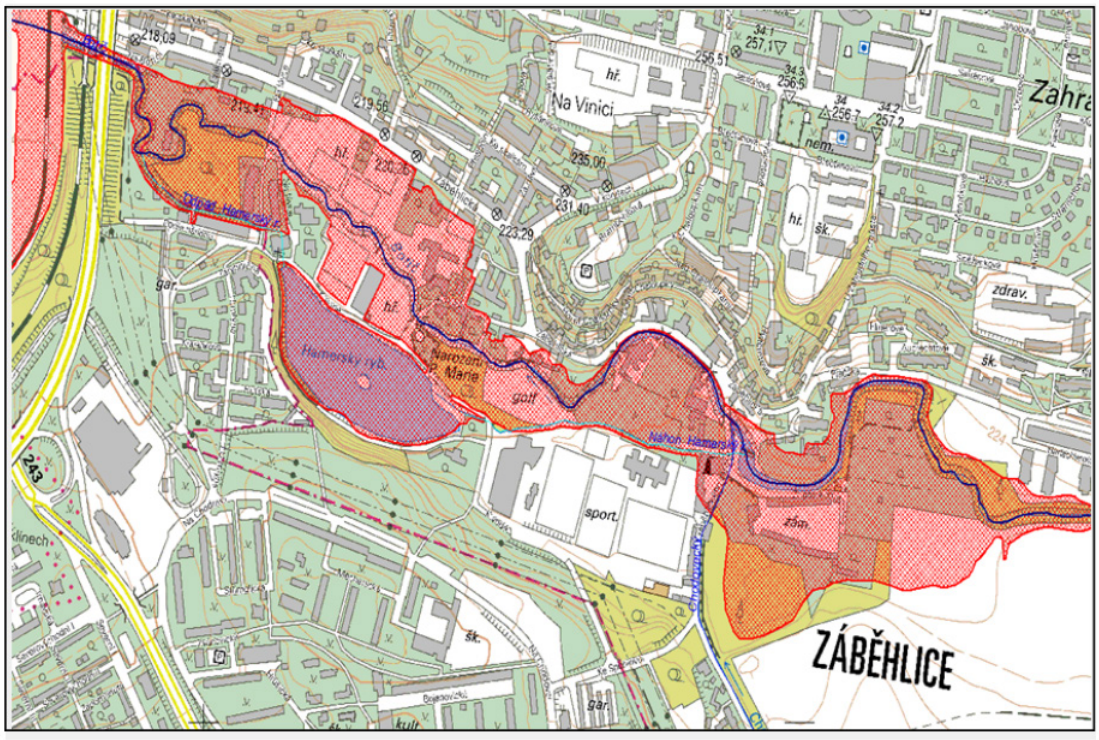

Fig. 8**:** Floods and flood spill area on the Botič Brook in Prague in 2013

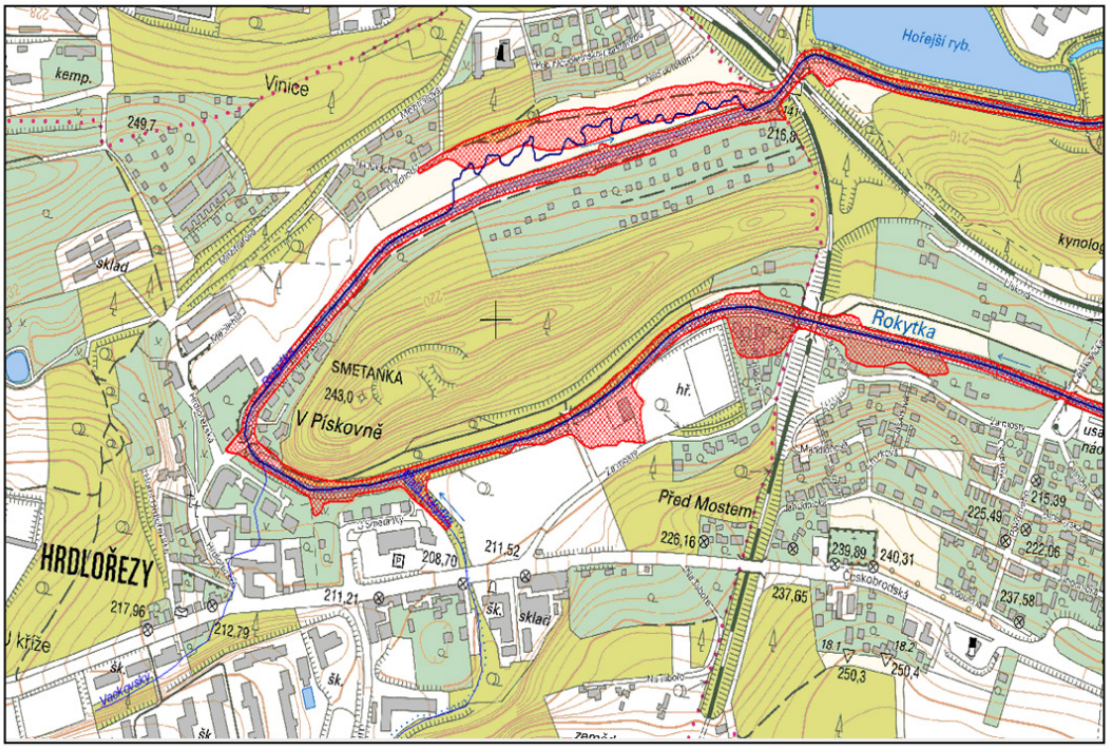

Fig. 9: Foods and flood spill area on the Rokytka Rivulet in Prague in 2013

Ability to forecast torrential floods is strongly limited, due to high dynamics in conventional cloudiness where torrential rainfalls are formed. Although meteorological conditions for creating strong torrential rainfalls can be successfully forecasted, the particular site, duration and intensity in torrential rainfalls and thus a threatened area cannot be exactly and precisely predicted.

2.3 Drought

Drought results from a long-term period with lack of rains which in addition can significantly be enhanced by above average air temperatures and consequently by increased water evaporation. Drought impacts on the landscape are not only a simple output of meteorological event processes, but they mostly reflect landscape management and adverse effects of soil degradation and permanent assignment of land to non-agriculture use. As a result of current management practices in farmland and in forests as well as enlargement of built-up areas with a quick surface rainfall water runoff, infiltration ability has decreased in the landscape. Therefore, landscape water retaining capacity has also decreased. Thus, rainfall-runoff relationship, measured by runoff coefficient (a dimensionless coefficient relating the amount of runoff to the amount of precipitation received) has been changing. Increase in the water retaining capacity drives not only the occurrence of the drought periods, but also floods and heat process degradation in the landscape. Not surprisingly, the microclimate as a whole has been degraded. Quick water runoff decreases amount of water in soils and in the particular periods, it can cause also decrease in underground water level compared with the standard conditions.

Due to lengthening and more frequent drought periods, surface water resources allocated for treatment to produce drinking water can be declining: the fact can threaten drinking water sources. If water resources in dams/water reservoirs are decreasing caused by increased evaporation, in addition to contamination by bacteria and viruses, human health can be negatively influenced.

Drought effects:

- Increase in underground water level, drying water wells and springs;
- Increased evapotranspiration (total evaporation), drying soils and wetlands;
- Drying watercourses;
- Eutrophication, worsened conditions for living and reproduction of water animals, declining in ability of watercourses to dilute domestic sewage and wastewater;
- Surface water oversoaking, phytoplankton and zooplankton growth, biodiversity declining and loss;
- Increased water consumption requirements – agriculture, watering in gardens, difficulties in providing inhabitants with drinking water, increased requirements for raw water treatment;
- Dried out soil surface and soil erosion;
- Increased tourism capacity – increased surface water quality and water reservoir drying.

2.4 Climate change impacts in Prague: A summary

In Prague, climate change has been manifested by air temperature increase, increase in urban heat island impacts and increased number of heat waves. According to climate models, the impact shall be even deeper in future.

Annual precipitation totals are to be similar to current ones, but winter precipitation totals are predicted to increase, while summer ones are to decrease. The number of days without precipitation and that of drought period days shall significantly increase. Higher intensity and more pronounced extreme fluctuations in torrential rainfalls as well as frequency and length in the periods without precipitation and in droughts have also been projected. Frequency and intensity have also been increasing in other extreme weather events (*e.g.*, thunderstorms, hailstorms or strong winds).

In the urban environment of the Capital City of Prague, these events are particularly related with following impacts:

- Higher frequency in heat waves and their longer duration enhanced by the urban heat island effect;
- Flash floods in small urbanized stream basins, supported by a high proportion parcels/plots with a quick surface rainfall water runoff;
- Drought (hydrologic, biological/agricultural, socio-economic).

More detailed data provided by the study (Analysis and projection of climate change impacts in Prague, CzechGlobe 2016) are available at www.portalzp.eu.

2.4.1 Non-action option: no adaptation measures will be adopted

Due to future demographic development in the Prague population and increasing number of days with extremely high temperatures it can be expected that heat wave impacts shall be more severe than at present.

If measures to improve microclimatic conditions in the affected areas are not step-by-step implemented, the following effects should be expected:

- Extreme temperatures and lower air quality will pronounce heat wave impacts on human affecting larger areas and thus higher proportion of human population in the Capital City of Prague.
- High temperatures and more frequent drought periods will negatively influence vegetation which will become degraded and will even step-by-step vanish in the periods characterized by lack of water.

- For sensitive groups in the population, *e.g.* seniors/elderly citizens, babies/small children and sick persons, living and movement in a hot heated city will pose a health risk.
- Mitigating extreme temperature by air-condition is another source of anthropogenic heat also increasing a heat load in Prague.
- Flood risk including that of flash floods in small urbanized stream basins, supported by a high proportion of parcels/plots with a quick surface rainfall water runoff will be further increasing.
- On the other hand, there will be more frequent longer drought periods strongly influencing water sources in watercourses and soils as well as underground water quantity. Lack of water can threaten providing inhabitants with drinking water and water abstraction for industry and irrigation.
- High temperatures, drought and low water availability will negatively influence vegetation which will become degraded, thus worsening the unfavourable environment in Prague.

Elaboration and consequent implementation of suitable adaptation measures can step-by-step mitigate the adverse effects and create satisfactory living conditions for Prague inhabitants.

3. Capital City of Prague Climate Change Adaptation Strategy vision

3.1 Adaptation strategy vision

Enhancing a long-term resistance and reducing vulnerability of the Capital City of Prague to climate change effects by step-by-step implementation of suitable adaptation measures, preferably by implementation of nature-based solutions combined with grey, i.e. technological, and soft measures, thus providing the Czech Republic capital´s inhabitants with high well-being.

To deliver the vison of enhancing the resistance and reducing vulnerability to negative climate change effects, particularly those of high temperatures, urban heat island and heat waves and insufficient rainfall water infiltration it is reasonable to apply nature-based solutions[1], using ecosystem services[2] provided by blue and green Infrastructures.

The green infrastructure[3], consisting of all greenery types in the landscape, cools naturally its neighbourhood by providing shade and evapotranspiration. The cooling effect is the highest in woody plants, particularly in full-grown trees, if there is a sufficient underground water source.

For evapotranspiration by vegetation, water availability is necessary: thus, favourable conditions for vegetation elements trough providing water availability in soil layers should be improved by the blue infrastructure[4].

For stabilizing the hydrological cycle, it is reasonable to support water infiltration and retention at the site where they have reached the ground by introducing water permeable and semi-permeable patches and establishing sites allocated for rainfall/storm water retention and

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[1] Nature-based solutions use ecosystem services provided by the Green and Blue Infrastructure.

[2] Ecosystem services – processes and conditions in natural ecosystems, supporting human activities and maintaining the human civilization on Earth. They are a set of ecosystem functions beneficial for humans. They include various benefits, provided by nature to humans (photosynthesis, soil forming, water retention in soils, positive effects on human health, forming aesthetically valuable environment, production functions, *etc.*).

[3] Green infrastructure – a set of semi- natural and man- made structures that provide directly or indirectly multiple benefits to society which we have used to call ecosystem services (see above) and support and improve ecological functions. In other words, it is a strategically planned network of natural and semi- natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It includes both a protected area network and the non-reserved landscape outside protected areas including various greenery sites/areas in human settlements, from green roofs and greenery belts to urban parks of various size. Therefore, the green infrastructure concept consider land-use/territorial planning as a key tool allowing multi-purpose use of the landscape. In broader sense, the Green Infrastructure also covers water areas.

[4] Blue infrastructure consists of water elements, such as watercourses, water bodies, other wetlands, springs, wells, water infiltration vegetation belts, *etc.*, helping to retain water in the landscape and slowing rainfall runoff from the particular area. The blue infrastructure supports water availability for the green infrastructure in towns and cities.

accumulation, *i.e.* polders, water reservoirs, artificial wetlands and other Blue Infrastructure components.

Reducing solar radiation accumulation in urban environment can also be reached by using reflective materials and colour, if appropriate.

Ecosystem services provided by the green infrastructure include other benefits, such as air quality improvement, improvement in human health, providing space for recreation/leisure and sports, *etc.*

For more details on cooling effect provided by vegetation and green infrastructure benefits, see Annex IV - Primary information.

If ecosystem services cannot be used or are ineffective for mitigating the particular climate change effect, it is necessary to apply technological or grey solutions.

Other proposed soft measures help to enhance human society as individual inhabitants´ resistance by protecting them against climate change risks through early warning, communication, education and public awareness/environmental education, *etc.*

The proposed Capital City of Prague Climate Change Adaptation Strategy follows other pan-European, EU, national and Prague policy documents, presented in a table in Annex I - List of policy documents related to the Capital City of Prague Climate Change Adaptation Strategy. It also elaborates the Strategic Plan for Prague (2016) and a table showing compliance of measures proposed by the Adaptation Strategy with the Strategic Plan is a part of the Annex II - Tables on measures proposed and a table on the Strategy compliance with the Strategic Plan.

4. Main and specific targets in the City of Prague Climate Change Adaptation Strategy and a proposal on adaptation measures

4.1 Main strategic target

Enhancing Prague´s long-term resistance to climate change effects

Analysis of the current state and projections of climate change effects in the Capital City of Prague by 2030 as well as city´s vulnerability assessment is a background for proposal of climate change adaptation measures aiming at enhancing city´s resistance with the specific targets.

4.2 Specific targets

A: Enhance microclimatic conditions in Prague and reduce the adverse impacts of extreme temperatures, heat waves and urban heat island on Prague inhabitants;

B: Reduce extreme hydrological event impacts, *i.e.* torrential floods, floods and long-term droughts on the Capital City of Prague´s territory as well as in the adjacent landscape in the Prague Metropolitan Area;

C: Reduce energy performance in Prague incl. adaptations in buildings;

D: Enhance Prague´s preparedness in risk management;

E: Enhance conditions for sustainable mobility in Prague;

F: Enhance conditions in communication, education and public awareness/environmental education, support monitoring of and research on climate change impacts.

A. Adaptations to increasing temperatures, urban heat island and heat waves

A.1 Specific target

Enhance microclimatic conditions in Prague and reduce the negative impacts of extreme temperatures, heat waves and urban heat island on Prague inhabitants

A.2 A brief description of projected climate change impacts

In Prague, mean annual air temperature has for long term been increasing and climate models project an increase in the tropical day number ($T_{max} > 30\ ^0C$) as well as in tropical night number ($T_{min} > 20\ ^0C$). For more details, see the study Analysis and projection of climate change impacts in Prague, CzechGlobe (2016) available at www.portalzp.eu.

In the downtown, densely built-up area impact on air temperature and thus intensification of urban heat island can be documented also by Landsat-8 satellite images, They show where the air is the hottest and therefore wherever it is desirable to implement measures to mitigate the urban heat island effect, to enhance then respectively (see Fig. 10).

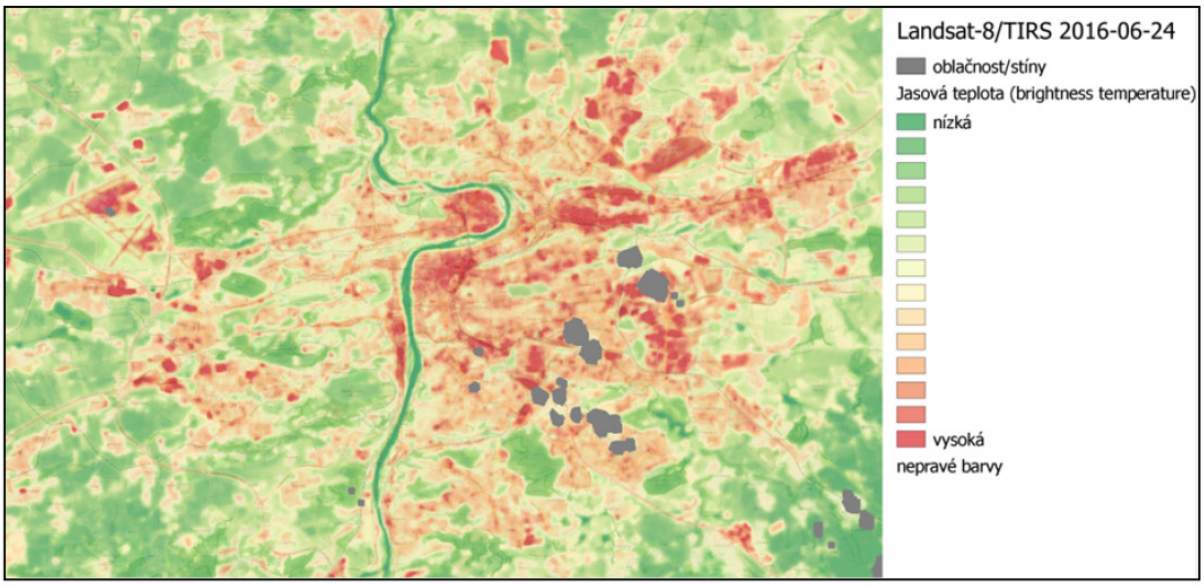

Fig. 10: Brightness temperature in Prague, June 24, 2016 at 12.00 (Source: Landsat-8.)

oblačnost/stíny – cloudiness/shades; nízká - low; vysoká - high; nepravé barvy- spurious colours.

A.3 Vulnerability and challenges

Increase in vulnerability of citizens, as shown in Chapter 3.1., can be expected particularly in the Prague downtown (*i.e.* Prague 1, Prague 2, Prague 3, Prague 4, Prague 7, Prague 10 and Prague 11 city districts). At the same time, higher sensitivity to heat wave impacts is more pronounced there, driven by

higher proportion of the population older than 65 years and of built-up areas within the individual quarters.

Suitably selected and well-located adaptation measures can enhance heat comfort, mitigate adverse impacts on human health and thus improve human well-being also in other city´s densely built-up areas.

For more details on projected climate change impacts, risk and Prague´s vulnerability assessment, see the study Analysis and projections of climate change impacts in Prague, CzechGlobe (2016) available at www.portalzp.eu.

A.4 Proposed measures

Below proposed measures A.4.1 to A.4.7. for adaptation to increase in temperatures, urban heat island and heat waves are interlinked and positively influence also meeting the Specific target B (Reduce extreme hydrological event impacts, *i.e.* torrential floods, floods and long-term droughts on the Capital City of Prague´s territory as well as in the adjacent landscape in the Prague Metropolitan Area).

A.4.1 Enhance the city´s microclimatic conditions by multi-functional green infrastructure

Adverse impacts of high temperatures, urban heat island and waves can be mitigated by nature-based solutions, using the green infrastructure.

The green infrastructure, consisting of all greenery types in the landscape, cools naturally its neighbourhood by providing shade and evapotranspiration. The cooling effect is the highest in woody plants, particularly in full-grown trees.

Increase in vegetation elements and green spaces proportion and their functional connectivity in an urbanized areas offer in addition to cooling effects other ecosystem services, *e.g.* positive effects on human health and on air quality. It also provides space for recreation/leisure and sports, enhances environment aesthetical perception quality and is a provider of other benefits.

For more details on green infrastructure and cooling effects provided by vegetation, as well on other benefits from green infrastructure, see Chapter 3 and Annex III – Primary data.

Recommended measures:

- Elaborate and adopt a green infrastructure strategy including the appropriate policy.
- During the green infrastructure planning, delineation and creation and in line with its multi-functional role aim at its positive effects on the city´s microclimate: therefore, current knowledge of the topic should be applied in practice.
- The individual measures effective from a point of view of climate change mitigation should not be applied separately, but together with other green infrastructure´s functions, *e.g.* through enhancing permeability in the individual green infrastructure spaces and their connectivity with public spaces to support sustainable mobility. Further, it is suitable to support local identity, offer

spaces for fostering social interactions and promoting a sense of community and to provide opportunities for sport activities, all by applying a tailored landscape management.

- Acquire lands to be owned by the Capital City of Prague´s for keeping key functions of the green infrastructure and of the Territorial System of Ecological Stability, a multi-level ecological network being established across the whole Czech Republic.
- Use the Capital City of Prague´s legal rights to initiate changes in legislation to allow, according to land-use set up by a land-use/territorial plan to without charge sign over lands having been owned by the Czech Republic to the municipality´s ownership for green space enlargement. Further, it is necessary pursuant to the valid land-use/territorial plan to establish new green spaces and enlarge the existing ones on lands owned by the State (the State Land Office or other governmental authorities).
- Provide the multi-purpose green infrastructure with sustainability and long-term high quality management.

A.4.2 Take into account climate change adaptations in planning and background study elaboration

Greenery, particularly trees, forests and parks, is a natural tool for cooling densely built-up areas in the Prague´s downtown. Analysis on air ventilation can display further possibilities for better air ventilation as well as connectivity between urban and suburban landscapes.

Recommended measures:

- Elaborate an analysis on air ventilation in Prague and on urban heat island distribution across the city.
- According to the outputs of the above analysis, delineate the current green spaces including parks, forests or slopes for better air ventilation in the city. Continue in enhancing the green belt concept (landscape divide or interface), to propose new green spaces to improve air ventilation in the Prague´s downtown. At the same time, it is necessary to take into account visual quality at the respective sites/areas and to provide functional connectivity between the urban and suburban greenery. To initiate in this respect the appropriate amendments to the current pieces of law.
- Ensure an environmentally friendly development in the suburban landscape, *e.g.* by establishing or managing suburban parks for use for recreation/leisure by local people and for sustainable suburban landscape development.
- Delineate, establish and manage greenery components and sites/areas within the city and outside it in relation to open public spaces and a network of hiking trails and bicycle paths or bikeways.

A.4.3 Establish and restore vegetation components in the city

For providing favourable microclimatic conditions on Prague open public spaces, priorities have to be set for restoration of vegetation components, particularly alleys and open spaces, and investment into green, blue and grey/technological infrastructure should be coordinated.

Recommended measures:

- Carry out an analysis of sites with lack of vegetation components and green spaces in Prague, particularly in areas where urban heat island can newly occur.
- Enhance quality and quantity of vegetation components on open public spaces and other sites/areas and thus, mitigate the urban heat island effect. Protect air quality and provide inhabitants with the pleasant and high-quality environment. Enhance positive effects of greenery on physical and mental health of city´s inhabitants.
- Establish new parks and restore the existing ones as well as other green spaces, particularly at sites or in areas where they have been missing or lacking, taking into account the urban heat island distribution across the capital City of Prague.
- When elaborating policy documents, seek for using in a proper way vegetation components. Develop guidelines for more use of suitable vegetation components, particularly in areas where is higher risk of new urban heat island occurrence, if this approach is supported by local conditions and does not contradict natural heritage management commitments.
- Seek for possibilities to establish and restore street alleys and avenues and set up priorities for investment into alleys on the selected streets, taking into account their designation within the Strategic Plan for Prague.
- Provide a functioning and targeted coordination of green, blue and grey infrastructure managers for planning and building including the procurement procedure for project files and documents. Provide coordination in city´s investments into the green infrastructure.
- Update a methodology and guidelines for expert assessment on selection of resistant against climate change to be implemented under current conditions in the Capital City of Prague, particularly on streets and paved surfaces. In collaboration with a landscape architect, test new species, tree cultivars respectively, for such conditions. When selecting suitable sites, tree species and tree management measures the specific urban conditions and project climate change impacts (higher temperatures, more frequent drought periods) should be taken into account.
- When establishing and restoring underground utility constructions and other technological and transport infrastructure on the city´s streets, provide trees in alleys and on open public space with space enough for root growth. Coordinate the Capital City of Prague´s investnet schemes during technological utility streamlining on the selected streets, particularly schemes on building collectors or data network multichannels, to allow further consequent planting or restoration of alleys.

- Wherever appropriate, build on the city´s avenues multichannels for streamlining telecommunication cables and optimally also power cables managed by the city, to free up space under pavements.
- Provide high quality background documents for developing management plans, *e.g.* updated dendrological surveys and inventories and general spatial studies/policy analyses of greenery structure and diversity with respect to the projected climate change impacts.
- Support establishing gardens, parks and other vegetation components and areas in inner courtyards and to develop guidelines for establishing them.

A.4.4 Provide unified street greenery and alleys management

Street vegetation and alleys management in Prague display at present quite complicated and fragmented approach in urban greenery management caused, *inter alia*, by different competences of the individual managers and by non-unified commonly agreed methodology. By introducing integrated street vegetation management, it shall be possible to conduct assessments, setting categories and elaborating and implementing management of street vegetation just in the field, including capital investment evaluation and costs spent on alleys management and restoration.

Recommended measures:

- Update guidelines for integrated street greenery management.
- Update and consolidate street greenery management guidelines across the whole Capital City of Prague´s territory based on new requirements and the best science available and knowledge of climate change impacts (increases in temperatures, more frequent drought periods). To the current target vegetation, add new vegetation types, *e.g.* green areas/swards on tram routes.
- Provide unified compatible background documents for developing management plans, *e.g.* updated dendrological inventories & surveys and general spatial studies/policy analyses of greenery structure and diversity) taking into account the projected climate change impacts.
- Update guidelines for financial support to street greenery and alleys planting.
- Using the Capital City of Prague´s legal rights to initiate changes in legislation to allow introducing a unified management of the open landscape that should not be built-up, *e.g.* suburban park management.

A.4.5 Create the conditions for suburban and urban agriculture development as a climate change adaptation

Support to building and restoring semi-public and semi-private open spaces (community and allotment gardens) allows increasing the extent and quality of green infrastructure components and enhancing microclimatic conditions in the Capital City of Prague.

During the development of the city recreation/leisure and economic activities should be supported that can be implemented in parks and in the suburban landscape. They need minimum building and technological equipment: thus, they can be carried out in gardens, orchards and pastures.

By supporting suburban and urban agriculture development, an alternative to prevailing intensive agriculture carried out on extensive field and soils units can be offered. Therefore, conditions for more extensive environmentally friendly crop production or livestock breeding are provided. Such production is intended for partial self-supplying and supplying local and safe food.

Recommended measures:

- Update general study on allotment gardens in Prague.
- Maintain the tradition of allotment gardens and develop new ones, wherever appropriate with respect to location and state of the environment. Elaborate guidelines, targets and principles of their further development, keep on the large possible scale the original character and productive use of allotment gardens and prevent their uncontrolled changes in permanent housing facilities.
- Support organic farming and other agricultural production friendly to soils, the landscape and biological diversity including transforming arable land into permanent grasslands.
- Support establishing community gardens and temporary community gardens with the specified permitted period of their functioning
- Support community management of vegetation, *i.e.* green infrastructure components on public spaces.
- Support agricultural activities maintaining and forming the diverse and biologically valuable landscape and enhancing the short hydrological cycle in the particular area.
- Include the issue of allotment and community gardens into communication, education and public awareness/environmental education projects, programmes and campaigns (*cf.* Subchapter F.4).

A.4.6 Enhance ecological stability/ecosystem health and self-restoration/recovery ability in the landscape

Landscape permeability and fragmentation significantly influence health of the landscape and its ability to recover because it reduces movement and dispersal of organisms within the landscape, thus degrading their life cycles and the whole ecosystem. Preventing further landscape fragmentation and other degradation allows to maintain and restore ecosystem services and to contribute to better ability of ecosystems to adapt themselves to climate change impacts.

Recommended measures:

- Protect, conserve, manage and enhance biological diversity in the urban environment: the efforts are one of the coordinated development and vegetation management targets in the Capital City of Prague.
- Complete step-by-step the Territorial System of Ecological Stability (TSES) missing components with establishing new ones, manage in a proper way the existing ones, thus providing ecosystem functioning in the particular area given by valid land-use/territorial planning documentation.
- Create and restore landscape elements and protect and conserve the existing Significant Landscape Elements (SLE) and provide them with effective management, plant non-productive forests, establish orchards, permanent grasslands, *etc.*
- Support establishing unbuilt natural areas being transition/buffer zones between the built-up area and the selected Specially Protected Areas and the Sites of European Importance (pursuant to Act No. 114/1992 Gazette on the Nature Conservation and Landscape Protection, as amended later, the term for Site of Community Importance, SCI under the European Union's Habitats Directive).
- Monitor resistance in vegetation and wild animal populations against climate change as well climate change impacts on fauna and flora, using, *inter alia*, citizen science.
- Prevent spreading invasive alien plant and animal species across the landscape.

A.4.7 Use technological and ecosystem measures to reduce solar radiation accumulation in built-up areas

For reducing solar radiation absorption and accumulation in buildings and on paved surfaces, it is reasonable to use materials and colours reflecting and not accumulating solar radiation. Surface temperature measurements on building facades and the streets at the crossroads of Communards and Workers Streets (Prague 7) display higher solar radiation absorption of colour frontages than white and light paints.

Recommended measures:

- Develop guidelines on technological measures, materials and colours reflecting and non-accumulating solar radiation.
- Elaborate recommendations on nature-based solutions, using green and blue infrastructures (infiltration strips and belts and gravelly drains, rainfall retention through water permeable and semi-permeable surfaces) and on proposed vegetation components on open public spaces allowing cooling by vapour, evapotranspiration respectively.
- For reducing heat accumulation in city´s built-up areas, analyse possibilities provided by green and blue infrastructures and introduce their other elements, *e.g.* green roofs, facade greenery, drinking fountains, fountains, springs, wells, man-made wetlands including water courses, *etc.*

B. Adaptation measures to reduce impacts of torrential rainfalls, floods and long-term drought on the Capital City of Prague´s territory

B.1 Specific target

Reduce extreme hydrological event impacts, *i.e.* torrential floods, floods and long-term droughts on the Capital City of Prague´s territory as well as in the adjacent landscape in the Prague Metropolitan Area

B. 2 Brief description of projected climate change impact in hydrological cycle

B. 2. 1 Torrential rainfalls and changes in rainfall distribution

Research having been carried out up to now suggests that rainfall distribution in time and space will also be changing on the capital City of Prague´s territory although a significant change in precipitation totals has not been projected. Frequency, intensity and duration of extremely weather and climatic events (torrential rainfalls, floods or on the other hand periods without precipitation or droughts) will possibly be increasing in Prague.

Because of the projected increase in temperature vapour or evapotranspiration: water level can consequently decline while water temperature would be increasing in watercourses and water bodies or reservoirs. Therefore, soil humidity can decrease and reduce underground water resources.

B.2.2 Floods

As presented in Subchapter 3.2., the Capital City of Prague has been threatened by two flood types. The floods mostly on the Vltava and Berounka rivers have slower arrival, thus allowing to prepare preventive measures against floods including installing mobile facilities or to evacuate people from the affected areas, *etc.*

In the Capital City of Prague, summer floods caused by short-term highly intensive rainfalls, *i.e.* torrential floods, affect relatively small areas along smaller watercourses and display a very quick increase in water level. Forecasting particular location, duration and intensity of torrential rainfalls and emergence of flash floods has been strongly limited yet.

B.2.3 Drought and soil & underground water loss

The drought emerges as a result of long-term lack of rains when higher temperature causes higher evapotranspiration. In summer, at the same time discharges in watercourses can temporarily decrease and water quality declines in watercourses and water reservoirs or other bodies. During the drought period, soil and underground water availability for vegetation also decreases.

B.3. Vulnerability and challenges

B.3.1 Vulnerability to floods

In the urban landscape, floods pose a lot of adverse effects, *e.g.* threatening human lives, health and properties of citizens and negatively effecting economic activities, water management, agriculture (negative effects are particularly caused by torrential floods and related soil erosion), transport, industry and energy, cultural heritage and temporarily also tourism. Therefore, effective flood prevention requires continuing development and enhancing the integrated joint rescue system.

After floods in 2002, the Capital City of Prague built flood prevention and control system, consisting of 19.225 kilometres of flood prevention and control defences made of reinforced concrete walls, earthworks and flood prevention and control barriers being almost 7 kilometres long. Measures in sewage and sewer network also became an integral part of the system. Possibility to enhance flood prevention and control measures in other areas has been still considered.

Prevention is a precondition to mitigate flood impacts: it includes, *inter alia*, integrated settlement unit planning, consistent decreasing in possible damages extent or magnitude in flooded areas, developing and updating flood prevention and control plans, enhanced forecasting systems, local warning systems, adaptive crisis and emergency management, technological flood prevention and control measures in built-up areas and related components of measures to provide citizens with safety.

B.3.2 Vulnerability to drought periods

Longer and more frequent drought periods can decrease surface as well as underground water resources that can result in long-term lack of water in the landscape, thus threatening drinking water sources. Lack of rains can also negatively affect industry and agriculture.

The Capital City of Prague is provided by drinking water from the Želivka and Káraný water treatment plants and in the case of emergency or as a fall back, also by the Podolí water treatment plant. The drought period can temporarily decrease surface and underground water sources allocated for drinking water treatment or can threaten its high quality.

Therefore, it is desirable to introduce measures to manage water and water sources more reasonably and to develop indicators to identify time when the suitable measures should be applied in the field.

Rainfall water infiltration, retention and accumulation should be preferably enhanced by applying nature-based solutions (green and blue infrastructure), *e.g.* restoration of the selected stretches of Prague watercourses in the course of the Brooks for Life project.

If nature-based solutions cannot be applied or are ineffective, suitable technological solutions (the so-called grey infrastructure*), e.g.* building water reservoirs, introducing rainfall water storage tanks, using water infiltration facilities, *etc.* will be used.

B.4. Recommended measures

B.4.1 Flood prevention and control on the Vltava and Berounka rivers and on other watercourses on the Capital City of Prague´s territory

The measures aim at saving lives and properties on the Vltava River by building flood prevention and control facilities and examining their complementation.

When preferably using nature-based solutions, flood prevention and control measures can be implemented, thus providing stable water regime along the watercourse total length and across the whole Capital City as well as the whole Prague Metropolitan Area. If nature-based solutions cannot be applied or are ineffective, it is reasonable to use suitable technological solutions (the so-called grey infrastructure*).*

Measures recommended for flood prevention and control on the Vltava and Berounka rivers

- Complete flood protection measures on the Vltava River wherever it is effective.
- Examine other flood prevention and control possibilities in the Capital City of Prague including assessing effectiveness of flood prevention and control on the Berounka River downstream. Studies, analysis and models available have shown that building flood prevention and control facilities in the Lahovice and Lahovičky quarters would be totally ineffective. Moreover, possibility to introduce more flood prevention and control measures in the Troja quarter, namely within the Troja Basin, Lipence and Zbraslav have been considered. Other measures under preparation include the Rokytka pumping station and Maniny polder enhancement and building a retention reservoir on the D sewer overflow protection device.
- Carry out regular checks, working tests and maintenance in flood prevention and control facilities.

Measures recommended for flood prevention and control on other watercourses on the Capital City of Prague´s territory

- Analyse and support measures and projects enhancing flood prevention and control effect in the landscape on the Capital City of Prague´s territory and within the whole stream basins.
- Enhance building small water reservoirs, both retention and accumulation ones, on the small watercourse upper parts on the Capital City of Prague´s territory and its neighbourhood wherever it is effective and to support such efforts. To support small water reservoir restoration.
- Avoid building-up the flooded areas in Prague.

B.4.2 Enhancing rainfall water management

Measures aim at providing drainage of the city´s urbanized parts in the way similar to the natural hydrological cycle, particularly by decentralized facilities, accumulating, infiltrating, evaporating or cleaning rainfall water close to a site where rain falls on the surface instead of a quick surface rainfall water runoff to watercourses by a sewage network.

The measures can affect surface water quality because decreasing the amount of ballast water entering a waste-water treatment plant: thus, there will be less water coming from the sewage system to individual watercourses or streams.

Due to various approaches among infrastructure managers how to deal with rainfall water introducing the measures based on current legal and standard requirements into practice has becoming more difficult.

Therefore, it will be necessary to introduce unified rules stimulating better rainfall/storm water management including consideration of possible imposing of fees on rainfall/storm water draining, at the same introducing incentive measures to subside all facilities retaining rainfall/storm water and allowing its infiltration.

Recommended measures:

- Elaborate a study on possible risk torrential rainfalls and on their impacts on the Capital City of Prague territory.
- Continuously update and review rainfall and runoff models of the Prague´s territory itself as well as of the Metropolitan area.
- In cooperation with the respective public service authorities, sewage network managers and expert/technical bodies, consistently enforce the rainfall/storm water management strategy and to monitor water rainfall management effects according to the principles provided by the Strategic Plan for Prague, or propose its amendment respectively.
- Support changes in legislation dealing with rainfall water management including consideration of possible imposing of fees on rainfall water draining which would positively motivate water rainfall accumulation and infiltration.
- Assess and eventually update standards for water management, construction and transport buildings on the city´s territory where the rules are set up to allow to in proper way and in coordination apply rainfall/storm water management principles.
- Coordinate activities of infrastructure managers in applying existing and proposed measures in practice.
- Support communication with, education and public awareness of citizens and public and private bodies on rainfall water management principles (*cf.* Subchapter F.4).

B.4.3 Implementation of measures aiming at slowing surface water runoff from the landscape and erosion prevention

The measure deals with rationalization in rainfall water use by infiltration, retaining water drained by open drainage elements and introducing appropriate rainfall water management including reuse of that water.

Through applying measures to slow surface water runoff from the landscape, adverse effects of flooding urbanized areas during highly intensive rains can be mitigated. In addition, a quick rainfall water runoff to watercourses can also be reduced by the above measures as well as flood risk particularly on small watercourses. At the same time underground water can be supplied and soil loss through erosion reduced, thus protecting agricultural land resources against degradation. The measures contribute to eliminating watercourse contamination and small water reservoirs alleviation by sediments.

Recommended measures:

- Finish studies on possibilities for rainfall water infiltration in the Capital City of Prague.

- Elaborate an analysis on possible natural hydrological cycle restoration and enhancing retention capacity on the Capital City of Prague´s territory and to identify priority areas with respect to the current conditions, *e.g.* soil erosion hazard and risk, degraded hydrological cycle within the target area, low ecological/environmental values, *etc.*
- Examine possibilities of and provide the landscape with continuous natural hydrological cycle restoration and enhance natural retention capacity there through nature-based solutions (watercourse restoration, grassed depression strips, infiltration strips and belts, hedges, wetlands, vegetation along field roads and bicycle paths/bikeways, measures towards elimination of accumulated surface water runoff, *e.g.* grassing or reforestation/afforestation of vulnerable lands, other Blue Infrastructure measures).
- Develop and implement land replotting or land consolidation/reparcelling on agricultural lands within the watercourse basins on the Capital City of Prague´s territory as well as in the Metropolitan Area, *e.g.* measures on slowing surface water runoff from the landscape, erosion prevention and flash flood impact mitigation.
- In coordination with drainage system managers possibly propose civil engineering and technological measures (retention reservoirs on watercourses and on sewer network, dry polders, infiltration facilities and other grey infrastructure measures within the urbanized areas and on watercourses).
- Enhance sustainable production on agricultural lands through promoting suitable agri-technological measures and land management, *e.g.* crop rotation, suitable crop planting considering slope of lands, tillage or ploughing and sowing along contour lines, *etc.*

B.4.4 Continuous changing paved water impermeable surfaces into water permeable and semi-permeable ones

The measure deals with changing paved water impermeable surfaces into water permeable and semi-permeable ones, the latter allowing reducing solar radiation absorption and accumulation and consequently releasing accumulated heat during the negative energy balance period.

In addition, areas covered with water permeable and semi-permeable surfaces allow enhancing and stabilizing soil humidity and strengthening water infiltration during rainfalls, thus feeding the underground water.

Recommended measures:

- Reduce the proportion of paved surfaces and vice versa, increase that of water permeable and semi-permeable ones. The measure can be implemented *e.g.* in parking or manipulation areas, some transport infrastructure buildings, such as pavements and bicycle paths/bikeways), inner courtyards, squares, *etc.*
- Create new spaces and drainage systems allowing water infiltration, accumulation or retention at the site where rain falls on the surface.
- Elaborate guidelines and recommendations on water impermeable surface adjustments, using, *inter alia*, new technologies, innovations and methods.

- Support introducing green roofs, green strips along tramway tracks and other green infrastructure elements (*cf.* subchapters A.4.5. and C.4.4.).
- Monitor impacts of possible increase in the proportion of built-up and other water impermeable surfaces.

B.4.5 Continuing integrated restoration of floodplains, watercourses and reservoirs

The measure deals with reducing flood risks on small watercourses, providing water facilities with security both during everyday operations and floods and enhancing water management, biological, landscaping and recreation/leisure functions of watercourses and reservoirs.

Recommended measures:

- Within the current Brooks for Life project continue in seeking for suitable sites/areas for comprehensive river landscape restoration including enhancing retention capacity in neighbouring areas (floodplains, talwegs, springs, wells), *e.g.* by their grassing, building pools, planting suitable woody plant species, *etc.*
- Wherever it is possible, put watercourses outside artificial cannels with paved banks back to naturally flowing and meandering beds.
- Pursuant to Article 49 of the Water Act, to provide permanent vegetation growths/vegetation cover on watercourse and fishpond banks.
- Within the current Prague Water Reservoir Restoration project carry out repair, restoration and reconstruction of fishponds and other water reservoirs, remove mud from them, complete missing riparian stands and bank vegetation, manage their neighbourhood according to their multi-functionality and provide them with suitable long-term management.
- Restore watercourse beds and floodplains as well as their functions in both natural and semi-natural areas and in the urban landscape, manage riparian stands and bank vegetation and enhance permeability and accessibility of watercourse banks, implementing the Prague Riverbank Policy.
- Restore springs, wells and waterholes.

B.4.6 Testing possibilities of the current water management infrastructure and providing citizens with drinking water

The measure deals with reliable and effective providing the city with high-quality drinking water, testing the concept of three available drinking water sources (the Želivka, Káraný and Podolí water treatment plants) and necessary technological innovations and enhancements in the above facilities and other possible sources (cf. subchapters D.4.1. and D.4.2.).

Providing drinking water to Prague citizens can be coordinated with the Central Bohemian Regional Office and the Vysočina Regional Office within the whole Želivka river basin and on the Jizera River downstream.

Recommended measures:

- Gather timely data on drinking water sources and underground pipelines on the Capital City of Prague´s territory or enhance them for drinking water treatment.
- Map springs, wells and other underground water sources on the Capital City of Prague´s territory which can be used as alternative water sources. Examine possibilities of their usage including those having been drained into sewage system.
- Minimize loss and leakages in the water distribution system by regular restoration of water mains having been displaying high susceptibility to failure and have almost reached the end of their life cycle.
- Examine water resource sustainable use by water withdrawal for providing citizens with drinking water, industry and agriculture from a point of view of the landscape management.
- Update maintaining minimum streamflow levels under a series of dams and water reservoirs on the Vltava River called the Vltava River Cascade.
- Check minimum streamflow levels on the individual watercourse stretches from a point of view of the permitted withdrawal and consequently to propose measures needed.
- Check alternative solutions in the case if withdrawal cannot be carried out in the period of lack of water.
- Check measures on the sewage system to minimize drainage effects caused by pipes and their packs.

B.4.7 Enhancing landscape permeability and its use in recreation/leisure

The measure deals with improving the landscape permeability pro wild animal dispersal and movement, providing hikers and bikers with free passing the landscape and promoting more extensive use of the landscape in citizens´ outdoor recreation/leisure activities of citizens.

Recommended measures:

- Enhance landscape permeability including river/watercourse network for wild animal dispersal and movement.

- Provide hikers and bikers with free passing the landscape and promote more extensive use of the landscape in citizens´ outdoor recreational/leisure activities.

- Implement measures mitigating effects of increasing temperature in surface waters, thus reducing related deteriorated oxygen patterns and phytoplankton growth there through environmentally friendly threatened waste water management.

- Enhance surface water quality for bathing and recreation/leisure, *e.g.* by outdoor public swimming pool restoration using habitat water treatment.

C. Adaptation measures to reduce energy performance in Prague incl. adaptations in buildings

C.1 Specific target

Reduce energy performance in Prague and enhance adaptations in buildings

C.2 Description of the issue

The most important climate change adverse effects Prague has to be prepared to include an increase in mean annual outdoor air temperature, tropical day and night number and heat waves as well as in length in their continuous periods. In addition, they have been amplified by the urban heat effect on the Capital City of Prague´s territory.

Changes in perception total and in particularly rainfall distribution in space and time is another important climate change pattern, causing on one hand lengthening drought periods and increase in torrential flood frequency on the other hand. Therefore, the Capital City of Prague should enhance public space improvements as well as civil engineering and technological measures in buildings, because that is where its inhabitants spend most of their time.

C.3 Vulnerability and challenges

Buildings consume approx. 40% of the total energy: thus, they are responsible for about one third of the total greenhouse gas emissions. Therefore, reducing energy performance in buildings is a step to of the city´s enhanced resistance and reducing its ecological footprint: at the same time, it is an important climate change mitigation measure. The current legislation, namely Act 406/2000 Gazette on Energy Management, as amended later, aims at energy balance of new building-up that can be specified by the Capital City of Prague´s own building regulations.

C.4 Proposed measures

C.4.1 Reducing energy performance in Prague

The Capital City of Prague´s strategy aims at minimizing carbon footprint and increasing the proportion of energy produced from renewable sources, therefore contributing to an energetically self-sufficient city vision. At the same time, the targets contribute to enhancing Prague´s resistance and to meeting targets set by the EU climate and package, national targets respectively (the EU 20-20-20 Strategy).

Recommended measures:

- Elaborate the Capital City of Prague´s Energy Atlas and diversify energy sources.
- Consistently implement the 2013 – 2020 Territorial Energy Strategy of the Capital City of Prague and when elaborating its Action Plan to prefer the PROAKTIV scenario.
- Support incentive programmes for restoring buildings at higher energy effectivity standard than the legal minimum, both at the national level *(e.g.,* the New Green Savings Programme) or by

implementing own programmes (the Operational Programme Prague – Growth Pole of the Czech Republic), taking into account cultural heritage conservation, protection and management and built-up area patterns.

- Support energy saving urban and civil engineering structures with low floor area coefficient comparing to envelope one. Take into account the Prague specific conditions, particularly built-up urban blocks and other patterns.
- Support use of locally available renewable energy sources in buildings, *e.g.* heat pumps, biomass burning boilers, solar thermal panels, solar panels on roofs and other fixed constructions.
- Install an energetically efficient lighting system.
- Integrate the intelligent BMS (Building Management System) applying current information technologies.
- Support central energy consumption monitoring system and energy management in facilities and buildings. The efforts aim at finding reasonable solutions to monitoring and efficient management of energy consumption there.

C.4.2 Enhancing adapting buildings in Prague

Restoration and innovation of the current buildings and other facilities is another challenge for Prague. In addition, there have been a lot of restrictions and prohibitions caused by cultural heritage conservation, protection and management in areas covered by territorial heritage conservation.

At the same time, the Prague´s historical centre having been conserved due to its extraordinary cultural values is an area where urban heat island effects are most severe and hard. Therefore, implementation of adaptation measures just in the city´s downtown has been to some extent restricted and it does not allow the comprehensive well-balanced approach, but only partial adjustments. Thus, a suitable trade-off among cultural heritage management, final effects and economical adequacy is needed.

Heritage conservation in buildings is strictly defined by Act No. 406/2000 Gazette on Energy Management, as amended later, setting precisely where the act´s requirements should be applied.

There are different conditions particularly among cultural monuments, buildings in urban conservation zones and those in urban heritage zones. It is unacceptable to significantly change patterns or appearance of buildings there when seeking for meeting some energy efficiency requirements. Consequently, it is necessary to take into account interests of the State Heritage Conservancy, always respecting the binding opinion.

Recommended measures:

- Elaborate an analysis on possible adaptation measures in Prague buildings and other facilities in relation to built-up types, site/area and heritage conservation requirements.
- Taking into account heritage conservation and built-up type, to propose classification into some categories based on building´s appearance and structure, heritage conservation performance and building typology.

- Taking into account heritage conservation requirements and built-up type, implement suitable adaptation elements, *e.g.*
    - Replacement or restoration of building aperture fillers;
    - Thermal insulation of building envelopes;
    - Installing active sun shading systems in buildings;
    - Using outside shutters, shades and permanent shading elements;
    - Systems on controlled ventilation and night cooling in constructions;
    - Permanent shading elements with solar panels or films or transparent solar tables to shade buildings, parking places/lots, public transport stops, *etc.*;
    - Introducing roof and/or vertical greenery;
    - Using renewable energy sources;
    - Installing rainfall water usage systems;
    - Installing grey water usage systems.

- Analyse possible introducing climate change adaptation incentives supporting implementation of measures.
- Consider possibilities how to influence real estate owners to implement the above adaptation measures, *e.g.* public building adaptations, particularly buildings and other facilities owned by the Capital City of Prague, the individual Prague city districts and organisations established by the latter.
- Elaborate possibilities to introduce incentive programmes/schemes specifically aiming at support to Prague building adaptations.
- Consider possibilities on the specific incentives for friendly restoration of buildings preserved due to heritage conservation values, *e.g.* for replacement or restoration of building aperture fillers on historic buildings. The level of incentives can be related to the individual heritage conservation zones.
- Adjust current programmes on building restoration in the way that allowable expenses should allow to fund climate change adaptation measures or their parts, *e.g.* installing sun shading, green roofs and facades.
- Support awarding the most efficient building adaptations and the best green roofs in the Capital City of Prague.

C.4.3 Implementing sustainable building-up

Implement the EU Energy Performance Directive and Energy Efficiency Directive and contribute to reaching the EU 20-20-20 Strategy targets.

Recommended measures:

- Elaborate sustainable building-up strategy and during the construction licence procedure, enforce consistently fulfilling energy performance requirements in buildings. Avert overheating in summer and provide sufficient ventilation.
- Enhance building new buildings and other facilities owned by the Capital City of Prague, applying sustainability principles within the passive house standard.
- Building new houses within the standards above the minimum legislation requirements towards building-up buildings and other facilities within the passive house standards.
- During public procurements highlight the project´s quality and try to avoid an assessment of public procurements based only on the offered price.
- Continue in energetically efficient and low-powered restoration of the buildings and facilities owned by the Capital City of Prague.
- Enhance incentive programmes on restoration of the building at higher energy effectivity standard than the legal minimum, both at the national level *(e.g.,* the New Green Savings Programme) or by implementing own programmes (the Operational Programme Prague – Growth Pole of the Czech Republic).
- Assess sustainability in the whole lifetime of a building including ecological and energy footprints caused by construction materials and their successive disposal and enhance environmentally friendly and energy saving solutions.

C.4.4. Enhancing rainfall water management in buildings taking into account cultural heritage conservation and built-up types

Setting mandatory requirements on surfacing in the vicinity of building to allow close-to-nature or semi-natural rainfall infiltration or retention is needed. Maintain or improve infiltration ability within the prescribed area of a plot (defined as percentage of the parcel/plot´s total size).

If due to the unsuitable geological bedrock it is not possible to infiltrate water, it is necessary to require technological measures for rainfall water accumulation.

Recommended measures:

- Enhance rainfall/storm water infiltration or retention trough the green infrastructure in adjacent areas.
- Introduce changing paved water impermeable surfaces into water permeable or semi-permeable surfaces in adjacent areas (*e.g.* grass pavements or facilities on torrential rainfall water infiltration).

- Introduce technological measures to rainfall/storm water retention in adjacent parcels/plots (polders, surface and underground tanks or reservoirs).
- Enhance implementing measures aiming at effective water management and usage: installing systems on using grey and rainfall water.

C.4.5 Enhancing measures to reduce solar radiation absorption

Recommended measures:

- Set mandatory requirements on surfacing in relation to surface permeability, reflectivity and accumulation ability (*cf.* Subchapter A.4.7).

C.4.6 Providing legal, technological and organizational support to application of climate change adaptation measures in practice

Recommended measures:

- Provide that adaptation to climate change in buildings is a part of building practice, particularly to reduce summer overheating; provide sufficient ventilation, rainfall/storm water management, preventing buildings from flooding by appropriate technology and making checks on fulfilling the current Act on Energy Management requirements on energy performance during the construction licence procedure.
- Include recommended technology into the construction licence procedure.
- Include recommended measures into planning documentation.
- Elaborate methodological manual for the Building Authorities. The manual will define which parameters on climate change adaptations in buildings should be monitored and the way they can be required from building owners and employers.
- Enhance using climate models during building project elaboration and public space improvements (*cf.* Subchapter F.4).
- Enhance education on energy savings and other effective use, aiming at building users and operators (*cf.* Subchapter F.4).

D. Adaptation measures in risk management and providing citizens with safety

D.1 Specific target
Enhance preparedness in risk prevention and management

D.2 Description of the issue
Extreme meteorological events affect human health and the environment as well as other factors. For minimizing the extreme events, climate change measures should aim in the way they are able to quickly and effectively response and to maximally protect human lives, health and properties of citizens, the environment and the infrastructure.

D.3 Challenges
As regards the projected higher frequency in extreme meteorological events (sudden and acute torrential rainfalls, floods, droughts, hear waves, *etc.*), enhance communication with citizens so that preparedness for handling extraordinary events, risks and hazards is higher in all the citizen groups.

D.4 Proposed measures
D.4.1 Enhance technological infrastructure resistance
Providing legal, technological and organizational support to applying climate change adaptation measures in practice

Recommended measures:

- Continue in providing the Capital City of Prague energy resistance for the case of power outage aiming at completing emergency/auxiliary power supplies and provide them with sufficient fuel supplies.
- Enhance and develop energy resistance and ability of the long-haul land line network to handle energy run-offs.
- Enhance improvements in water management facility security.

D.4.2 Develop security and protection of citizens and their properties
It is necessary to enhance security of citizens and their properties, develop city´s protection in the case of emergency, enhance cyber security and security of data as well as flood prevention and control management.

Recommended measures:

- Enhance measures and projects increasing flood prevention and control effect of the landscape on the Capital of Prague´s territory.

Push on the Ministry of the Environment of the Czech Republic to prepare a piece of legislation which should replace Decree No. 236/2002 Gazette on the Manner of Drafting Proposals and Establishing Flood Areas so that it reflects lesson learnt from the practice. From a point of the view of risk management it is very undesirable to permit building dwelling/apartment buildings in the flooded area in front of flood prevention and control facilities as it at present happens.

- Complete flood prevention and control facilities on the Vltava River (*cf.* measures described in Subchapter B.4.)

On the Capital City of Prague´s territory, flood prevention and control facilities consist of 21 kilometres of the flood prevention defences made of reinforced concrete walls, earthworks and flood prevention barriers. Measures in sewage and sewer network including, *inter alia*, check/non-return valves on storm water sewer also became an integral part of the system.
Possibility to introduce more flood prevention and control measures in the Troja quarter, namely within the Troja Basin, Lipence and Zbraslav have been considered.

- Enhance implementation of measures aiming at slowing surface water runoff from the landscape and erosion prevention (*cf.* measures described in Subchapter B.4.3.)

These are measures to slow surface water runoff from the landscape to reduce possibility of flooding urbanized areas during highly intensive rains, reducing a quick rainfall water runoff to watercourses, thus reducing flood risk particularly on small watercourses.

- Continue implementing flood plan digitalization.

As a part of flood prevention and control activities within the Capital City of Prague, it is necessary to continue implementing integrated flood plans for the selected small watercourse basins which shall be a backbone of digital flood plans. They aim at more efficient approach to floods on small watercourses in Prague. The system does not interfere the procedure pursuant the respective legislation in flood early warning, but it applies it for the respective conditions in small watercourse basins.

Gathering all the necessary early warning information is a key way to improve decision-making by the flood prevention and control authority during the flood. Therefore, the Capital City of Prague has begun to elaborate the Digital Flood Prevention and Control Plan for the Capital City of Prague and digital flood prevention and control plans of all the City´s districts. The project has been submitted to the Ministry of the Environment of the Czech Republic, applying for financing from the EU Operation Programme *The Environment*. The application has been approved and nowadays the tender for a contractor is running.

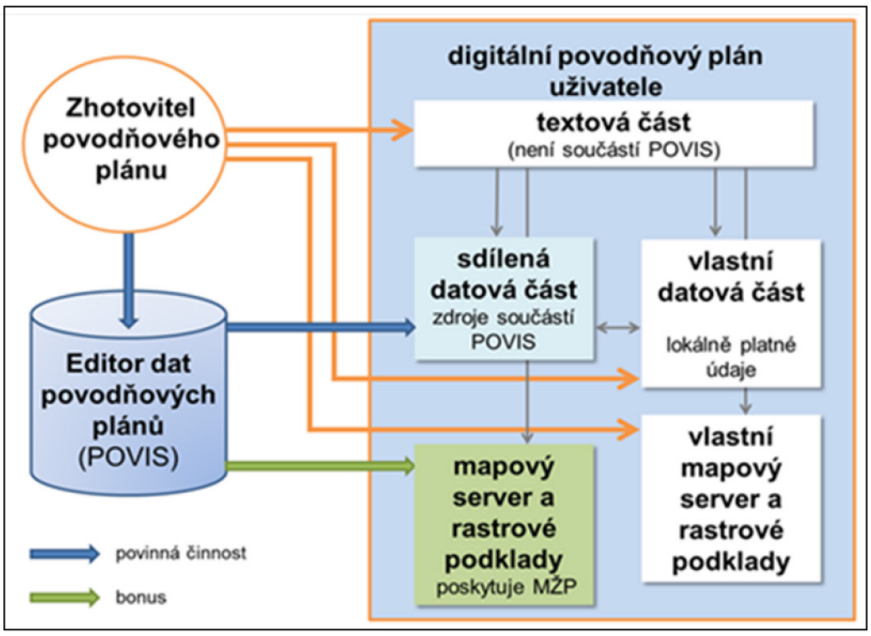

Fig. 11: A proposal on the Capital City of Prague´s Digital Flood Prevention and Control Plan

zhotovitel povodňového plánu – flood plan designer; editor dat povodňových plánů – flood plan data editor; povinná činnost – obligatory activity; digital povodňový plan uživatele – users´s digital flood plan; textová část (není součástí POVIS) – text part (it is not a POVIS plan); sdílená datová část, zdroje součástí POVIS – shared data part, source being POVIS parts; vlastní datová část, lokálně platné údaje – data part itself, locally valid data; mapový server a rastrové podklady, poskytuje MŽP – map server and raster background, provided by the Ministry of the Environment of the Czech Republic; vlastní mapový server a rastrové podklady – map server and raster background themselves.

- Map wells that can be used as alternative water sources on the Capital City of Prague´s territory (*cf.* Subchapter B.4.5.)

In the past, there were a lot of wells on the Capital City of Prague´s territory. Since the 14th century when the water public systems have been step-by-step built many of them were not more used. Because of increasing built-up area within the city a lot of them have been closed out. Moreover, environmental protection and safety requirements have been changing, thus alternative water sources are needed to be used in the case of emergency or a crisis.

At present there unfortunately is no overview on how many wells owned by the Capital City of Prague Municipal Office or put into the custody of the Prague districts are operational so that they can be used as alternative drinking water or non-potable/service/industrial water sources.

D.4.3 Enhancing risk management

Providing risk management and enhancing emergency communication within the region, city, city´s districts, institutions and citizens; enhancing ability to adequately response by the public administration

and citizens to emergencies caused by extreme meteorological events, *e.g.* torrential rainfalls, floods and heat waves.

Tab. 2: Overview of the identified threats causing unacceptable risks – the outputs of the recent Analysis of Threats for the Czech Republic

Threat category		Types of threats with unacceptable risk	Responsibility*
naturogenní	*abiotic*	long-term droughts	**MoE**, MoA, MoI
		extremely high temperatures	**MoE**
		torrential floods	**MoE**, MoI, MoA
		heavy rains	**MoE**, MoI
		extreme winds	**MoE**, MoI
		floods	**MoE**, MoI, MoA
	biotic	epidemics – mass diseases in humans	**MoH**
		mass diseases in crops	**MoA**
		epizootics– mass diseases in animals	**MoA**
antropogenní	*technological*	disruption of great magnitude in food supply	**MoA,** MoIT
		disruption in important electronic communication system operations	**CTO,** MoIT
		disruption in critical information infrastructure security**	**NSA,** MV
		specific floods	**MoA,** MoI, MoE
		loss, release or spill of dangerous chemical substance from a stationary installation	**MoE,** MoI, SONS
		disruption of great magnitude in drinking water supply	**MoA**
		disruption of great magnitude in gas supply	**MoIT,** MoI
		disruption of great magnitude in oil and oil product supply	**ASMR,** MoIT
		nuclear accidents	**SONS,** MV
		disruption of great magnitude in energy supply	**MPO**, MoI
	social	human migration waves of great magnitude	**MoI,** MoFA
		breaching the law of great magnitude (including terrorism)	**MoI**
	economic	disruption of great magnitude in the national financial and exchange sector**	**MoF,** CNB

* Responsible ministries and other central administration authorities and the Czech National Bank are marked in bold.

** Classification of the type of threats into the threat category is based on the fact that the legislation suggests declaration of the state of emergency for them.

Abbreviations: ASMR – Administration of State Material Reserves. CNB – Czech National Bank, CTO – Czech Telecommunication Office, MoA – Ministry of Agriculture, MoE – Ministry of the Environment, MoF – Ministry of Finance, MoFA – Ministry of Foreign Affairs, MoH – Ministry of Health, MoI – Ministry of Interior, MoIT – Ministry of Industry and Trade, NSA – National Security Authority, SONS – State Office for Nuclear Safety

antropogenní - anthropogenic; naturogenní – natural

Recommended measures:

- Update the crisis documentation according to the recent Analysis of Threats for the Czech Republic and Analysis of Threats for the Capital City of Prague´s Territory. The updating should include:
  - Elaborating a plan for long-term drought period;
  - Elaborating a plan for extreme high temperature period, *i.e.* for heat waves;
  - Elaborating plans for the specific floods.
- Regularly train the Capital City of Prague´s crisis emergency and the Integrated Rescue System bodies to enhance their activities and mutual cooperation to handle emergencies and crises.
- Provide early and effective communication to Prague citizens and visitors on possible or real emergencies or crises and on desirable responses under such conditions through the Capital City of Prague´s Security and Crisis Management Portal.
- Develop an early warning and notification system in the Capital City of Prague.

  At present, the early warning signal is spread by 431 sirens, of them 211 are revolving owned by the State and managed by the Fire Rescue Service of the Capital City of Prague, being a part of the Integrated Rescue System of Early Warning and Notification. 220 sirens are electronic, owned by the Capital City of Prague and forming Autonomous System of Early Warning and Notification.

  It is necessary to enhance replacement of the current revolving system with electronic one as well as building new electronic sirens. Development and integration of Prague districts´ local public address systems into the Integrated Rescue System of Early Warning and Notification.

  Replacing an anolog signal with digital one would enhance clarity and readability of information provided to citizens. At the same time, it would be possible to manage and control sirens from various workplaces. Mayors in the individual Prague districts could warn and inform citizens in their respective districts.

E. Adaptation measures in sustainable mobility

E.1 Specific target

Enhance conditions for sustainable mobility in Prague

E.2. Description of the issue

Car transport/motor traffic, particularly gas and diesel engine cars is an important air pollution source as well as source of anthropogenic heat in Prague.

In the extreme temperature/heat wave periods, there are other chemical reactions increasing harmful pollutant levels in the air and negatively affecting human health.

E.3 Challenges

One of the tasks set by the Capital City of Prague´s Sustainable Mobility Plan having been under preparation is reducing emissions from transport and enhancing the city public transport. Another possibility is enhancing electromobility and hiking & bicycle transport, which are the most advantageous from a point of view of climate change mitigation.

E.4 Proposed recommendations

- Provide a link between sustainable mobility and other sustainable/smart city aspects.
- Enhance city public transport, rail transport and electromobility both in public and individual transport.
- Enhance carbon-free ways of transport, *i.e.* hiking and bicycle ones.
- Provide possibilities to use local energy sources for the Prague public transport.
- Provide the suitable inner indoor environment, particularly temperature, in the Prague public transport.

The above measures will be included into the Capital City of Prague´s Sustainable Mobility Plan.

F. Adaption measures in communication, education and public awareness/environmental education

F.1. Specific target

Enhance conditions in communication, education and public awareness/environmental educaton, support monitoring of and research on climate change impacts

F.2. Description of the issue

Communication, education and public awareness (hereinafter CEPA) aim at acquiring knowledge, skills and habits, forming a hierarchy of values and lifestyle necessary for environmental protection ad sustainable development at local and global scale.

In cooperation with other bodies, the Capital City of Prague Municipal Office implements the Capital City of Prague´s key projects on CEPA. They include educational projects and field trips for primary and high schools, educational projects for teachers, a project on support to eco-councelling, a campaign on the Earth Day, CEPA regional conferences or developing public relation materials for the general public.

F.3. Challenges

At present, CEPA aims at nature conservation and environmental protection. Moreover, it should also to include climate change causes and impacts having been considered the most important global threat. Therefore, it is necessary to enhance communication and education on policy strategies, concepts and programmes on climate change mitigation and adaptation.

Green infrastructure healthy ecosystems play a significant role in climate change mitigation. General awareness of green infrastructure importance and healthy ecosystems and ecosystem services provided by them has to be enhanced by better communication, particularly on appropriate green infrastructure conservation, protection and management not only in relation to climate change.

In addition awareness of natural patterns in the landscape among the general public, particularly on water retention ability, supplying underground waters and mitigating transition periods between drought and rains, should be also enhanced. The public has to be informed on friendly management of water resources, both underground and surface ones, using rainfall/storm water, *etc.*

F.4 Proposed measures

F.4.1. Enhance communication and education on and awareness of the environment

It is necessary to be personally responsible for the environment, to set ways for having been involved in environmental protection since early childhood, jointly form the morality and influence intellectual, emotional and willpower components of human´s personality. In addition, social skills, particularly communication within the society, should also be developed.

Recommended measures:

- Enhance CEPA programmes and projects aiming at climate change mitigation and adaptation.
- Propose suitable communication, education and public awareness strategies to involve the general public in climate change adaptation measures, applying current information technologies including social networking.
- Provide educational programmes for schools, teachers and CEPA coordinators at the individual schools, *e.g.* through the CEPA Regional Conference, education of CEPA coordinators at the individual schools, enhancing ecopsychology tool application.
- Enhance activities of Environmental Education Centres in Prague.
- Enhance communication and education on and awareness of stormwater/rainfall water management among citizens and public and private bodies.
- Include allotment and community gardens into CEPA educational programmes (*cf.* more in Chapter A.4.5.).
- Provide educational projects on climate changes with the appropriate funding.

F.4.2 Enhance providing information in the public health and sanitation sector

The important target groups (particularly senior/elderly citizens, babies and small children parents, people in a poor state of health, sick people) should be informed on possibilities how to individually response to extreme events caused by climate change and to mitigate their negative impacts.

Recommended measures:

- Enhance eco-councelling.
- Develop and disseminate CEPA materials on possibilities how to individually adapt to climate change impacts.

F.4.3 Enhance science, research & development and innovation in the field of climate change

Recommended measures:

- Provide effective support to science and research on urban ecosystems and green infrastructure, sustainable/smart city technologies, building industry, sustainable use of natural resources and energy, transport and sustainable development at the local, Capital City of Prague and global scale.
- Provide gathering and processing data on climate events and their impacts in the urban environment and on implementation of the individual climate changes adaptation measures to be monitored.
- Enhance applying climate models in developing building projects and public space improvements (cf. more Subchapter C.4.6.).
- Cooperate in popularizing scientific results and outputs.

5. Proposal on Elaboration of the Capital City of Prague´s Implementation Plan 2018 – 2019

Elaboration of the Capital City of Prague´s Implementation Plan 2018 – 2019 will follow the Capital City of Prague Climate Change Adaptation Strategy and develop in more detail, in cooperation with other Capital City of Prague´s stakeholders, individual steps towards implementing partial adaptation measures as well as pilot projects.

Within the Implementation Plan, assessment of vulnerability to climate change for the selected sites/areas will be in more detail developed, taking into account threats and risks related to temperature extremes, urban heat island and insufficient rainfall/storm water infiltration, based on more detailed risk assessment, consequently particular adaptation measures will be set out, and the selected measures will be assessed from a point of view of economic benefits. Furthermore, other measures for enhancing climate adaptation measures in the Capital City of Prague will be elaborated. Monitoring the climate change adaptations will be carried out as a pilot project, particularly for considering a scheme to further implement the measures. At the same time, the Implementation Plan shall also include a clear division of competences and definition of responsibilities for the individual activities and their time framework.

The proposal on elaboration of the Capital City of Prague Implementation Plan will consist of some phases:

1. Complementing analytical background documents and vulnerability analysis
Within the phase, background documents will be completed. For the selected sites in the Capital City of Prague, a specific vulnerability analysis will be carried out, in more detail aiming at threats and risks related to temperature extremes, urban heat island as well as to insufficient rainfall/storm water infiltration.

2. Specific adaptation measures, pilot projects and their assessment
Following the above vulnerability analysis outputs, adaptation measures will be set out, examples of possible solutions will be presented and pilot projects selected. The selected measures will be assessed from a point of view of economic benefits and ecosystem service provisioning. At the same time, a time framework of implementing the pilot measures will be developed.

3. Developing an adaptation monitoring scheme
For the particular adaptation targets, measures and selected pilot projects, indicators and a monitoring scheme will be proposed. In cooperation with the city´s representatives, competences will be divided as well as responsibilities defined and a time framework for their implementation will be set out.

4. Setting out recommendations in adaptation development in the city
Based on the analysis and assessment carried out recommendations in adaptation development in the city will be set out (recommendations on the further direction, *e.g.* for complementing data backgrounds, developing methodologies for the individual

sectors and fields of activities, communication and education on climate change and awareness of the process among citizens, *etc.*

Capital City of Prague Climate Change Adaptation Strategy

I. List of policy documents related to the Capital City of Prague Climate Change Adaptation Strategy

II. Tables on measures proposed and a table on the Strategy compliance with the Strategic Plan, the latter having been updated in 2016

III. Primary information

1. Solar energy and cooling effects of trees

2 Ecosystem services and benefits provided by green infrastructure

IV. Good practice examples/lessons learnt in Prague

Annex I

List of policy documents related to the Capital City of Prague Climate Change Adaptation Strategy

United Nations Environment Programme (UNEP)

Related European Union´s and pan-European strategies, policies and concepts

Europe 2020: A strategy for smart, sustainable and inclusive growth (2010)
European Landscape Convention (2000)
EU Strategy on adaptation to climate change (2013)
EU thematic strategy on the urban environment (2006)
Green Paper: A 2030 framework for climate and energy policies (2013)
Green Infrastructure (GI) – Enhancing Europe´s natural capital (2013)
Building a Green Infrastructure for Europe (2013)

Related national strategies, policies and concepts

Strategy on Adaptation to Climate Change in the Czech Republic (2015)
State Environmental Policy of the Czech Republic 2012 – 2020 (updated in 2016)
Climate Protection Policy of the Czech Republic (draft)
Strategic Framework for Sustainable Development of the Czech Republic (2010)
Strategy for Protection against Floods in the Czech Republic (2000)
Flood prevention concept in the Czech Republic applying technological and close-to-nature provisions (2010)
Flood Risk Management Plans in the Czech Republic (2015)
Regional Development Strategy of the Czech Republic 2014-2020 (2014)
State Energy Policy (2015)
National Energy Efficiency Action Plan for the Czech Republic (2017)
Labe/Elbe River Basin National Plan
Partial river basin plans for the Lower Vltava River, the Berounka River and thew Upper and Middle Labe/Elbe River

Related Prague strategies, policies and concepts

Strategic Plan for Prague (updated 2016)
Operational Programme Prague – Growth Pole of the Czech Republic (2015)
Communication, Education and Public Awareness Regional Strategy for the Capital City of Prague (2016)
Prognosis, Concept and Strategy in Nature Conservation and Landscape Protection in Prague (2008)
Greenery Management Strategy for the Capital City of Prague (2010)
Air Quality Improvement Programme for Prague Agglomeration CZ01 (2015)
SMART Prague 2014 – 2020 (2014)
Capital City of Prague Municipal Energy Policy for 2013 – 2033 (2011)

Prague Public Space Design Manual (2014)
Prague Riverbank Policy (2014)
Prague Building Regulations
Integrated Strategy for Integrated Territorial Investment in the Prague Metropolitan Area (2016)

Related documents under preparation
Metropolitan Plan draft

Annex II

Table of specific targets and measures provided by the Capital City of Prague Climate Change Adaptation Strategy

Specific target A: Enhance microclimatic conditions in Prague and reduce the adverse impacts of extreme temperatures, heat waves and urban heat island on Prague inhabitants

A.1 Enhance the city´s microclimatic conditions by multi-functional green infrastructure

Recommended measures:

A.1.1	Elaborate and adopt a green infrastructure strategy including the appropriate policy
A.1.2	During the green infrastructure planning, delineation and creation and in line with its multi-functional role aiming at its positive effects on the city´s microclimate
A.1.3	The individual measures effective from a point of view of climate change mitigation should not be applied separately, but together with other green infrastructure´s functions
A.1.4	Acquire lands to be owned by the Capital City of Prague´s for keeping key functions of the green infrastructure and of the Territorial System of Ecological Stability (TSES)
A.1.5	Use the Capital City of Prague´s legal rights to initiate changes in legislation to allow, according to land-use set up by a land-use/territorial plan to without charge sign over lands having been owned by the Czech Republic to the municipality´s ownership for green space enlargement
A.1.6	Provide the multi-purpose green infrastructure with sustainability and long-term high-quality management

A.2 Take into account climate change adaptation in planning and background study elaboration

Recommended measures:

A.2.1	Elaborate an analysis on air ventilation in Prague and on urban heat island distribution across the city
A.2.2	According to the outputs of the above analysis, delineate the current green spaces including parks, forests or slopes for better air ventilation in the city
A.2.3	Ensure an environmentally friendly development in the suburban landscape, *e.g.* by establishing or managing suburban parks for use for recreation/leisure by local people and for sustainable suburban landscape development
A.2.4	Delineate, establish and manage greenery components and sites/areas within the city and outside it in relation to open public spaces and a network of hiking trails and bicycle paths or bikeways

A.3 Establish and restore vegetation components in the city

Recommended measures:

A.3.1	Carry out an analysis of sites with lack of vegetation components and green spaces in Prague, particularly in areas where urban heat island can newly occur
A.3.2	Enhance quality and quantity of vegetation components on open public spaces and other sites/areas and thus, mitigate the urban heat island effect
A.3.3	Establish new parks and restore the existing ones as well as other green spaces, particularly at sites or in areas where they have been missing or lacking, taking into account the urban heat island distribution across the capital City of Prague
A.3.4	When elaborating policy documents, seek for using in a proper way vegetation components wherever local conditions and natural heritage management commitments make it possible
A.3.5	Seek for possibilities to establish and restore street alleys and avenues and set up priorities for investment into alleys on the selected streets
A.3.6	Provide a functioning and targeted coordination of green, blue and grey infrastructure managers for planning and building including the procurement procedure for project files and documents
A.3.7	Update a methodology and guidelines for expert assessment on selection of woody plant resistant against climate change
A.3.8	When establishing and restoring underground utility constructions and other technological and transport infrastructure on the city´s streets, provide trees in alleys and on open public space with space enough for root growth
A.3.9	Wherever appropriate, build on the city´s avenues multichannels for streamlining telecommunication cables and optimally also power cables managed by the city, to free up space under pavements
A.3.10	Provide high quality background documents for developing management plans, *e.g.* updated dendrological surveys & inventories and general spatial studies/policy analyses of greenery structure and diversity with respect to the projected climate change impacts
A.3.11	Support establishing gardens, parks and other vegetation components and areas in inner courtyards and to develop guidelines for establishing them

A.4 Provide unified street greenery and alleys management

Recommended measures:

A.4.1	Update and consolidate street greenery management guidelines across the whole Capital City of Prague´s territory
A.4.2	Update and consolidate street greenery management guidelines across the whole Capital City of Prague´s territory based on new requirements and the best science available and knowledge of climate change impacts
A.4.3	Provide unified compatible background documents for developing management plans, taking into account the projected climate change impacts
A.4.4	Update guidelines for financial support to street greenery and alleys planting
A.4.5	Using the Capital City of Prague´s legal rights to initiate changes in legislation to allow introducing a unified management of the open landscape that should not be built-up, *e.g.* suburban park management

A.5 Create the conditions for suburban and urban agriculture development as a climate change adaptation

Recommended measures:

A.5.1	Update general study on allotment gardens in Prague
A.5.2	Maintain the tradition of allotment gardens and develop new ones, wherever appropriate with respect to location and state of the environment
A.5.3	Support organic farming and other agricultural production friendly to soils, the landscape and biological diversity
A.5.4	Support establishing community gardens and temporary community gardens
A.5.5	Support community management of vegetation, *i.e.* green infrastructure components on public spaces
A.5.6	Support agricultural activities maintaining and forming the diverse and biologically valuable landscape and enhancing the short hydrological cycle in the particular area
A.5.7	Include the issue of allotment and community gardens into communication, education and public awareness/environmental education projects, programmes and campaigns (*cf.* Subchapter F.4).

A.6 Enhance ecological stability/ecosystem health and self-restoration/recovery ability in the landscape

Recommended measures:

A.6.1	Protect, conserve, manage and enhance biological diversity in the urban environment
A.6.2	Complete step-by-step the Territorial System of Ecological Stability (TSES) missing components with establishing new ones
A.6.3	Create and restore landscape elements and protect and conserve the existing Significant Landscape Elements (SLE) and provide them with effective management, plant non-productive forests, establish orchards, permanent grasslands, *etc.*
A.6.4	Support establishing natural unbuilt areas forming transition/buffer zones between the built-up area and the selected Specially Protected Areas and the Sites of European Importance (pursuant to Act No. 114/1992 Gazette on the Nature Conservation and Landscape Protection, as amended later, the term for Site of Community Importance, SCI under the European Union's Habitats Directive)
A.6.5	Monitor resistance in vegetation and wild animal populations against climate change as well climate change impacts on fauna and flora, using, *inter alia*, citizen science
A.6.6	Prevent spreading invasive alien plant and animal species across the landscape

A.7 Use technological and ecosystem measures to reduce solar radiation accumulation in built-up areas

A.7.1	Develop guidelines on technological measures, materials and colours reflecting and non-accumulating solar radiation
A.7.2	Elaborate recommendations on nature-based solutions, using green and blue infrastructures (infiltration strips and belts and gravelly drains, rainfall retention through water permeable and semi-permeable surfaces)
A.7.3	For reducing heat accumulation in city´s built-up areas, analyse possibilities provided by green and blue infrastructures and introduce their other elements, *e.g.* green roofs, facade greenery, drinking fountains, fountains, springs, wells, man-made wetlands, *etc.*

Specific target B: Reduce extreme hydrological event impacts, *i.e.* torrential floods, floods and long-term droughts on the Capital City of Prague´s territory as well as in the adjacent landscape in the Prague Metropolitan Area

B.1. Flood prevention and control on the Vltava and Berounka rivers an on other watercourses on the Capital City of Prague´s territory

Measures recommended for flood prevention and control on the Vltava and Berounka rivers

B.1.1	Complete flood protection on the Vltava River wherever it is effective
B.1.2	Examine other flood prevention and control possibilities in the Capital City of Prague including assessing effectiveness of flood prevention and control on the Berounka River downstream
B.1.3	Carry out regular checks, working tests and maintenance in flood prevention and control facilities

Measures recommended for flood prevention and control on other watercourses on the Capital City of Prague´s territory

B.1.4	Analyse and support measures and projects enhancing flood prevention and control effect in the landscape on the Capital City of Prague´s territory and within the whole stream basins
B.1.5	Enhance building small water reservoirs, both retention and accumulation ones, on the small watercourse upper parts on the Capital City of Prague´s territory and its neighbourhood wherever it is effective and to support such efforts. To support small water

	reservoir restoration
B.1.6	Avoid building-up the flooded areas in Prague

B.2 Enhancing rainfall/storm water management

Recommended measures:

B.2.1	Elaborate a study on possible risk torrential rainfalls and on their impacts on the Capital City of Prague territory
B.2.2	Continuously update and review rainfall and runoff models of the Prague territory itself as well as of the Metropolitan area
B.2.3	Consistently enforce in cooperation with the respective public service authorities, sewage network managers and expert/technical bodies the rainfall/storm water management strategy and to monitor rainfall/storm water management effects
B.2.4	Support changes in legislation dealing with rainfall/storm water management including consideration of possible imposing of fees on rainfall water draining
B.2.5	Assess and eventually update standards for water management, construction and transport buildings on the city´s territory
B.2.6	Coordinate activities of infrastructure managers in applying existing and proposed measures in practice
B.2.7	Support communication with, education and public awareness of citizens and public and private bodies on rainfall water management principles (*cf.* Subchapter F.4)

B.3 Implementation of measures aiming at slowing surface water runoff from the landscape and erosion prevention

Recommended measures:

B.3.1	Finish studies on possibilities for rainfall/storm water infiltration in the Capital City of Prague
B.3.2	Elaborate an analysis on possible natural hydrological cycle restoration and enhancing retention capacity on the Capital City of Prague´s territory
B.3.3	Examine possibilities of and provide the landscape with continuous natural hydrological cycle restoration and enhance natural retention capacity there trough nature-based solutions
B.3..4	Develop and implement land replotting or land consolidation/reparcelling on agricultural lands within the watercourse basins on the Capital City of Prague´s territory as well as in the Metropolitan Area
B.3.5	In coordination with drainage system managers possibly propose civil engineering and technological measures (retention reservoirs on watercourses and on sewer network, dry polders, infiltration facilities and other grey infrastructure measures within the urbanized areas and on watercourses
B.3.6	Enhance sustainable production on agricultural lands through promoting suitable agri-technological measures and land management (*cf.* Subchapter A.5.2)

B.4 Continuous changing paved water impermeable surfaces into water permeable and semi-permeable ones

Recommended measures:

B.4.1	Reduce the proportion of paved surfaces and vice versa, increase that of water permeable and semi-permeable ones. The measure can be implemented *e.g.* in parking or manipulation areas
B.4.2	Create new spaces and drainage systems allowing water infiltration, accumulation or retention at the site where rain falls on the surface
B.4.3	Elaborate guidelines and recommendations on water impermeable surface adjustments, using, *inter alia*, new technologies, innovations and methods
B.4.4	Support introducing green roofs, green strips along tramway tracks and other green infrastructure elements (*cf.* subchapters A.5 and C.4)

B.5 Continuing integrated restoration of floodplains, watercourses and reservoirs

Recommended measures:

B.5.1	Within the current Brooks for Life project continue in seeking for suitable sites/areas for comprehensive river landscape restoration including enhancing retention capacity of neighbouring areas
B.5.2	Provide protection, conservation, management and restoration of permanent vegetation growths/vegetation cover on watercourse and fishpond banks
B.5.3	Within the current Prague Water Reservoir Restoration project carry out repair, restoration, reconstruction of fishponds and other water reservoirs
B.5.4	Restore watercourse beds and floodplains as well as their functions in both natural and semi-natural areas and in the urban landscape, manage riparian stands and bank vegetation and enhance permeability and accessibility of watercourse banks, implementing the Prague Riverbank Policy
B.5.5	Restore springs, wells and waterholes (*cf.* Subchapter D.2)

B.6 Testing possibilities of the current water management infrastructure and providing citizens with drinking water

Recommended measures:

B.6.1	Gather timely data on drinking water sources and underground pipelines on the Capital City of Prague´s territory or enhance them for drinking water treatment
B.6.2	Map springs, wells and other underground water sources on the Capital City of Prague´s territory which can be used as alternative water sources. Examine possibilities of their usage
B.6.3	Minimize loss and leakages in the water distribution system by regular restoration of water mains having been displaying high susceptibility to failure and have almost reached

	the end of their life cycle
B.6.4	Examine water resource sustainable use by water withdrawal for providing citizens with drinking water, industry and agriculture from a point of view of landscape management
B.6.5	Update maintaining minimum streamflow levels under a series of dams and water reservoirs on the Vltava River called the Vltava River Cascade
B.6.6	Check minimum streamflow levels on the individual watercourse stretches from a point of view of the permitted withdrawal and consequently to propose measures needed
B.6.7	Check alternative solutions in the case if withdrawal cannot be carried out in the period of lack of water
B.6.8	Check measures on the sewage system to minimize drainage effcts caused by pipes and their packs

B.7 Enhancing landscape permeability and its use in recreation/leisure

Recommended measures:

B.7.1	Enhance landscape permeability including river/watercourse network for wild animal dispersal and movement
B.7.2	Provide hikers and bikers with free passing the landscape and promote more extensive use of the landscape in citizens´ outdoor recreation/leisure activities
B.7.3	Implement measures mitigating effects of increasing temperature in surface waters, thus reducing related deteriorated oxygen patterns and phytoplankton growth there through environmentally friendly treated waste water management
B.7.4	Enhance surface water quality for bathing and recreation/leisure, *e.g.* by outdoor public swimming pool restoration using habitat water treatment

Specific target C: Reduce energy performance in Prague and enhance adaptations in buildings

C.1 Reducing energy performance in Prague
Recommended measures:

C.1.1	Elaborate the Capital City of Prague´s Energy Atlas and diversify energy sources
C.1.2	Consistently implement the 2013 – 2020 Territorial Energy Strategy of the Capital City of Prague and when elaborating its Action Plan to prefer the PROAKTIV scenario
C.1.3	Support incentive programmes for restoring buildings at higher energy effectivity standard than the legal minimum
C.1.4	Support energy saving urban and civil engineering structures with low floor area coefficient comparing to envelope one
C.1.5	Support use of locally available renewable energy sources in buildings
C.1.6	Install an energetically efficient lighting system
C.1.7	Integrate the intelligent BMS (Building Management System) applying current information technologies
C.1.8	Support central energy consumption monitoring system and energy management in facilities and buildings. The efforts aim at finding reasonable solutions to monitoring and efficient management of energy consumption there

C.2 Enhancing adapting buildings in Prague
Recommended measures:

C.2.1	Elaborate an analysis on possible adaptation measures in Prague buildings and other facilities in relation to built-up types, site/area and heritage conservation requirements
C.2.2	Taking into account heritage conservation and built-up type, to propose classification into some categories based on building´s appearance and structure, heritage conservation performance and building typology
C.2.3	Taking into account heritage conservation requirements and built-up type, implement suitable adaptation elements, *e.g.* replacement or restoration of building aperture fillers, thermal insulation of building envelopes, installing active sun shading systems in buildings, using outside shutters, shades and permanent shading elements, systems on controlled ventilation and night cooling of constructions, *etc.*
C.2.4	Analyse possible introducing climate change adaptation incentives supporting implementation of the measures
C.2.5	Consider possibilities how to influence real estate owners to implement the above adaptation measures, *e.g.* public building adaptations, particularly buildings and other facilities owned by the Capital City of Prague, the individual Prague city districts and organisations established by the latter
C.2.6	Consider possibilities on the specific incentives for friendly restoration of buildings preserved due to heritage conservation values, *e.g.* for replacement or restoration of building aperture fillers on historic buildings. The level of incentives can be related to the individual heritage conservation zones
C.2.7	Adjust current programmes on building restoration in the way that allowable expenses should allow to fund climate change adaptation measures or their parts, *e.g.* installing sun shading, green roofs and facades
C.2.8	Support awarding the most efficient building adaptations and the best green roofs in the

	Capital City of Prague

C.3 Implementing sustainable building-up

Recommended measures:

C.3.1	Elaborate sustainable building-up strategy and during the construction licence procedure, enforce consistently fulfilling energy performance requirements in buildings. Avert overheating in summer and provide sufficient ventilation
C.3.2	Enhance building new buildings and other facilities owned by the Capital City of Prague, applying sustainability principles within the passive house standard
C.3.3	Building new houses within the standards above the minimum legislation requirements towards building-up buildings and other facilities within the passive house standards
C.3.4	During public procurements highlight the project´s quality and try to avoid an assessment of public procurements based only on the offered price
C.3.5	Continue in energetically efficient and low-powered restoration of the buildings and facilities owned by the Capital City of Prague
C.3.6	Enhance incentive programmes on restoration of the buildings at higher energy effectivity standard than the legal minimum, both at the national level *(e.g.,* the New Green Savings Programme) or by implementing own programmes (the Operational Programme Prague – Growth Pole of the Czech Republic)
C.3.7	Assess sustainability in the whole lifetime of a building including ecological and energy footprints caused by construction materials and their successive disposal and enhance environmentally friendly and energy saving solutions

C.4 Enhancing rainfall/storm water management in buildings taking into account cultural heritage conservation and built-up types

Recommended measures:

C.4.1	Enhance rainfall water infiltration or retention through the green infrastructure in adjacent areas
C.4.2	Introduce changing paved water impermeable surfaces into water permeable or semi-permeable surfaces in adjacent areas (*e.g.* grass pavements or facilities on torrential rainfall/storm water infiltration)
C.4.3	Introduce technological measures to rainfall/storm water retention in adjacent parcels/plots (polders, surface and underground tanks or reservoirs)
C.4.4	Enhance implementing measures aiming at effective water management and usage: installing systems on using grey and rainfall water

C.5 Enhancing measures to reduce solar radiation absorption

Recommended measures:

C.5.1	Set mandatory requirements on surfacing in relation to surface permeability, reflectivity and accumulation ability (*cf.* Subchapter A.7).

C.6 Providing legal, technological and organizational support to application of climate change adaptation measures in practice

Recommended measures:

C.6.1	Provide that adaptation to climate change in buildings is a part of building practice, particularly to reduce summer overheating; provide sufficient ventilation, rainfall/storm water management, preventing buildings from flooding by appropriate technology and making checks on fulfilling the current Act on Energy Management requirements on energy performance during the construction licence procedure. The measures should be fully applied in building a new building and adequately in reconstruction an existing building.
C.6.2	Include recommended technology into the construction licence procedure
C.6.3	Include recommended measures into planning documentation
C.6.4	Elaborate methodological manual for the Building Authorities. The manual will define which parameters on climate change adaptations in buildings should be monitored and the way they can be required from building owners and employers
C.6.5	Enhance using climate models during building project elaboration and public space improvements (*cf.* Subchapter F.4)
C.6.6	Enhance education on energy savings and other effective use, aiming at building users and operators (*cf.* Subchapter F.4)

Specific target D: Enhance preparedness in risk prevention and management

D.1 Enhance technological infrastructure resistance

Recommended measures:

D.1.1	Continue in providing the Capital City of Prague energy resistance for the case of power outage aiming at completing emergency/auxiliary power supplies and provide them with sufficient fuel supplies
D.1.2	Enhance and develop energy resistance and ability of the long-haul land line network to handle energy run-offs
D.1.3	Enhance improvements in water management facility security

D.2 Develop security and protection of citizens and their properties

Recommended measures:

D.2.1	Enhance measures and projects increasing flood prevention and control effect of the landscape on the Capital of Prague´s territory (cf. Subchapter B.2)
D.2.2	Complete flood prevention and control facilities on the Vltava River (*cf.* measures described in Subchapter B.4.)
D.2.3	Enhance implementation of measures aiming at slowing surface water runoff from the landscape and erosion prevention
D.2.4	Continue implementing flood plan digitalization
D.2.5	Map wells that can be used as alternative water sources on the Capital City of Prague´s territory (*cf.* Subchapter B.5.)

D.3 Enhancing risk management

Recommended measures:

D.3.1	Update the crisis documentation according to the recent Analysis of Threats for the Czech Republic and Analysis of Threats for the Capital City of Prague´s Territory. The updating should include elaborating a plan for long-term drought period, a plan for extreme high temperature period, *i.e.* for heat waves and plans for the specific floods
D.3.2	Regularly train the Capital City of Prague´s crisis emergency and the Integrated Rescue System bodies to enhance their activities and mutual cooperation to handle emergencies and crises
D.3.3	Provide early and effective communication to Prague citizens and visitors on possible or real emergencies or crises and on desirable responses under such conditions through the Capital City of Prague´s Security and Crisis Management Portal
D.3.4	Develop an early warning and notification system in the Capital City of Prague including building new electronic sirens and replacing an anolog signal with digital one

Specific target E: Enhance conditions for sustainable mobility in Prague (more details given in the Clean Mobility Plan)

E.1	Provide a link between sustainable mobility and other sustainable/smart city aspects
E.2	Enhance city public transport, rail transport and electromobility both in public and individual transport
E.3	Enhance carbon-free ways of transport, *i.e.* hiking and bicycle ones
E.4	Provide possibilities to use local energy sources for the Prague public transport
E.5	Provide suitable inner indoor environment, particularly temperature, in the Prague public transport

Specific target F: Enhance conditions in communication, education and public awareness/environmental publication, support monitoring of and research on climate change impacts

F.1 Enhance communication and education on and awareness of the environment

Recommended measures:

F.1.1	Enhance CEPA programmes and projects aiming at climate change mitigation and adaptation.
F.1.2	Propose suitable communication, education and public awareness strategies to involve the general public in climate change adaptation measures, applying current information technologies including social networking
F.1.3	Provide educational programmes for schools, teachers and CEPA coordinators at the individual schools, *e.g.* through the CEPA Regional Conference, education of CEPA coordinators at the

	individual schools, enhancing ecopsychology tool application
F.1.4	Enhance activities of Environmental Education Centres in Prague
F.1.5	Enhance communication and education on and awareness of rainfall/storm water management among citizens and public and private bodies
F.1.6	Include allotment and community gardens into CEPA educational programmes (*cf.* more in Chapter A.5.)
F.1.7	Provide educational projects on climate changes with the appropriate funding

F.2 Enhance providing information in the public health and sanitation sector

Recommended measures:

F.2.1	Enhance eco-councelling
F.2.2	Develop and disseminate CEPA materials on possibilities how to individually adapt to climate change impacts

F.3 Enhance science, research & development and innovation in the field of climate change

Recommended measures

F.3.1	Provide effective support to science and research on urban ecosystems and green infrastructure, sustainable/smart city technologies, building industry, sustainable use of natural resources and energy, transport and sustainable development at the local, Capital City of Prague and global scale
F.3.2	Provide gathering and processing data on climate events and their impacts in the urban environment and on implementation of the individual climate changes adaptation measures to be monitored
F.3.3	Enhance applying climate models in developing building projects and public space improvements (*cf.* more Subchapter C..6.)
F.3.4	Cooperate in popularizing scientific results and outputs

Annex II

Compliance of the Capital City of Prague Climate Change Adaptation Strategy with the Strategic Plan for Prague, the latter having been updated in 2016

Adaptation Strategy measures	Strategic Plan measures
5.A.1. Enhance the city´s microclimatic conditions by multi-functional green infrastructure	1.3-E.1 Apply landscape management aspects in building the city 1.3-E.2 Establish and restore urban greenery 1.4-A.1 Establish a functioning system of green infrastructure and urban greenery 1.4-A.2 Provide unified greenery and natural sites/areas management 1.4-A.3 Enhance ecological stability/ecosystem health and self-restoration/recovery ability in the landscape 1.4-B.3 Reduce dustiness in the urban environment 1.4-C.2 Create the conditions for suburban and urban agriculture development. 3.3-B.1 Respond to climate change
5.A.2 Take into account climate change adaptation in planning and background study elaboration	
5.A.3 Establish and restore vegetation components in the city	
5. A.4 Provide unified street greenery and alleys management	
5.A.5 Create the conditions for suburban and urban agriculture development as a climate change adaptation	
5.A.6 Enhance ecological stability/ecosystem health and self-restoration/recovery ability in the landscape	
5.A.7 Use technological and ecosystem measures to reduce solar radiation accumulation in a built-up area	
5.B.1 Flood prevention and control on the Vltava and Berounka rivers and on other watercourses on the Capital City of Prague´s territory	1.4-A.1 Establish a functioning system of green infrastructure and urban greenery 1.4-A.3 Enhance ecological stability/ecosystem health and self-restoration/recovery ability in the landscape 1.4-A.4 Enhancing landscape permeability and its use in recreation/leisure 1.4-A.5 Enhancing rainfall/storm water management 1.4-A.6 Implementation of measures aiming
5.B.2 Enhancing rainfall/storm water management	
5.B.3 Implementation of measures aiming at slowing surface water runoff from the landscape and erosion prevention	
5.B.4 Continuous changing paved water impermeable surfaces into water permeable	

and semi-permeable ones	at slowing surface water runoff from the landscape and erosion prevention 1.4-A.7 Continuing integrated restoration of floodplains, watercourses and reservoirs 3.3-A.2 Develop security and protection 3.3-B.1 Respond to climate change 3.3-B.3 Manage resources friendly and effectively
5.B.5 Continuing integrated restoration of floodplains, watercourses and reservoirs	
5.B.6 Testing possibilities of the current water management infrastructure and providing citizens with drinking water	
5.B.7 Enhancing landscape permeability and its use in recreation/leisure	
5.C.1 Reducing energy performance in Prague	1.4-A.5 Enhancing rainfall water management 3.3-B.1 Respond to climate change 3.3-B.2 Implementing sustainable building-up
5.C.2 Enhancing adapting buildings in Prague	
5.C.3.Implementing sustainable building-up	
5.C.4. Enhancing rainfall/storm water management in buildings taking into account cultural heritage conservation and built-up types	
5.C.5.Enhancing measures to reduce solar radiation absorption	
5.D.1 Enhance technological infrastructure resistance	3.3-A.1 Enhance technological infrastructure resistance 3.3-A.2 Develop security and protection 3.3-A.3 Enhancing risk management 3.3-B.1 Respond to climate change
5.D.2. Develop security and protection of citizens and their properties	
5.D.3. Enhancing risk management	

Annex III

Primary information

1. Solar energy and cooling effects of trees

Fig. 1 Cooling effects of vegetation (© Jan Pokorný, 2011)

1.1 How do trees cool their vicinity?

A tree with a crown of 5 meters in a diameter covers the projected surface area of approx. 20 square meters: a crown receives solar energy amounting at least 120 kWh during a clear summer day: of them, 1% is used by photosynthesis, approx. 10% is reflected back as a solar energy, 5 – 10% is radiated as heat and approx. the same proportion warms soils. The greatest proportion of energy reaching a tree enters evapotranspiration by a plant. If a tree has been sufficient supplied by water, it evaporates more than 100 litres of water per day, consuming about 70 kWh (250 MJ) of solar energy. The energy is subject to water vapour and is released back during condensation of water vapour to vapour. It is because one litre of water uses 2.5 MJ (0.7 kWh), *i.e* the amount of the internal latent heat of evaporation[5].

During a sunny summer day, a tree evaporates 100 litres of water, thus cooling its vicinity by 70 kWh; as an average, it is cooling by power of 7kW during ten hours. By comparison, an air-conditioning power in a luxury hotel is 2 kW, those of deep freezers and refrigerators even

[5] Pokorný J. (2011): *Co dokáže strom.* In Kleczek J. (ed.): Kniha o vodě. Radioservis Praha: 429-431.

more than one order of magnitude less. A refrigerator, deep freezer or air-conditioning heat its vicinity by power which displays on the other hand cooling effect. Water vapour from a tree heat cold places where it condenses.

1.2. What is a regulatory ability of trees and a fate of the solar energy from a water vapour?

A leaf has a lot of stomata, the water is passed through: they influence the rate of water evaporation according to total volume of available water as well as according the solar radiation intensity. Within the single square millimetre there are approx. 50 to 100 stomata, each of them responding to temperature and humidity in its vicinity: following conditions in the environment they close and open themselves. Therefore, every tree harbours dozens of millions of stomata, operating as the regulatory vents equipped with temperature and humidity sensors.

Evaporated water vapour contains the solar energy bounded and it condenses at cold sites in the landscape, emitting the heat bound during evapotranspiration. Thus, the solar energy flows through the environment, buffering sudden temperature changes. Under physical conditions, water vapour can condense only in the early morning (production of dew, small rainfalls) and it heats its vicinity by the internal latent heat emitted during the condensation. Thus, the solar energy is transferred also in time.

The difference between a tree and shade of a parasol or a shelter is significant. While a parasol reflects the radiation only passively (according to the colour of surface), a tree transforms it into cold and moisture. For appropriate functioning, a tree requires only occasional watering. In addition, a broad-leaved deciduous tree in front of a window sheds its leaves during the autumn, thus the solar radiation can passively heat a house in the winter and early spring.

A tree cleans water, both by the described passing air through stomata and by its roots, absorbing nutrients and creating conditions for life of other organisms which take other substances from the soil water.

1.3. Can vegetation influence climate in its vicinity?

Water and plant management can influence microclimate in their vicinity.

In large areas without vegetation and water, most of the hitting solar radiation is converted into heat, the vicinity is overheated and dries up. The surface temperature on the Capital City of Prague´s territory is evidenced by a satellite image made by Landsat 8 (Fig. 2).

If a small garden covering 300 square meters is hit by the solar radiation powering up to 30 kW in summer, it amounts up to 1,500 to 1,700 kW of the solar energy for the whole day. The same amount of energy is reflected back as an unused heat on dry spaces without vegetation. If a space is covered by plants and supplied with water, more than a half of the energy is bound to water vapour and the site with trees and other plants cools itself or its vicinity by power of approx. 100 kW.

In return for one single received carbon dioxide molecule, each tree or other green plant emits into the air one oxygen molecule. Trees also emit various chemical substances, *e.g.* terpenes or terpenoids positively influencing human physical and mental health[6]

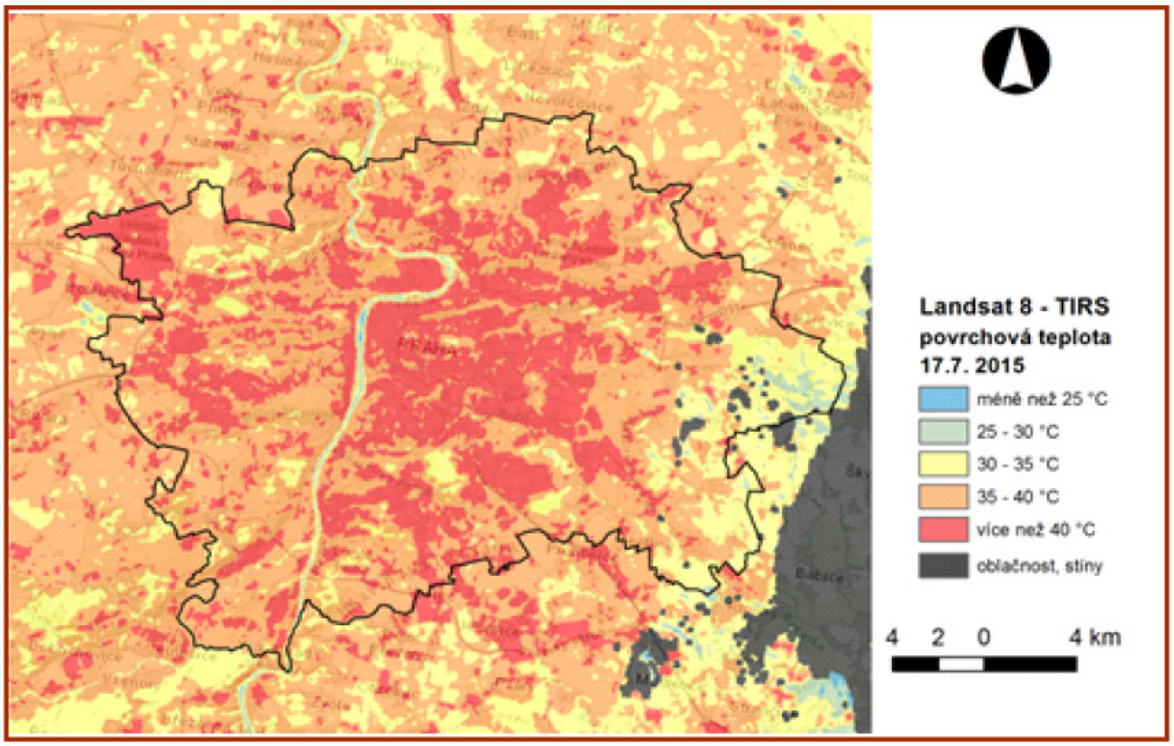

Fig. 2**:** Surface temperature on the Capital City of Prague´s territory, July 17, 2015 around the noon. Satellite imagine from Landsat 8 (Source: Gisat)

povrchová teplota – surface temperature; více než 40^0C - > 40 ^{0}C; oblačnost/stíny – cloudiness/shades.

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[6] WHO (2016): *Urban green spaces and health. A review of evidence*. WHO Office for Europe Copenhagen, 79 pp. http://www.euro.who.int/en/health-topics/environment-and-health/pages/news/news/2016/11/who-report-shows-urban-green-spaces-deliver-multiple-health-benefits.

2 Ecosystem services and benefits provided by green infrastructure

Fig. 3: What are humans provided free of charge by nature (Source: metrovancouver.org.)

Green infrastructure in the urban environment provides important ecosystem services, *e.g.* cooling the environment by evaporation and shading by full-grown trees (the so-called natural air-condition), cleaning the air from various contaminants, providing suitable habitats to organisms in the urban environment and creating a pleasant cultural spaces.

Other ecosystem services include buffering the hydrological cycle, from retaining rainfall/storm water, slowing surface water runoff from the landscape to supplying soil humidity and underground water.

Green infrastructure, both as a whole and its individual components, can provide a lot of ecosystem services which can be divided into four groups:

(1) Benefits from regulatory ecosystem services

- Local climate regulation (by slow evaporation of retained water, the environment in its vicinity is humidified and cooled, thus regulating the local climate. At the same time, trees provide shade and reduce overheating on streets, house facades and cars in warm weather, while during the winter, they reduce wind intensity and buffer cold sudden changes or fluctuations in air temperatures. Therefore, presence of trees can save energy).
- Rainfall/storm water runoff regulation (vegetation enhances rainfall/storm water retention and accumulation and reducing runoff peaks and reduces flood negative impacts).
- Enhancing air quality (vegetation, particularly woody plants reduce dustiness and contaminant levels in the air by capturing them in a crown and in soils, thus regulating impacts of various harmful contaminants on human health).
- Noise regulation, particularly that from land transport;
- Global climate regulation (vegetation sequesters carbon as carbon dioxide from the atmosphere).

(2) Benefits from cultural ecosystem services

- Recreation, leisure, relaxation and resting (greenery makes life in cities more pleasant and provides space for walking and meeting other people);
- Greenery visual patterns enhance aesthetic quality and attractiveness of the urban environment including city streets and form aesthetic elements there, providing aesthetic values.

(3) Benefits from supporting ecosystem services

- Enhancing biodiversity including habitats;
- Soil forming;
- Water cleaning;
- Positive effects on human health, improving physiological functions in human body including psychic relaxation, reducing stress and enhancing physical activities[7].

(4) Benefits from provisioning ecosystem services

- Plant production – fruits in private orchards and gardens, medical herbs (*e.g.,* lime blossom);
- Biomass production, *e.g.* for fuel (using waste from woody plant growth thinning during urban greenery management).

[7] Konijnendijk C., Cornelis C., Lindholst A.Chr. & Gulsrud N.M. (2012): *Green areas make the city attractive*. Landskab 3.

Green infrastructure capacity is enhanced by synergistic effect of ecosystem services (functioning ecosystems can provide some ecosystem services at the same time: in addition, ecosystem services are often interrelated each other).

Costs for implementing nature-based solutions, *i.e.* ecosystem services provided by green infrastructure and their effectiveness and efficiency can be assessed and compare with traditional technological solutions. From a long-term point of view, green infrastructure is mostly more beneficial than grey infrastructure, the former also being cheaper.

In the urban environment, there is the evidence that property prices are higher in the streets with alleys and other green infrastructure than those in adjacent streets with missing green infrastructure[8].

Therefore, using the green infrastructure is economically more profitable and its application in climate change adaptation strategies is among priorities.

Green and blue infrastructure can be used in counteracting urban heat island effects as well as in reducing impacts of torrential rainfall, floods and long-term drought on the Capital City of Prague´s territory.

Only if the above measures cannot be applied or are not effective enough, it is necessary to use technological solutions through the so-called grey infrastructure.

[8] Melichar J. & Kaprová K. (2012*): Revealing preferences of Prague's homebuyers toward greenery amenities: The empirical evidence of distance-size effect*. Landscape Urban Plann. 109: 56-66.

Annex IV

Good practice examples/lessons learnt in Prague

Example 1: Designed tree alley in Leger Street

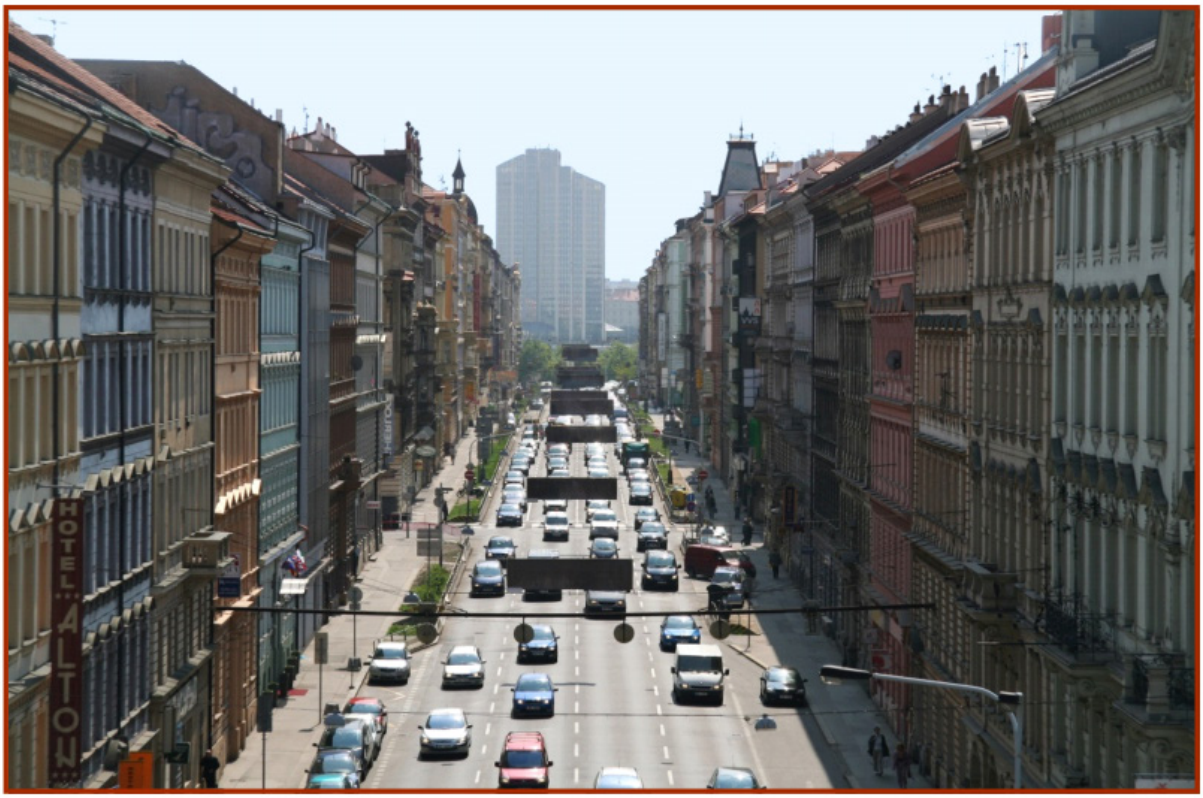

Fig. 4: Leger Street in Prague (Source: www.eu-uhi.eu.)

Description of the measure:

At present, Leger Street located right in the Prague downtown is strongly overloaded by motor traffic emissions and in summer, also by increased temperatures caused by the urban heat island (UHI) effects, thus negatively influencing human health there. In the course of the project on the UHI funded by the European Union, temperature and air quality analysis was carried out. The main aim was to assess microclimatic conditions and to propose a strategy to mitigate undesirable harmful impacts on human well-being there.

Applying micrometeorological measurements as well modelling and simulations/scenario analysis by computer programs, some variants for introducing a tree alley there were tested. During the computer simulation, the current air quality was also taken into account.

Because of overloading of the street by intense motor traffic, it has not been recommended to introduce a green alley there, since full-grown trees would prevent ventilation in the street.

Moreover, simulations/scenarios by modelling have shown that establishing an alley of relatively low trees along both the street sides does not prevent air ventilation and at the same time it reduces extreme temperatures present there, particularly in afternoons.

According to scenario analysis, human well-being would be enhanced by planting an alley of less grown trees, being able to form an axis trunk: trees should be planted in the appropriate distance between them.

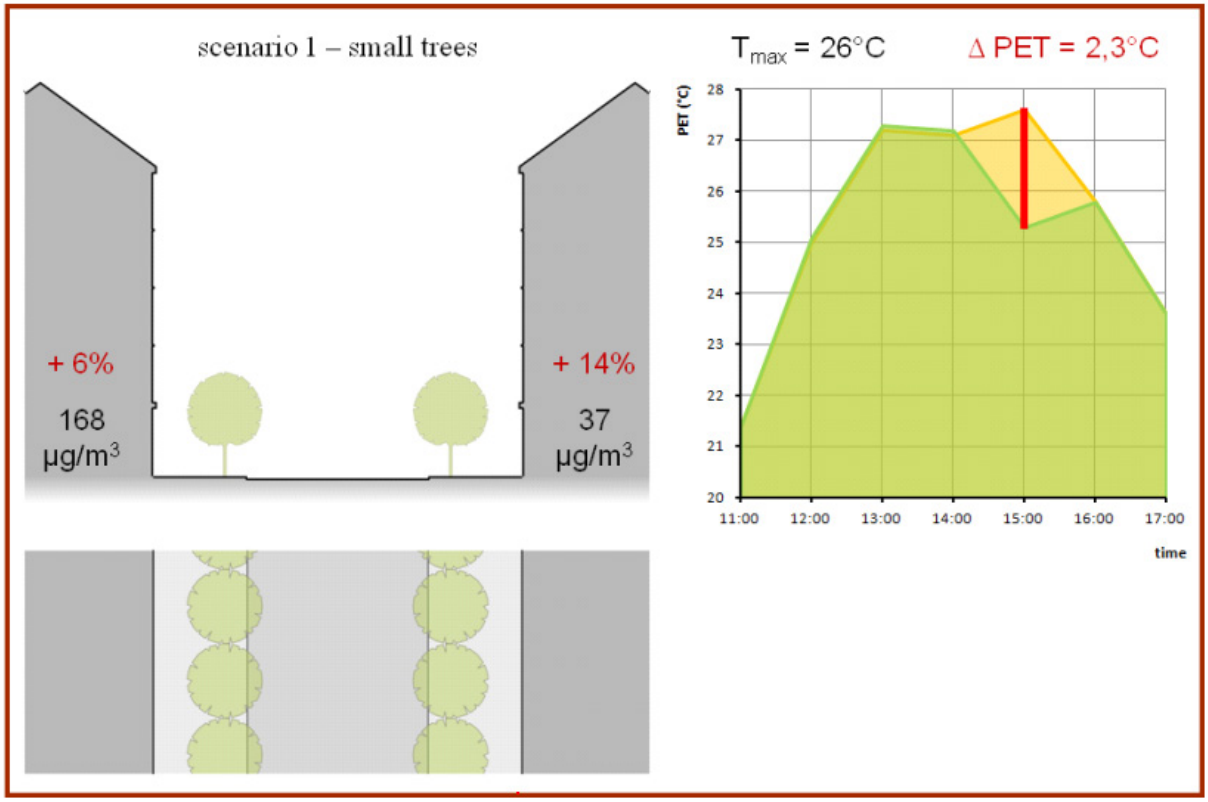

Fig. 5: Outputs of modelling temperature and pollutant level in Leger Street (Source: www.eu-uhi.eu.)

Notes:

Less grown tress should be able to form an axis trunk and step-by-step branches at least 2.5 meters high to allow walking or 4.5 meters to allow motor traffic there (see Fig. 6).

Nursery stocks with minimum crown height of 220 to 240 centimetres are supplied for alley planting: in consecutive years, they are artificially shaped to reach the target crown during consequent management (*cf.* Prague Public Space Design Manual, 2014).

The distance between the individual trees should be sufficient to allow free growing of a crown, thus avoiding their dying. The sufficient distance from facades and passages is also important.

Selection of the suitable woody plant species should be consulted with a landscape architect and the particular proposal again assessed by microclimatic condition modelling.

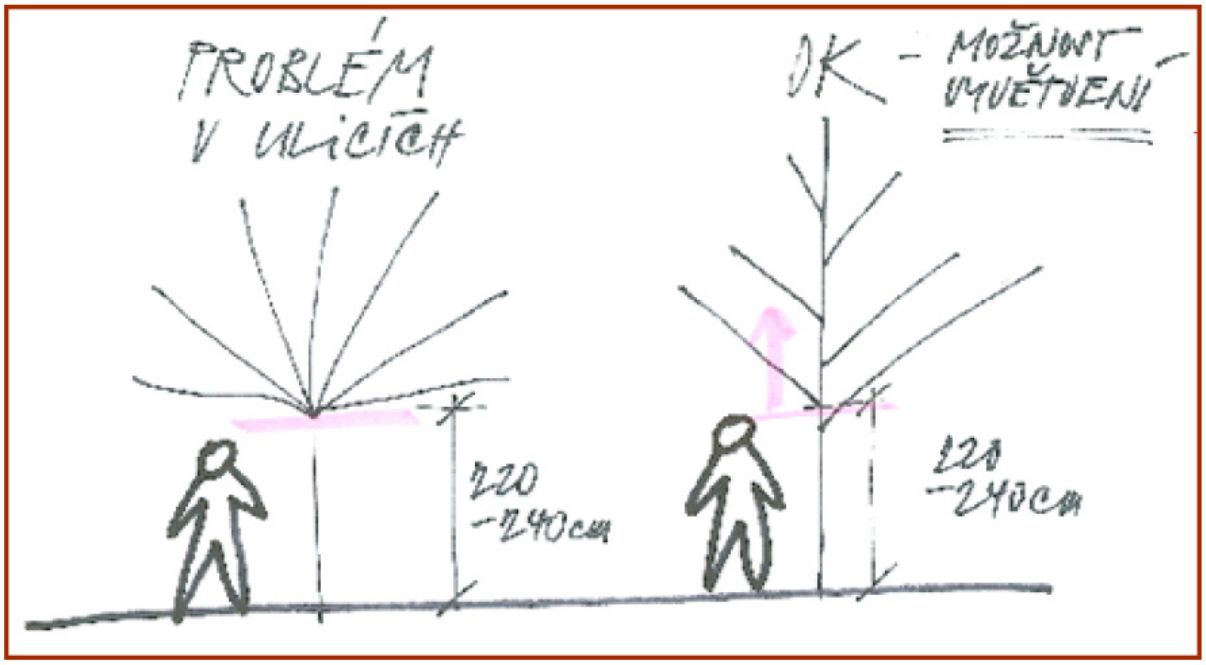

Fig. 6: Outline of a small tree alley proposed for Leger Street (Source: Department of Environmental Protection, Capital City of Prague Municipal Office)

problem v ulicích – difficulties in streets; možnost vysvětlení – possible explanation.

Fig. 7: Would Leger Street look like this in the future? (Source: www..eu-uhi.eu.)

Example 2: Alley restoration along the Leger St. – Jan Želivský St. stretch in Vinohrady Street

Fig. 8: Total restoration of an alley along the Leger Str. – Jan Želivský St. stretch in Vinohrady Street (Source: Department of Environmental Protection, Capital City of Prague Municipal Office 2007/2008).

In the end of 2017, the Department of Environmental Protection, Capital City of Prague Municipal Office has been preparing planting about 33 trees following the updated project on alley restoration – Atelier a05. More trees not included into the proposed alley restoration can be planted only after finishing technical infrastructure relocation or building collectors there.

Description of the measure:

Within the alley restoration, 15 trees were cut down there. In total, 171 new plants, *i.e.* three times more, have been planted there. During elaborating the documentation on total restoration of the alley the stretches where the alley can be restored only by expensive technical infrastructure relocation or building a collector have been identified. The project also includes recommendations on consequent tree management for the next five years. The trees were planted in holes larger than set by the standard, namely in volumes from 3.7 to 4.5 cubic metres. In the end of 2017, the Department of Environmental Protection, Capital City of

Prague Municipal Office has been preparing planting about 33 trees following the updated project on alley restoration – Atelier a05.

More trees not included into the proposed alley restoration can be planted only after finishing technical infrastructure relocation or building collectors there.

Investor: Department of Environmental Protection, Capital City of Prague Municipal Office

Project by: Atelier a05 – Martina Forejtová MSc., Aleš Steiner MSc. (Project 2005-2007).

Implemented by: consortium made by Gabriel Ltd. & Imramovský – Vegetation Management Ltd.

Implemented in: Autumn 2007 – spring 2000

Total costs: CZK 11.5 million (EUR 444,875.00): VAT not included

Management costs/year: CZK 350,000.00 (EUR 13,540.00): VAT not included (management of both newly planted and existing trees)

Example 3: Design on cells providing space enough for root growth in Budeč Street

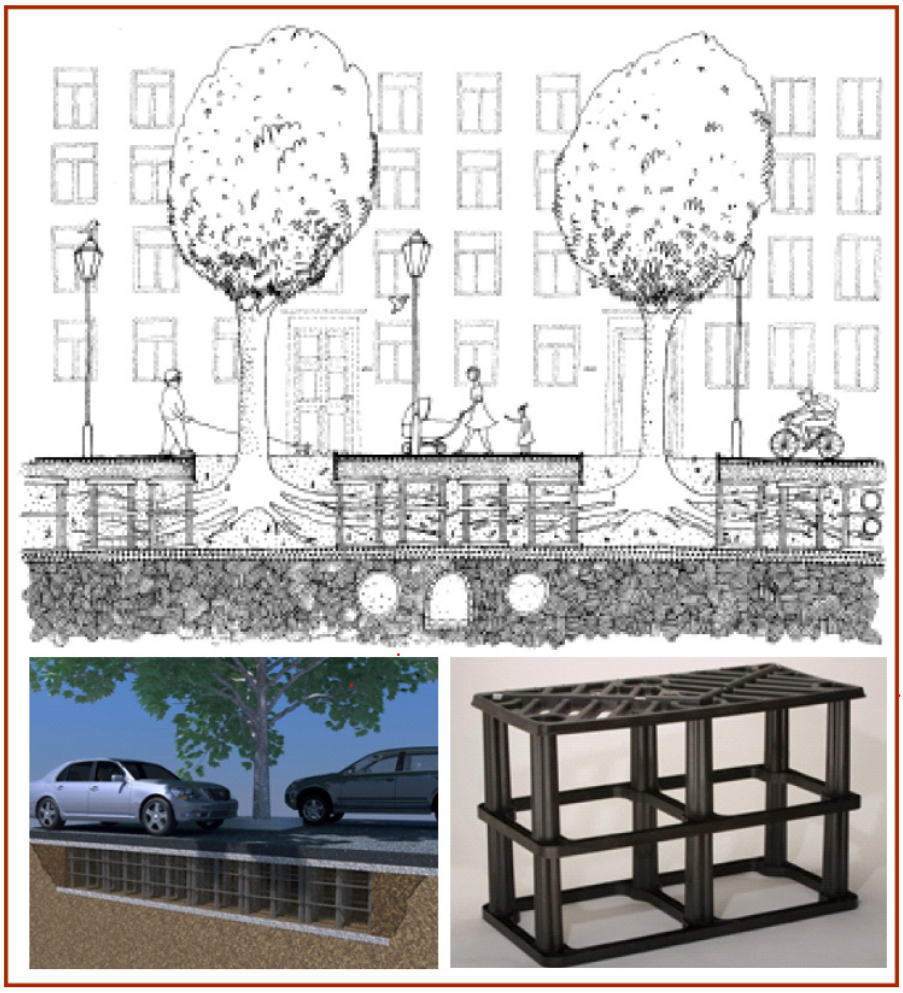

Fig. 9: Cells providing space enough for root growth in streets (Source: Department of Environmental Protection, Capital City of Prague Municipal Office)

Viable trees prospering in a long time in streets enhance significantly human well-being in city downtowns: simply, they cannot be replaced by anything.

Providing trees with space enough for root growth is a key precondition for their functionality and longevity in the strongly unfavourable urban environment (limited space, poor supplying by nutrients and soil air, salinization, overheating, heat, soil compaction, mechanical destruction, dog urine, space joined with technological infrastructure).

For late 2016 and spring in 2017, the Department of Environmental Protection, Capital City of Prague Municipal Office prepared implementation of a pilot project aiming at alley restoration in Budeč Street using a new technology. Relatively more expensive building underground cells providing space enough for root growth is an important technological innovation to enhance habitats for growth of trees in the urban environment.

The simple system installed under paved surfaces in the tree´s vicinity provides space enough for root growth and at the same time also permanent passing such an important soil air together with nutrients to the tree. Due to solid module construction, it also is possible to use the close vicinity to the tree for car parking avoiding soil compaction. Ideally, continuous strips with space enough for root growth between trees are made along the whole street. The facility can integrate technological infrastructure, namely cables and pipelines.

Selection of the suitable particular tree species in alleys is based on its possible high prosperity in the urban environment. For the alley in Budeč Street, using the single species, namely the Honey locust (*Gleditsia triacanthos*), variety Skyline is planned. In spring 2017, thirteen full-grown trees were planted at the site. In late 2016, preparatory activities had been carried out there.

Spaces enough for root growth, suitable growing media, air ventilation and irrigation digs, protective components in the tree´s vicinity and other enhancing measures are together with subsequent high-quality management a precondition for the alley´s long-term prosperity.

Example 4: Restoration of and building parks in Prague

Fig. 10: The new Max van der Stoel Park in the District of Prague 6 (2014). (Source: http://www.praha.eu/.)

Fig. 11: A children´s playground in the new Max van der Stoel Park (Source: www.praha.eu.)

Fig. 12: Restoration of a former fishpond bottom at the Stromovka Royal Game Preserve (Project by FLORART)

Fig. 13: Enlargement of water bodies at the Stromovka Royal Game Preserve (Project by FLORART, technological design of water bodies by Mr. Jílek)

Example 5: Design on the Soutok/Confluence Suburb Park

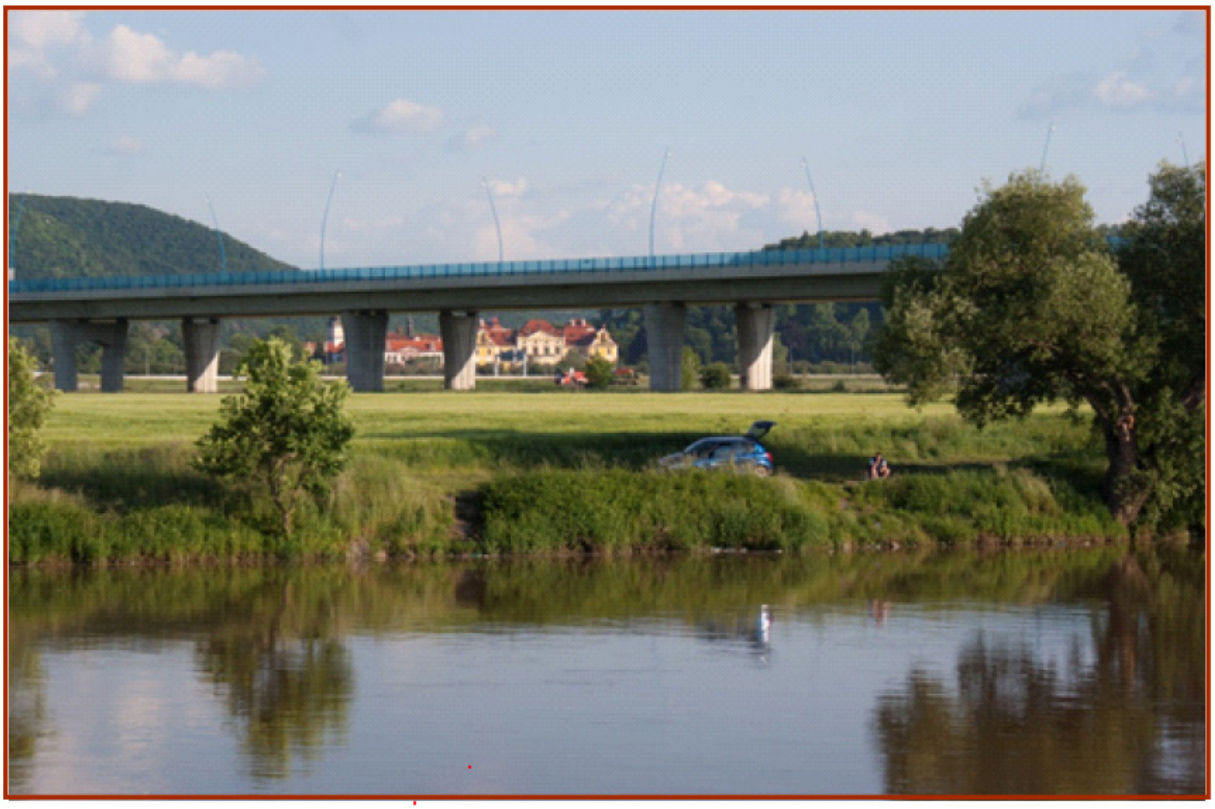

Fig. 14: Design on the Soutok/Confluence Suburb Park on the confluence of Vltava and Berounka rivers (Source: Prague Institute for Planning and Development)

Example 6: Restoring inner courtyards

Fig. 15: Restoring a courtyard locked by Křížkovský, Ševčík, Kubelík and Slavík streets in Prague 3(Source: www.ekocentrumkoniklec.cz.)

Example 7: Community gardens

Fig. 16: The Kuchyňka/Little Kitchen community garden in Prague-Troja (Source: www.kzkuchynka.cz.)

Example 8: Development of further flood prevention measures in Prague

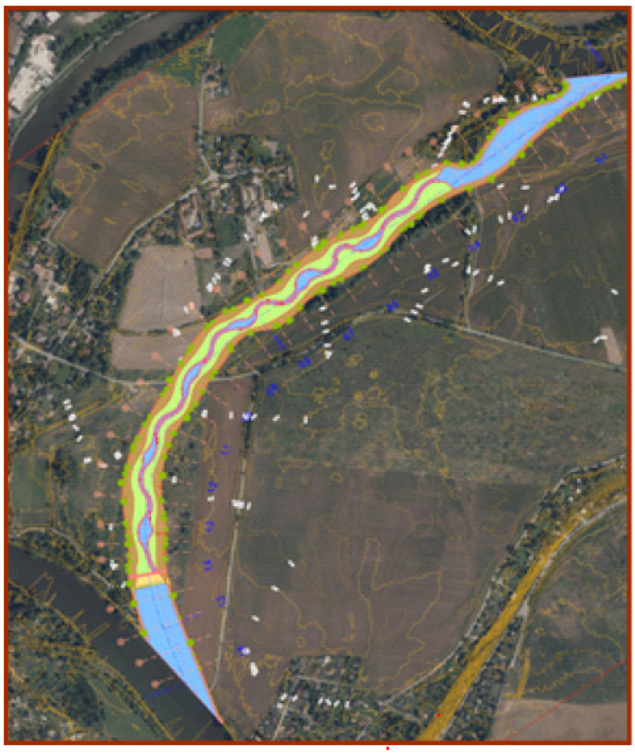

Fig. 17: Flood prevention measures to protect the Capital City of Prague, Stage 000, part 32 Lipenec – Broad-based terrace. The phase of development: a background study has been elaborated (Source: Water Management and Building, pls Prague)

Fig. 18: Building No. 4679 Maniny – Prague Flood Prevention and Control Measures, decreasing the Karlín profile levelling baseline. Stage 0001 (a polder with a recreation/leisure zone) and stage 0002 (enlargement of a polder). Preparatory phase as of November 2016: final water management and building permissions have been issued (Source: Water Management and Building, pls Prague)

Fig. 19: Flood prevention and control measures to protect the Capital City of Prague, Stage 0011, part 31 (Čakovice). The phase of development: the land-use/ territorial documentation has been tabled for discussion for planning permission procedure (Source: Water Management and Building, pls Prague)

Example 9: Study on retention capacity, dry polders and retention water reservoir on the District of Řeporyje´s territory

The study assesses seven sites under study from a point of view of flood prevention measure effectiveness, land-use/territorial planning, property relationships, types of parcels/plots and ownership structure in the close vicinity of the water retention measures.

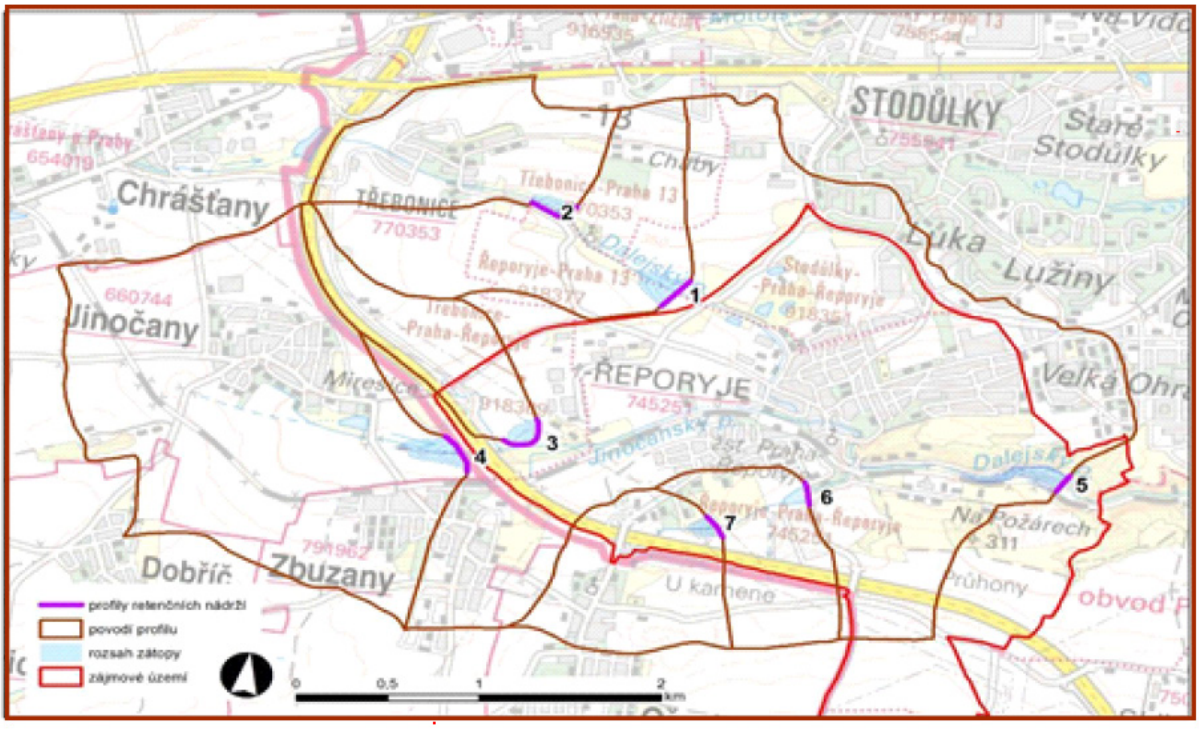

Fig. 20: Division of the District of Řeporyje´s territory for assessing the water retention capacity of the area under study (Source: Study on water retention capacity on the District of Řeporyje´s territory, Water Management and Buildings, pls, 2016.)

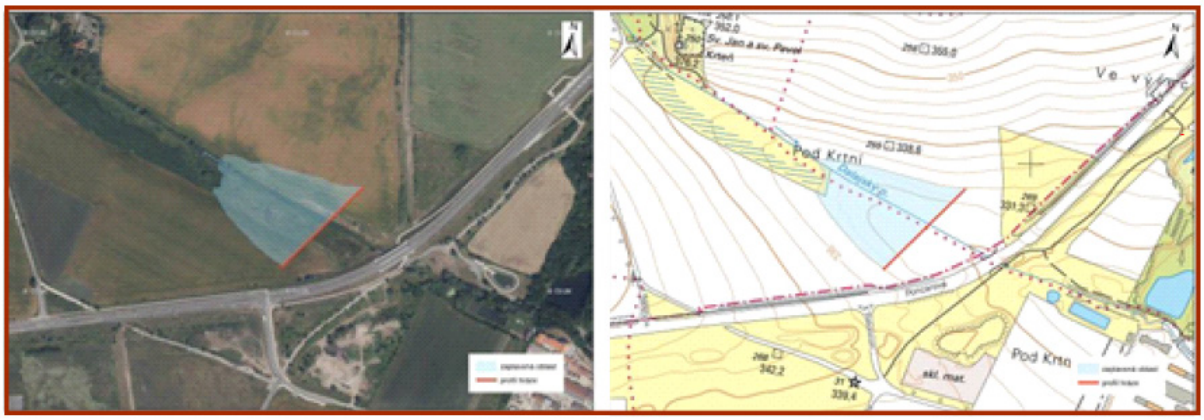

Fig. 21: The study recommends to further develop designs of water retention profiles at sites 1 and 4 as well as more detail design for watercourse restoration incl. measures across site 3 and 7. The measures enhance water retention in the landscape including designation of supporting elements, particularly a walking path linking the Prague District of Řeporyje and the municipalities of Ořech and Jinočany (Source: Study on water retention capacity on the District of Řeporyje´s territory, Water Management and Building, pls, 2016.)

Example 10: Elaborating land replotting or land consolidation/reparcelling design on the Capital City of Prague´s territory and the territory of the District of Prague-East, Prague-West respectively

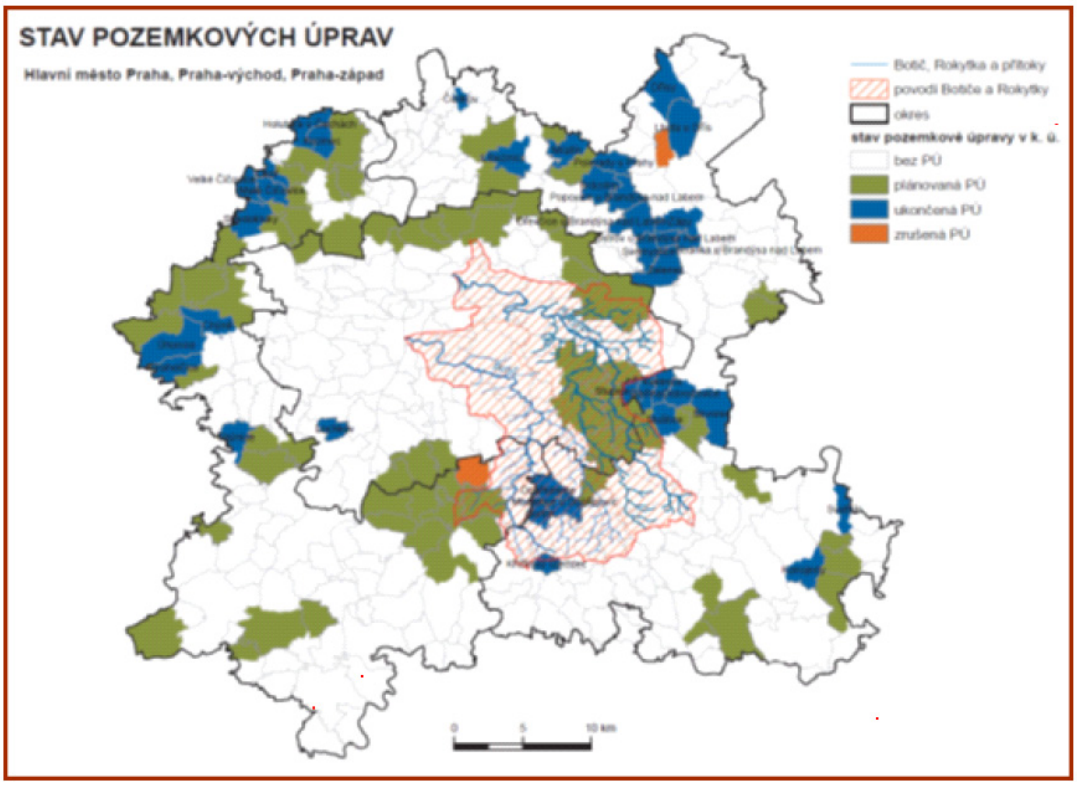

Fig. 22: State of land replotting or lands consolidation/reparcelling on the Capital City of Prague´s territory and the territory of the District of Prague-East, Prague-West respectively (Source: Map background document analysis, Marada, 2016)

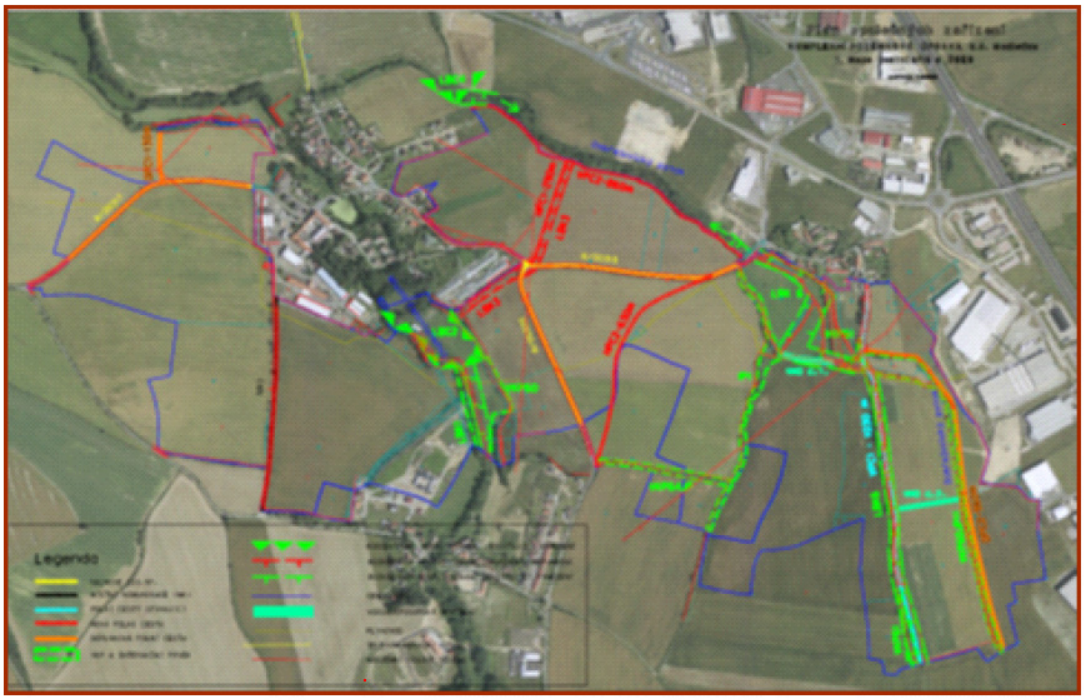

Fig. 23: Design of the plan on a common measure the Modletice cadastre unit/registered land plot
(Source: Map background document analysis, Marada, 2016)

Example 11: Prague water reservoir restoration

Fig. 24: The Hořejší rybník/Upper Fishpond restoration within the Prague Water Reservoir Restoration project (Source: Department of Environmental Protection, Capital City of Prague Municipal Office.)

Fig. 25: The Kajetánka Fishpond restoration in Břevnov (Source: Department of Environmental Protection, Capital City of Prague Municipal Office)

Example 12: Prague watercourses restoration – the Brooks for Life project

Fig. 26: The Rokytka Brook restoration within the Brooks for Life project (Source: Department of Environmental Protection, Capital City of Prague Municipal Office)

Fig. 27: Restoration of the Zlatnice site on the Litovice-Šárka Brook within the Brooks for Life project (Source: Department of Environmental Protection, Capital City of Prague Municipal Office)

Example 13: Green roofs

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Fig. 28 An intensive green roof, vegetation shading and other energy saving measures on the ČSOB Bank headquarters in Radlická Street (Source: http://www.csob.cz/cz/Csob/O-CSOB/Budova-CSOB-Radlice/Stranky/default.aspx.)

Fig. 29: Passive and low-powered Primary School and Kindergarten with an extensive green roof and a semi-permeable paving in Prague – Slivenec (Source: http://www.skolaslivenec.cz/.)

Example 14: Green roofs and green vertical walls

Fig. 30: An extensive green roof, Dům v úžině/House in Gorge, Praha - Jinonice (© Pavel Dostál, 2015.)

Fig. 31: A vertical green wall at the Smíchov Shopping Centre (© Smíchov Shopping Centre)

Example 15: Educational actions for primary school children

Fig. 32: Visits to community gardens and family farms (demonstration of vegetation planting in the urban environment, vertical gardens, raised beds, compost bins, use of rainfall/stormwater, *etc.*) (Source: http://www.ekocentrumkoniklec.cz/)

Example 16: Flowering Libuš and Písnice city districts: A photo competition on the most beautiful flowering window, balcony, little garden or the vicinity of a house

Fig. 33: Involvement of the public into management in the vicinity of a place of residence by a photo competition entitled Flowering Libuš and Písnice having been organized by the District of Libuš Office within the Healthy Libuš and Písnice and MA21 projects since 2009 (Source: District of Libuš Office)

Example 17: Planting trees on ceremony of welcoming babies as new citizens

Fig. 34: Planting trees for new little citizens in the K jezírku/To a Little Lake Park (the District of Libuš) has begun in 2013, aiming at enhancing relations of citizens to the local environment, enlarging and improving green spaces on the Capital City of Prague´s

territory and contribute to the better environment and its perception in the respective Prague (© Vendula Audolenská.)

Fig. 35: A commemorative plaque on planting tree for new little citizens in the K Jezírku/To a Little Lake Park (© Vendula Audolenská.)

Example 18: Long-term project on environmental education of pupils from upper primary schools and for high school students entitled Microclimate in the School´s Vicinity

Fig. 36: The Microclimate in the School´s Vicinity project has been carried out by the Koniklec/Pasqueflower EcoCentre, charitable trust: more than 60 primary and high schools and 3,000 children have participated in it. The project aims at involving pupils in

identifying, analysing and solving environmental problems in the vicinity of their schools from a point of view of the microclimate protection and enhancing a role of schools as community centres (Source: http://www.ekocentrumkoniklec.cz/.)

Example 19: Local Adaptation Fora: Initiating Adaptation Activities - a project for pupils, students, local representatives and the general public

Fig. 37: The project implemented by the Koniklec/Pasqueflower EcoCentre, charitable trust, based on cooperation among pupils, citizens and city quarter representatives enhances communication on and awareness of climate change negative impacts as well as ability to identify suitable measures and stimulates developing local climate change adaptation strategy trough education, lectures and workshops (Source: http://www.ekocentrumkoniklec.cz/.)