LIFE LOCAL ADAPT | Integration of climate change adaptation into the work of local authorities

Municipal adaptation to a changing climate - from urban planning to self-preparedness

Increasing heavy rain, soil erosion and heat stress resilience

Deliverable to Sub-Action C6.3, C7.3, C8.1, C8.2

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Content

1 Municipal adaptation to a changing climate - Getting started

In the last decades, we observe a changing climate worldwide. Emissions of greenhouse gases are leading to an increase in global temperature with more frequent extreme weather events such as heavy rain and heat waves, which threaten our livelihoods and health. Agriculture and forestry are struggling with crop failures and massive forest damage. Citizens and municipalities incur high costs due to heavy rainfall-related damage to buildings and infrastructure, and the heat waves of recent years have claimed thousands of lives.

In order to stop this development, efforts must be made to reduce the emission of greenhouse gases, which is referred to as ***climate mitigation or climate protection***. Measures to cope with climate change that can no longer be avoided are referred to as ***climate adaptation***. Current planning and investments must always take both aspects - climate protection and climate adaptation - into account, especially in construction measures that will last for many decades. The effects of climate change must also be considered in water supply, water disposal and disaster control, which are tasks within the scope of local self-government. This is a major challenge, especially for small and medium-sized municipalities.

The EU project LIFE LOCAL ADAPT (Box 1) aims to support these municipalities in climate adaptation with advisory services and various products. This is the first of four short brochures on climate adaptation at the municipal level. The first brochure introduces the topic, the following three brochures deal with heavy rainfall, heat stress and erosion. Info boxes provide brief additional information and examples: blue boxes for background information, green boxes for do-it-yourself recommendations and orange boxes for good practice examples from the project.

Box 1 – Background: EU project LIFE LOCAL ADAPT - Integration of climate change adaption into the work of local authorities

Duration: 2016 – 2021

Project partners:

- TU Dresden, Chair of Meteorology (Lead) and European Project Center
- Saxon State Office for Environment, Agriculture and Geology
- Climate Service Center, Hamburg
- Czech Globe, Czech Republic
- Provincial Government of Styria, Austria
- Valka Municipality, Latvia

Objectives:

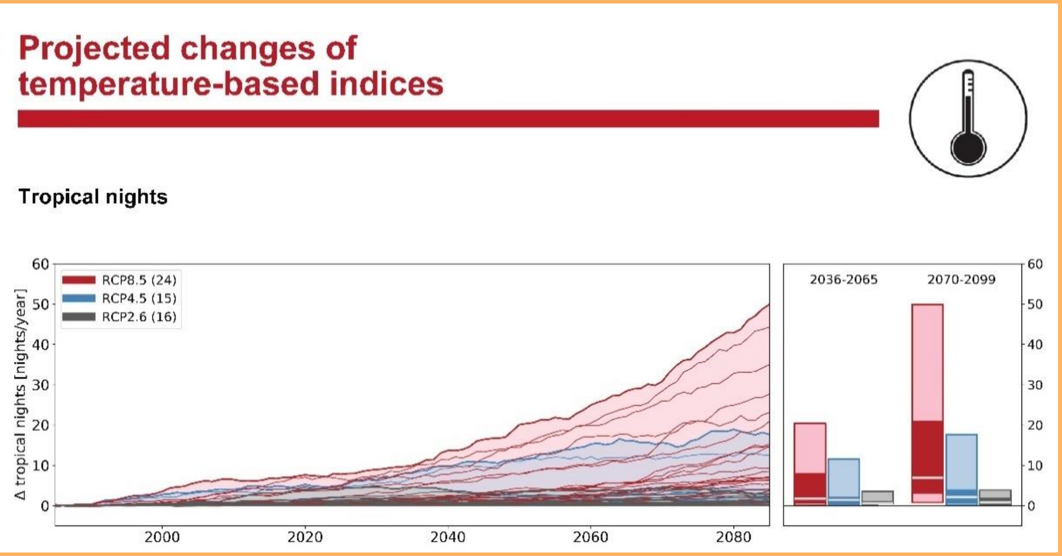
1. Improving the data base and information
2. Enhancing the knowledge of municipalities
3. Integration of climate change adaptation into the administrative work of local authorities
4. Implementation of specific measures of climate change adaptation in cooperation with municipalities

1.1 Climate changes

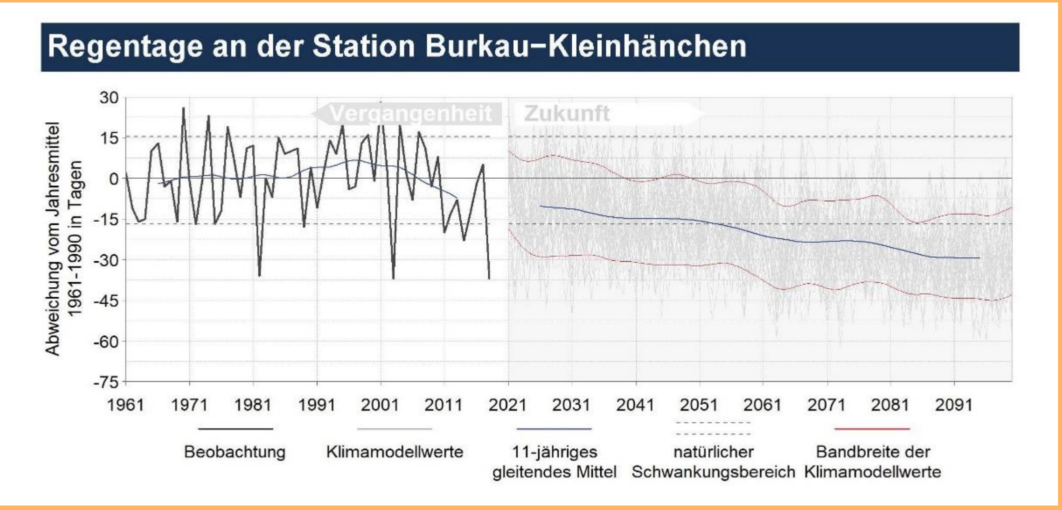
In order to set up a climate adaptation strategy, both climate change and its impacts in the municipality need to be known. There is information on changes for a wide range of climate variables and their impacts - first and foremost temperature and precipitation - for the global, national and regional scale. For the target group of cities and municipalities, LIFE LOCAL ADAPT produced climate fact sheets for the four project regions and additionally at the municipal level in two project regions - Styria in Austria and Saxony in Germany (see Box 2). These fact sheets contain information about past and future climate changes regarding temperature, number of heat days, frost days, precipitation, days with heavy rain, drought etc.

Box 2 - Example: LIFE LOCAL ADAPT - Regional and local climate factsheet

This figure of the Regional Climate Fact Sheet for Saxony (Climate Service Center Germany, 2019) shows the increase of the Number of Tropical Nights for three different scenarios until 2100.



This figure of the Local Climate Fact Sheet for the municipality Kamenz in Saxony shows the future decrease of the Number of Rainy Days based on an ensemble of different climate models (LfULG, 2021).



Statements about future changes are of course subject to uncertainties. To take these into account, various emission scenarios are simulated with various models. The result is an ensemble of climate projections that covers a range of possible climate developments for each scenario. The greater the agreement within the ensemble, the smaller the bandwidth.

In order to provide users with information on past and future climate changes, many services and platforms have been developed to meet different needs. Box 3 shows a selection of climate information sources. Information portals can offer data, graphical analyses or climate fact sheets.

Box 3 – Background: Examples for Climate information portals

Europe

Climate data Store of Copernicus

National

German Climate Atlas
Climate Change in Czech Republic
Climate Scenarios for Austria

Regional

ReKIS for Saxony, Saxony-Anhalt and Thuringia
Climate Change Styria

Find out if your region also offers specific climate information.

1.2 Climate impacts and vulnerabilities

Knowledge of climate change alone is not sufficient as a basis for decision-making for municipal action. The impacts of climate change differ within regions and depend on the sectors, e.g., water management, spatial planning, human health (see Box 4). Therefore, in addition to the question of climate change, the following questions must also be answered:

1. Are the municipality and their citizen affected by these changes? → Impact, Exposure
2. How vulnerable is the municipality? How great is the risk? → Vulnerability

For example, measurements and climate models show an increasing variability of precipitation with a greater frequency of droughts and at the same time heavy rain events. It must be clarified how strongly the municipality is affected by these climate changes. Is the municipality located in a rather dry region, do the soils characteristic promote or prevent rainwater infiltration or water storage, or is heavy precipitation particularly likely due to the orography? The final damage to be expected is determined by the vulnerability of a municipality. Is the infrastructure in good condition and designed for extreme rain events? Are citizens and homeowners informed about private precautionary measures, such as the installation of backwater flaps? Is the drinking water supply provided with sufficient reserves? The task of the municipality is to clarify these points for all expected natural hazards, possibly altered by climate changes. For all sectors in municipal responsibility an adaptation strategy with necessary measures has to be derived.

Box 4 - Example: Selection of expected climate change impacts for different sectors in Saxony (modified after UBA 2015)

Sector	Impact
Human health	heat stress (cardiovascular disease, heat shock, heat death, performance reduction)
Soil	erosion (by water or wind), landslides
Agriculture	waterlogging, drought and frost damage
	shift of phenological phases and alteration of growth phase
Forestry	damages by extreme events (wind, snow and ice breakage)
	heat and drought stress
	insect calamities
Fishery	invasive species
	alteration of aquaculture (growth rate, reproduction and mortality of fish stock)
Water management	availability of groundwater
	floods and low water
	water quality

Erosion and dried up spring. Photos: Thomas Pluntke

1.3 Climate mitigation and adaptation

Both, climate protection and adaptation to the consequences of climate change are municipal tasks that are steadily gaining in importance. Climate protection laws prescribe legally binding climate targets with annually decreasing greenhouse gas budgets for sectors such as transport, energy, industry, buildings, agriculture and waste management with the corresponding measures. Many municipalities are already actively engaged in climate protection, even if this is primarily motivated by savings in energy costs. In contrast, climate adaptation measures are necessary to adapt to the impacts of climate change and to limit economic, ecologic and human damages. However, the legal basis in the field of climate adaptation is still insufficient and has often only a recommendatory character. Many large cities but only a few small and medium-sized municipalities have already developed adaptation strategies. Often there is a lack of financial and human resources or of expertise. If municipalities become active, it is mainly due to damaging events that have already occurred. It is urgently necessary to replace this event- and sector-specific approach with a comprehensive, sustainable and strategic climate adaptation. This includes the following steps:

- hazard analysis,
- risk and vulnerability assessment,
- strategy and action plan with detailed measures and its prioritisation as well as
- monitoring and evaluation.

The involvement of all relevant actors and the use of participatory methods is highly recommended for strategy development. Support in the process of climate mitigation and adaption can be found at national and European level, for example in the initiative "Covenant of Mayors for Climate and Energy" (Box 5). In addition, the European web-based knowledge platform “Climate-ADAPT offers the Urban Adaptation Support Tool (UAST) to assist local authorities in developing, implementing, monitoring and evaluating climate change adaptation strategies and plans.

Box 5 – Background: Covenant of Mayors for Climate and Energy and Climate ADAPT

The initiative **Covenant of Mayors** was established in Europe in 2008 with the aim of bringing together and supporting municipalities to meet or exceed the EU's climate and energy targets. More than 7000 local and regional governments around the world are now part of the initiative, including our project partner, the small municipality of Valka in Estonia. Members are supported in their efforts by receiving the recognition, resources and networking opportunities they need to further improve their energy and climate action. Neighbouring small and medium-sized local authorities may participate as a signatory group and submit a joint Sustainable Energy and Climate Action Plan.

https://www.eumayors.eu/

The European Climate Adaptation Platform **Climate-ADAPT** is a partnership between the European Commission and the European Environment Agency. It helps users to access and share data and information on:

- Expected climate change in Europe
- Current and future vulnerability of regions and sectors
- Adaptation strategies and actions
- Adaptation case studies and potential adaptation options
- Tools that support adaptation planning

UAST: https://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast/step-0-0

1.4 Risk communication and actors

Risk communication aims at increasing the risk awareness of citizens. It is an important part of risk prevention and henceforth of an integrated risk management. Information is needed on

- where which risk develops,
- who is affected,
- which measures can be taken to minimize the risk and
- which risks cannot be avoided.

Combined with good praxis examples it motivates to reduce the risks.

Various target groups should be addressed: private persons, administration, politicians, farmers, entrepreneurs etc. Information has to be tailored in terms of content and language to meet specific demands. Regular communication is important to maintain the awareness. Innovative information formats should be used to attract the public.

There are various types of risk communication and public relations:

- Risk communication with maps: indicate specific on-site risk. Well suited for an online portal of the municipality. Helps to select appropriate measures.
- Reading material: as print or online products, such as handbooks, guidelines, flyers, brochures etc. Easy access should be guaranteed and content and language should be tailored to target groups.
- Interactive communication and participation: information events, workshops, trainings, individual consulting services. Serves networking and mutual learning at the same time.
- Education: helps to increase the awareness and knowledge of risks in the future.
- Putting up signs in places damaged by past events or where measures have already been taken.

For an effective communication it is critical to understand the public. Pre-existing beliefs are usually difficult to change unless those beliefs are explicitly addressed. A successful communication that bridges the gap between experts and the public is possible knowing what people think, belief, opine and know about specific risks. The public's concerns must be appreciated even if they seem unfounded.

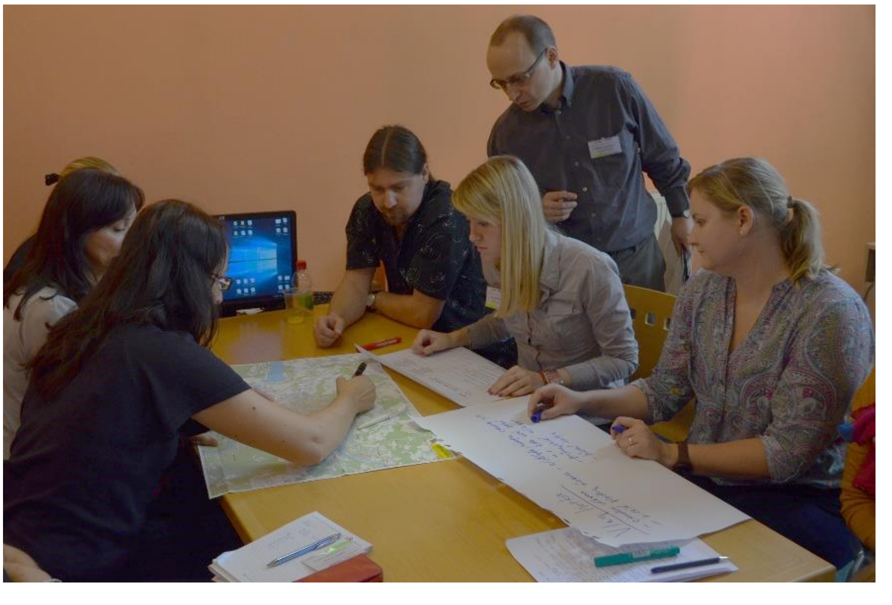
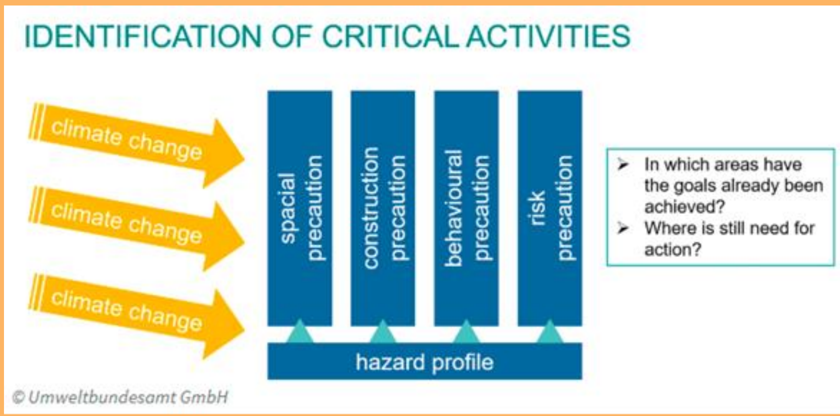


Photo: Adam Emmer

Box 6 – Example: Tailored information in Styria, Austria:

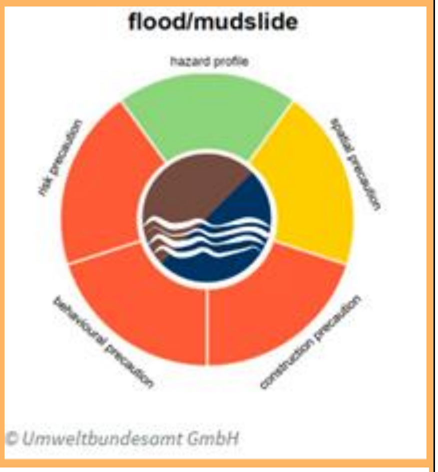
Natural hazard preparedness and adaptation to climate change are necessary measures to be prepared for climate change and disaster risk scenarios. Municipalities are central actors in precautionary measures and are the central point of contact when it comes to safety. For this reason, the federal and state governments in Austria jointly developed the precautionary check "Natural Hazards in Climate Change". It has now been officially offered and carried out for municipalities in the federal states since 2020.

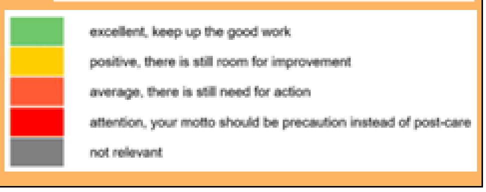
The aim of the natural hazard check is to raise the awareness of municipal decision makers and actors for locally relevant natural hazards and climate risks, and to strengthen their risk awareness and capacity to act. This method identifies existing potentials, the preparedness, and possible needs for action for the four pillars of precaution (spatial, constructive, behavioral and risk based).



The check is carried out in the municipality itself. It is based on the methodology of a moderated self-assessment. In the best case, all important decision-makers in the municipality with regard to natural hazards and climate risks participate, for example the mayor, the heads of building and planning authority, and responsibles for emergency services. In addition, those responsible for municipal infrastructure, legal issues and administrative or financial matters can also be involved. The following topics are addressed:

- **Hydrological natural hazards** (heavy precipitation events, floods/mudflows)
- **Gravitation natural hazards** (landslides/settlements, rockfall and avalanches)
- **Climate-related natural hazards** (heat, drought, forest and wildfire, storm, hail, lightning, snow and ice loads, late frost, pest calamities and invasive species)





The auditors prepare a report with summarized findings for each natural hazard (ring diagrams). In addition, a qualitative description of the current precautionary state is given, as well as recommendations for further steps, especially considering changing climate conditions. The municipality receives the full report and a confirmation of the successful completion of the precautionary check. The auditors treat the results confidentially.

1.5 Funding opportunities

Municipalities often lack financial resources to carry out measures and activities supporting their own resilience towards adverse climate change impacts. And the search for funding opportunities possesses a challenge for most municipalities and local authorities. National and regional governments, municipalities, private companies, foundations and banks provide sources to fund climate adaptation activities, which are often hidden under particular and more traditional sector themes, e.g., water management or natural and cultural resources. The European Environment Agency (EEA) distinguishes between four sources of funds, depending on the type of institution providing the funding (EEA, 2017). The last group stands aside, as it is more mainstreaming option than a direct provider of financial source.

1. Governmental sources: international, EU as well as national funding instruments including regional and local sources, mostly grants
2. Banks and other financial institutions: either directly or in partnership with local retail banks, providing loans or guarantees
3. Private stakeholders: companies/foundations, non-profit/non-governmental organizations or real estate developers
4. Early integration of urban adaptation measures into spatial/infrastructure planning and/or mainstreaming into other areas of urban governance (e.g., urban greenery protection or water management). Mainstreaming adaptation into current municipal practices can provide free or low-cost solutions.

Box 7 – Example: LIFE LOCAL ADAPT Funding Fact Sheets

The project LIFE LOCAL ADAPT produced fact sheets for 18 selected funding programs available for local municipalities in the Czech Republic (Severozápad Region), Austria (Styria Region), Germany (Saxony) and Latvia (Valka municipality). The presented programs range in scale from regional to national and European funding programs and offer financial support to projects in various sectors of climate change adaptation (e.g., urban planning, water management, environment). Funding fact sheets typically include:

- Short information about a funding program
- Funding rate
- Funding objects
- Funding period

PDF-versions of Funding Fact sheets can be found at the website of LIFE LOCAL ADAPT: https://life-local-adapt.eu/en/

1.6 References and further readings

Climate Service Center Germany (2019): Climate-Fact-Sheets for Regions. https://www.climate-service-center.de/products_and_publications/fact_sheets/climate_fact_sheets/detail/080193/index.php.en

EEA (2017): Financing urban adaptation to climate change, doi: 10.2800/235562.

LfULG (2021): Klimainformationen – Faktenblatt Niederschlag. https://rekis.hydro.tu-dresden.de/kommunal/sachsen-k/herausforderungen/

UBA (2015): Vulnerabilität Deutschlands gegenüber dem Klimawandel. Umweltbundesamt, Dessau-Roßlau.

Further readings:

Bausch, T., Koziol, K.: Kommunale Klimawandelanpassung. Gestaltung und Steuerung von Anpassungsprozessenin kleinen Gemeinden; Hochschule München, Fakultät für Tourismus, München 2017.

Bundesinstitut für Bau-, Stadt- und Raumforschung, Hrsg. (2016): Anpassung an den Klimawandel in Stadt und Region. Forschungserkenntnisse und Werkzeuge zur Unterstützung von Kommunen und Regionen

EU platform for climate change adaptation (https://climate-adapt.eea.europa.eu/)

Difu (Hrsg.) (2015): Klimaschutz & Klimaanpassung. Wie begegnen Kommunen dem Klimawandel? Beispiele aus der kommunalen Praxis.

European Environment Agency – Climate Change Adaptation: https://www.eea.europa.eu/themes/climate-change-adaptation/

2 Municipal adaptation to a changing climate - Increasing heavy rain resilience

2.1 Introduction

Heavy rains occur at any time and any place, but mostly during heavy summer thunderstorms. Often, they occur very fast whereby local weather forecast uncertainty is very high. High amounts of rainfall cannot penetrate into the soil and into the sewage systems and runs down the slopes to the next river, lake or depression line. They can lead to flash floods in small and medium catchments, to urban flooding, trigger soil erosion and can lead henceforth to severe damages. Two types of heavy rain related hazards can be differentiated:

- Heavy rain flood hazard proceeds from above to below. It is also called "wild running off water", and occurs on sloped areas with limited infiltration capacity.
- In contrast, river and torrential flooding's are characterized by an increase of the river water level. This means the river flood hazard proceeds from below to above.

A higher frequency and intensity of heavy rainfall was found for most parts of Germany, Czechia and Austria in the last decades. Projections of the future climate does not indicate clearly towards a continuation of this trend.

Precaution measures are necessary - on a municipal and private level!

Municipal management of heavy rain risks should follow three steps:

- Risk assessment and mapping
- Risk communication
- Risk reduction

Graz-Andritz in 2013, 95mm in 8 hours (Photo: Bernhard Egger-Schinnerl)

It is a cross sectional task. Cooperation, coordination and communication between the sectors water management, agriculture, forestry, civil protection and other sectors are essential for a successful risk management.

A recent EU project that had a focus on heavy rain and related risks was RAIMAN. Information from this project, LIFE LOCAL ADAPT and further European projects as well as literature is merged here to give a short overview.

2.2 Risk assessment and mapping

Risk maps show the combination of the hazard endangering an object or subject (in this case heavy rain) and its vulnerability. Risk mapping helps to promote the understanding of these issues in the citizenship and helps civil protection organizations in their preparation. Note, risk assessments and mapping of river and torrential floods exist already for many European regions. As the characteristics of fluvial and heavy rain flooding are different, risk assessments differ as well. National or regional approaches for a heavy rain risk assessment and mapping does not exist in each country or region. Some examples can be found in Box 8.

Box 8 – Background: Overview of regional approaches of risk assessment and mapping

Photo: Dominic Rumpf

Germany

There is no nationally coordinated approach, but several German states have provided guidelines describing approaches for the local level. Some examples are listed:

- The state of Baden-Württemberg provides detailed guidance on assessing and mapping heavy rainfall risks for municipalities. Methods, data use, and guidance for an action plan are described: https://www.lubw.baden-wuerttemberg.de/wasser/starkregen
- Stuttgart: interactive example of a heavy rain hazard and risk assessment for a municipality: Regina Starks Aufgabe (https://reginastark.starkregengefahr.de/)
- The state of North Rhine-Westphalia provides a guide to assess and map heavy rainfall risks for municipalities. Methods, data use, and guidance for an action plan are described: https://www.flussgebiete.nrw.de/system/files/atoms/files/arbeitshilfe_kommunales_starkregenrisikomanagement_2018.pdf

Austria

- HORA – Überblick über Naturgefahren und Risikobewertung Österreich – digitale Gefahrenlandkarte
- The Austrian Ministry of Agriculture, Regions and Tourism provides a guide for design, new construction and adaptation in case of a surface runoff: https://www.bmlrt.gv.at/wasser/schutz-vor-hochwasser/finanzierung/leitfaden-eigenvorsorge-bei-oberflaechenabfluss.html
- Flood hazard and risk maps from Ministry of Agriculture Regions and Tourism: https://www.bmlrt.gv.at/wasser/schutz-vor-hochwasser/hochwasserrisiko/bin-ich-hochwassergefaehrdet.html

Czech Republic

- National map with flow paths and critical points during heavy rainfall: http://webmap.dppcr.cz/dpp_cr/povis.dll?MAP=rizika_prival

The first step: Assessment of the heavy rain hazard

You should start with an assessment of heavy rain related hazards and its mapping for the area of municipal responsibility. If no appropriate hazard information exists for the municipality, you can follow one of the three mentioned methods to identify spaces of water concentration during or after heavy rain events and the pathways to the next downward situated river or lake:

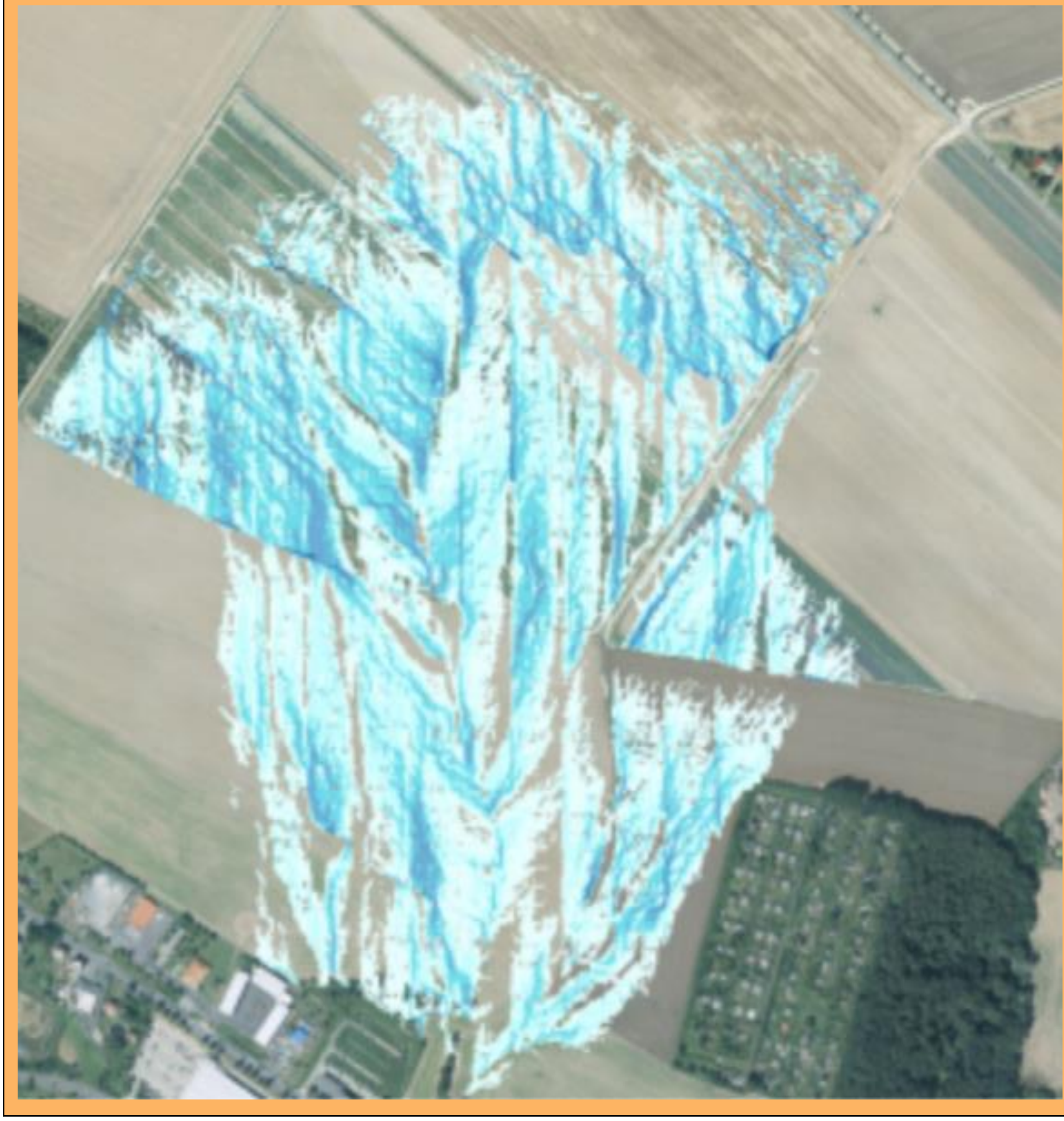
- ***Empirical methods:*** Based on historical knowledge, the probability of heavy rains and flash floods can be concluded. Information from civil protection, citizens, newspaper etc. should be collected and used for a mapping. It is a cheap, sometimes time consuming, but at the same time fragmentary and henceforth erroneous method. Information serves also for the validation of more advanced methods.
- ***Flow path analysis:*** An analysis of the topography (e.g., using Geographical Information Systems GIS) identifies depression lines, where rainwater is collecting and flowing downwards. A highly resolved digital elevation model (e.g., 1x1 m) can be extended by information of streets, walls, culverts to improve the analysis. An experienced GIS expert should conduct the analysis and local knowledge be included. No information can be gathered for flow velocity, flow depth, flooded areas and temporal cause of the event. For regions with moderate terrain slopes, the flow path analysis gives a valuable first indication of the regions at risk.
- ***Hydrodynamic simulations:*** With the help of complex computer models, the division of rainfall into runoff and infiltration into the soil is possible. Highly resolved topographical data, information on surface characteristics (soil, vegetation) and climate data are necessary. If the municipal waste- and rainwater canalization is expected to have an influence on the flooding event, the inclusion of such data is possible. Inundated areas, water depths and velocities as well as the temporal development of the flooding are quantified and allow a comprehensive risk assessment. An evaluation of measures and scenarios is possible. This method is appropriate even for regions with high terrain slopes, but demand detailed data and modelling experts and henceforth more time and financial resources.

The second step: Assessment of the vulnerability of objects and subjects

In the second step of the risk analysis, the vulnerability of objects and subjects which are prone to flooding and might be harmed or damaged is investigated.

- In the ***receptor analysis***, detailed characteristics of persons, animals, buildings, streets etc. are determined. This also includes the vulnerability of commercial and industrial buildings and facilities and installations which might cause accidental pollution and might affect protected areas.
- The susceptibility of the receptors to the negative consequences of the hazard are studied in the ***consequence's analysis***. The relations between the intensity of the flood impact in terms of water level, flood duration and flow velocity and the resulting consequences such as drowning of people, damages of buildings, infrastructure, vehicles etc. due to the impact of water and sediments have to be determined.

Box 9 – Example: Simulated surface runoff with EROSION 3D in Zittau (Photo LFULG)



2.3 Risk reduction

2.3.1 Early warning system

Early warning systems serve to prepare for flood related risks. They should be used to set up a danger prevention, i.e., to warn persons at risk and local key actors and enable them to react properly. The warning information are standardized messages in form of signs, words, sounds or images that announce an imminent danger. Local authorities, but also enterprises and private persons are recipients of warning information. Local information should be added to existing warning messages by local authorities and then further disseminated.

Waring systems exist at different levels: EU, regional and local. Mostly they can be obtained from specific internet websites or via apps for mobile devices. Examples for meteorological warning systems are provided in Box 10 and for flood warning systems in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Box 10 – Background: Meteorological warning systems

They supply information about where and when a heavy rain occurs, its duration and possible impacts

Germany

Feuerwehr Wetterinformationssystem FeWIS

App WarnWetter (German Weather Service)

NINA (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe)

KATWARN (Fraunhofer FOKUS)

Austria:

INCA, from weather service ZAMG.

App National alarm system for emergency situations

Czech Republic:

Flood forecast and information service, from Czech Hydrometerological Service; App

Box 11 – Background: Flood warning systems

They supply information about water levels in rivers, warning levels and its development.

Germany

Regional Flood Centre

Austria:

Water level news and flood forecast

Czech Republic:

Flood forecast and information service, from Czech Hydrometeorological Service; App

Recent water level information and simulated development in Saxony, Germany. Map of the Regional Flood Centre.

2.3.2 Contingency plans

Contingency and measurement plans (also called emergency response plans) help public authorities and organisations with security tasks when a flash flood or flooding event is anticipated, is in the process of occurring or has occurred. They support emergency services in setting up appropriate measures especially at the tactical level of operation management. Risk of life and number of damages can be minimized. Furthermore, it increases public awareness. The contingency plan needs to be designed to facilitate preparedness for future extreme events.

Possible negative effects or impairments of heavy rain are:

- overloading of water bodies and drainage systems, sewage overflow,
- damage to infrastructure and buildings,
- closure of municipal facilities,
- overload/impairment of municipal services and tasks,
- erosion, landslides
- cancellation of events due to extreme weather conditions etc.

Prevention and disaster control are cross-sectional tasks. An intensive communication and cooperation between all parties involved is necessary. Stakeholder are offices of municipality (mayor) and counties, fire brigade, civil protection agencies and emergency services (in Germany for example the THW – Technisches Hilfswerk), operators of infrastructures, public, media etc.

Box 12 – Background: Critical infrastructures divided by sectors and subsectors

Energy → electricity, gas, oil

Information technology and telecommunications

Transport and traffic → air, maritime, inland water rail, road transport and logistics

Health → medical services, pharmaceuticals and vaccines, laboratories

Water → public supply and sewage treatment

Food → industry and trade

Finance and insurance industry → banks, stock exchanges, insurance companies

Government and public administration → parliament, judicial bodies, emergency services, civil protection

Media and culture → broadcasting (TV and radio), print and E-media, cultural property

Three steps to set up a contingency plan:

1. Review of existing hazard analysis to identify areas of hazard, critical heavy rain scenarios and sources of reliable rainfall forecasts and warnings (see chapter 2.2).
2. Review of existing vulnerability analysis to identify vulnerable persons, animals, constructions and prioritize them. Critical infrastructures in sectors like energy, information technology, transport, etc. have to be considered (see Box 12). A public participation process with relevant actors should be set up to discuss the hazard and vulnerability analysis. Set up a contingency plan, which contains:
   - Definition of general protection objectives for different warning levels
   - Implementation of appropriate measures should include
     - operational disaster control,
     - mean and long-term construction and
     - publicity measures.
   - Set up plans with different phases (rescue, recovery and restoration phase)
   - Definition of the responsibility (legally and in terms of action)
   - Definition of the resources for setting up emergency measures
   - Guarantee that all public authorities, actors and the population are informed (recommendations for actions and guidelines)
   - Alliance/discussion groups between counties and municipalities
   - Trainings and testing of the plans and operational procedures
   - Schedule plan revisions

Photo: Dominic Rumpf

2.3.3 Physical measures

Principal tasks of the constructional precautions of the management of heavy rain risks are:

- Keep outer area water away from the settlement area
- Keep preferential flow paths of surface runoff clear
- Areal retention of surface water in the settlement area
- Unavoidable surface water
  - ➢ Direct it to open spaces with little or no damage or
  - ➢ Drain it off or
  - ➢ Store it temporarily in an orderly manner in the street area or
  - ➢ Drain it in an orderly manner into water bodies and drainage ditches
- Protect areas at risk to human life and critical infrastructure objects

Derivation of outer area surface water

Exemplary measures to keep the surface water from heavy rain events away from settlements and to redirect it into non-critical and low-damage areas are:

- Construction or upgrading of control structures for the management of water in the outer area such as open ditch systems, embankments, hollows and cascades (Box 13), and if necessary, pipes,
- Construction of adapted inlet structures with a hydraulically favourable design of the inlet structures and pipes and rakes for coarse flotsam
- Opening / expansion of culverts

It is essential that these installations are subject to regular inspection, maintenance and repair.

Box 13 - Example: Hollows and cascades to retain outer water in Dresden Gompitz

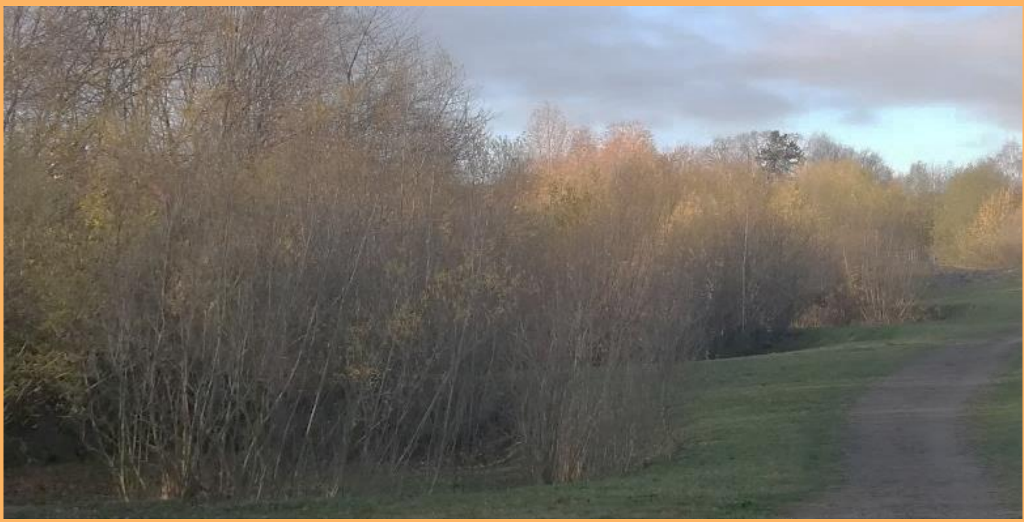


Photo: Thomas Pluntke

Upgrading of drainage-relevant water bodies

Drainage-relevant water bodies should be oriented towards runoff retention, retardation and protection of erosion in the outer area. In the inner area, measures should focus on low-damage runoff.

Runoff-relevant watercourses are also the "dormant" watercourses, which are only temporarily water-bearing. They often pose a particular hazard because of the lack of awareness of the dangers during heavy rainfall events. This often leads to insufficient maintenance of the water course and constructions.

Drainage obstacles pose a major hazard within localities. The removal or optimisation of drainage-reducing structures (footbridges, bridges, fences, walls, crossing pipes, deposits, vegetation, etc.) reduces the risk of water bodies overflowing their banks at these bottlenecks and finding new drainage paths.

Inlet structures should have a hydraulically favourable design. The use of spatial rakes and pre-rakes for coarse flotsam as well as the installation of debris traps can reduce the risks of clogging (Box 14). Here, too, regular inspection, maintenance and clearing of floating debris should be fixed in maintenance plans.

Box 14 - Example: Rakes to prevent clogging of culverts (Dresden Gompitz)

Photo: Thomas Pluntke

Urban drainage

The sewer network can play a runoff-relevant role during heavy rainfall events, it drains off and stores to a certain extent water. Works at the sewer system should always consider an improvement of the hydraulic situation.

Structural measures can relieve the inflow into the sewer system. These are for example:

- reducing the degree of sealing or the runoff effectiveness of settlement areas,
- water-permeable pavements for rainwater infiltration,
- permeable surfaces (e.g., parking places),
- green roofs or
- decentralised rainwater retention in troughs, cisterns and infiltration trenches.

Since these decentralised measures have relatively little effectiveness individually, they must be implemented on a large scale in order to be effective during heavy rainfall events. The creation of financial incentives for citizens to voluntarily implement retention measures (e.g., fee splitting or targeted municipal support programmes in existing areas) can support this.

Retain rainwater

Natural water retention capacity has reduced in the last century due to human activities (land use changes, urbanization), at the same time surface runoff has increased. Paired with an increased frequency of heavy rain events in the past, flood events happened more frequently. The increase of water retention capacity is a key element in the heavy rain risk management.

Measures in the inner area:

- Roads and paths become drainage routes and can thus also be used in a targeted manner to drain off water with as little damage as possible. Depending on the gradient and the design of the kerbs, streets have a certain storage volume. This allows a retarded drain into urban sewage system. Structural measures that improve the drainage situation in the street space further include gutter and infiltration systems and roadside ditches and greeneries.
- Open and green spaces can be used multifunctionally as emergency retention areas during heavy rainfall events. Potential impacts on vegetation and ecosystems have to be considered.
- Measures mentioned in urban drainage (see above)

Measures in the outer area:

- Construction of retention areas (Box 16 and Box 17)
- Activating and increasing the storage capacity of existing soil depressions and sinks
- Retention-oriented construction and design of drainage systems for agricultural and forestry roads
- Adapted management of agricultural and forested land:
  - grassland management, conservation tillage, ploughing parallel to the slope
  - conversion to stable near-natural mixed forests, revitalisation of riparian forests,
  - renaturation of peatlands and creation of ponds and wetland biotopes

Box 15 – Example: Cost-benefit analysis of rainwater retention tanks

Two underground rainwater retention tanks were constructed in a primary school in the city of Kadaň, Czech Republic. The expected volume of collected rainwater is 625.6 m^3 per year. A cost-benefit analysis was conducted to compare the costs and benefits for the period 2020-2050.

Rainwater collection provides various benefits. For the investor these are: reduction of costs for a) rainwater drainage and b) for fresh water used for irrigation (at school's playground). Social benefits are: a) reduction of water consumed for watering (especially important in times of drought), b) groundwater recharge enhancement, c) flash flood mitigation, d) educational benefits, e) prolonged life of sewer system due to lower flow intensity, and f) improved water quality due to better performing wastewater treatment plant.

Private benefits could be monetised (see table below). The amount of collected rainwater exceeds the annual usage for school premises watering (168 m^3). However, it will be used by the city to water, e.g., decorative flower beds. Since watering is needed only during the growing season, which lasts between 6 (50% of annual rainfall) and 8 (70% of annual rainfall) months, the savings are calculated for these months. Savings due to reduced drainage to the sewer system are calculated according to applicable legislation. Maintenance costs are calculated with 2% annual increase in prices.

Table: Costs / Savings [EUR]

	Portion of collected water used	
	50%	**70%**
Investment costs	159.993	159.993
Maintenance cost	4.156	4.156
Total costs	164.148	164.148
Savings on drinking water	14.847	20.785
Savings on rainwater drainage	28.155	28.155
Total savings	43.001	48.940
Costs/revenues	3,82	3,35

The implementation costs are significantly higher than the benefits. But not all benefits could be accounted for in monetary terms, because it is very hard to quantify them and was not possible in the scope of the project. For example, educational benefits or the mitigation of floods and their impacts. Henceforth, overall benefit is expected to be much higher than the calculated one. Moreover, the costs in this case were high, because a) underground instead of above ground tanks were installed and b) higher costs due to higher construction effort on existing school grounds compared to an initial construction.

2.3 Risk reduction

Nature-based solutions:

Often a set of small retention measures has a similar or better impact than conventional technical solutions. Green instead of grey solutions often feature multiple positive impacts onto ecosystems, microclimate, groundwater recharge etc.

Box 16 - Example: Rain water retention basin in Dresden Pennrich

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Photo: Thomas Pluntke

Box 17 – Background: Planning of retention measures

For the planning of retention measures the following influencing factors have to be considered:

- Topography: High flow velocity results in steep areas, and temporal ponds develop in flat terrain.
- Degree of sealing: In highly sealed areas like cities, water cannot infiltrate into the soil and runs off directly.
- Vegetation cover: Vegetated areas lead to better infiltration, higher evapotranspiration losses and lower flow velocities, naturally depending on vegetation type.
- Soil characteristics: Natural conditions determine in first place the infiltration of rainwater: clayey and loamy soils have low and sandy soils high infiltration rates. Agricultural management practices can influence the degree of soil compaction and henceforth infiltration capacity.
- Weather conditions: Pre-event weather determines the degree of soil moisture as well as if soils are snow or ice covered, factors which lead to high surface runoff.

Protection of objects

For structural objects, the rapid filling of depressions or building basements (cellars, underground garages) is a major hazard. The sometimes very high flow velocities can pose a danger to the static of buildings and henceforth to people.

Box 18 – Do-it-yourself: Measures for protection of objects

Precautionary measures to protect against flooding should be provided at the planning stage for building projects in areas at risk. In some cases, an upgrade is possible.

First aim: Keep away water from buildings!

- Consider embankments, earth dams, terrain modelling or protective walls!

Second aim: Avoid to intrusion of water into buildings!

- For basement light wells and windows consider basement window with raised light well, or install mobile closures!
- For basement exits provide an upstand!
- For ground level entrances to houses plan a step or ramp!
- For underground garages provide mobile protection systems (e.g., dam beams)!

Third aim: Limit the damage, if water is intruding!

- Consider adaptation of the technical building equipment (e.g., replace an oil heating with a gas heater)!

2.3.4 Adapt spatial planning

Flood issues have to be considered in urban development planning (in German: Bauleitplanung). National building regulations provide the framework for an efficient spatial planning with respect to adapt to heavy rain. In Germany, it is the building code BauGB and relevant paragraphs and subparagraphs are § 1/6, § 5/2, § 5/3, § 9/1 and § 9/5.

The ***first stage, the land use plan*** (in German: Flächennutzungsplan), contains the urban development and spatial development concept of a municipality. Areas prone to natural hazards that require structural measures should be marked here (building, traffic areas etc.) Priority areas can be designated for the prevention of heavy rainfall, which are to be taken into account in subsequent planning procedures. This also serves to draw the attention of the owners and users to existing risk of flooding due to heavy rainfall.

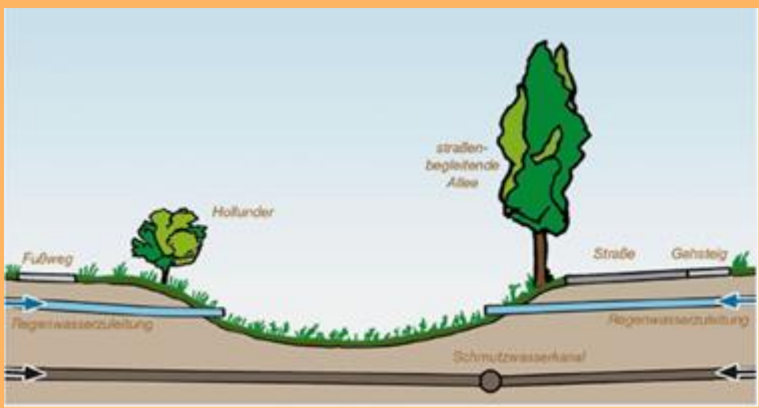
The ***second stage is the development plan*** (in German: Bebauungsplan). It contains legally binding stipulations for the urban development order. Areas with the need for structural precautions against natural hazards should be designated (e.g., areas for the retention and infiltration of rainwater). Also, areas which should be kept free of further development are defined. This applies in particular to keeping the main flow paths of precipitation water free, as shown in the heavy rain hazard maps. Important components of precaution can be the adaptation of single-family houses and precautionary measures for basements. Overall, there are sufficient legal possibilities for flood prevention and urban planning adaptation to climate change. However, the options for action in existing residential areas are severely limited.

Box 19 – Example: Good practice - near-natural surface drainage in Mistelbach (Austria)

© Good practice brochure of the Federal Environment Agency, 2016

Affected by: More and more frequently, the capacities of surface drainage are exhausted by intensive heavy rain in the so-called region Weinviertel in Lower Austria. Progressive settlement development and the associated soil sealing further increase the flood risk. On the other hand, dry episodes and heat deteriorate the groundwater recharge.

Funding: a combination of state, federal, and Housing Element Improvement Program funds.



© Good practice brochure of the Federal Environment Agency, 2016

How it works: In order to delay runoff during heavy rainfall and to create sufficient retention space, a system of swales and ditches was created for a newly developed residential area in Mistelbach. The ditches, which can be up to 15 m wide, serve as recreational area and playground and form near-natural habitats for animals and plants. The troughs are linked to the eco-belt - a transition zone between the settlement area and the surrounding agricultural landscape designed with copses and meadows - by green connections. The maintenance requirements for the swales and ditches are low and the costs for the construction of this form of surface drainage are no higher than for a stormwater drain, despite the significantly larger area required.

More information: http://www.umweltgemeinde.at/naturnahe-oberflaechenentwaesserung-am-foersterweg-mistelbach

The responsibility for spatial planning adaptations is shared:

- At the state level, the management of first order water bodies includes among others measures to retain water and to retard surface flows in the area. Authorities like the Central Land Management Saxony care about the redevelopment of fallow land and the sustainable land use.
- At the county level, the natural revitalization of water bodies, the areal retardation of surface flows and rain water management are typical tasks of the lower water authority and in some cases of the rural reorganisation office.
- At the municipal level, the parks and building offices have to adapt, plan and implement above mentioned tasks and include measures of specific municipal interest (e.g., fire pond). The provision of relevant spaces for water retention and harmless runoff has to be implemented in urban development planning.
- Further responsibilities depend on the ownership: landscape conservation associations, for rural reorganisation associations, famers and other private persons.

2.4 References and further readings

RAINMAN project website with extensive details on methods and examples: https://rainman-toolbox.eu/

Further readings:

Austrian Fact Sheets und Policy Briefs (in German), https://ccca.ac.at/wissenstransfer/fact-sheets

Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA) (2018): LAWA-Strategie für ein effektives Starkregenrisikomanagement

Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau – (BWK) e.V. (2013): Starkregen und urbane Sturzfluten – Praxisleitfaden zur Überflutungsvorsorge. BWK-Fachinformation 1/2013

Climate change adaptation in Austrian municipalities, https://www.klimawandelanpassung.at/goal

Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (2015). Die unterschätzten Risiken "Starkregen und Sturzfluten": Ein Handbuch für Bürger und Kommunen. (Bonn).

Bundesamt für Bevölkerungsschutz und Katastrophenhilfe und Bundesamt für Sicherheit in der Informationstechnik (2019). KRITIS - Internetplattform zum Schutz Kritischer Infrastrukturen.

Deutschen Städte- und Gemeindebund (2006). Sichere Städte und Gemeinden, Unterstützungs- und Dienstleistungsangebote des Bundesamtes für Bevölkerungsschutz und Katastrophenhilfe für Kommunen.

Deutscher Städtetag (2015). Starkregen und Sturzfluten in Städten - Eine Arbeitshilfe.

Deutscher Städtetag (2019). Anpassung an den Klimawandel in den Städten - Forderungen, Hinweise und Anregungen.

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall DWA (2015). Stark gegen Starkregen. Korrespondenz Wasserwirtschaft, Sonderdruck 02/2015.

2.4 References and further readings

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall DWA (2013): Starkregen und urbane Sturzfluten: Praxisleitfaden zur Überflutungsvorsorge. Hennef (Sieg): Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall.

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall DWA (2015): Merkblatt DWA-M 550: Dezentrale Maßnahmen zur Hochwasserminderung.

Municipal Heavy Rain Risk Management in Baden-Württemberg, very practical working materials and examples: https://reginastark.starkregengefahr.de/

Landesanstalt für Umwelt Baden-Württemberg (2016). Leitfaden Kommunales Starkregenrisikomanagement in Baden-Württemberg (Karlsruhe).

3 Municipal adaptation to a changing climate - Increasing heat stress resilience

3.1 Introduction

Heat events and heat waves increased in intensity and duration in the last two decades and affected human health, wildlife, forestry, agriculture etc. 70.000 excess deaths were observed between June and September 2003 in Europe (Robine et al. 2008). Climate change projections indicate a further increase in frequency, intensity and duration of heat-waves. An increase of up to 8,500 additional heat-related deaths might occur annually by the end of this century in Germany (Eis et al. 2010).

Photo: Gerd Altmann auf Pixabay

Heat stress is not only relevant for people living in large cities. Atmospheric circulation patterns are often very stable over large parts of the continent, so that warm air masses affect large parts of the population. In densely populate areas the heat stress is augmented due to 'urban heat island' effect (Box 20). However, it is not possible to identify excess mortality attributable to a localised heat island effect within cities.

There is no standard definition for heat events or waves. Mostly air temperature and the duration of such events are used as indicators for a heat-wave. More complex approaches apply a description of the thermal situation additionally with air humidity, wind speed, and cloud cover (Koppe 2005). A simple indicator is the hot day, which is defined as a day with a maximum temperature over 30°C.

Impacts of heat stress range from heat oedemas over cramps, exhaustions to heat strokes. Highest impact on mortality is due to respiratory and cardiovascular causes. Elderly and very young children are more vulnerable to heat, and mortality is greater in women than in men. Virtually all chronic diseases present a risk for heat death or illness. There is growing evidence that the effects of heat-waves on mortality are larger during days with high ozone or fine particulate matter (PM10) concentrations. These are conditions of the so-called "summer smog".

3.1 Introduction

Box 20 – Background: Urban heat island

… is an urban area that is significantly warmer than its surrounding rural areas due to human activities. The temperature difference is usually larger at night than during the day, and is most apparent when winds are weak. The main cause of this effect is the modification of land surfaces. Streets and buildings have a high thermal storage capacity and evaporation is very reduced. Waste heat generated by energy usage is a secondary contributor. Often, air quality decreases due to increased production of pollutants such as ozone.

Photo: Pixabay

Adverse health effects of heat events and heat waves are largely preventable. The setup of **heat health action plans HHAP** is recommended by WHO Europe (2008). The concept was largely taken over by Germany (BMU 2017), Austria and many other countries. Central elements of HHAP are:

- Establishment of a central coordination and interdisciplinary cooperation
- Use of an accurate and timely heat warning system
- Strategies to reduce individual and municipal exposure to heat
- Long-term adapted urban planning, transport policies and building design
- Particular care for "vulnerable" populations
- Provision of health care, social services and infrastructure
- Heat-related health information and communication strategies
- Monitoring and evaluation of the measures

For the implementation of the aforementioned elements, the WHO recommends an approach in five time horizons:

- Long-term development and planning
- Preparations in time before the summer
- Protection during the summer
- Special measures during acute heat periods
- Monitoring and evaluation

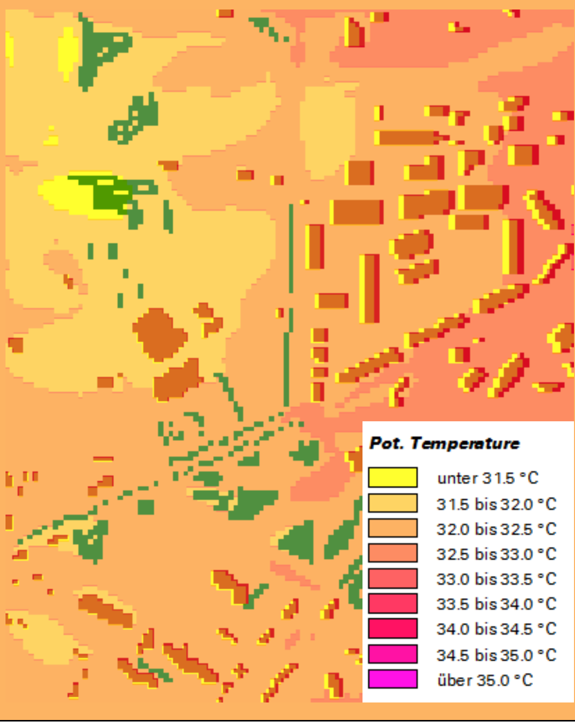
Details on how to set up HHAP are given in chapter 3.3.

3.2 Risk assessment and mapping

Risk assessment and mapping are pre-requisites for a long-term planning to adapt to increasing heat stress. The assessment bases mostly on simulations of models, which describe the interactions between the surface, vegetation and air in an urban environment. But also, local knowledge can give an indication of problematic areas and allow a first assessment. Models provide a mapping of overheated areas, and on the other side, of areas of thermal relief (e.g., shaded areas, parks). In combination with further datasets (such as climate, demography etc.) various maps can be created (examples in Box 21).

Box 21 – Example: Heat stress mapping for Valka (Latvia, Estonia).

Right figure shows the modelled temperature at 4 pm on a sunny day in June. Temperatures are higher in the city centre (red colours), where there is a high density of buildings and sealed surfaces. Outside of the centre, where there are alleys, parks (green) and close to the river, temperatures are about 2 Kelvin lower.



3.3 Contingency plans

According to WHO we call contingency plans in the following heat health action plans HHAP. They have to be specifically set up for each region or city, because of the large heterogeneity of heat exposure and susceptibility of the local population.

Interventions need to be targeted on susceptible population subgroups such as people over 75 years, females, people with respiratory diseases and people with other risk factors that increase heat-related susceptibility (lack of self-sufficiency, pre-existing diseases, social isolation, deprivation, housing conditions, etc. (see also below).

In the following we give details on the central elements of a HHAP.

3.3.1 Central coordination and interdisciplinary cooperation

A ***central coordination office*** should be established at the state level, e.g., in a health authority, but could also be carried out by another authority in acute cases. It is responsible for coordinating the cooperation between involved authorities and the authorities and institutions of the federal states. A ***central network of all stakeholders*** involved in the development of the HHAP should be established. Next step is the identification of relevant institutions (governmental and non-governmental) that can implement local measures (e.g., fire brigades, emergency and rescue services, hospitals, doctors/practitioners, pharmacists, outpatient and inpatient care facilities, rehabilitation facilities, kindergartens, schools, aid organisations, disability assistance and home inspectorates).

The planning of concrete measures and their timely implementation is municipal responsibility, but should be reported back to the coordination office. Higher-level measures that are deemed necessary and cannot be implemented at the municipal level (e.g., regional planning) should be planned by the central network in direct contact with relevant institutions. Measures and procedures are evaluated by all involved parties after implementation of measures and/or after acute heat events.

3.3.2 Heat warning system

It is recommended to prepare HHAP based on the national heat warning systems. They are based on calculated or modelled thermal indicators (see).

Heat warnings are addressed to responsible bodies and are intended in particular for old people's and nursing homes as well as kindergartens. However, they are also addressed to other facilities, e.g., outpatient and inpatient care services, as well as to the general population. The warnings are issued down to the municipality level via apps (WarnWetter, NINA, KATWARN) and down to county level via newsletters.

Box 22 – Background: Examples for heat warning systems:

The German Weather Service issues heat warnings when a severe heat load is predicted for at least two consecutive days and sufficient night-time cooling of living spaces is no longer guaranteed. The perceived temperature is simulated with the so-called "Klima-Michel model", which calculates the human thermal budget based on climate variables (temperature, wind, humidity, solar radiation). There are two warning levels:

I - severe heat load (perceived temperature for two days in a row above 32°C, additionally only slight cooling at night);

II - extreme heat stress" ("perceived temperature" above 38°C in the early afternoon; for elderly 36°C).

As a basis for the Austrian warning system, the contact data of the most important facilities and persons affected are acquired and stored in a database. This data pool is built, verified and maintained by the Provincial Sanitary Directorate. It includes the most important organizations from the areas of nursing Homes, hospitals, child care facilities, schools, other social and handicapped care facilities, emergency and blue-light organizations and administrative authorities.

Source: Heat protection action plan Styria, 2016

steirischer Hitzeschutzplan

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Internet: http://www.zamg.ac.at

ZAMG

Das Land Steiermark
→ Gesundheit

Informationen zum Hitzeschutzplan 2017 - Vorwarnstufe

Sehr geehrte Damen und Herren!

Aufgrund immer häufiger auftretender schwerer Hitzewellen im Zuge des Klimawandels (bspw. 2003 mit europaweit bis zu 70.000 Hitze assoziierten Todesfällen) und der insgesamt zu erwartenden Temperatursteigerung in der Steiermark - www.umwelt.steiermark.at, wurde für die Steiermark ein **Hitzeschutzplan** (HSPL) erarbeitet.

www.verwaltung.steiermark.at

Auf dieser Internetseite stellen wir Informationen zum Thema Hitze und damit einhergehenden gesundheitlichen Belastungen zur Verfügung. Zusätzlich finden sie im Downloadbereich Merkblätter, die für sie und ihre Organisation bzw. Ordination und Zielgruppe relevant und interessant sein könnten.

Der HSPL sieht bei einer Prognose von mind. drei Tage anhaltende starke Wärmebelastung die Aktivierung der **Warnstufe** des Hitzeschutzplans vor.

In Folge dessen erhalten sie im Zeitraum **Mai bis September** bei Überschreiten der Grenzwerte und aktiver Warnstufe frühestmöglich vor Beginn der Hitzewelle nach Erkenntnisstand der ZAMG eine Email mit regionalen Prognosen zu Temperatur und Luftfeuchtigkeit, etc.

Zahlreiche wissenschaftliche Studien zeigen einen raschen Anstieg der Mortalität bei Risikopersonen unter Hitzestress, daher sind schnellstmögliche Anpassungsmaßnahmen wichtig, um das Ausmaß von gesundheitlichen Folgeschäden zu reduzieren. In der Regel werden Ihre Betreuungseinrichtungen bzw. Ordinationen bestens auf die Bedürfnisse ihrer Klienten eingestellt sein, dennoch werden die Auswirkungen der ersten schweren Hitzewelle im Jahr und der länger anhaltenden Hitzeperioden auf die menschliche Gesundheit meistens unterschätzt. Dieser Zeit- und Informationsvorsprung soll ihnen bei der Koordination und Organisation in ihrer Einrichtung von Nutzen sein.

www.zamg.ac.at/steiermark/hitzeschutzplan/ & www.zamg.ac.at

Leiten Sie im allgemeinen Interesse Informationen zum steirischen Hitzeschutzplan an Betroffene bzw. Einrichtungen Ihrer Organisation weiter!

After the research has been completed, the data set will be made available to the Central Institute for Meteorology (ZAMG) as a distribution list for sending the heat warning emails.

3.3.3 Information and communication

Heat-related health information to the public should be created and communicated: on one side information regarding anticipatory planning and, on the other side, information during an acute event.

In an ***anticipatory planning***, the communication content as well as the communication channels should be defined as well the responsibility.

Health prevention recommendations should be gives as target group-specific as possible. Exemplarily, some general information is provided in Box 23 and Box 24.

Information should be given in newspapers, television, radio, social media as well as other multiplier groups to target specific population groups such as older and younger people. It should be fixed when exactly information is given after a heat warning. Prevention information should be provided continuously at municipal and state internet sites. Also, a telephone consultation during heat events helps to reach all population groups.

Information **during an acute event** includes behavioural information passed by physicians in personal conversations. Flyers, brochures or TV spots can transport health risks and appropriate measures. Schools, kindergartens, hospitals, nursing homes and homes for the elderly should be actively notified and provided with information material.

Box 23 – Do-it-yourself: Recommendations to stay healthy in case of heat

Protect from heat: → Adjust daily routine: avoid midday heat outdoors → avoid physical exertion, if not avoidable drink a lot of cool, non-alcoholic beverage → stay outside in the shade → wear a hat and sunglasses → use a sunscreen with SPF of at least 20 (at least 30 for young children) → never leave children or people in poor health in a parked car

Drink and eat enough: → compensation of fluids and electrolytes needed → take sodium-containing mineral water, juices, soups, water-rich fruits (melons, cucumbers etc.) → consume at least 1.5 -2 litres of fluid daily → avoid alcohol, caffeine or lots of sugar and very cold drinks → eat several small, light meals spread throughout the day.

Cooling: → stay in a cool room → ventilate at night and in the morning → darken the rooms during the day → take a cool shower or use cool damp compresses wear light, non-constricting clothing in light colours

For infants and young children: → do not to be exposed to direct sunlight, especially between 11:00 a.m. and 3:00 p.m. → airy, light-coloured cotton clothing, wide-brimmed hat or cap with neck protection → waterproof sunscreen with a high sun protection factor (at least 30)

Photo: Hans Braxmeier (Pixabay)

Photo: Pezibear (Pixabay)

Box 24 – Do-it-yourself: Symptoms of heat related health problems and recommended measures

Sunburn: skin reddens, hurts and is abnormally warm → retire from sun → use cold compresses and cooling lotion → in case of fever (e.g., infants) notify physician

Sunstroke: severe headache, stiff neck, photophobia, nausea, vomiting → go to cool shady place → cover with cold wet compresses

Heat rash: skin rash with red pimples or small blisters → change to a cool less moist place → keep affected body parts dry → use talcum powder, but no creams

Pictogram: Gordon Johnson (Pixabay)

Heat cramps: muscle cramps in case of physical exertion → rest in a cool place → take electrolyte-containing drinks → do not resume physical exertion for some hours

Heat exhaustion: slowly increasing weakness, pale grey and clammy skin, muscle cramps, nausea, dizziness, confusion, fever, circulatory collapse, unconsciousness → cool down with cool drinks, rest, cool shower, cooler place, light clothing → possibly notify physician

Heat collapse: decreasing cerebral blood flow leads to short-term unconsciousness and collapse → move to a cooler place → remove excess clothing → drink → notify physician

Heat stroke: high body temperature, thirst, clouding of consciousness etc. → notify physician immediately → change to a cooler place → drink → cool and moist compresses

3.3.4 Indoor heat reduction

Three main factors are associated with indoor heat exposures:

- the thermal capacity of buildings (building material, actual conditions),
- the position of an apartment (exposure to sun, floor etc.) and
- the behaviour of the occupants (ventilation regime, shading etc.).

Recommendations for short- and medium measures are summarized shortly in and Box 26. Long-term measures can be found in chapter 3.3.7.

Box 25 – Do-it-yourself: Short-term measures for protection from heat

- Increase internal shading
- Ventilation adapted to outside temperature (especially in late night/early morning hours)
- Electric fans provide relief until 35 °C (important to drink enough)
- Mobile evaporative coolers (cooling effect decreases with relative humidity of the air)

Photo: Hans Braxmeier (Pixabay)

Photo: StockSnap (Pixabay)

- Reduce the use of heat emitting devices
- Install thermometers and preferentially stay in cooler rooms
- Consider local air conditioning only in case that the other methods are not sufficient, because high energy and waste heat are counter-productive

Box 26 – Do-it-yourself: Medium-term measures for protection from heat

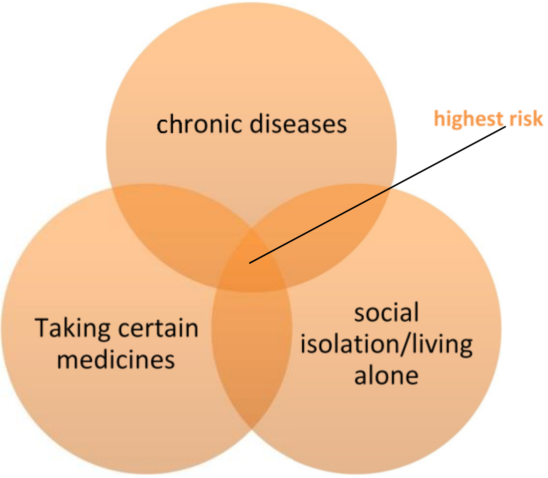
- Increase external shading (roller shutters, external blinds with air slits, awnings and sun sails)
- Building insulation protects from heating I summer and cooling in winter
- Microclimatic cooling effects by green roofs and facades and by deciduous trees along streets, in gardens and green spaces.
- Consider technical cooling methods in an upcoming renovation of e.g., hospitals, retirement and nursing homes

Photo: Dominic Rumpf

3.3.5 Special consideration of risk groups

Risk groups which require special attention are:

- Elderly: reduced ability of the body to regulate heat and the feeling of thirst decreases with age.
- People living in isolation: lack of social control and assistance
- People in need of care: health-related impairments limit their ability to act.
- Persons with severe overweight: intense reaction to heat stress on top of the already existing basic health stress. Low reserve capacities of the cardiovascular system
- People with chronic diseases: limited ability to react to extreme situations. Chronic diseases often lead to a worsening of symptoms.
- People with febrile illnesses: limited ability to release heat
- People with dementia: reduced ability to react adequately, intake of sufficient fluids often not guaranteed



- People taking certain medications: possibly altered effects and side effects of medications (esp. diuretics and antihypertensives) when exposed to heat
- Individuals with thermo-physiological adaptation problems: circulatory problems due to a drop in blood pressure as cause of severe heat stress
- Infants and small children: particular sensitivity and pronounced dependence on supervisors

Consideration should also be given to persons engaged in intensive outdoor physical activity (e.g., occupations in construction, agriculture, and food service). An adaptation of working conditions by employers (e.g., by adjusting working hours and break schedules) to extreme heat and UV exposure should be considered.

Furthermore, homeless persons often require individual care by social services in extreme situations.

Photo: estableman (Pixabay)

3.3.6 Preparation of health and social systems

Continuing education and training for health and social care workers can help provide important content on how to act adequately during hot spells.

Facility action plans to prepare for heat events should be developed specifically for old people's and nursing homes, facilities for people with physical and mental disabilities, Hospitals, emergency and rescue services, rehabilitation facilities, schools, kindergartens and certain workplaces.

Concrete care and support measures in outpatient care can be adjustment and monitoring of drinking behaviour and nutrition, the adaptation of clothing, adjustment of medication etc.

Water and energy shortage, but also personnel are issues to deal with in prolongated heat periods.

Cool rooms should be made available in health care facilities. Structural measures to protect against heat (shading, room fans, air conditioning if necessary) can be found in the next chapter.

3.3.7 Adapt spatial planning and civil engineering

There are many competing priorities for urban planning. A sense of proportion is required when planning and implementing building and urban planning measures. Although urban planners are interested in climatic aspects, the use of climate information is often unsystematic. There is no model solution, but a consideration of the year-round, region-specific and climatic situation is required. We distinguish here in building-related and urban and building planning measures.

Building-related measures:

- Development of specifications for heat protection of buildings (e.g., thermal glass, louvered blinds integrated into windows, shading by roof overhangs).
- Technical construction measures such as ventilation technology, heat/cold exchangers, room fans, possibly also the use of air conditioning systems in particularly sensitive areas
- Heat-adequate building planning for new buildings (orientation, location etc)
- Use of heat-reducing and avoidance of heat-storing building materials
- Installation of drinking water dispensers in buildings
- Establishment of "cooling rooms”, e.g., in government offices, shopping arcades, train stations etc.

Photo: PIROD4D (Pixabay)

Urban and building planning measures:

- Promotion of green spaces and tree and shrub planting in streets, as they provide shade, drop temperature due to evaporative cooling and improve air quality (see Box 27)
- Promotion of green roofs and facades (low-allergen and heat/drought-tolerant plants)
- Establish ample shaded areas: structurally by means of outdoor roofs, awnings, fixed sun-shades, and by means of green planning
- Establish humidification systems in outdoor areas and for patios
- Increase natural space cooling (grasslands) and keeping free or creating cold air conduction paths
- Increasing ventilation and air flow between buildings (which also improves air quality)
- Reducing the degree of sealing of open and public spaces to reduce heat and UV stress due to reflection
- Establish shade canopies and roofing, preferably with materials that also reduce exposure to UV radiation
- Establish permanently installed drinking water dispensers in public spaces

Photo: Dominic Rumpf

Legislation, building codes for homes and particularly nursery homes need to be reviewed and adapted. Guidelines should be established and appropriate options described:

- Increasing reflection of heat from the surface of the building, e.g., through cool paints
- Identification of areas at risk of urban heat island effects
- Restriction on living on top floors, or improvement of roof insulation
- Cool pavements
- Building structures: radiant barriers, insulation
- Energy efficient air conditioning

There are many synergetic effects adapting with natural measures. Trees and hedgerows contribute to carbon storage and act as a sink for air pollutants, especially fine dusts. Meadows, grassed areas, and ground-cover vegetation perform an important function in soaking up rainwater. A high proportion of greening creates places for re-laxation and recreation and significantly increases the quality of life in urban areas.

The responsibility for spatial planning adaptations is shared:

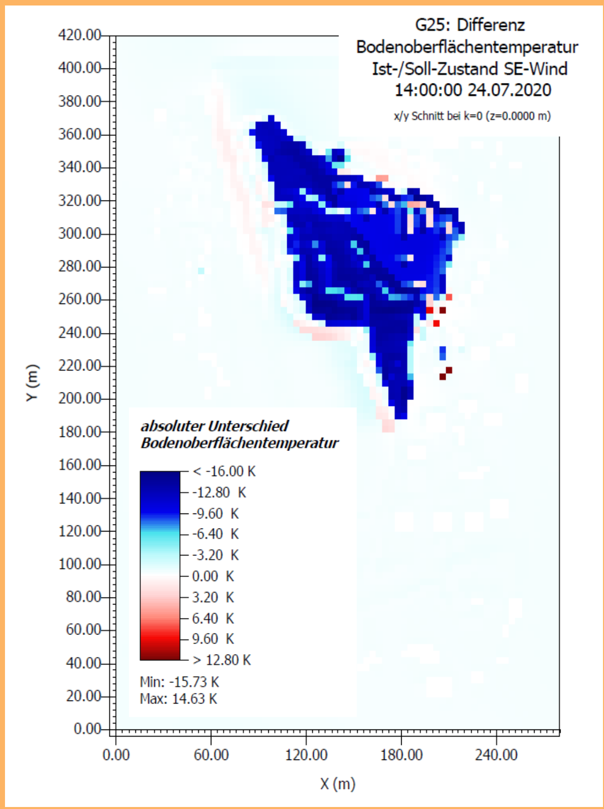
- At the state level, the designation of fallow land is decided.
- At the county level, the regional development of green (plants), blue (water) and grey (technic) infrastructure is planned.

3.3 Contingency plans

- At the municpal level, the regional the parks and building office plan greening, unsealing and shading measures. In urban development planning, provision of climate relevant spaces (e.g., for cold air development and transport) as well as adaptations in constructions are needed.

Box 27 - Example: Impacts of unsealing and tree planting

Unsealing and tree planting in Coswig, a small town near Dresden, was investigated with the urban climate model Envi-met 3.1 (Naumann 2021). As an example, a landfill site in the town is shown here to explore what effect tree planting of unvegetated areas would have. This measure would lead to a lowering of the air temperature, of the ground surface temperature (of up to -16 K at 2 pm on a sunny day in July, see figure) and lower average daytime radiation temperatures. This would reduce the thermal load for people significantly.



Comparing all investigated measures, the large-scale planting of trees creates largest differences in the micro-climate and improves the climate in the city enormously. The increasing specific humidity due to rising evaporation and lower wind speeds near the ground reduce the positive effects somewhat. Urban forests or forests on the outskirts of cities are highly beneficial, both for the microclimate and as recreational areas and biotope.

The planting of individual trees or unsealing of areas showed much smaller positive impacts. Modelling uncertainties in these cases were higher and could be validated with in-situ measurements. Areas that are no longer in use are particularly suitable for the creation of comfortable places in cities. Positive microclimatic effects can also be achieved by greening of roofs and facades. Furthermore, the choice of building materials, their thermal properties and colour also influence the microclimate.

3.3.8 Monitoring an evaluation of measures

A quantitative monitoring and evaluation of heat events and their consequences is necessary in order to initiate improvements and further developments of intervention measures.

Data for timely evaluations come from hospital emergency departments and admission registers, emergency medical services, medical on-call services, emergency telephones, registry offices, state statistical offices (number of deaths) etc.

3.4 References and further readings

BMU Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (2017): Handlungsempfehlungen für die Erstellung von Hitzeaktionsplänen zum Schutz der menschlichen Gesundheit, DOI: 10.1007/s00103-017-2554-5

Eis D, Helm D, Laußmann D, Stark K (2010): Klimawandel und Gesundheit - Ein Sachstandsbericht. In: Robert Koch-Institut, Berlin

Koppe C (2005): Gesundheitsrelevante Bewertung von thermischer Belastung unter Berücksichtigung der kurzfristigen Anpassung der Bevölkerung an die lokalen Witterungsverhältnisse. Berichte des Deutschen Wetterdienstes, Nr. 226, Deutscher Wetterdienst, Offenbach am Main.

Naumann M (2021): Auswirkung des Maßnahmenkonzeptes Natur und Landschaft auf das Mikroklima der Stadt Coswig, Masterthesis, TU Dresden, Chair of Meteorology, pp. 60.

Robine J-M et al. (2008): Death toll exceeded 70,000 in Europe during the summer of 2003. C. R. Biologies, 331(2):171-180)

WHO Europe (2008): Heat-health action plans, https://www.euro.who.int/__data/assets/pdf_file/0006/95919/E91347.pdf

Further readings:

About the right behaviour during heat events (in German), https://www.umweltbundesamt.de/sites/default/files/medien/364/dokumente/schattenspender_hitzeknigge.pdf

14 days heat forecast, http://euroheat-project.org/dwd/index.php

General rules of behaviour: https://www.dwd.de/DE/leistungen/hitzewarnung/uba_hitzeflyer.pdf?__blob=publicationFile&v=4, https://www.umweltbundesamt.de/publikationen/klimawandel-gesundheit-tipps-fuer-sommerliche-hitze

Rules of behaviour for elderly: https://www.dwd.de/DE/leistungen/hitzewarnung/alter_und_hitze_flyer.pdf?__blob=publicationFile&v=1

Austrian Fact Sheets und Policy Briefs (in German), https://ccca.ac.at/wissenstransfer/fact-sheets

Climate change adaptation in Austrian municipalities, https://www.klimawandelanpassung.at/goal

4 Municipal adaptation to a changing climate - Increasing soil erosion resilience

4.1 Introduction

Soil is one of the most important natural resources, which is the basis of food production and all land born natural life. Soil erosion is a serious environmental, economic and social problem. It degrades agricultural land, induces crop production losses and threaten the landowners' livelihoods. In this fourth part of the series of brochures dealing with "Municipal adaptation to a changing climate" we focus on soil erosion which is mainly an impact of heavy rain events, but also of wind. Increases in rainfall intensity and summerly drought (due to increased evapotranspiration) made soil erosion a relevant threat in many regions.

The potential risk of **erosion by water** depends on the given site characteristics such as climate, surface relief and soil. The actual risk is also determined by the current condition of the soil as a result of use and management, the soil cover and the land use mosaic. The individual erosion event results from the coincidence of a specific heavy rainfall with the site and management conditions prevailing at that time.

Soil erosion has on-site impacts (soil removal, material transport and deposition) and off-site impacts (soil deposition and influx of water with its constituents), which affects water bodies and lowlands as well as roads and settlements.

Wind erosion is often considered as less hazardous as it is percepted as an event with lower risk and rare impairments of public life. Nevertheless, the constant soil loss and soil redistribution through wind erosion on sandy and slightly loamy soils as well as on the loess sites in dry seasons lead to long-term adverse effects such as the decrease in soil fertility.

An adaptation to recent and expected climate change and its impacts is necessary to safeguard this important resource, the soil. It encompasses on one hand the prevention of the on-site soil erosion and, on the other hand, the off-site protection against the adverse impacts of such events.

Box 28 – Background: What is soil erosion?

Soil erosion can be defined as the physical wearing of the earth's surface by the action of wind or water. It is a natural geomorphologic process, which is normally in equilibrium with soil forming process. It became an environmental hazard by human activities such as clearing of forests for cultivation, inadequate management practices, soil sealing and altered climatic conditions, especially more frequent and intense heavy rain events.

Photo: Döring

Soil erosion by water:

The energy of the impacting raindrops of a precipitation event leads to the destruction of soil aggregates and the detachment of soil particles. These particles are transported with infiltrating rainwater into macropores and clog fine pores. Infiltration capacity is reduced and excess precipitation water runs off, if the slope is steep enough. At gentle slopes, it starts with an extensive erosion. The longer and more inclined a slope is, the more the surface runoff increases. Water concentrates in small depression lines, forms grooves (depth <10 cm), and possibly gutters (<40 cm) and trenches (>40 cm). If slopes decrease again, soil particles sediment.

The rate and magnitude of soil erosion by water is affected by natural factors such as climate (frequency and intensity of heavy rainfall), topography (slope and length), soil characteristics (texture, structure, erodibility, erosivity), and land use/ cover.

Soil erosion by wind:

Strong winds induce turbulences at the surface and set soil particles in motion. If they collide with particles on the surface, they are destroyed or lifted up. Smallest particles are brought to suspension, larger ones are brought to saltation, and particles larger than 0.5 mm are brought to crawl or roll.

Impact factors of wind erosion are climate, soil erodibility, wind exposure, management and protection measures. Especially important is the increasing risk of erosion with increasing soil dryness.

Larger particles are transported mostly at the field and deposit in front of wind obstacles (e.g. field edge strips, wind protection strips). Croplosses and a reduction in soil fertility are the result. Only suspended particles are transported over long distances. Smallest particles are the most fertile soil parts (silt and clay minerals, humus and plant nutrients), and they get lost for the affected field.

4.2 Risk assessment and mapping

An assessment of the potential risk of soil erosion of agricultural fields is based on model simulations, whereby different erosion models exist.

4.2.1 Soil erosion by water

Erosion maps are often based on calculations with the Universal Soil Loss Equation (details in Box 29) and can show different grades of complexity or set different focal points.

Box 29 – Background: How to calculate soil erosion by water?

For Germany, the Universal Soil Loss Equation is considered the empirical standard variant for estimating soil erosion by water in the case of extensive erosion. It evaluates in simplified form the relationship between long-term mean soil loss and the influencing factors precipitation, soil, slope length, slope inclination as well as soil cover and soil tillage. It is documented in DIN 19708.

$A = R \times K \times L \times S \times C \times P$

The average annual soil loss of an area *A* [t/ha] is based on the following influencing factors:

- The R-factor is a measure used to describe precipitation erosivity and effective surface runoff. It is calculated for individual precipitation events.
- The K-factor describes the erosion susceptibility of a soil. Factor components are soil type, humus content and stone cover.
- L-factor quantifies the slope length. The slope is considered from the point where surface runoff occurs until the point where soil material is deposited.
- The S-factor describes the inclination of a slope. The steeper a slope, the higher the S-factor and thus the risk.
- The C-factor quantifies the erosion-reducing effect of the covering by cultivated crops or plant residues. Depending on crops and the time of cultivation, the C-factor varies throughout the year. The determination of the C-factor is very complex due to the large number of possible crops and cultivation methods. The C-factor can range between 1 (for uncovered soil) and 0 (for completely covered soil). For example, maize under conventional tillage has a C-factor of 0.3 and permanent grassland 0.01.
- The P-factor is used to describe erosion control measures. The data basis is still very limited, which for the value is mostly set to '1'.

Box 30 – Example: Erosion modelling

In June 2016, a heavy rain event causes strong surface flow carrying soil particles from cropland to a downward situated settlement (Freital, Saxony). Below, mapping of erosion by water simulated for this field with the model EROSION-3D based on a 60 minutes rain event with a 2-year recurrence interval.

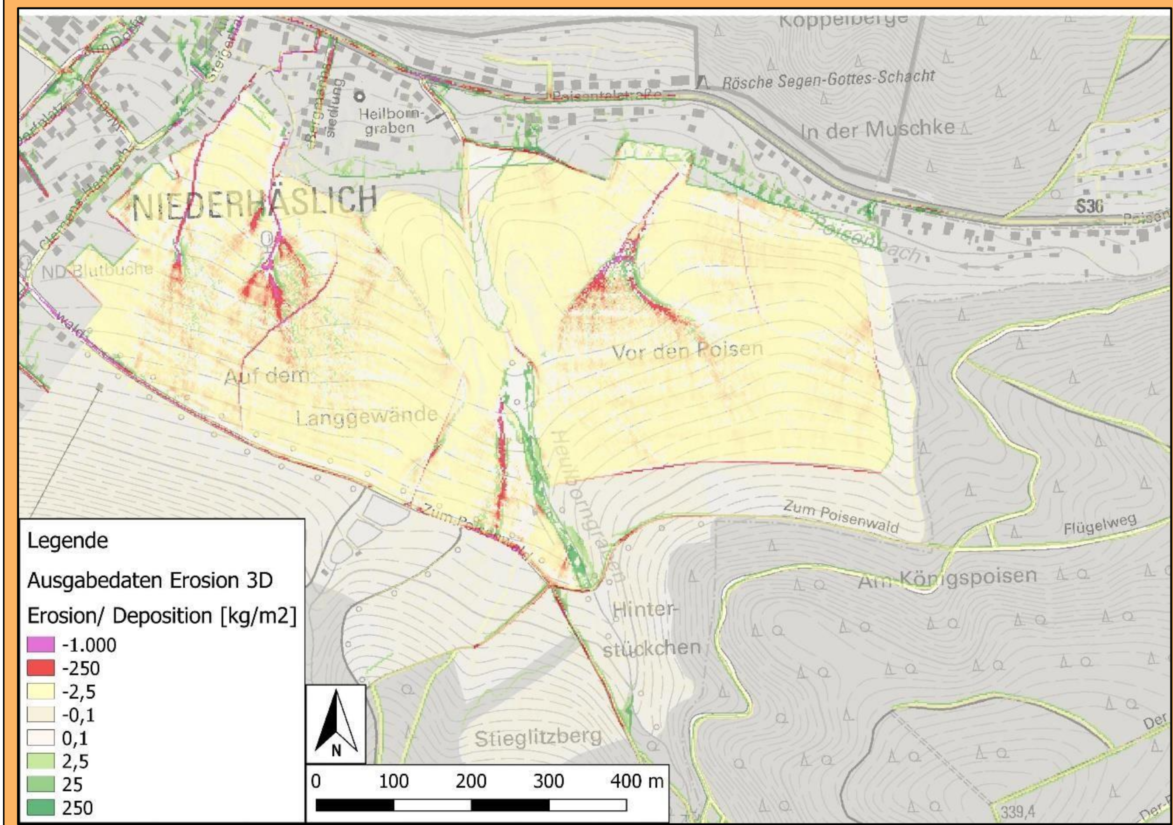


Photo and map: LFULG

4.2.2 Soil erosion by wind

Soil erosion by wind occurs especially on sandy, uncovered soils that have dried up on the soil surface. Missing wind obstacles in the landscape (e.g., hedges and forests) favour wind erosion additionally.

The wind erosion hazard is currently classified by the matrix-based expert system DIN 19706 in Germany, which indicate hazard levels but no soil loss quantities. Risk potential is estimated by linking matrices of the protection levels for the site factors soil and wind with the management related protection levels for the cultivated crops and the wind obstacles.

A map of potential risk can be obtained by a combination of the matrices soil, wind and wind obstacles. Data needed are

- highly resolved soil map to assess soil erodibility,
- highly resolved grid on mean wind speed,
- the frequency of the eight main wind directions for winds > 7 m/s in the period February to May, and
- map of wind obstacles.

The current wind erosion hazard for a field can then be derived by linking the potential risk map to the protective effect of the cultivated crops (DIN 19706).

4.3 Risk reduction

4.3.1 Early warning

A soil erosion event which might have serious impacts in-site and off-site of the field is bound to heavy rain events. Therefore, heavy rain early warning systems should be used as they are described in chapter 2.3.1.

Soil erosion due to strong winds impact mainly traffic warning. A regular warning service is not known, but some weather services provide such information, e.g., Wetter24 (http://www.wetter24.de/news/detail/2016-09-28-norddeutschland-staub-und-sandsturmgefahr/)

4.3.2 Physical measures

Farmers should follow good agricultural praxis (see also Box 31) to preserve their production basis and prevent other socio-economic and ecologic sectors from harm.

Box 31 – Background: Codes of good agricultural practice

Farmers receiving agricultural payments are obliged to comply with cross-compliance regulations of the European Union since 2014. They consist of 13 statutory management requirements (SMRs) deriving from Union law, and seven standards for maintaining land in good agricultural and environmental condition (GAEC). These are regulations from the fields of human, animal and plant health, animal welfare, environmental protection, climate change and good agricultural condition of land. The latter one concerns soil protection (soil cover, soil erosion, and the preservation of organic matter.

In Germany, the Soil Protection Law (BBodSchG) obliges users to take measures to prevent the threat of harmful soil changes (e.g., through soil erosion) from their property. But the soil protection authority is not authorised to order specific precautionary measures against soil erosion due to the lack of concretising ordinances.

Phacelia and Sinapis as intercropping, Photo: ThomasB (Pixabay)

In-site (field) and off-site (in towns and villages) measures can be distinguished.

An assessment of the need for action is possible according to the long-term average annual soil loss A (in t/ha) in relation to the soil number BZ (LLG 2018). The soil number is an index for the soil quality and is determined from soil type, (geological) formation type and soil state level. It ranges between 1 and 100 and is mostly mapped on the state level[1].

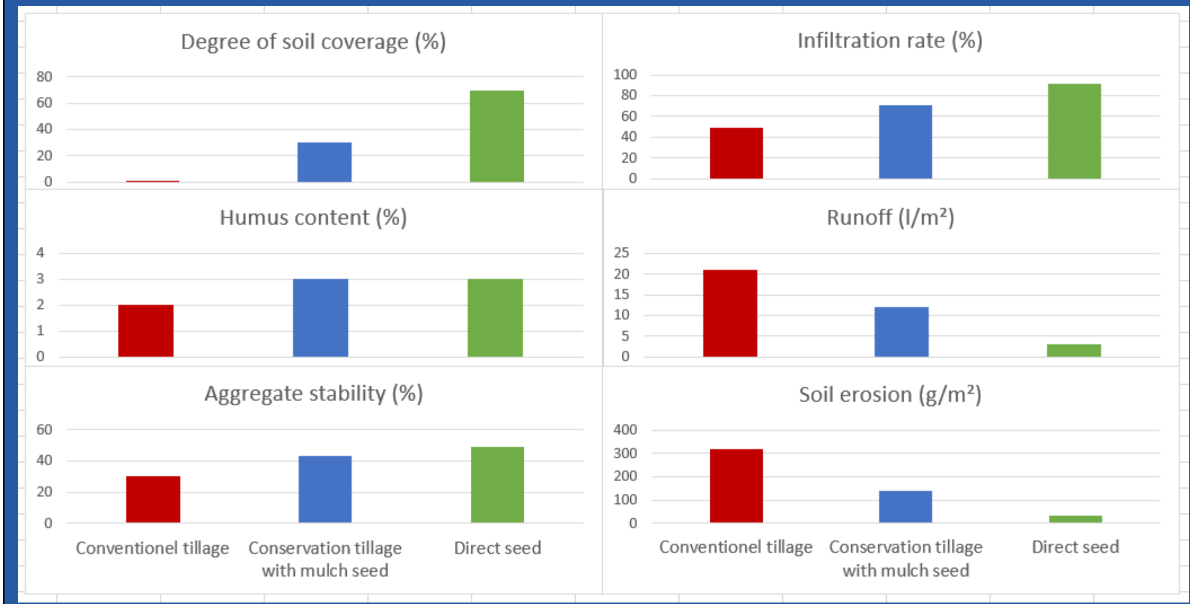
[1] For example: https://www.umwelt.sachsen.de/umwelt/download/boden/Bodenatlas-Teil2.pdf

Long-term average annual soil loss A (t/ha/year)	**Assessing the need for action for the protected good soil**
A ≤ BZ/8 Capping limit: 7	Suspicion of danger is excluded. With increasing threshold values, the requirements for precautionary measures against soil erosion increase.
A > BZ/8 and *A ≤ BZ/4* Capping limit: 13	Precautionary and hazard prevention requirements are generally met if all reasonable erosion protection measures are taken. Precautionary advice is recommended.
A > BZ/4 Capping limit: 13	Requirements of precaution usually not fulfilled and of hazard prevention probably not fulfilled. Precautionary advice is necessary. Suspicion of danger, further investigations are necessary. Hazard prevention measures may be necessary.
A > BZ/2	Measure for hazard prevention mostly urgently needed.

In-site measures at the field are aimed at increasing the soil cover and improving the soil structure and thus the infiltration capacity of the soil. Specific measures are:

- Intercropping is used between the growing seasons of the main crops. The intercrops can be used as green manure or animal feed. Soil fertility and soil stability are promoted.
- An undersowing, additionally to the main crop, protects the soil, is used as green manure or animal feed.
- Conservation tillage means renouncing the ploughing. Instead, a shallow soil preparation is practiced (10 cm deep) and harvest residues are worked into the soil.
- Strip-till is a form of conservation tillage in which only the strip for seed placement is tilled reducing the area of bare soil of the field.
- No-till system means avoiding any tillage. With a special machine, the seed is placed in a sowing slot.
- Humus supply and liming stabilize the soil structure with a positive effect on infiltration capacity.
- Repair and reduction of structural soil damages by lowering the air pressure of the tires, driving on the fields only under dry conditions, using the widest possible tires or twin tires etc.
- Coarse seedbed preparation increases the erosion resistance of soils.

Box 32 – Background: Effects of different tillage methods after 8 years. The rainfall intensity for the experiment was 0.7 mm/min over 60 minutes (Schmidt et al. 2001).



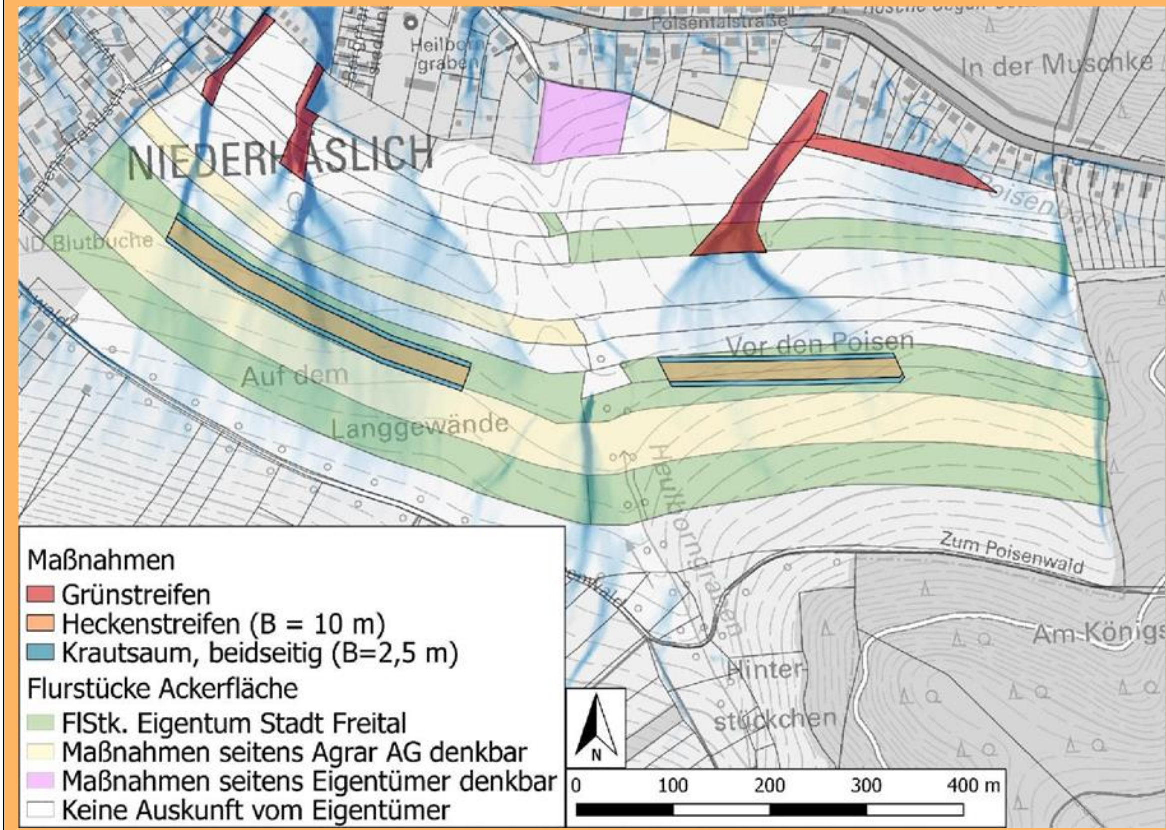
Strip-till (Photo: Jäckel) and no-till (Photo: Schmidt)

An erosion-reducing design of the fields is possible via

- Subdivision of larger fields into smaller units, if possible, with different crops.
- Green strips are created across the slope to reduce the flow velocity of the water and allow the retention of eroded soil material.
- Changing the direction of cultivation by tilling across the slope and avoiding erosion-promoting ruts downslope.

Box 33 – Example: Measures against soil erosion

To prevent or reduce erosion events and its impacts to nearby buildings and infrastructure, measures were planned in Freital (see also Box 30): 10 m wide hedges (ochre-coloured) with herbaceous border on both sides (blue) and green stripes (red).



Map: LfULG

Technical protection measures include:

- Creation of trap trenches to drain water from upslope fields
- Soil melioration of heavy or deep soil damages by deep loosening, crumb base loosening, planting of deep rooting crops, liming etc.
- Slope division by barriers (e.g., woody green strips/ hedges of at least 10 m width) and biological cross-buildings in drainage lines to reduce flow velocities.
- One- to three-row windbreak plantings perpendicular to the main wind direction to reduce wind speed upwind and downwind of the plantings. Besides the direct reduction of wind erosion, the drying of the soil decreases, which in times of increasing summer droughts is very favourable.

<u>On-site measures</u> to prevent soil erosion are related to permanent structures in the agricultural landscapes, to field size and slopes as well as to soil type and adapted management at the field level. Avoiding soil loss by erosion has always been a basic issue of good agricultural practice. Farmers should be aware that climate change increases the threats of soil erosion. This is especially related to the impact of more dry spring periods on wind erosion and of more heavy rain events in summer on water erosion. Instead of tolerating soil loss, it is required to improve soil fertility and water holding capacity to at least partly compensate negative effects of changing climatic conditions on plant production.

Off-site measures (in towns and villages) include measures to avoid the overloading of the sewer system with rainwater by

- Keeping inlets to the sewer system free,
- Regular sewer flushing,
- Avoiding inflow of external water and
- Draining off the excess water without causing damage in case of overloaded sewer system.

Measures for home and property owners are for instance

- Elevated house entrance building, or a wall or an enclosure,
- Dams along contour lines and
- Planting of trees in historical runoff paths and permanent soil cover by grassland

4.3.3 Adapt spatial planning

Risk management starts with planning by minimizing or excluding future risks. The issue of soil erosion and its possible impacts must be given greater consideration in future municipal planning of their rural and urban areas.

Urban development planning, but also planning of land consolidation (in German: Flurneuordnung) should generally assess the risk of flash floods and mudflows. Existing maps are to be consulted (erosion hazard, relief conditions, surface runoff), verified by on-site investigations, and the need for measures determined. Developments in areas at risk are to be critically examined.

It is possible to anchor precautionary and protective measures against soil erosion and flash floods in these plans or to establish them in a legally binding manner, so that risky areas are kept free of development or other forms of sensitive use. Also, a specification of certain forms of design and use for these areas is possible.

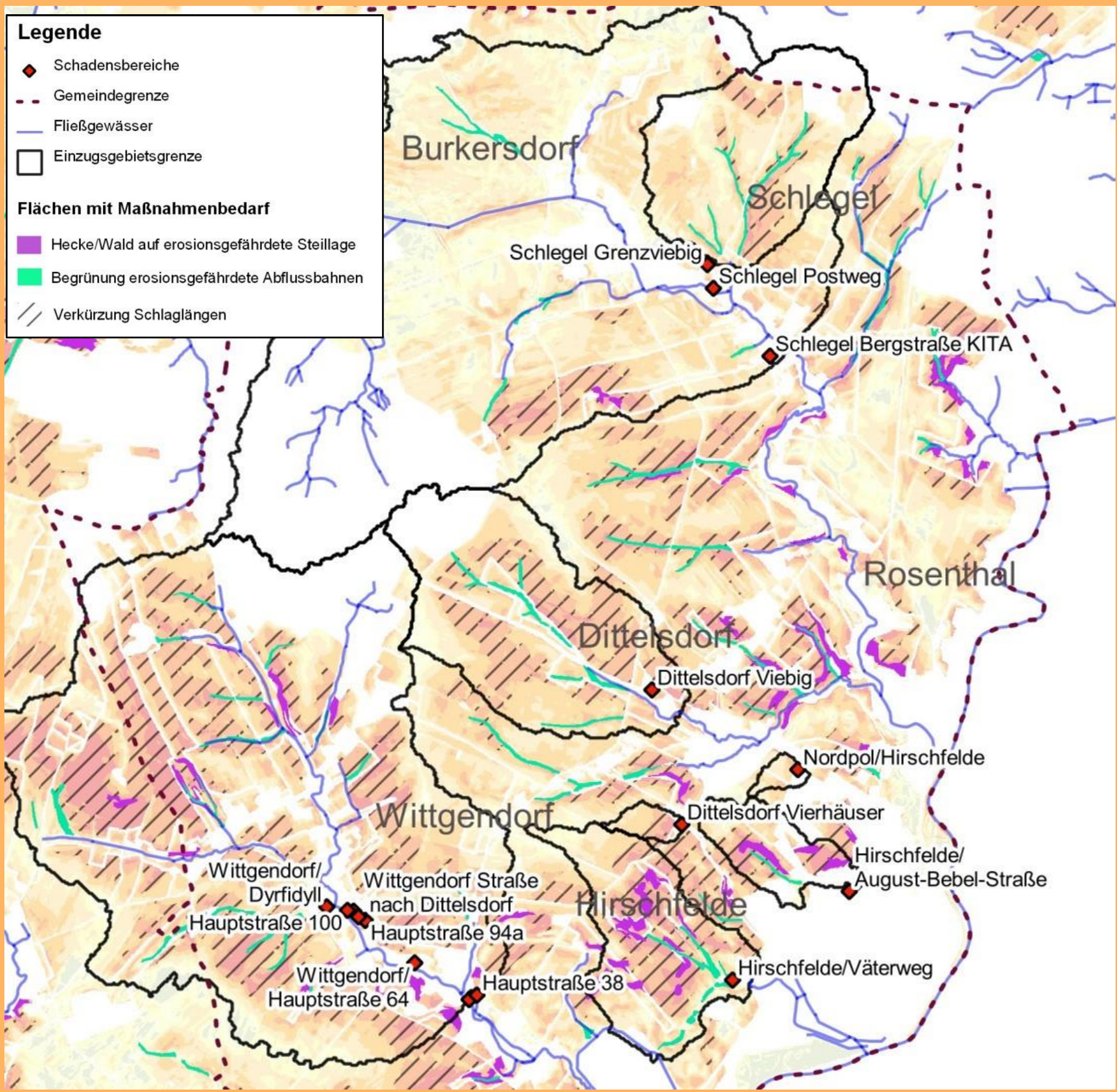
Public interest entities (e.g., counties, energy suppliers, water and waste disposal companies, fire department) must demand that the planning authorities take this issue into account more strongly in order to comprehensively guarantee the protection of soil and the protection claims of the citizens.

To solve mentioned problems, an action alliance of different actors is required: land owners/managers, municipality, maintenance associations, state office responsible or flood protection and water management, road authorities and county authorities (for nature conservation, water, soil protection). Forced influence on the management of land in the agricultural area is not conducive. Conviction by facts and voluntariness must be in the foreground.

The concept of measures must be coordinated with the neighbouring areas.

Box 34 – Example: Measures against soil erosion

To prevent or reduce erosion events and its impacts to nearby buildings and infrastructure, measures were planned in communities close to Zittau (Saxony): greening of erosion prone runoff paths (green), hedges on steep slopes (violet) and shortening of the length of the individual agricultural fields (hatched).



Map: LfULG

The responsibility for spatial planning adaptations is shared:

- At the state level, the Land Development Plan (in Germany LEP) treats erosion prone areas as "landscape areas in need of restoration". In Regional Plans, the objectives and principles of the LEP are often spatially and factually concretised and should be considered in further planning activities.
- Authorities like the Central Land Management Saxony care about the redevelopment of fallow land and the sustainable land use.

- At the county level, the natural revitalization of water bodies, the areal retardation of surface flows and rain water management are typical tasks of the lower water authority.
- At the municipal level, the parks and building offices have to adapt, plan and implement above mentioned tasks and include measures of specific municipal interest (e.g., to avoid in-flow of external water). The provision of relevant spaces for water retention and harmless runoff has to be implemented in urban development planning.
- Further responsibilities depend on the ownership: landscape conservation association, famers and other private persons.

4.4 References and further readings

Ad-hoc-AG Boden der Staatlichen Geologischen Dienste und der BGR (2002): Verknüpfungsregel 5.25 zur Ermittlung der Schutzwirkung der angebauten Fruchtarten gegenüber Erosion durch Wind.

DIN 19706 (2013): Bodenbeschaffenheit - Ermittlung der Erosionsgefährdung von Böden durch Wind.

DIN 19708 (2017): Bodenbeschaffenheit - Ermittlung der Erosionsgefährdung von Böden durch Wasser mit Hilfe der ABAG.

LLG (2018): Beratungsleitfaden Bodenerosion und Sturzfluten, Schriftenreihe der LLG, Heft 1/2018

Schmidt W, Zimmerling B, Nitzsche O, Krück ST (2001): Conservation Tillage — A New Strategy in Flood Control. In: Marsalek J, Watt E, Zeman E, Sieker H (eds) Advances in Urban Stormwater and Agricultural Runoff Source Controls. NATO Science Series (Series IV: Earth and Environmental Series), vol 6. Springer, Dordrecht.

Further readings:

Austrian Fact Sheets und Policy Briefs (in German), https://ccca.ac.at/wissenstransfer/fact-sheets

Climate change adaptation in Austrian municipalities, https://www.klimawandelanpassung.at/goal