7. CLIMATE AWARE ARCHITECTURAL SOLUTIONS

Building-energetics is one of the major priorities of the European Union's energy and climate policy. Directive 2002/91 and directive 2010/31 of the European Parliament and of the Council on the Energy Performance of Buildings (EPBD) specifies, inter alia, that after 2020, or in the case of public establishments after 2018, only buildings with **nearly zero** energy consumption will be granted planning permission. It is also a mandatory specification that as of 2012, no support can be granted to new constructions or renovations not fulfilling the minimum requirements calculated according to the **cost optimum,** as to be later defined by the Commission.

Directive 2006/32/EC on energy end-use efficiency and energy services specifies that member states elaborate an Energy-efficiency Action Plan for the period up to 2020 and specifies buildings, transport and public institutions as the main sectors. The common climate and energy policy has set the objective of a proportion and a growth of 20% in the field of energy saving and in renewable energy, respectively, at the EU level by 2020. It is important that in its resolution of 17 November, 2009, the European Council made it clear that the developed industrial countries have to reduce their greenhouse gas emissions by 80% by 2050. The major pillar of this decarbonisation process is achieving a significant decrease in energy consumption – and consequently in CO_2 emissions -- related to buildings. But the sustainability and climate-friendly strategies and solutions relate not only to energetics but also to water management and aspects of green architecture (green roofs, green fronts, etc.).

7.1. FOSSIL ENERGY CONSUMPTION OF EXISTING BUILDINGS

The energy consumption of buildings depends strongly on climate. Logically, in the northern part of Europe ensuring the ideal internal temperature is necessary mainly during the winter season, while in the Mediterranean region, this is more necessary in summer. The largest, central part of Europe stretches over the border areas of the temperate and continental climatic zones. Consequently, the summer and winter temperatures can be very extreme, so emphasis has to be laid both on cooling and heating, as well as on sun protection when designing buildings. With their long-established form and construction materials, traditional buildings have adapted well to local climates in every region of Europe, although, it must be said, at a comfort level significantly lower than today's. However, modern architecture and contemporary life styles have broken away from local climatic features. The modern man satisfies his heat comfort demand, which is considerably higher than in previous times, with more and more sophisticated machinery. The operation of these entails higher energy consumption, which leads to the fast exhaustion of fossil energy resources and, through CO_2 emission, significantly affects global climate change.

Over the past decade, significant changes have taken place in the relationship between the natural and built environments. Rising levels of demand, increasing individual consumption and a growing population combined have resulted in an exponentially increasing burden on the environment, a significant part of which is related to the creation and maintenance of the built environment. 7-800 years ago buildings consisted only of the main structures, and were durable. Since the beginning of the 20th century, the proportion of more quickly aging engineering and professional industrial solutions has become predominant in a building. This requires cyclic reconstruction and modernisation. Clearly, the main direction of technological development is HIGH TECH and intelligent buildings, but processes can also be observed which are going in the opposite direction, with the objective of minimising mechanical engineering and technology, and prioritising passive and semi-natural tools and LOW TECH. In certain cases intelligent buildings and building automation are inevitable; but the more sophisticated a system is, the more vulnerable it is. Passive architectural solutions, e.g. passive heating-cooling-ventilation, natural lighting, etc., ensure that buildings perform their basic functions even in the event of power cuts and electronic disturbances.

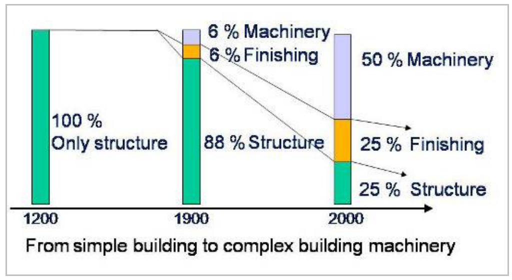

Figure 13: Lifecycle cost analysis (Czerny J.)

Currently, **heating** still constitutes the highest energy cost to residential buildings. In Hungary, the heating of residential and public buildings represents 32% of total CO_2 emissions! Due to the rise in average summer temperatures and the increasing extremities, besides those buildings demanding a high level of comfort and are already fitted with air-conditioning (e.g. hotels, office buildings, theatres), other types of buildings, including residential houses, have had masses of cooling equipment installed instead of proper sun protection. Even in statistics, this issue is not handled in its own right, despite the fact that this subject is gaining increasing significance. In the case of certain residential buildings and all modern office buildings, the cost of cooling energy exceeds that of heating, and the cooling demand prevails when preparing the mechanical engineering designs. Typical cooling equipment is powered by electricity, so their primary energy demand is high, and since a significant proportion of electricity is produced by burning gas and coal in power plants, their CO_2 emissions exceeds those from using gas or solid fuels for heating.

When examining energy use and environmental load, it is important that we not only consider the consumption occurring during the usage of buildings but also throughout their entire life cycle. In the course of **Life Cycle Assessment**, the total environmental load of a building is calculated starting from its construction, through its operation and necessary maintenance, to its demolition.

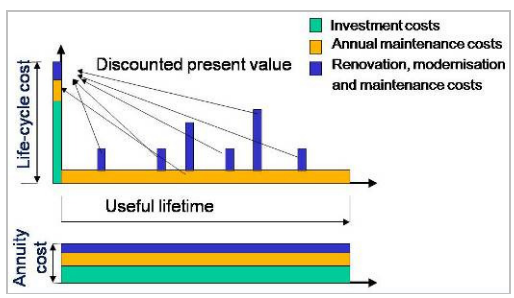

Figure 14: Costs related to the buildings (Czerny J.)

The amount of energy consumed in the establishment of buildings includes the energy spent when producing the construction materials and when transporting them to the site. A sustainable settlement strategy, or structure and land use plan, can determine the maximum built-in energy content to be achieved in the case of a new construction. Priority has to be given to local, natural and recycled construction materials. At the same time, maintaining an existing, poor-quality building demands a significantly higher amount of energy than that energy spent on the production of the materials and on construction.

Buildings' sustainability not only means environmental but also economic sustainability. Thinking in life cycles takes the entire environmental load of the building into account, including utilisation after demolition. The cost analysis calculates all the costs of the entire life cycle, i.e. construction,

operation, cyclic renovation, modernisation and demolition, in advance, at today's cost. Hence, we can get a picture of the following even before the commencement of the project:
– will the user be able to maintain the building after its construction?
– how long will it take to recoup expenditure in energy-efficiency and renewable energy?
– by how much do these devices or solutions reduce life-cycle costs, i.e. how much more expensive would operation be without having invested in their installation?

This calculation is especially essential from the dual perspectives of the national economy and the state of the environment, as it provides the means to achieve permanent and full sustainability. This cost calculation is gradually becoming part of the toolkit of property developers and facility maintainers, and it is expected that it will become one of the requirements of public procurement, from where it will spread to the wider industrial - construction praxis.

Ostend, construction consultancy and loans

The city of Ostend lies along the coast in the north-western part of Belgium. It has approx. 70,000 inhabitants.

The city of Ostend established an organisation called EOS (Energy Saving Ostend) to reduce individuals' and organisations' energy expenses. In order to achieve this the organisation provides free consultancy and even gives loans with favourable conditions.

EOS experts examine 700 households every year to assess the condition of the houses in terms of energy management. Every household is given a free programme package including useful energy-economic products. The professionals also make recommendations on how to cut the buildings' energy consumption.

The actual implementation of any given advice will, of course, be expensive, so the organisation also helps its clients with interest-free loans. The organisation gets 2% loans from FRGE (Fonds ter Reductie van de Globale Energiekost – Fund for Reducing Global Energy Costs), an institution supporting energy-cost reducing projects, but the city takes on paying the interest, so this is why EOS grants loans free of charge. The loan can be a maximum of € 10,000 and has to be paid back in 5 years.

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7.2. ARCHITECTURAL POSSIBILITIES FOR MITIGATING CLIMATE CHANGE

Every settlement needs a **sustainable development strategy**, integral parts of which are its energy strategy and its climate strategy. A settlement is part of the land, the land supplies the settlement with power resources and the settlement returns this with services and products. A sustainable settlement lives in balance and symbiosis with the surrounding land providing for its needs. To achieve this, firstly the land's ecological balance has to be defined, and then a strategy needs elaborated to restore this balance, based on sustainable use of the land. Sustainable land use means - contrary to sectoralised, industrialised agriculture - organic and biological agriculture, where the cultivation of plants and animal husbandry constitute an organic unit. Biological farming puts an end to the overuse of the land and soil, and introduces their rhythmic rejuvenation. Sustainable forestry is also part of this kind of economy.

Due to the above reasons, the preparation of the energy strategy has to be preceded by the examination of land use in the inner and outer areas of the settlement and then by the elaboration of a strategy for switching to sustainable land usage. The energy strategy has to be prepared alongside this strategy. The first step of preparing a strategy is assessing the entire renewable energy and energy-efficiency potential, in light of which the energy-efficiency actions can be drafted. Subsequently, it is possible to construct alternative energy models based on knowledge of the economically exploitable renewable resources and then, examining their feasibility, to prepare proposals and a strategy. The final objective is to develop a vision to implement the settlement's energy-independence within a 20 to 30-year timeframe.

Assessing energy potential means estimating or calculating the exploitable quantity of all types of renewable energy:

- solar energy potential: calculating the amount of surface suitable for the energetic utilisation of solar energy and their performance potential, which are:
    - well-oriented high-roof surfaces, flat roofs;
    - noise barrier surfaces that can be located along linear establishments (railway, express highways, motorways);
    - areas unsuitable for other purposes.

Figure 15: 17 hectare PV field, Burgtonna, Austria

- biomass potential:
  Data on solid and liquid, primary and secondary biomass quantities and their energy yield:
    - firewood and forestry waste;
    - agricultural waste: green waste, liquid dung, etc.;
    - yield of energy plantations;
    - organic content of communal waste;
    - communal and industrial wastewater.
- wind-energy potential:
  Categorisation of places suitable for producing wind energy in the inner and outer areas of the settlement; the amount and performance level of installable equipment.
- hydraulic energy:
  Estimating performance based on fall data and the opportunities for damming creeks and rivers suitable for producing hydropower.
- geothermic energy
  Potential of thermal wells; performance data of the cascade-system utilisation; possibility of deep geothermic utilisation (Hot Dry Rock – HDR – technology) for the purposes of a large power plant.

All these potentials can be examined on smaller units scale, e.g. a residential block, plots of land, too. The locally produced energy reduces the ecological and carbon footprint of the area.

Energy-efficiency potential

To decrease energy consumption and, consequently, buildings' CO_2 emissions in a city, the first step should be mapping the quality of the existing building stock. This is the duty of the city management, the energetics expert and the engineer-in-chief, or the settlement's chief architect. Increasing energy efficiency has the greatest potential to decrease CO_2 emissions and a proper picture of this could be obtained if the buildings' energy certificate were available.

It would be important to establish a **spatial information system and database** extending to plots and buildings, into which data on building stock could continuously be uploaded. However, until this is available, an energetics audit could be prepared on the entire stock of buildings or part of it, e.g. on public buildings.

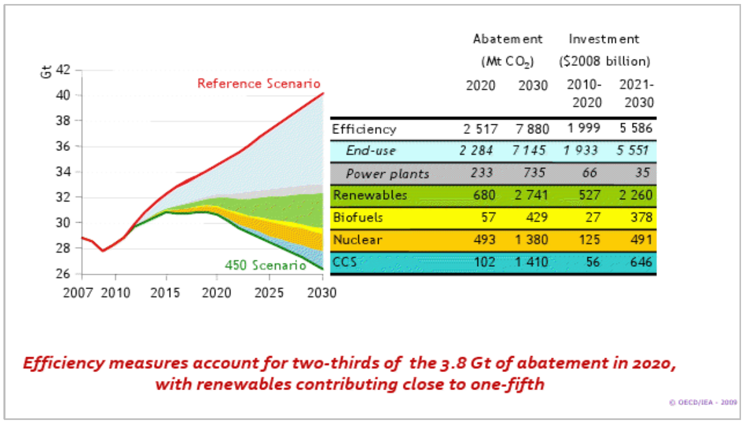

Figure 16: World abatement of energy-related CO_2 emissions in the 450 scenario (OECD-IEA, 2009)

The most important data concerns heated floor space, the nature of the main building structures and the annual energy consumption based on utility bills. In possession of this information, the buildings' energy-efficiency can be calculated to a good approximation. It is expedient to determine heating energy demand first in kWh/m^2a, which can be completed with the data about the cooling energy demand and electricity consumption.

A data sheet to be filled in by surveyors has to be prepared for each building.
Major data:
- heated floor space of building in m^2;
- wall structure;
- type of window;
- energy costs for 1 year;
  - heating (gas, firewood, etc.);
  - electricity (heating, cooling).

A simplified method is sufficient for preparing a strategy. Data on the following has to be collected from the whole settlement (settlement part):
- number of households;
- number of persons;
- annual heating demand;
- annual sanitary hot water demand;
- energy demand of industrial establishments (heat + electricity);
- energy demand of agricultural establishments (heat + electricity);
- energy demand of commercial establishments (heat + electricity);
- energy demand of public buildings (heat + electricity);
- electricity demand of public lighting;
- total heat demand (heating + sanitary hot water);
- total electricity demand.

It is possible to categorise the buildings according to their energy class and total energy demand based on the collected data. Some help in this is provided by the table by PHI indicating domestic hot water and electricity demand in addition to heating demand. In the table, the last one is the 'zero' (i.e. autonomous) house.

Based on the building stock's energetics data, the amount of energy that can be potentially saved with energy-efficiency measures can be determined with good approximation. As a decrease in emissions can be achieved in the most cost-efficient way through energy-efficiency, the primary task is to prepare an energy-efficiency action plan. This is the primary condition for using renewable energies. The savings potential of the existing stock of buildings can be achieved in 20 to 30 years. A complete switch, i.e. setting the objective of establishing a sustainable and energetically independent settlement, can be implemented in 30 to 50 years, provided that a good strategy exists.

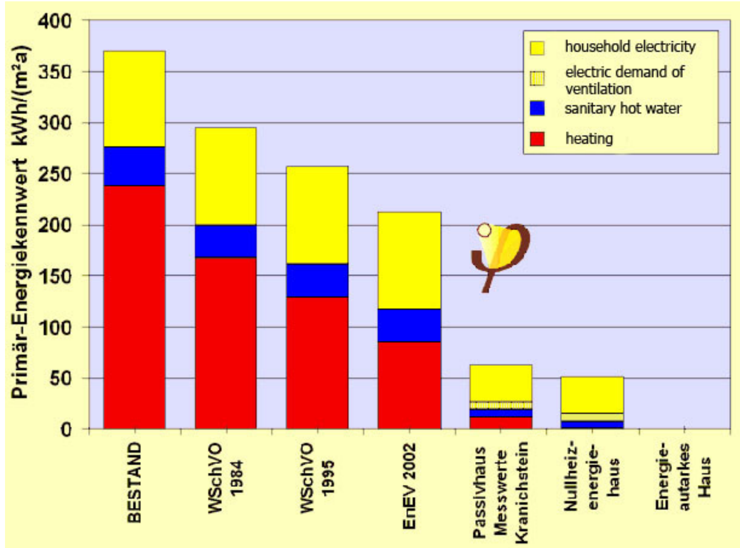

Figure 17: Comparison of energy ratings of homes (Passive House Institute)

Quick and spectacular results can be achieved by switching public lighting to LED+PV operation. LED lighting fixtures already include streetlamps with outstanding energy saving features. Low consumption allows the energy needed during the night to be collected by a post-mounted photovoltaic unit and stored by a battery. This way public lighting operates independently from the network, using a dusk-switch. The action plan includes the elaboration of a funding programme which, with complementary support from the EU, provides financial assistance from local sources, e.g. with interest-free credit to ensure the own-contribution for the funding schemes, accelerated planning permission, local tax benefits as well as by supporting the domestic energy-efficiency industry. Besides carrying out a survey from 'below', it is practical to perform the status survey from 'above', i.e. starting out from the energy consumption data of the entire settlement, from statistical data.

We have limited possibilities for reducing energy consumption in respect of our existing buildings, but in the case of new buildings it is useful to take the energy-conscious design principles into account in the initial design phase; this way low energy usage can be developed much more easily, cheaply and efficiently.

Naturally, the entire year has to be taken into account in respect of energetics and heat. It is important to emphasise this as recently the energy-conscious approach has been mostly concerned with reducing heat energy consumption and by increasing solar heat gain. However, the objective is to find solutions reducing primary energy demand throughout the year, ensuring a pleasant heat comfort for the users. When possible, designers have to ensure the appropriate internal heat comfort by 'natural' passive architectural and structural means, because of the significant primary energy demand of mechanical cooling.

The energy demand for heating consists of the balance between the following factors (J. Várfalvi, A. Zöld, 1994):

– **transmission heat loss:** subject to heat transmission factors of the bordering structures and to thermal bridges;
– **ventilation heat loss:** heat loss originating from filtration and artificial ventilation;
– **solar heat gain:** subject to orientation, proportion of glazing, shading and the energy transmission characteristic ('g' value) of the glazing;
– **heat gain from internal heat sources:** depends on the number of people staying in the building, the equipment used and the artificial lighting.

Besides energy for heating, the demand for domestic hot water (DHW) also needs mentioned, which is permanent throughout the year and independent from the structure of the building. The most general solution for supplying DHW is preparing hot water with solar collectors, which covers the demand in ¾ of the year. Among passive houses, a 'compact device' is spreading, which not only ensures heat recovering ventilation but also produces DHW from the heat extracted from the escaping air with the help of a heat pump. Heating energy demand can be decreased, logically, through the following factors:

– by heat insulation and reducing thermal bridges;
– air-tight structures and heat recuperation (by making doors and windows air-tight and with ventilation devices);
– by increasing solar gain (by constructing solar traps and increasing glazed surfaces).

It is expedient to cover the remaining heating demand with highly efficient, regulated heating relying on renewable resources.

7.2.1. Energy conscious construction

The first step in reducing transmission heat losses, in addition to achieving an optimal surface/volume ratio, is the intensive **heat insulation** of all the external structures of the building and those bordering unheated spaces. As well as this, and in order to avoid mould, it is essential to stop or decrease the impact of heat bridges, which can be achieved by placing insulation on the external sides of the bordering structures. Fashionable terraces with reinforced concrete consoles and the shading concrete slabs are typical thermal bridges.

Figure 18: Dresden, housing estate rehabilitation, reducing from 6 to 3 storeys, independent terraces

Solutions used for avoiding thermal bridges:
– thermal bridge-free consoles interrupting the heat-conductive structure, i.e. the terrace slab,
– development of a terrace structurally detached from the building.

Programme for improving energy efficiency in Slovakian households

Housing refurbishment and modernisation is among the long-term strategic priorities of the national housing policy in Slovakia. One of the aims is to achieve gradual decrease of energy consumption of buildings subject to the provision of the Act No. 555/2005 Coll. on the Energy Efficiency of Buildings. Many buildings in Slovakia were constructed during the soviet era; these houses are not energy efficient at all. In 2009 to improve efficiency and to reduce the emission of carbon-dioxide the Governmental Insulation Programme was launched. The programme was managed by the Ministry of Transport, Construction and Regional Development and involved all Slovakian cities. The programme provided beneficial loans (0% interest rate, total fund of 70 million EUR) for a complete insulation of residential buildings. Funding was provided from the emission trading, loans were administered by the State Housing Development Fund. The financial resources were spent for more than 350 projects representing 14 775 housing units. As a result the calculated decrease in energy consumption of insulated residential buildings was more than 40%.

This programme can be ideal for cities, which have buildings with low energy efficiency and where the residents need a financial assistance to restore their homes.

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Proper doors and windows are an important part of well heat-insulated wall structures. Today's modern heat-insulating triple-glazed doors and windows are practically equivalent to the external walls in terms of energetics. However, in certain cases it is risky to install excellent quality doors and windows because, if rooms with air-tight doors and windows are not sufficiently ventilated, then the humidity of the internal space can quickly increase and the air becomes stale. Vapour may cause periodical condensation on the internal surface of thermal bridges, which, in the long term, leads to mould. Because of the lack of air exchange, ventilation becomes more frequent, which results in an increased heating demand. The decreased filtration loss requires a proper air exchange is ensured.

Winter heat loss can be further reduced primarily by decreasing **ventilation heat loss**. The basis of low energy consumption is a favourable surface/volume ratio, an airtight design extending to the entire external space delimitation, mechanical ventilation with heat recovery and an air exchange matched to the temperature (preferably, not too high). The entire building shell has to be designed in an air-tight manner, with particular regard to the installation of doors and windows. However, all joints are critical, so this is why it is necessary to apply air- and vapour-tight foils and barriers. Heat recuperating ventilation equipment can be supplemented with a terrestrial collector, which sucks in the fresh air through an air intake pipe sunk into the ground. This pre-heats the fresh air in the winter and pre-cools it in the summer.

Another, simpler but less efficient version of air exchange is using air-intake units installed in the wall or window casements, attached to an internal exhaust ventilator. The air-intake unit, detecting the humidity level increasing along with the air becoming stale, automatically opens and then closes down when normal humidity is reached. In the course of renovation works carried out in the interest of energy-efficiency, it is essential to apply heat and humidity scaling; in the absence of such technical calibration, moulding, corrosion, illnesses and damage to the building can be expected.

In the case of low-energy or passive houses, the glazed doors and windows are no longer the sources of heat loss but rather the sources of heat gain, so it is often important to increase the glass surfaces on the sunlit fronts in order to maximal solar gains. The possibilities for this are the following: using south-oriented glazed surfaces and/or special glazing (mass wall, Trombe-wall, transparent heat insulation).

The cooling energy demand arises from the following components:
- warming of the building structures (transmission);
- solar load;
- ambient heat entering through air exchange;
- interior heat load (heat from inhabitants or users and machinery).

The cooling demand can be reduced by:
- increasing heat insulation (the warming time will be longer than the duration of the heat load);
- regulated air exchange and the instalment of passive heating;
- efficient sun protection and shading, including leafy trees and green fronts;
- increasing the heat storage capacities (heavy structures);
- reducing internal heat sources;
- night ventilation (free cooling).

In the case of residential houses, the above means are usually sufficient and there is no need for mechanical cooling.

7.2.2. Protection against the impact of warming

It is expected that climate change will directly result in a rise of peak summer and average temperatures within decades. Soon, peak temperatures of 40-45°C will not be infrequent, which will render certain types of buildings (offices, housing estates, light construction houses and lofts) unusable without cooling or heat protection interventions. According to Géza Molnár, there can be a difference of 10°C between the summer temperature of areas covered with forest and flat plains. The simplest extensive green roof is able to reduce the summer surface temperature by even 50°C (the temperature of solid paving or sheet metal surfaces is 80°C, while that of the surface of a green roof is 25 to 30°C). Consequently, the best climate regulatory device is vegetation and forest cover, which facilitates evaporation 8 times higher than that of surface of water. If air-conditioning is installed in each and every housing estate flat built using concrete panels, the street temperature may even rise by 10°C. The vegetation itself is able to perform the task of cooling just as well, as, according to G. Molnár's observations, air-conditioning equipment usually cools the internal temperature to 10°C lower than the outside temperature.

The process of desertification poses a double threat:
- the process of the land's desiccation,
- the decrease of humus in the topsoil.

The best protection against both dangers is increasing the proportion of green surfaces and helping the generation of humus, including through green architecture. Increasing the area of green surfaces is the most cost-efficient means of climate protection and, as such, belongs to the toolkit of local climate protection strategy. Green areas slow down precipitation run off, store it, and allow evaporation.

Developments in building energetics support, amongst other things, the spread of green technologies, the fulfilment of climate protection obligations, the creation of workplaces and the promotion of entrepreneurship. In the construction industry, a significant amount of the qualified labour force (not necessarily highly-qualified) is needed for energy-saving refurbishment and new constructions, which provides a great impetus for entrepreneurship in the creative and green industries (e.g. the application and distribution of high-performance construction products). The demand set by developments in building energetics improves the competitiveness of small and medium construction ventures and mobilises the designing, manufacturing, construction, trading, etc. capacities of the construction economy.

All in all, reducing buildings' energy consumption constitutes 'good practice' in the transition towards sustainable development, as it simultaneously decreases the dependence of countries on foreign energy sources, improves the economic situation of families and public institutions, encourages ventures, and helps us meet our international commitments and obligations undertaken in climate protection conventions.

The wide-scale application of climate-friendly solutions simultaneously serves the mitigation of climate change and adaptation to its inevitable consequences. Through proper heat insulation, sun protection and the proper orientation of buildings, their heating and cooling energy consumption can be considerably reduced. This results in a cut in greenhouse gas emissions and, consequently, in the mitigation of the climate change they cause. At the same time, the application of water-saving and semi-natural wastewater treatment technologies and the principles of green architecture also serve the adaptation to the changing environmental conditions.

Protection from the sun is generally achieved with fixed or mobile shading structures. The shading device can be placed on the external or internal side of the glazing or between the layers of the heat insulating glazing. As the glazing works as a sun trap, the shading devices absorb part of the incident solar radiation and warm up; furthermore, to ensure heat protection, structures are placed on the external side which can be ventilated and provide maximal summer sun protection. A traditional solution is fitting covered terraces and verandas to buildings so that their roof structures, making the most of the difference between the heights of the winter and summer sun in the sky, provide shade in the summer but let the sunrays enter the buildings in the winter, reducing this way the winter heating demand. Amongst passive houses there are, again, numerous buildings with verandas. Shading structures include transparent solar cells transmitting part of the incident light and producing electric energy at the same time.

If the demand for heating has been minimised by careful design but cannot be reduced any further, active cooling needs to be applied. In this case, three solutions are possible:
- the greatest comfort is provided by air-conditioning equipment which also treats the air; this entails the largest investment and operational costs;
- he investment and operational costs of air cooling (climate control) devices operating in the summer are also very high;
- the most cost-efficient solution is operating a heat pump with both heating and cooling functions in the building.

Some types of special glazing have in-built features, such as absorbent, reflexive and coated glasses; besides, there are ones with varying characteristics: the light-transmitting capacity of some glasses depends on environmental impacts (photo-sensitive, thermo-sensitive panels) or may be regulated by electricity. With the emergence of passive houses, the primary duty of glazing is to ensure maximum light transmission and winter heat gain. Therefore, instead of coating, efforts have been made for clarity and transparency and sun protection is solved by using special shading structures.

Figure 19: Passive house, Weiz, Austria

In buildings with large mass and heavy structures, the wall and floor structures absorb part of incident radiation, thus diminishing fluctuation in the room's air temperature. It also has to be mentioned that painting the external walls in white increases their albedo (ability to reflect light), as a consequence of which they absorb less radiation and warm up less than coloured walls. Similarly, the development of roof gardens, green roofs, double-shell cold roofs and attics has a heat insulating and climate regulating effect. The heat storing capacity is linearly proportionate to the mass of structures bordering the room. The impact of warming can be reduced in the simplest and cheapest way by good night ventilation, which cools off the bulky building structures with cool night air, significantly delaying reaching the maximum value of the inside daytime temperature. Excessive warming is further decreased by using a double-shell ventilated building cover on all the bordering structures.

Figure 20: Wind chimneys, Yazd, Iran

If the structures of a residential building are heat-technologically appropriate and its sun protection is solved, then there is no need for any cooling. This is primarily due to the fact that in the daytime most of the residential buildings are empty as the occupants work outside their homes or are in school, and apart from them there is no other heat source in the flat but the refrigerator. If they are at home, both the air exchange and fresh air cooling need to be solved. If the building has a proper heat storing mass, then, after having been cooled down during night-time ventilation (free cooling), the building can keep the lower temperature all day long, provided that the doors and windows are closed. Cooling incoming fresh air can be solved by passive, partly passive and active means:

- with earth collectors (fresh air is brought into the house through a pipeline laid in the earth which has a temperature of approx. 14˚C, hence cools without active cooling),
- with compact devices producing domestic hot water from the heat extracted from fresh air with heat pumps, as these devices provide cooled air for the living space,
- with passive ventilation systems such as wind chimneys, solar chimneys, or Venturi discs, which move the air without the aid of ventilators, leading it through cool places like cellars or shady yards with fountains, etc.

The simplest means of sun protection is planting deciduous trees in front of the sunlit front. This is followed by using veranda-type and other external shading structures. In addition to summer sun protection, the main goal is to maximise the winter solar gain, which can be achieved by designing fixed shading fittings similar to a veranda, or by using a mobile shading screen.

Even if a public building's sun protection is perfect and its structures are thermodynamically adequate, cooling demand is standard in terms of the buildings' energy consumption. This has two reasons:

- the persons present in the building, and
- the office equipment and lighting continuously produce heat.

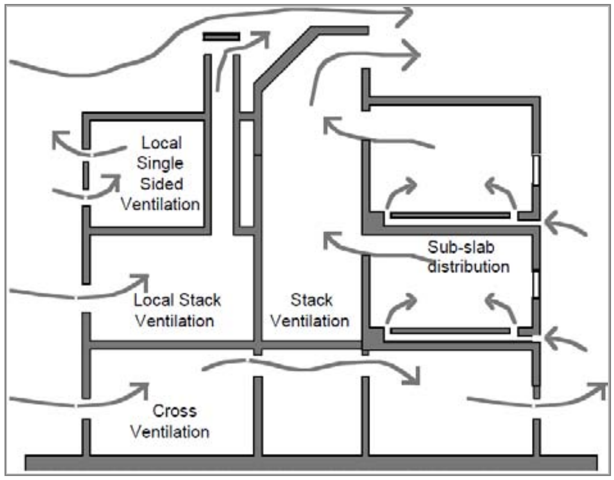

Figure 21: The Queen's Building, De Montfort University, Leicester (source: A. Zöld)

Heat produced this way comes in handy in winter because it diminishes heating demand to some extent. However, in summer this has to be removed from the building. It is possible to influence heat producing equipment (however, naturally, only the interior ones) in the following ways:

- with special architectural design which maximises both natural lighting and sun protection: proper depth of floor, atrium design, transparent partition walls, single-space offices, controllable shading or projecting lamellae;
- passive light units: skylights, photo-conductive channels (Velux, Solatube);
- selection of energy-saving office equipment: notebooks instead of desktop computers, LCD monitors instead of cathode-ray picture tubes, standby-killers which cut off the current for the night, separate server room with cooling or ventilation;
- energy-saving lighting, presence-detecting lighting, local lighting, light fixtures with LED's or compact light tubes.

It is important that the operator of the building can influence the selection of office equipment operated by the users.

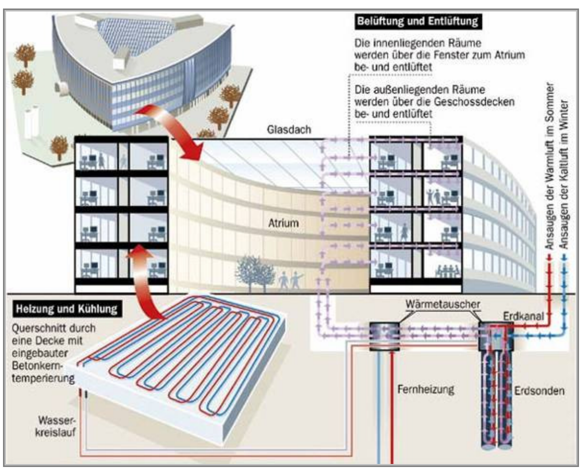

Figure 22: Ulm, Energon passive office building

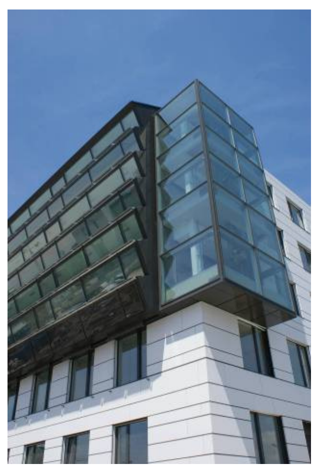
Figure 23: Vienna, Energy Base, passive office building (photograph: L. Szekér)

If we have already exhausted all options in terms of passive sun protection, the selection of proper building structures and the decrease of the internal heat load, then cooling demand has to be determined based on the remaining heat load. From among the active cooling devices, heat pump systems, which are also useable in winter for heating, are more economic than appliances only serving cooling. Those heat pump solutions which channel the heat withdrawn from the building into the earth or into the groundwater, using them as buffers, have outstandingly high effectiveness. Heat stored in the summer can be withdrawn from the earth in winter.

7.2.3. Buildings with almost zero energy consumption

Energy certificate, energy classes:

The European Union has introduced energy classes for buildings, too: a given building can be classified by preparing its energy certificate (green card). It is important to note that calculating the energy class not only takes the energy demand for heating into account but also the energy carrier used, effectiveness, and the heat needed for domestic hot water. Due to this, it cannot be considered as identical with the requirements of a passive house.

The EPBD does not define requirements related to 'buildings with nearly zero energy consumption' and leaves those up to the national authority. It is necessary to designate these categories clearly in the Energy-Efficiency Action Plan. There are a number of definitions and concepts circulating on this topic, which should be specified through professional consensus and included in legal regulations.

Passive houses (PH)

This is a concept elaborated by PHI (Passivhaus Institut, Darmstadt, Germany) and generally accepted, defining requirement values for the annual heating energy demand in respect of different types of buildings. In a basic situation, the requirement value is a heating energy demand of 15 kWh/m^{2}a for residential buildings, but the total primary energy demand of the building may not exceed the value of 120 kWh/m^{2}a. In comparison, the average annual heating energy consumption of Hungarian residential buildings is between 180 and 350 kWh/m^2. Passive houses also have heating but the heat demand for heating is so low that the necessary heating performance is some one-tenth of today's average: for a single home only 2-3 kW instead of approx. 18. Fewer heat-transfer appliances with smaller surfaces are needed. However, the ventilation system has to be part of 'active' engineering, because in the case of a perfectly insulated, air-tight building, the significance of heat loss during air exchange increases. The ventilation of a family house is operated merely by a ~60 W ventilator, the energy consumption of which is insignificant compared to the recuperated energy. The developed calibration software (Passivhaus Projektierungs Paket – PHPP) enables a more accurate calibration than that of the general, wide-spread software and, in addition to the engineering solutions, their primary energy demand also plays a role when evaluating the buildings. The PHI also offers solutions for passive house technology to reach this value (no thermal bridges, U values, air-tightness, heat-recuperating ventilation system) and has also elaborated and operates the qualification system for buildings and industrial construction products. The definition of passive house is acknowledged all over Europe. However, it needs to be localised, which also means aligning it with the more specific climatic features of the geography of the Carpathian Basin and consideration of the different requirements relating to residential houses and public buildings. For instance, besides a lower heating energy demand, the cooling requirements are of greater importance in Southern Europe than in Germany. (In Germany 'A^{++}' is ≤ 10 kWh/m^{2}a, passive houses.)

The EPBD still has not determined the requirements of cost-efficiency but the regulation's direction is clear. Passive house costs vary greatly. The first Hungarian passive house was built at a lower cost than the average price of a detached house built using traditional technology. But we can also find passive houses constructed at a price much higher than the aforesaid. According to the German data, the construction cost of a passive house is an average of 10% higher compared to traditional buildings. Several questions arise:

1. Can a passive house be constructed at the price of an average detached house?
2. Can the 'nearly zero' requirement be achieved with simpler technology and at a lower cost?
3. Can the passive house standard be made mandatory?

The answer to the first question is yes. Even if it can be difficult to implement the example mentioned above, the objective can be achieved with a light-construction building developed as a passive house and, in certain cases, and in certain cases, using even wet-process technology, too. The different types of light-construction passive houses eliminate the negative points that buildings with light structures usually have (e.g. the lack of heat storage capacity); in Austria most passive houses are built this way.

With solid walling, it is already more difficult to stay within the cost limits, but using local construction materials (adobe brick, straw) and with self-build, it is still possible.

The design of the house in the figure above was financed partly from a GIS (Green Investment Scheme) grant. The 125 m^2 residential house is independent of utility networks and operates with zero overhead charges for the price of an average residential house +8% extra expenses (www.autonomhaz.eu).

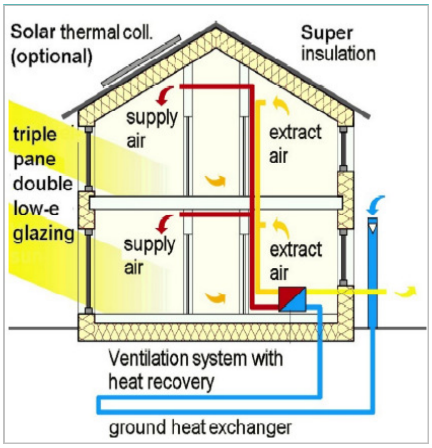

Figure 24: Principles of a passive house (Source: Passive House Institute)

To answer the second question: primary energy demand can be kept low by using locally produced renewable (solar and biomass) energy. So, in the case of a building with a lower heat-technology performance, this can be constructed more easily and cheaply than a passive house and the environmental load can be kept at nearly the same level.

Finally, answering the third question: making passive houses mandatory can be practical in the case of certain building types, but in the case of private construction, is by no means necessary. Passive houses, as a peak solution, must remain voluntary, similarly to active houses.

Both passive houses and low-energy houses can be constructed cost-efficiently and with nearly identical primary energy needs. With some further development, both of them are suitable for meeting the near zero requirement. The example shows well that producing domestic hot water with solar collectors significantly reduces the primary energy demand.

In the case of residential and public buildings, the renewable resources commonly utilised are mostly biomass, solar and terrestrial heat. The energy of the sun can be used for producing electric energy with so-called photovoltaic cells (otherwise known as solar cells) and for preparing domestic hot water with solar thermal collectors. These ancillary units can be placed on southern or south-western fronts or roofs.

Szada, the first certified passive house in Hungary

The passive house in Szada is a single-storey building with a floor space of 125 m^2 and no cellar. Its heating energy demand is 15 kWh/m^2 per annum. It has been built on a slab foundation, with polystyrene-framework, reinforced concrete technology.

Its hot water is produced by a vacuum-pipe collector and its heating is provided by a pellet boiler.

Its construction cost a gross sum of HUF 230,000/m^2a. With further development, installing photovoltaic units, the house is able to meet the requirements of a 'zero energy house'. The house was designed by László Szekér.

Växjö, a city quarter made of wood

Växjö lies in the southern part of Sweden and has approx. 56,000 inhabitants.

In 2006 the local government started to build a new district not far away from the city centre. The name of the 25-hectare quarter is Välle Broar and its speciality is that it is planned to construct the entire district from wood.

The objective of the construction is to demonstrate that it is possible to build from wood an environment that has a completely urban atmosphere and services of urban quality. As the country has an enormous stock of wood, obtaining the material is no problem. Due to its nature, wood is more environmentally-friendly than e.g. concrete, glass or plastics and is excellent also from a climatic perspective.

The project was started with three goals:
- increasing knowledge and raising interest related to wood construction,
- encouraging the use of wood, a material that can be used with less energy and a smaller ecological footprint,
- encourage customers to choose wood as a material providing a higher aesthetical experience.

Additionally, the new district will serve as the development site of the professionals of the University of Växjö, the city, local companies and research institutions. According to preliminary estimates, construction will take 10 years.

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Low-energy houses (LEH)

Originally of German origin (Niedrig Energie Haus – NEH), the definition of the low-energy house has spread from there all over Europe. In each country different requirement values of between 40 and 80 kWh/m^{2}a have been determined, including the heating energy demand. When establishing the requirements, it is an important to bear in mind that a value of 50 to 100 kWh/m^{2}a can be reached using traditional construction materials, with non-passive-house technology (the average value of contemporary buildings is around 350), and that the primary energy demand specified for passive houses can be easily achieved through their operation with local renewable energy resources. From a climate protection and cost-efficiency perspective, solutions equivalent to the passive house are also possible with this; therefore, it is not necessary to specify too strict values. It seems to be expedient to draw the line at energy class 'A' (for example, in Hungary 'A' ranges from 55 to 75 kWh/m^{2}a, in Germany, due to the different calculating method 'B' is ≤ 50 kWh/m^{2}a, 'A' is ≤ 25 kWh/m^{2}a, and 'A$^+$' is ≤ 15 kWh/m^{2}a, both called 'Lowest Energy House').

For the construction of 'nearly zero' buildings specified by the EPBD, an essential, primary condition is that the new buildings satisfy at least the requirements of the Low-energy Houses or energy class A or A$^+$. The next priority is that the energy supply of these buildings can be met with locally produced renewable energy and low primary-energy demand. This requires the development of local, decentralised, communal energy producing systems.

***Energetically self-sufficient houses, autonomous houses (AUH), active houses**:*

The concept of 'zero', i.e. energetically self-sufficient, active or Zero-energy houses surpasses the definition of 'nearly zero' houses. The nearly zero requirement is best covered by the concept of the **Autonomous house**, which means independence from energy needs. To meet all these requirements it is essential to extend the requirements to the field of electric energy consumption. The literal interpretation of the strictly ‘zero’ category excludes biomass heating, as it is necessary to input a renewable external energy carrier (biomass). This renders individual self-sufficiency impossible and only facilitates heat-pump solutions operating based on electricity. This, obviously, cannot be an exclusive requirement, as there is an enormous potential available in CO_2-neutral biomass fuel. Therefore, rather than **self-sufficiency,** the concept of **independence (autonomy)** can be set as a requirement for the objective of building-energetics, local energy strategy, as well as national energy strategy. This requirement facilitates co-operation between areas with different characteristics (residential blocks, city quarters, cities and their outskirts, microregions and even cross-border regions), where the actors can supplement each other’s surpluses and shortages. Self-sufficiency, such as isolated network operations, requires the construction of unnecessary storage and reserve capacities, which can otherwise be replaced by a multi-sourced, network system.

A settlement's climate protection strategy has to include a system of requirements for new building stock and the tasks required to upgrade the existing buildings. In the case of new construction, the requirements of EPBD prevail; therefore, houses with at least lower energy demand (AEH or Class A) need to be constructed. In the case of a building worse than this, the aforesaid objective cannot be achieved in a cost-efficient manner. The passive house technology is particularly suitable for public buildings, e.g. schools, where there are many people staying in one room, e.g. in the class room, and fresh-air supply has a great significance. In school time this is over 90% effective, which is reached by minimising heat loss and using heat recuperating ventilation equipment; this is made possible by the heat released by the children, which warms the building.

Dresden-Loschwitz Passive school,

The Friedrich Schiller elementary school in Dresden. 171 children study here. The building has 2,777 m^2 useful floor space and a heating demand of 80 kW. Heating only operates when there are no students in the building. In school time the students’ body heat warms the building. The new school building was built in 2008-2010.

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The existing stock of buildings have the highest saving potential if energetically upgraded to the highest degree, so this has to be given a particular role in the strategy.

Active houses

The definition of **Active house** is rather a ‘PR concept’ used to highlight the difference from passive houses. Accordingly, active houses are energetically self-sufficient buildings, which, as per the definition, produce more energy than they consume. These buildings mostly have heat-pump heating operating with electricity produced by their own photovoltaic (PV) surfaces, where extra production only occurs seasonally, i.e. in summer. In winter, active houses produce less energy than they consume and they buy energy to cover this shortage from the income originating from the electricity they sold in the summer. Taken on an annual average, there is a zero cost balance between the surplus energy produced and sold, against the shortfall purchased. Here we are speaking of an energetically autonomous building which presumes a high-capacity electric grid. If too many such houses are built, this shifts the energy used for heating towards electricity and this may cause national problems and CO_2 emissions may increase more. This risk does not exist, for example, in Austria as it has significant hydroelectric potential. However, the number of heat-pump systems can only be successfully increased in countries like Hungary if these systems are capable of utilising night-time electricity. This requires a more subtle regulation of the heat-pump systems.

Producing more electricity than required for sufficiency is possible but not profitable as producing electricity in a decentralised manner and on a small scale (by the help of solar and wind energy) is very investment-intensive. What is the traditional definition of a facility producing more energy than is required for its own consumption? A power plant. Producing electricity on the scale of a power plant is far more efficient and cheaper than this, even when speaking of a local, decentralised, small power plant (e.g. biogas-based combined heat and power production, or wind-power plant). It is a challenging enough requirement for a building to achieve autonomous and independent operation, meeting its own electricity demand, even with biomass heating.

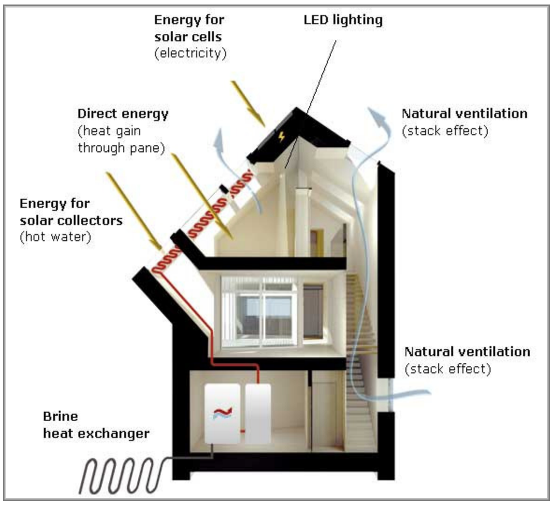


Figure 25: Sunlighthouse active house, Austria

Figure 26: Autonomous rest house at the Monte Rosa, Switzerland

***Zero CO_2, Zero carbon, or Climate-neutral buildings**:*
Given the lack of a precise definition, there is a wide room for interpretation due to the fact that the building itself does not emit any CO_2 or its primary energy consumption is also free of CO_2. In certain cases, specifying total CO_2-neutrality means a requirement level exceeding even that of a passive house, which can, at the very most, be conceived as a long-term objective.

***Water-efficiency**:*
Climate change requires that drinking water be better appreciated. Drinking water resources are finite and the price of water, too, will keep increasing. These expenses may exceed the annual heating costs of an apartment. Consequently, in addition to the unarguably crucial energy-efficiency, it is also essential to favour water-efficient solutions; these can reduce costs by 50 to 80 %. In their absence, the practice of illegal wastewater disposal will become more widespread. In climate control, an important role is played by the local treatment and recycling of wastewater and water-saving solutions, including the utilisation of rainwater, which collectively decreases the burden on water stocks. From among the decentralised treatment technologies, phytoremediation plays an important role in evaporation, in carbon sequestration and in oxygen production. Technologies without any protective distance, e.g. the Kickuth reedbed technology, can even be applied within the cities (Berlin-Kreuzberg, Block 6).

7.3. ADAPTATION TO AND PREPARATION FOR CLIMATE CHANGE IN THE CONSTRUCTION INDUSTRY

According to estimates, one of climate change's most significant effects is the expected increase in the occurrence of extreme weather events. These events may be, for example: heat waves, early and late frosts, heavy rains, storms, and as a consequence, floods and excess inland water, and at the same time extended dry periods, severe droughts, and strong windstorms.

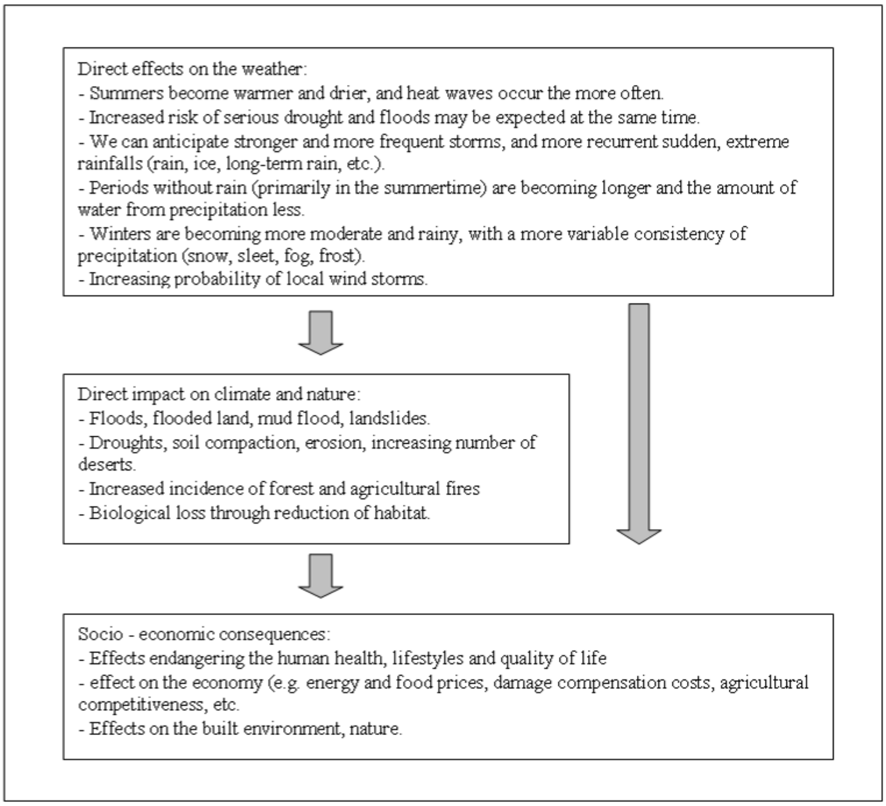


Chart 1: Direct and indirect climate effects, complex social consequences

In many cases, the majority of local climate changing events are caused by human activity. From among the factors influencing the micro-climate, the most important is the proportion of forest areas and open plains, the proportion of green areas and paved surfaces. Increased aridity and its opposite, excess inland water are general phenomena due to the regulation and diversion of natural water courses, drainage and other factors. Clear-cutting forests also affects the mesoclimate, and as a consequence, the area receives less rain. These human interventions disturb the balance of surface and underground waters.

When developing the built environment - with the exception of the areas in the Mediterranean - today only a little attention is paid to climate change, despite the fact that summer heat waves affect people’s home comfort. When designing the buildings, both the inhabitants and the construction industry focus primarily on the decrease of winter heat loss. Generally, besides insulation, greater emphasis should be laid on sun protection and the buildings’ thermal comfort.

Another deficiency needing taken into consideration in building design, is the fact that summer rains are becoming less frequent. The expected increase in maximum wind speeds is another factor not receiving adequate attention in current building practices. Construction regulations relating to roofs and facades do not provide sufficient specification, therefore, the increase in wind speeds will also cause a major problem in the case of both existing and new buildings.

A critical problem for construction is that in the future, building sites and activities are expected to become increasingly weather-sensitive. During external construction, activities performed in the summertime may carry an increased work-security risk due to the high temperature and an increase in UV radiation. The conditions for concreting operations are becoming more and more difficult; as a consequence of dryer and warmer summers, the time required for hardening is affected. Roof-building work also becomes harder to carry out on hot surfaces (steel roofs).

7.3.1. Adaptation to heat waves, extreme weather events and storms

In southern Europe countries, summer heat waves are common seasonal events; however, in the future they are expected to become more frequent in the northern areas of Europe, too. The fore-mentioned architectural solutions for adaptation make the use of energy dependent air-conditioning redundant.

The expected increase in the intensity of maximum **wind gusts** due to climate change affect primarily the structures on the buildings' exterior, those constructed on façades and roofs. Besides concerns about the supporting structure, problems can primarily be expected with windows, shading, and façade decoration. On the roof, damage is most likely to occur to the roofing material and water-proofing, furthermore, to objects projecting from the roof such as lightning rods, chimneys and antennas. Strong winds occurring around the buildings may also damage road-side infrastructure and objects (traffic lights, electricity pylons, phone booths), and trees as well, potentially causing serious damage to the buildings.

In order to prepare for the increased frequency of big storms, city authorities have to make appropriate calculations and measure how resistant the buildings are against such events.

Tatabánya, effects of climate change on the building stock

One possible method for assessing the estimated effects of climate change has been prepared by the research project CLAVIER (Climate Change and Variability: Impact on Central and Eastern Europe). The buildings of a Hungarian middle-sized city, Tatabánya were evaluated taking into consideration the effects climate change predicted for 2021-2050 may have on the wind-resistance of roof structures. However, the methodology may be effectively applied in the case of any city. The first step of the evaluation is to put the buildings into different categories, following which the vulnerability of these building types is assessed in terms of their exposure, sensitivity and their ability to adapt.

The level of exposure, i.e. the degree to which buildings potentially suffer from storm damage depends on the basic wind load; when calculating this, the two most significant factors have to be included: the height of the building, that is, its roof, and the building density of the neighbourhood. The **sensitivity** against wind storms depends primarily on the construction of the roof, its size and type of cover (roof covering with small or large panels), as well as other buildings and trees in the closer proximity of roofs. Regarding the performance of the main structure, the age of the building is one of the most significant factors, because the time of construction determines what kind of standards and regulations were applied by the designers and the architects.

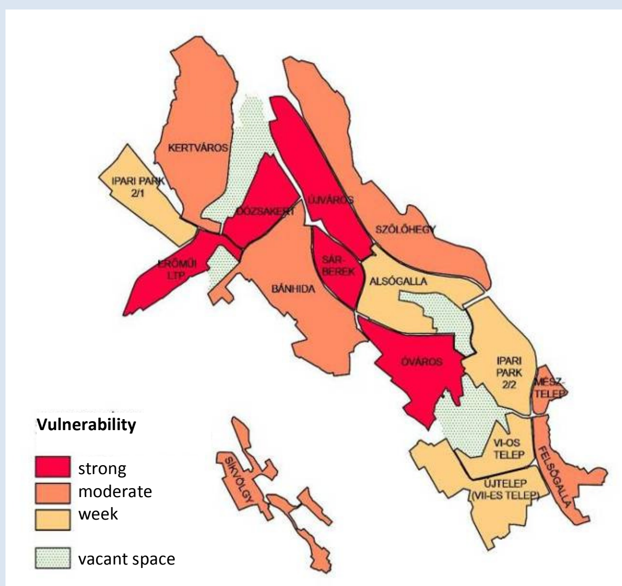


Figure 27: The wind-vulnerability of the buildings in Tatabánya

Finally, when assessing the **ability to adapt,** the social circumstances of the residents and users of the buildings, as well as their attitudes and financial possibilities had to be investigated in the areas studied. Having defined the level of exposure, the sensitivity, and the adaptation ability of the different building types, their complex vulnerability was calculated by means of a simple algorithm.

The results were summed up in a map, based on which it is understood that almost 25% of the citizens of Tatabánya, live and work in the most vulnerable building types in terms of wind hazards.

Source: D. Jacob, A. Horányi, L. Li, A. Gobiet, S. Pfeifer, G. Bálint, T. Pálvölgyi, and F. Prettenthaler (2008): Climate Change and Variability: Impact on Central and Eastern Europe. THE EGGS (EGS Newsletter) ISSUE 25 October 2008, 22-26

Having thus evaluated the vulnerability of buildings to wind hazards, the results can help identify those buildings and building types with roof structures that need to be urgently reinforced. In addition to outlining the immediate protection tasks for the current situation, the most effective wind-protective measures for the future are the planting of forest shelter belts and the creation of green surfaces in terraced structures. In the case of forestation, mixed forests and deciduous species have a stronger resistance against wind storms than spruce.

7.3.2. Flood-proof construction

Generally, extremely heavy rainfalls occur unexpectedly, and hence they can only be forecast a few hours in advance. Topography, plant cover of the area, the condition and capacity of the water drainage systems, the structure and location of the settlements may all have an influence how much damage occurs. These excessive rainfalls have increased flood hazards in Hungary, too, where an increased occurrence of excess inland water is anticipated in lowland areas. Sudden rains can also induce landslides in certain regions, which can cause serious financial damage, and there is also likely to be an increase in damage to buildings, caused by swelling clay.

As a consequence of sudden massive rainfalls, water drainage is gaining in importance in the life of a settlement (rain collecting drainage network) and for the safety of individual buildings (drainage canals, sinks). Due to the increased amount of rain, these may easily become overloaded. Chapter 8 provides more details regarding the tasks of water management in preparation of the communal urban infrastructure for extreme weather situations.

In order to avoid future financial losses caused by floods, it is imperative to revise **construction regulations** and make them stricter, as well as to obey them in a consistent way. Among these regulations, the most important is to introduce a construction ban in the areas under direct threat by floods, and also, to identify the areas that are potentially endangered by subsidence (high banks and loess walls). Measures are needed to avoid socio-economically disadvantaged groups settling (even illegally) in areas at risk of flood, excess inland water, and subsidence. Nevertheless, in regulating flood protection, it is necessary to judge rationally the balance between the value protected and the costs of protection.

7.3.3. Preparing the existing building stock for water scarcity

Water is a valuable resource. After energy, drinking water and fertile soil are the two most important strategic resources. The protection of water reserves goes far beyond environmental protection, impacting other issues. In today's world, local wars break out partly over the possession of water. There are still some opportunities to fight further desertification, one consequence of which is the depletion of soil and its humus content. We have to design land use that contributes to humus formation, starting from the smallest scale (households, small gardens, green roofs) to the largest ones (agricultural development). For this, integrated water management strategy is needed, where regional water resources are treated as a system in order to be able to recreate the balance between surface and ground waters.

To help the adaptation of settlements to climate change, the reduction of water consumption by the residents and the introduction of water saving practices are among the most important policy areas.

Their significance may be compared to energy saving and the importance of cutting GHG emission from transport. Besides the technical solutions, conversion and regulation of consumer behaviour also play a crucial role. Although climate change dictates a more considered, resource-light, pattern of individual water consumption, this also needs to be realised in regions with ample water supplies.

Amongst the non-technical solutions, one possible option is the regulation of the **price of water**. Experience shows that there is a clear connection between the increase in the price of water and the decrease in water consumption. Nonetheless, there is a need to assess the application of this and the degree of its application from various perspectives. In an urban environment, where there is no alternative way of obtaining water, it may be really effective. However, in the countryside and in areas with detached houses, it may increase the amount of illegal water extraction and prove contra-productive. Privately-owned water works can (ab)use the argument of 'higher prices = more water savin' in order to support the idea of water privatization and to justify otherwise unreasonable price increases, against the interests of local municipalities. This reasoning flies in the face of the main aim of saving water, that is, to make this resource accessible for everybody over the long term – which is almost impossible on a market basis.

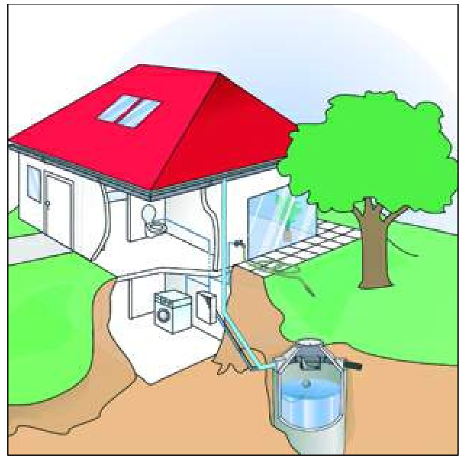


Figure 28: Schematic structure of a domestic rainwater harvesting system

Water is a renewable natural resource and therefore, it cannot be privatised. In water provision, there is a possibility for the emergence of private entrepreneurs if it does not result in distortions in the access to water. The user of water reserves (whether it is a service provider or a private person drilling a well) has to be obliged to pay compensation for the use of water. Drilling wells has to remain an activity needing a license because water resources are not infinite.

The **installation of individual water meters** and the termination of flat-rate water fees are two of the most effective solutions. In flats in prefabricated housing blocks, before the installation of individual water meters, consumption reached 400 l/person, and following the installation of the meters it immediately fell to half of this (200 l) (A. Ertsey, G. Helyes, 1994). The desired average urban consumption is around 150 l/ person. This may be reduced to 70 l/ person by making the most of water-saving opportunities.

The most important technical solution is to **use water conservation devices, taps and bathroom equipment**. Most household appliances, such as washing machines and dishwashers, garden watering systems and multi-sink kitchen basins may be purchased equipped with low-flow water devices, and the producers, understandably, support their use. It is mainly financial limitations that restrict customers' choices. However, the installation of certain more expensive devices may be substituted simply by more careful water consumption.

It is possible to reduce water consumption by even 10-20% with the help of low-flow taps and other equipment. Water and energy saving dishwashers consume less of these resources than doing the washing up by hand (1 litre/place setting), although their price is still relatively high and the investment-return time is between 10-15 years. In the case of washing machines, the saving can be greater: investment in a top-quality machine is paid back in less than 10 years. Water-efficient toilets make it possible to flush the toilets in two phases. Should the building be connected to a traditional drainage system, the longer flush must not be less than 4.5 litre/flush, because using less water than this is not sufficient to transport solid dirt and may cause blockage. If the toilet flushes 4.5 litre, it is necessary to install a flushing siphon into the outlet pipe, because this collects a safe amount of water and flushes at once, safely forwarding the sewage to the street canal.

Domestic rainwater harvesting in Europe has gone out of fashion in the times of abundant water supply, although rainwater collecting cisterns were still part of the basic infrastructure of holiday homes and press houses in Central Europe, in the first half of the last century. Collecting rainwater is becoming popular in Germany and in Austria. Nowadays, suitable filtering and storage devices are available on the market, designed for home-assembly. Provided with proper filters, they may also be installed in densely built, urban areas. In the case of a house with a garden, 20% of a family's water consumption may be met from an annual precipitation of 500-600 mm, naturally with the exception of bathing and drinking water. This has further advantages, such as reducing the burden on the drainage system. Using soft rainwater in the washing machines is also advantageous: less washing powder is needed, and scaling will stop.

Recycling **grey wastewater** (greywater) also offers a good opportunity for conserving water. There is equipment available on the market which cleans from 1.5 m^3 of greywater for re-use in the washing machine. A theoretical solution has long existed but has not yet been mass produced in commercial quantities; home-made, DIY versions, of a device that allows greywater to be diverted for the purpose of flushing the toilet. All that is needed is a 200 l tank, a washing machine pump and some ancillary equipment. Solutions able to handle larger amounts of water efficiently offer a transition towards whole-house sewage recycling. In the desert areas of Australia and the US, greywater recycling systems are operated in public buildings. Greywater recycling can substitute 40% of water consumption. Using rainwater and greywater together may reach 60%, hence conserving drinking-quality water; this may be increased to 70% if water conserving devices are also installed.

Some types of the **dry toilets** available for the home do not dilute the bodily wastes but dry it and mix it with additional material. The small amount of odourless material has to be emptied from time by time into a garden compost prism, or silo, where it continues to compost.

Compost toilets mix faeces with additional material containing cellulose (wood chips), organic waste from kitchen and a small amount of material containing soil bacteria (soil, compost). Proper ventilation, temperature and oxygen supply are ensured, so that natural hot composting can start. During composting, the organic waste is reduced to one-quarter of its volume and becomes odourless, sterile humus. Certain types of compost toilets have outlet pipes long enough to run between floors, which solves composting in a single container in two-storey houses. One type is able to manage waste from 8 toilets on a single line. In this case water-efficient toilets are required. When these toilets are flushed, sewage flows into a device for removing fluid, similar to a spin dryer, which forwards the solid content to the compost chamber and the liquid part flows into the drain.

Compost toilets save approximately 1/3 of the drinking water consumption, but their real significance is in reducing the amount of sewage and in creating humus. Their application is positive both in areas with and without a public sewage system. In the later case, they facilitate a simpler cleaning of the sewage, since the most contaminating part is eliminated from the water. They reduce the amount of sewage emission by ~ 30%, and improve its quality.

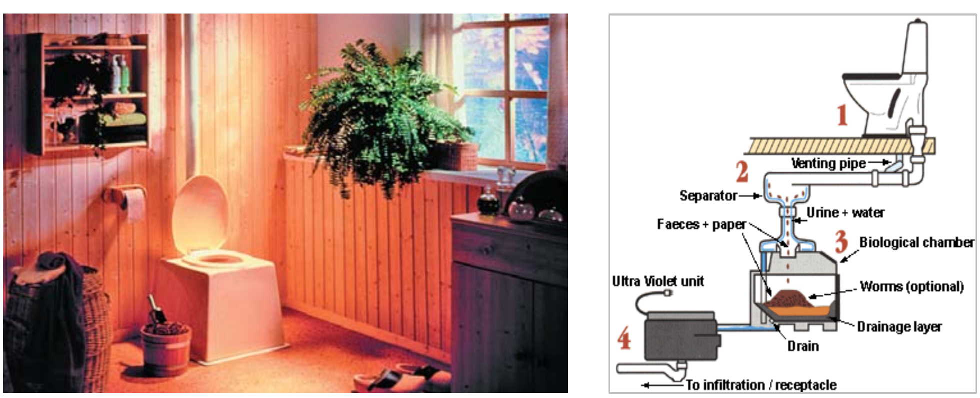


Figure 29: Compost toilet and its schematic structure

Domestic sewage management systems treat the entire amount of sewage, grey- and blackwater, together. As well as compact equipment, we also have to mention the semi-natural cleaning technologies which use plants and soil bacteria for purification, without using machines or energy (reedbed technology). Where soil is able absorb, simple filtration basins or tanks are able to treat sewage, too: sewage is first diluted into a thinner solution and then its purification is completed on the filtration site, in the soil. These solutions also conserve root-level irrigation water, and help the restoration of ground water.

In contrast to properly operated, simple or extended septic tanks, there are (formerly wide-spread) cesspits which have to be closed; sewage from these passes undiluted, directly into the ground, and into the ground water. Even more dangerous are those mandatory sewage containers which were constructed as ‘closed’ but were subsequently illegally punctured; contaminated solids from these pass straight into the ground. It would be more advisable for planning authorities to permit the use of simple cleaning technologies and make closed storage facilities mandatory in exceptionally sensitive areas, as well as strictly monitoring the volumes of transported sewage.

Over-rigorous requirements sabotage correct behaviour, causing more serious damage than less efficient cleaning technology. If somebody constructs a single treatment system on his own land, it is in his own interest to avoid using materials that go into the sewage water and harm the environment (e.g. chemicals, used oil, etc.), since these would damage his own garden. By using environmentally-friendly washing and cleaning substances, both of the above situations can be prevented.

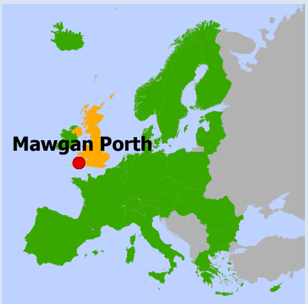
The use of **green roofs** also contributes to the implementation of sustainable water management. One of the first steps in sustainable water management is retaining rainwater with the help of green roofs. These have a beneficial effect on noise levels and heat insulation, and impede the creation of urban heat islands. Since the utilisation of green roofs depends primarily on the construction of the buildings, their implementation is an element of sustainable construction. When installing a roof with vegetation on it, the selection of plant species and planning irrigation are serious tasks. Extensive green roofs carry drought-tolerant plants which can generally do without irrigation, while the intensive green roofs need a continuous water supply. However, the idea of frequent irrigation is contrary to the reason for creating green roofs. This needs to be avoided because it consumes a significant amount of energy and water. The creation and maintenance costs make it uneconomical, although, of course, having a raised bed on our terrace may provide a welcome supplement to home cooking.

Figure 30: Reedbed sewage treatment in Vácrátót, Hungary

With the latest generation of extensive green roofs (with a total layer depth of 6-15 cm, and with a relatively low weight of approximately 60 kg/m^2), it is possible to utilise this technology extremely quickly on any roof which has a slope of less than 45°. The green roof protects the roof as well, extending its durability.

The summer ‘canyon climate’ phenomenon is a particularly unpleasant experience in traditional Southern-European cities. The high surface temperature on flat roofs create hot air above the city, while the slightly colder air is locked into the narrow, shady streets, where, mixed with the exhaust gas, creates smog. This problem may be alleviated by green roofs and wider streets that can facilitate ventilation.

However, although some sustainable construction solutions can substantially contribute to the reduction of water consumption in an indirect way, through carefully planning and building our gardens, we can reduce their water demand; by fitting our house with a dual water system (drinking water and rainwater) and drainage (grey- and blackwater), we can choose to utilise rainwater as well as recycling greywater.



Scarlet Hotel, complex sustainable architectural solutions

Mawgan Porth is a popular holiday resort in the North of Cornwall, Great Britain, and is home to the recreation centre, 'Scarlet Hotel'. The 37-bedroom hotel was opened in the summer of 2009, and is special in that the architects aim was to create a hotel that provided comparable services with less and cleaner energy; sustainability was to be achieved at the highest possible level.

Sustainable construction and operation are served by the following solutions. Parts of the roofs were built using green roof technology, slowing down the flow of water. Special attention was paid to insulation, the use of alternative energy resources (e.g. via solar collectors), ventilation (7% passive, 85% with heat recovery). Rainwater and recycled greywater are both utilised: the former is used to fill a swimming pool (in which natural vegetation was planted to clean the water in an organic way); the latter is used for flushing the toilets. Firewood obtained from sustainably managed sources is used to heat water. Recycled and recyclable materials are widely used as part of the structure and interior equipment.

The building has a wooden structure, and the materials used are certified by the FSC (Forest Stewardship Council). The product chain certification of the FSC manages the timber through processing and trade, from the forest to the final consumer. Also, when building this hotel, concrete containing less cement was used. To further reduce its ecological footprint, the hotel offers an additional route planning service for both guests and staff.

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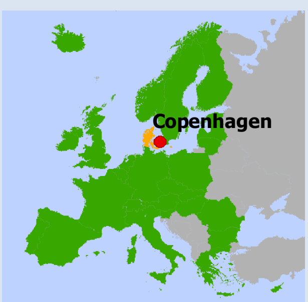

Copenhagen, Green roofs

The Danish capital of Copenhagen is the most important economic center in the Øresund region and, with 1,167,569 inhabitants, is the largest city in Scandinavia. The 'Green Roofs in Copenhagen' project was launched in 2008, and was initially only connected to sewage treatment plans and local rainwater management. Its main aim is to cover the roofs with vegetation, making a significant contribution to the city's adaptation to climate change. In order to be achieve the greatest success it was necessary to extend the use of green roof technology, for which the most effective method is regulation.

Discussion started on the use of green roofs at the 15th UN Conference on Climate Change (COP 15), in Denmark. As the conference's host, Copenhagen took the opportunity to suggest green roof technology as a possible solution to the challenges of climate change. Consequently, Copenhagen successfully inserted a paragraph about green roofs into the Climate Plan, emphasising the connection between green roofs and rainwater management and arguing that an increase in rainfall can be expected in the near future. Importantly, this measure also aids the creation of an even greener city and helps tackle the urban heat island phenomenon. The green roof implementation period was clearly defined in the Climate Plan, and was also prescribed as a requirement in the Urban Development Plan.

In the last few years several initiatives similar to the green roofs were undertaken by the city:

- Urban Development Plan,
- Climate Plan,

- local plans,
- handbook on the creation of buildings' environment,
- sustainable measures,
- Green Roof Policy.

Green Roofs policy in Municipal plan 2012
In Copenhagen it will soon be compulsory to cover the roof of every newly constructed flat with a green roof. It is stipulated that every roof with a slope of less than 30 degrees has to be covered with greenery, both in the case of private and public buildings. Where an older roof needs converted and the owner of the building receives financial assistance for this from the city, it is compulsory to make it 'greener' (cover it with trees, bushes, moss, herbs and grass).

The institutional network plays a remarkable role in popularising green roofs. At the local level, the role of communities, independent environmental organisations and administrative institutions is the most crucial. At the national level, the co-operation between various universities and other institutions is indispensable, ensuring knowledge, technology and consultation, and disseminating technological and market-based innovation. Finally, at the international level, a key role is played by the international green roof associations, e.g. IGRA, GRHC, Living Roof, and the universities cooperating with these bodies.

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7.3.4. Heritage conservation

The effect of climate change on monuments is a key concern, not only because of tourism but also because of the need to preserve cultural heritage and its role in maintaining national identity. Therefore, eliminating the negative effects of climate change on urban heritage also constitutes a significant task.

The problem is not significantly different from architectural solutions for non-monumental buildings, although the modern building materials and construction methods used for newer buildings may prove more resistant to **environmental damage caused by climate change**. The walls of the buildings become porous after coming into contact with the chemicals dissolved in rainwater, they start to crumble and their structures become weaker. The increasing frequency of heavy rainfall may also cause considerable damage, as drainage systems are not able to bear the sudden, large amounts of run-off. Air-carried pollutants deposited on the building's surface can also have a harmful effect. The extreme fluctuation in daily and yearly temperatures also takes its toll. Changes in temperature and humidity cause cracks and splitting. In the moderate climate zone, the frequent shifts between freezing and melting also cause serious damage to the structures. The ever more extreme weather events such as storms, hail, lightning, etc., do not spare monuments either. In the summer of 2010, a number of Hungarian monuments suffered significant damage from storms: The Károlyi Castle in Füzérradvány, the Esterházy Castle in Fertőd and the L'Huillier-Coburg Castle in Edelény, as well as the buildings of Ménesbirtok in Mezőhegyes, the Dégenfeld Castle in Téglás.

Pests pose a danger to the wooden and other organic building components of monuments. The growth in their numbers, their spread, as well as the emergence of invasive pest species new to a given area has become quicker; their habitats have expanded, presumably as a result of climate change. Mould and insects which cause rot can cause substantial damage to organic construction materials, particularly if these historical buildings or monuments are out of use, there is no ventilation and the roof is leaking.

Floods affecting places of important national heritage can also cause significant destruction to monuments, especially in areas that were previously less threatened by floods; here the buildings' foundations and general construction were not planned to resist flood water. Floods have become increasingly frequent as a consequence of certain changes in human activity, such as deforestation and regulation of rivers, which change the water balance. Drying climatic conditions may also influence the structure of building materials; furthermore, an increasingly moist environment may also favour the spread of mould. Among recent floods, those during 2002 were especially notable; covering almost the whole of Central Europe, the downtown areas of Dresden, Prague, České Budějovice and Český Krumlov went under water, causing serious damage to monuments as well. In Hungary, due to heavy rainfall in the Spring of 2010, an important part of the Tokaj World Heritage Site, the Hercegkút cellars, were flooded and collapsed.

The erosion of river banks, sea coasts and lakesides leads to the modification of riverbanks and coastlines, posing a danger to the monuments found there. The rising sea-level and sinking coastline cause downtown Venice to be more frequently immersed. The increasing occurrence of land collapsing along river banks, subsidence and landslides (mass movements) rarely affects monuments, but when it does, it causes serious, irreparable damage. In July, 2010, in Abaújvár in Borsod-Abaúj-Zemplén county, Hungary, heavy rain caused a landslide that endangered the town's gothic church and caused several walls of the historical, Abaúj motte to collapse.

In many cases human activity has led to the increased vulnerability of cultural heritage. Alterations in the immediate natural environment (e.g. the reduction of green areas by increasing amount of constructed surfaces, changes in water run-off, indirect effects of increased tourism, the emergence of wind channels in cities, vibrations due to heavy traffic) as well as more indirect anthropogenic influences (e.g. deforestation in the water catchment area, changing groundwater level) may also increase monuments' vulnerability.

Historical gardens or parks form part of our cultural heritage. In many of these, small ponds were established which are fed from groundwater or streams. Neglecting these lakes adversely affected the groundwater balance in many places, as well as the microclimate of the garden, changing the composition of the vegetation. Almost all historic buildings (particularly in urban areas) have wells, which are often closed but they have an effect, even when covered, as they increase the moisture content in walls.

When **renovating** historical buildings or monuments, modern technological solutions which help adaptation to the adverse effects of climate change cannot usually be applied, or incur high costs. This is either because of the structural characteristics of the existing buildings or because the historical streetscape or vista is protected. Together, these make adaptation to the consequences of climate change all the more difficult. In historic gardens and parks, the landscape solutions that were once able to limit the negative environmental impacts should be restored. The use of authentic materials and techniques should also be considered in certain cases. The elimination of damage caused by air pollution and the harmful effects of natural processes are significant problems. Climate change negatively impacts the conservation of ruins, particularly through damage caused by subsidence, rapid temperature changes and frost. In these cases, efforts should be made to reconstruct authentic roof structures.

Archaeological sites and graves will also suffer significant damage due to climate change. A number of international initiatives have been launched at World Heritage Sites to mitigate the impacts of climate change and reduce its root causes.

Český Krumlov, monument protection after flood

Lying on the banks of the River Vltava, this small town has almost 14,000 inhabitants. The town was built around a 13th century castle and is home to gothic, renaissance and baroque monuments. Throughout history, it was lucky to avoid wars and bigger catastrophes and hence remained quite unique in Central Europe, having retained most of its original form. Thanks to this, in 1992 the historical downtown area of Český Krumlov was nominated by UNESCO as part of the World Heritage.

In August 2002, half of the monumental buildings and almost 150 gothic and renaissance constructions were flooded in the historical town. The water rose to 4 meters in some places and flooded the ground floors of the buildings. The city suffered damage estimated at almost 300 million Czech crowns, despite the fact that instead of wood and adobe, which were widespread in contemporary times, the builders used more resistant construction materials (brick, lime), which saved the city from even greater destruction.

After the water receded (September 2002), the most urgent task was drying out the wet walls before the winter freeze, which could have caused further serious damage to the buildings. Restoration and the prevention of further destruction by floods were made more difficult by the fact that the use of more up-to-date, resistant building materials was not allowed as due to the conservation order.

Extreme precipitation events are becoming more common due to climate change, a phenomenon that can be both observed and measured. Therefore, the Czech government has initiated the preparation of an action plan against floods in World Heritage Sites.

Further information:
Web: www.ckrumlov.info
Photo: www.czechproperty.blogspot.com

BRIEF RECOMMENDATIONS

- Reduction of existing buildings' energy consumption.
- Application of innovations in energy-efficient construction (e.g. passive house).
- Implement developments in construction energetics (e.g. energy-conserving renovation; use of climate-friendly solutions in construction).
- Analysis of the entire life cycle of buildings.
- Minimisation of energy consumption for heating.
- Support the use of renewable energy (solar and geothermal) for supplying domestic hot water.
- Pay attention to adaptation to the impacts of climate change in the building industry and the development of design solutions for heat waves, extreme weather conditions, and storms; utilise flood-proof construction.
- Preparation of buildings for extreme weather conditions or water-scarcity.
- Review building codes and regulations to support climate change mitigation and adaptation solutions.

8. ADAPTABLE WATER MANAGEMENT AND URBAN COMMUNAL INFRASTRUCTURE

The potential contribution of water management, drinking water supply, wastewater treatment and waste management to the reduction of greenhouse gas emissions is relatively smaller. In urbanised regions, however, it is still worth dealing with these smaller-scale emissions because settlements may this way show good example to the private sector and the consumers. Apart from this, the reduction of emissions also contributes to energy saving and economical operation; therefore, the mitigation of climate change may require some developments which are useful and necessary in other ways, too. Emissions are mainly indirect; greenhouse gases are released from the production of the energy in power plants that is needed to operate the infrastructure or by transportation vehicles. Mitigation primarily affects waste management, which is the prime direct greenhouse gas emitter of the communal infrastructure; however its share in emissions is still substantially lower than those of transportation or energy production. Methane and carbon dioxide is released from the anaerobic decomposition of organic materials in landfills and from composting plants, and optimally, only carbon dioxide is emitted from incineration plants. When it comes to wastewaters, some methane is emitted, generally in smaller amounts, the source of which can be biological decomposition and wastewater sludge treatment. At the same time, by utilising the energy generated from solid and liquid waste, part of the fossil energy resources can be replaced through the reduction of harmful substances.

However, regarding adaptation to climate change, water management and the supply of water have much higher importance. Both heat waves and drought caused by climate change as well as the extreme whether situations (thunderstorms, rainstorms, floods) seriously affect water management, surface drainage and drinking water supply. Unfavourable meteorological events directly damage the infrastructure; in hot weather, the increased demand for water becomes harder to meet; the reduction of the effects of floods means a great challenge in the fields of prevention and planning. Furthermore, there are solutions which serve the protection and replacement of groundwater in area of settlement or entire regions, thus having an indirect role in moderating the effects of climate change. Wastewater treatment is more and more closely connected to the whole of the water management system both technologically and regarding the principles of operation. Integrated water management systems treat the whole water cycle as a unified, harmonised process starting from the sources through the water supply network to the entire system of utilisation and emission, including also the regulation of land use and of some business activities using water. At the same time – unlike in the case of mitigation – waste management is less affected in terms of adaptation: in this respect, environmental safety is important when preparing waste landfills to resist extreme weather conditions.

8.1. PREPARATION OF WATER MANAGEMENT FOR EXTREME WEATHER SITUATIONS

The water management principles that are currently considered conventional were developed in the 19^{th} century assuming a much higher load-bearing capacity of the environment than what is in fact, acceptable today (water abstraction, wastewater treatment, and canalisation). At that time the importance of water was assessed applying a much narrower set of criteria than today. These principles are not effective anymore because of increased demand and impact on the environment by contemporary society. Additionally, the relevant environmental effects (extreme rainfall, drought, storms, heat-waves) taken into consideration and the requirements (flood and erosion protection, safe and secure water supply, demand for a more nature-friendly urban environment) have also transformed to a considerable extent because of the change in climate. Therefore, the implementation of sustainable water management is necessary and useful in itself; however, climate change makes it absolutely indispensable even in regions well-supplied with water.

It is generally true both in the cases of water management and flood protection that adaptation cannot be implemented in itself but only by inserting it into the whole catchment system. It is also practical to review the technological implications of water management in urban areas within its system: separately the measures targeted at the reduction of surface flow and the treatment of problems caused by water streams. This is true even in case of a more local intervention – carried out for example, in a park or a part of a settlement: its effects on the wider area must be known already before implementation. This way, also those effects and solutions which occur beyond the settlement both in terms of territory and authority will receive sufficient attention.

There are multi-level effects exerted by climate change on water management and on the possible responses in adaptation; and these also depend on the characteristics of the influenced environment. The table below outlines these effects and reactions.

Effect	Adaptation
Long-term droughts	Water retention; water saving
Increasing water consumption	Water saving; water utilisation based on non-drinking water
Floods caused by rainfall of extraordinary intensity and consequent erosion	Water retention in outlying areas of settlements; sustainable flood protection in both external and internal areas; urban drainage based on integrated water management
Rising sea-level, increasing storm surge and resulting erosion	Complex protection systems

Table 2: The effects of climate change on water management and the possibilities of adaptation

It is a special feature of climate change that too much water and too little water can cause problems at the same time. The intensity of rainfalls may increase even in those areas which are otherwise becoming drier; and this is going to be a tendency in most of Europe according to most of the forecasts. Therefore, flood protection has to get prepared for rapid and unexpected floods while water supplying systems have to be ready to handle shortages of water within the same year. On the settlement level, extreme rainfalls are important mainly from the point of view of flood protection, while water shortage is crucial mainly from the perspective of drinking water supply. It is important to call attention to the relative nature of water shortage. A lower quantity of precipitation – though not obviously extreme – may also cause a drought in an area which is used to better water supply; furthermore, an upset in the balance of consumption and supply may also cause shortage of water – which is not necessary a result of a reduction in the quantity of accessible water reserves. Such case for example is increasing urban water consumption during heat-waves or the extreme growth of towns and the change in water consumptions habits. At the same time, drought and water shortage affect agricultural production and land use in the surrounding areas, which in turn, have an impact on the towns.

8.1.1. Water drainage

The first step in sustainable water management is to preserve the quantity and quality of groundwater and to support infiltration instead of surface runoff. The preservation of groundwater quantities is supported by **water saving** and the **utilisation of alternative water sources.** The former is discussed in more detail in Chapter 7 about sustainable construction, while the utilisation of non-drinking water is discussed below within this chapter. The reduction of surface runoff and the facilitation of infiltration into the soil are methods to decrease erosion and flood risks due to high-intensity rainfalls. By preserving/increasing the moisture content of the soil, water can be retained for periods when droughts occur more frequently either for the needs of the vegetation or for the purpose of water abstraction from under the surface. More humid soil and lush vegetation have a positive effect on urban climate especially during heat-waves.

In connection with climate change, it is more and more important and an increasing emphasis is given to the fact that urban water surfaces also have micro-climatic, aesthetic and recreational effects, which also require water retention and preservation.

In urban areas, the best way to accomplish these tasks is by establishing a **sustainable urban drainage system** (*SUDS*), which has been elaborated relatively well both as a theoretical concept and as a practical application. Despite the fact that there have been several progressive investments all over the world, as well as a substantial amount of available literature in the subject, the number of actually operating systems is rather low. The essence of traditional drainage is that the rainwater should be collected from the built-up areas as soon as possible and as much in a regulated way as possible. Climate change and sustainability however, requires the preservation of water and surface drainage similar to natural runoff. For this reason, 'the objective of sustainable urban water management is not only the safe and efficient collection of surplus waters and the regulation of water quantity but also to realise aesthetical, recreational, ecological and economic advantages, including the value growth of the area in question.' (J. Gayer, F. Ligetvári, 2007).

Accordingly, the following objectives can be allocated to serve the purposes of up-to-date and sustainable urban canalisation and water management:

- decreasing of urban runoff in order to reduce peak runoff;
- reducing pollution by collecting and treating pollutants occurring in the urban catchment area;
- retention of rainwater and its utilisation to the maximum extent at the location or in its vicinity;
- improvement of the cityscape: instead of hiding water, making it visible by integrating it into functional green areas;
- reducing the infrastructural costs of canalisation by, for instance, directing rainwater to green areas.

The system borrows several ideas from water retention methods applied outside buildings in sustainable construction practices. Their regional-level employment requires a much more comprehensive system; however, the technical solutions are similar in many cases.

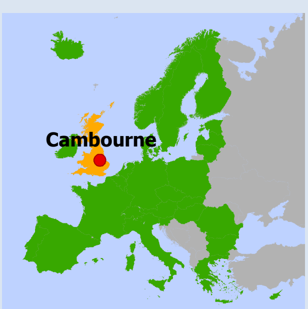
The system is composed of the following (B. Woods – R. Ballard et al., 2007) :

- **Bio filter strips:** Longitudinal, shallow strips and ditches planted with water plants, which are capable of filtering out mainly the suspended pollutants. Vegetation provides excellent filtration as it absorbs some of the dissolved contamination, and at the same time, it also causes sedimentation of drifting solid substances by lowering the speed of flow, furthermore, because of the roots, vegetation has an infiltrating effect by which it mitigates erosion, cleans up the runoff water and also reduces its quantity.
- **Pervious pavement:** Pervious or permeable pavement of roads and sidewalks allow rainwater to go through the surface. The water infiltrated this way can directly get to the soils below or to the sub-surface sewer network or to rainwater treatment plants. The pavement may be made of pervious concrete, bricks, block stones, granular stone cover without binding material or stone cover laid with open joints. Its main advantage is that it does not require separate space but it can be used as part of ordinary architectural solutions, and thus it enables the channelling of water directly into the soil even in areas reserved for traffic. There is another beneficial side-effect: pervious pavement reduces the danger of slipping in rainy and especially, snowy conditions as a result of a rapid collection of water from the surface. However, it has a limited drainage capacity.

Its disadvantage is higher costs (two or three-fold of the costs of traditional asphalt pavement), lower load-bearing capacity and sensitivity freezing. In order to avoid damage by freezing, careful construction is required. There is a danger of clogging; therefore, regular maintenance should be performed to prevent it.

- **Swales:** Traditional open swales are more common in settlement parts which are characterised by family houses or village features. Because of their size, they have a considerable role in infiltrating rainwater into the soil; however, because they also serve as watercourses, they are not able to efficiently withhold intensive rainfalls.
- **Balancing ponds:** Balancing lakes or ponds are similar to stormwater basins but are smaller, a few tens or a hundred square metres in surface area. These are usually shallow basins serving as temporary storages of rainfall received through the swales. They provide excellent possibility to be harmoniously adjusted to the environment by planting water vegetation and establishing parks around them.
- **Percolation (or infiltration) trenches:** These are trenches filled with loose granular material (crushed rock or gravel), which leads surface water into the soil or the sub-surface sewer network, while it withholds larger-sized suspended substance. Because of the filling, there is hardly any need for maintenance; and it is less dangerous in terms of accidents than traditional ditches located next to the sidewalk because they are level with the surface.
- **Infiltration basins:** These basins are similar to balancing lakes except that the construction of their floors enables water to migrate back into the soil. An infiltration basin is the end-point of the local water network; from here water does not usually continue its way on the surface. In this case, suspended material coming in with the rainwater cannot leave the system; therefore, regular cleaning and skimming is required.

The main advantage of a sustainable sewer system is the achievement of the main target: water retention. In addition, as it is mentioned above among the objectives of planning, it also contributes to establishing an aesthetic and comfortable urban environment. Its construction supported by the above technological solutions is considerably cheaper than that of traditional water drainage systems; and its maintenance costs are also lower. Among the limitations on its application, the protection of water quality has to be mentioned first, as only appropriately clean water can be channelled back into the soil. This is even the more important because in the urban environment today surface runoff is often more contaminated and more hazardous than household wastewater (for example, when public roads are salted in winter). Therefore, in the case of contaminated surface runoff (for example, in the surroundings of roads and petrol stations) a sustainable sewer system can be applied only if the water is suitably treated/cleaned. This can be achieved, for example, –by letting water infiltrate through pervious road pavement not directly into the soil but first to a reservoir or treatment plant through a sewer system. Another important restrictive factor is the water uptake capacity of the soil. Low-porosity, compact clayey and muddy soils are not able to absorb the infiltrating water rapidly enough and in sufficient quantities; therefore, in these situations the system cannot operate. The high sediment contents of the runoff water may also hinder infiltration. An increase in groundwater due to infiltrating surface water can result in a lowered load carrying capacity of the soil as well as in increased humidity in lower areas or in cellars in case planning was not careful enough.



Lamb Drove/Cambourne, Sustainable Drainage System

Lamb Drove is a part of Cambourne, which is a new settlement located west of Cambridge in East England. Its total number of inhabitants is expected to be 10 000.

During the construction of this part of the settlement, special attention was given to the introduction of different instruments of sustainable water management and drainage. In the project launched in 2004 different technical solutions were applied in order to achieve the slowest possible runoff and to retain rainfall at the location as much as possible (rainwater storage tanks at residential houses, green roofs, installing water-saving equipment, pervious pavement of public areas, swales, temporary reservoirs and infiltration basins).

The system is both significantly cheaper and more robust compared to traditional sewer systems both in its construction and maintenance. According to approximate calculations, at 2006 prices, GBP 11 thousand was saved in connection to its construction and annually GBP 30 by apartment related to its maintenance. Besides these savings, the success of the investment is also proved by the measurements taken in course of the monitoring activity of the project: in the sample area, significantly smaller quantity of water runs off the surface, and also, in a delayed manner, than on the control site. The final monitoring report will be completed by early 2011.

The investment was carried out as part of the Interreg III B FLOWS (Floodplain Land Use Optimising Workable Sustainability) project and the project owner was the County Council of Cambridgeshire.

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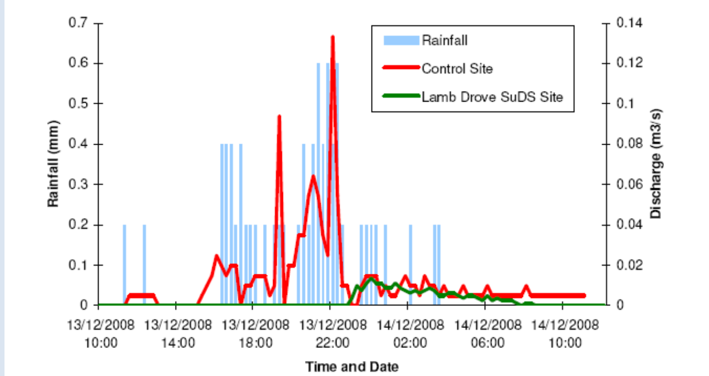
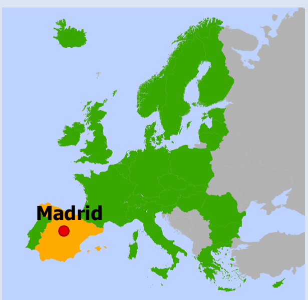


Figure 4.2 Comparison of Discharge at the Lamb Drove SuDS site and the Control Site on the 13th and 14th of December 2008

Figure 31: Comparison of surface runoff measured in Lamb Drove and in the control area



Gómeznarro Park, Madrid, park refurbishment with stormwater retention

Gómeznarro Street and the belonging park area are located in the southern region of Madrid, in Hortaleza District in Canillas part of the city.

There is a considerable danger of erosion in the park and its vicinity. More intense rainfalls caused flooding of the lower parts of the built-in areas. Therefore, in January 2003 – following careful preparations – the creation of the surface drainage system was started in the area and was completed already by May of the same year.

The following work was carried out in a total area of 10 000 m^2:

– demolishing the water-tight road pavements;
– replacement and restoration of the damaged and compacted soil;
– establishing sub-surface collection and infiltration tanks and the connecting collecting and distributing sewer network under the sidewalks;
– construction of sidewalks with permeable pavement;
– developing parks and restoring existing vegetation.

As a result of these (re)constructions, the total amount of the incoming rainwater remains within the area and there is no considerable surface runoff. What is more, moisture problems in buildings and erosion were eliminated, and a comfortable green area was established; furthermore, the load on the urban sewer network was also reduced. The costs (EUR 343 600) were covered by the Municipality of Madrid, and in 2004 the project was nominated for the best practice award of the UNO Habitat, where it received the qualification of 'good practice'.

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One of the possible incentives of local rainwater retention – which has come recently to the foreground, but is also rather contradictory – is the '**rainfall tax'**. Its main feature is that a part of the handling costs of rainwater drained through the canal network will be devolved to consumers who own large sealed surfaces, and its extent will depend on the size of the roof or the surface of the water-tight cover. The expression 'tax' is not necessarily correct since where it has been introduced so far, water suppliers define and collect this sum. However, also local governments may impose it, thus it can function as a local tax. Indeed, the payment imposed this way affects the inhabitants who own less sustainable means of water drainage; however, it has also some fundamental disadvantages. Firstly, this solution incites the tax collectors to sustain their income and the outdated solutions rather than to support modernisation. At the same time, the consumers do not generally have the resources to modernise (to build green roofs or permeable pavement), all the more so as they have additional expenses owing to the tax itself. Another problem is that a great share of the buildings having the largest water draining seal are not profit oriented, but non-profit buildings, schools, community or ecclesiastical buildings, which have low revenues. Such extra expenses can even make their operation impossible. A more suitable solution would be therefore, if instead of a one-sided burden sharing, the tariff system would also support the modernisation of old buildings and would distinguish between buildings of diverse purposes; furthermore, if, as a first step, water retention solutions were made obligatory for new constructions.

8.1.2. Making use of alternative water sources

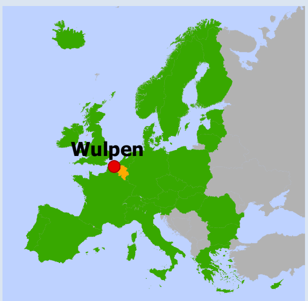
Water consumption based on non-potable water (*dual piping*) saves water, but it does so by influencing mainly the output end of the water network. In Europe, because of the strict public health regulations, only those water sources are regarded as established which provide water of appropriate quality. The exploitation of water reserves of non-potable quality is mostly missing; however, the re-utilisation of treated wastewater is already widespread in industry. There are two sources that can be considered: re-utilisation of treated wastewater and the use of collected rainwater. It is interesting to mention that in Singapore sea water is used for toilet flushing. There is no reason why this could not be implemented also in European cities provided that the issue of corrosion is solved.

The total transformation of the piped water supply system to dual piping is very expensive and complicated; not to mention the extremely high public health risks in case of a potential leakage. For this reason, the most expedient solution is to utilise rainwater or appropriately treated wastewater only for certain, well-defined purposes, such as the irrigation of parks and agricultural areas, fish breeding, and the dust abatement of construction and mining sites or roads.

Considerable water saving can also be achieved by **utilising the water discharged by wastewater treatment plants.** The amount of water leaving from the wastewater treatment plants and led to surface waters represents a considerable loss from the point of view of local or regional water management as it is not returned to the location of abstraction. This is especially true for supply based on groundwater reserves. Where soil conditions allow, infiltration of water into the soil can also be applied. Soils with an appropriate pore size – similarly to the operation of the bank-filtered wells - can perfectly filter the infiltrating water; this way it is possible to restore groundwater without deteriorating its quality. On the one hand, the water treated like this supports the vegetation in the periods of drought, and on the other hand, the restored groundwater can later be exploited and thus the costs of constructing artificial reservoirs can be spared. Root-zone wastewater treatment is the simplest solution for utilising the treated wastewater since a part of the water is directly used by the vegetation, and because a water habitat fits better with the treatment plants in terms of both landscape aesthetics and land use. This can also be implemented on a smaller scale: individual wastewater treatment systems can also supply water for irrigation of gardens and parks.

The main disadvantage of this solution is the hazards posed by chemical pollution (e.g. detergents, pharmaceuticals) which cannot be removed by the usual treatment of wastewater. This is especially true if the treated wastewater is used to replenish the groundwater base. When it comes to chemicals occurring in a low concentration, it is extremely difficult to detect those because, compared to more common water-polluting substances, there is a high number of potential chemical compounds in urban wastewater which have to be checked. In addition to the technical difficulties of performing regular tests, there are no established regulations concerning the threshold limit values of several, potentially dangerous substances for the reason that those could not occur in drinking water. In the utilisation of recycled water for non-potable purposes, for example irrigation or fish ponds – the nutritive content of the treated water, especially its nitrogen content can be an important restrictive factor.

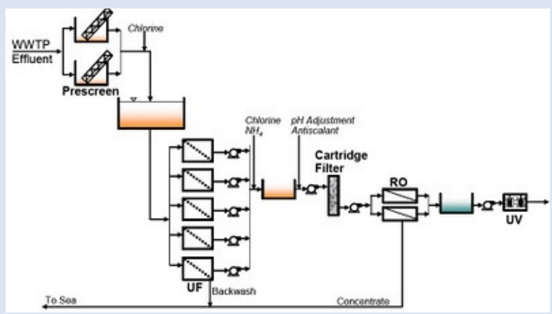
Currently, the most appropriate equipment for eliminating contamination seems to be the ones operating based on reverse osmosis. For now, drinking water production from wastewater with reverse osmosis only takes place in Malta, and mainly with the purpose of demonstration. In Belgium water treated with extraordinary care is led to the water base through the soil; so it is not utilised directly but through the standard wells, as drinking water. In Europe, treatment and recycling of wastewater is not a common practice unlike in United States or Australia.



Torreele, the recycling of treated wastewater as drinking water

Wulpen is a small community of 520 inhabitants situated on the coast of Belgium, 38 km from Brugge.

The first and to date, in Europe, the only considerable groundwater replenishment from treated wastewater was implemented here next to the local wastewater treatment plant. One objective of the investment was to restore the St-André water base with recycled, re-utilised water. The quantity of extractable water could not be increased anymore; therefore, the regional waterworks found communal wastewater treatment as the most applicable alternative source.



The water received from the Wulpen wastewater treatment plant, operating since 2002, is treated with ultra-filtering and reverse osmosis; and it also receives chemical treatment to the extent necessary. The last step in the treatment process is disinfection with UV light; however this is not necessary under normal operating conditions. The treated water gets to the groundwater through an infiltration basin. The groundwater extraction wells are located at a minimum distance of 40 m from the basin. The water extracted from the wells is aired and forwarded through a sand filter and then it gets into the network as drinking water.

The capacity of the plant is 2.5 million m^3 of water. Thanks to this, the amount of abstracted groundwater could be reduced by 30%, i.e. by 1 million m^3 per annum, and the groundwater level also increased. By operating the system, water hardness was also considerably reduced, almost to its tenth.

The investment and the trial operation were performed by the regional waterworks Intercommunale Waterleidingsmaatschappij van Veurne-Ambacht (I.W.V.A.), and the plant is operated by Aquafin NV, which also runs the wastewater treatment plant. The total costs amounted to EUR 6 million, which however, also includes the development itself.

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Source: www.iwva.be/docs/torreele_en.pdf

Rainwater collection has considerable traditions also in Europe. It is relatively simple and inexpensive to collect the rainwater and snow melt-water from the roofs. Water collected this way is mostly used locally for irrigating gardens or it is led into the soil. These local solutions belong more to the competence area of sustainable building (Chapter 7); this practice, however, can extend to entire settlements if precipitation water is collected from larger areas in a systematic way, and the gained water is stored in greater quantities to be utilised for public purposes. Leading the collected water into the soil supports water retention, as described above within the framework of sustainable drainage; therefore, it only affects water utilisation when, after the level of the groundwater is restored, water is abstracted from there again for the purposes of drinking water, for example. As to rainwater collected from urban areas, the treatment is absolutely necessary before use even for the purposes of irrigation or agriculture. From a technical point of view, retention basins are perfectly applicable for the storage of rainwater as well.
Thanks to their self-purification ability, lakes with a natural basin, vegetation, and a permanent water surface represent the solution that has the most positive effect on water quality. Wherever creating lakes of this type is not an option, a possible solution could be the construction of underground reservoirs. These can be located even in busy urban environments such as, for example, under parking areas.

The advantages of underground storage lie in the facts that it reduces the rate of water loss caused by evaporation to the minimum and that water quality is preserved as the excess growth of algae is avoided. When using closed reservoirs, it is very important to use an inflow filter to retain any solid waste or leaf-litter. While this may not be necessary in the case of open reservoirs surrounded by vegetation, a waste screen may still be needed.

8.1.3. Flood protection

Floods are natural phenomena which cannot be prevented; however, some human activities and climate change contribute to an increase in their likelihood and adverse impacts. The causes and consequences of flood events vary across the countries and regions of the European Union. Since 1998 there have been 100 major floods in Europe, causing about 700 fatalities, the displacement of about half a million people and at least €25 billion in insured economic losses.

Flood protection is closely related to other processes taking place within the catchment areas such as the quantity, intensity, and form of precipitation, melting and freezing, or the rate of infiltration versus drainage. In turn, these are influenced by factors many of which do not directly form part of flood protection such as building density, land use, and forms of farming. Therefore, one of the basic principles of effective flood protection is seamlessly incorporating flood protection into the system of **integrated water management** or even integrated environmental management. Implementing this is one of the most important tasks. Accordingly, the solutions mentioned hereunder cannot be applied on their own either, partly because of the interactions resulting between the interventions, and partly because the flood protection/water management system can only function effectively if it operates in a harmonised way. Regional and catchment area based planning and intervention must be inevitably implemented as flood protection and river control cannot possibly be the task of a single settlement. For this very reason, the possibilities of adaptation and protection at the settlement level are very limited.

It follows from the very essence of climate change that, regardless what flood protection issue or solution is in the forefront of thinking during the planning process, relying exclusively on the customary, observation-based flood risks (such as the probabilities of given water levels occurring within given timeframes) is just not sufficient. Modelling precipitations and surface runoff on the basis of climate models must inevitably serve as the starting point of planning. The importance of this idea is continuously proven by the fact that extremely large-scale and ever more violent floods are becoming more and more frequent. Therefore, in the field of adaptation, one of the most fundamental steps of flood protection is **modelling**. Modelling affects all areas and helps foresee expected new outflows and runoff conditions. Then the specific development projects to be implemented can be based on this foundation.

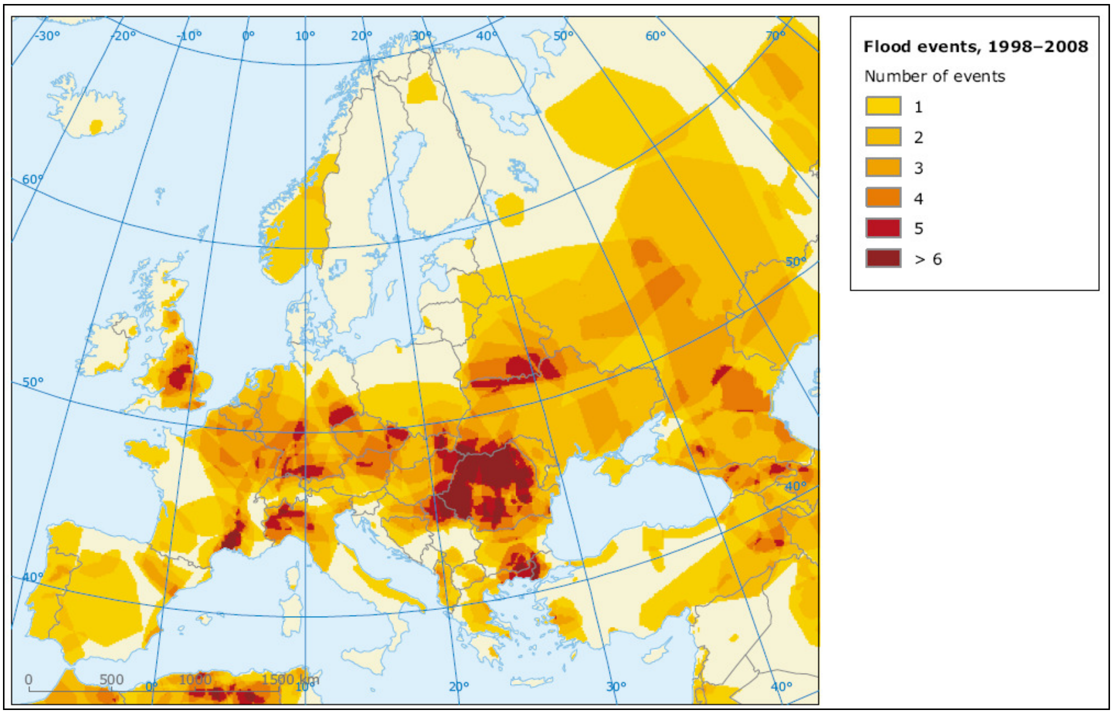

Figure 32: The frequency of flood events in Europe between 1998 and 2008 (Source: EEA, 2008b)

One main step of flood protection is to measure the risks properly. 'Flood risk' is the combination of the probability of a flood event and of its potential adverse consequences for human health, the environment, cultural heritage and economic activity. Flood risk assessment is in close relation with vulnerability assessment. Based on data on relief, precipitation, runoff, land use etc., the flood risk map and risk assessment highlight the most vulnerable areas and provide fundamental information for proper management activity. In the age of GIS, digital elevation models and climate change modelling, flood risk assessment has a sophisticated IT background, which facilitates the evaluation of not only the current risk situation but of potential future flood hazard, too.

Flood risk management is the social and engineering activity which can respond to the problem. This activity encompasses a rather diverse set of tasks, but there are some key elements applied in every case:

– Prevention: averting the risk of floods by means of land use management.
– Preparedness: using real-time flood forecasting to have sufficient amount of time before the incident happens.
– Emergency response: organizing the work of authorities during floods, and securing inhabitants against the effects of floods.
– Recovery: providing financial and material assistance for the remediation of the affected settlements.

One must always, in all areas of action, consider a fundamental principle: **maintaining complete flood protection often proves impossible over the long run**. Modern cities have sprawled into inevitably unsafe bay areas and floodplains. In these areas defence may require more of a sacrifice than what the valuables defended are actually worth, often simply because flood protection in these areas leads to the emergence of higher peak flood levels in other areas. What is needed is reasonable urban planning that respects environmental limitations to a greater degree. Possibilities must be found to secure adequately large expanses of spaces where water can run its course even in times of flood and where the natural processes (river bed changes, sedimentation and erosion) can also take place. Rivers must be given their space and it must be accepted to a certain degree that the most threatened areas will be flooded regularly. Major land use restrictions and rehabilitating the natural environment may be necessary in order to avoid that the implementation of river control and flood protection becomes ever less sustainable and ever more costly because of the fact that it relies on environmentally detrimental interventions.

In downtown areas, whenever there are adequate open surfaces that are not built in, **sustainable urban drainage systems** (SUDS; see described in the paragraphs on water retention) may increase infiltration, which in turn can significantly decrease the floods of minor water courses. However, the possibilities of such a system are limited; besides, it does not offer any protection against large amounts of water from external sources. Because of the building density, such protection is hardly possible by means other than **strengthening dams and embankments** to increased load-bearing specifications that take climate change into consideration.

In most heavily built in areas, the application of **mobile walls** may be the solution. Mobile walls are metal sections installed on-site, immediately prior to defence becoming necessary, using preinstalled foundations and permanent support pillars. This defence solution needs a very small surface area and does not permanently restrict access between the river and the protected areas. Water-filled hoses, a more modern and faster version of traditional sandbag defence, offer a similar solution. In this case water-tight, water-filled hoses of an adequate diameter (as much as one to two meters) act as dams. The water it takes to fill them is taken from the fire hydrants usually available in the urban environment. This ensures that the hose is 'blown up' to the required diameter and weight to ensure that it is not swept away by the flood. These hoses may have a length of 100 meters or more, facilitating the defence of entire city districts, but they are also suitable for protecting just a specific building. The advantages include not having to preinstall any structures, quick installation and transferability, and some cost saving because there is no need for building dams. However, this solution is not suitable as a form of protection against larger floods. Another version of the mobile wall is a water-tight wall system built using prefabricated plastic elements. This system is also used in a manner similar to sandbags. These last two systems have the added advantages that they are reusable several times, filling them up and installing them does not require heavy physical work, they are easy to handle, and they can be disinfected after the flood, therefore not becoming hazardous waste. Fully mobile walls are made even more economical by the fact that they do not need to be purchased; they can also be leased. This enables less affluent settlements to use them as well. The disadvantages lie in the fact that their protection capabilities are limited and that they need storage space during flood-free periods. Another factor restricting applicability is the quality of the surface upon which these systems are installed. Unlike in the case of a dam built from soil, here the surface materials are not protected from water and thereby may be underwashed. The inclination of the surface may also restrict applicability.

As a last resource, the solution may be **strengthening or raising the height of buildings and infrastructure** in the areas most exposed to flooding in order to weather occasional floods, or to **exclude** these areas from human activity. As flood protection systems are widely available in Europe, **improving the individual waterproofing of buildings** is a less frequently used solution. However, limited floods that last for a short period of time may be managed using this method. In practice, increasing the height at which ventilation holes and incoming pipelines enter the buildings, providing these holes and entry points with appropriate sealing, and rendering low-level walls waterproof help avoid the flooding of the lower parts of the building. In addition, watertight panels installed into or in front of doorways that function similarly to mobile dams may also prevent water from flooding the building. This type of flood protection wall may be raised along the full length of the buildings, such as, for example, in the case of large shop windows. Using these solutions might make sense in places where regular low-level floods are expected to occur such as, for example, in the case of waterfront resorts, where permanent dam systems cannot possibly be implemented. These solutions help decrease damage significantly; however, implementation must be of a high professional standard, and these solutions do not protect any areas or streets outside the buildings and do not facilitate traffic.

The concept of **buoyant buildings** and city districts is also of great interest. Of course, this rather costly solution is only needed in areas most exposed to flooding such as in Holland and, in general, in low or sinking shoreline areas, mostly nearby river estuaries. Nonetheless, in these special areas buoyant buildings can be very practical solutions as, for geological and climate related reasons, dam reinforcement in these areas would require never-ending and, after all, irrational development projects. For the time being, very few actual examples exist. Buoyant buildings have been built in the Netherlands since the turn of the millennium, and there are plans to make whole city districts buoyant. The basic idea is very simple: the buoyant buildings, which form traditional streets and rows of houses, are fastened to pillars in a manner that allows vertical displacement but does not allow the buildings to drift away. When the flood comes, the buildings rise on the back of the swelling water but practically no damage is done. However, based on the experiences thus far, this type of development remains both isolated and uneconomical as society is not really forced to maintain city districts at such high costs.

Double precipitation canalisation is a solution halfway between flood protection on the one hand and developing the sewer system on the other. The basic idea is doubling the traditional, low-capacity sewer system, which serves the purpose of draining more frequent but lower intensity precipitation peaks (small or comfort system), by creating a parallel network consisting of large-capacity elements that can tackle extreme loads. This parallel second system can be the road surface itself if it is designed and implemented appropriately. This method of draining excess water into less populated areas and parks costs very little while it avoids flood damage, and, more importantly, it helps decrease flood levels and thereby protect areas that are really valuable. Implementing a system like this requires the in-depth harmonisation of urban planning, flood protection, and infrastructure development, even though the actual material costs are negligible.

Areas outside human settlements offer much greater opportunities for implementing effective flood protection systems. However, these solutions are usually beyond the means and competences of any given settlement. **Widening the floodplain** increases the floodplain's storage capacity and reduces the level of the flood wave. However, this is not an option in the case of rivers that cross settlements; if the wide floodplain narrows down right upstream from a city, the flood level – and thereby the risk of flooding – may actually increase within the settlement's downtown area whenever the storage capacity upstream from the settlement proves insufficient. **Temporary water storage outside the floodplain**, a solution seen in the New Vásárhelyi Plan in Hungary, helps reduce flood levels, generates new economic opportunities, and creates (or reinstates) semi-natural habitats across wide expanses of land. In this scenario, some of the flood water is channelled into temporary reservoirs located along adequately safe river sections on the protected side and themselves protected by dams. This helps reduce the outflow during critical periods. Once the flood-wave has passed, the water may be drained and the area can once again be used, typically for extensive farming, until the next flood arrives. A disadvantage of the solution is that it can only be implemented if the terrain is suitable for the purpose. If implemented with due care, **river control** can also have a favourable effect on flood protection; however, whether this method is suitable can only be decided on a case-by-case basis as it requires extremely thorough planning.

In the case of smaller water courses or springs, even in hilly or mountainous terrain, a well-known solution is constructing **retention basins**. These are effective measures against floods caused by sudden, high-intensity local precipitation. The water so collected may be used for irrigation either directly or through infiltration into the soil during droughts in an effort to improve the area's water balance. There are several types of basins according to their principles of operation:

- **Transitional or 'dry' basins** (detention basins) are used to temporarily store excess runoff water during floods. The water introduced into these basins during downpours or floods is stored until the flood-wave passes and then gradually drained, leaving the basins mostly dry outside their periods of use. Since there is no permanent water environment in these basins, water quality tends to deteriorate rather than improve during storage.
- **Wet basins** (retention basins) are basins with a permanent water surface and landscaping appropriate to their environment. In addition to flood protection, they are also used for water retention. As they maintain natural aquatic habitats, they do not contribute to the deterioration of the water stored. The water collected in these basins may be used to improve water supply during periods of drought. As the water introduced into these basins is only used after a longer

period of time, there is enough time for sedimentation; this, in turn, requires continuous maintenance and the regular removal of the sediment matter.

– **Infiltration basins** differ from the types of basins described above in that the incoming water is not stored primarily as surface water but instead it is infiltrated into the soil, something made possible by the specially designed basin floor. This solution can only be used if the geological conditions are suitable, the soil is stable, and the infiltrated water is pure (given the fact that the water introduced is untreated water received from natural water courses), otherwise infiltration may lead to increased groundwater pollution, marsh formation, and even landslides in inclined areas.
– **Stormwater retention basins** can be implemented even in urban areas, for example as parts of a sewage treatment plant if a combined sewer system (sewage transport and precipitation drainage) is available. This solution already forms part of preparing treatment systems for climate change.

Preparing the local population for flood protection and disaster management is very useful and may be implemented at a low cost. Besides thorough defence plans, the education of the residents and their involvement in defence activities and the organisation of alarm and monitoring networks can offer significant support to disaster management agencies in performing their activities.

Greve, flood action plan

Located in the Sjælland region just 21 kilometres from Copenhagen, the Danish city of Greve has a population of approximately 47,000.

The city is located on a low plain near the sea. As a result, both massive precipitation and rising sea levels represent a flood hazard. After the great floods of 2002 and 2007, the city's municipal government decided to elaborate a climate change mitigation strategy. In elaborating the strategy, citizen accounts of the 2007 flood were recorded and taken into consideration along with meteorological data, forecasts, and GIS data obtained through a land and building survey.

As part of the strategy, the region's water draining system is renovated every 10 years, which always includes a capacity increase as well. GIS modelling was used to create a flood hazard map to indicate which areas are most exposed to the hazard of flooding. During the project, data collection and monitoring is continuous.

Implementing the strategy has brought visible results. During the first two weeks of August 2010, many parts of Denmark were exposed to downpours of extreme intensity, often followed by major floods. The region of Greve also saw an unusual amount of precipitation, as much as 100 mm within just a few days. However, thanks to the information processed in advance, the damage suffered by the settlement was minimal.

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8.1.4. Coastal regions and climate change

Coastal regions face the most specific impacts of the changing climate. While other areas are not affected in all fields of human life, in these regions the climate change has a significant effect on every aspect of life. The increasing sea level, storm surge height and frequency, higher peak river flows, coastal erosion threat even the existence of coastal cities. The historic cities of Greece, Croatia or the British Isles are especially vulnerable as the tourism – that would be so also affected – has a fundamental role in their economy. Coastal wetland ecosystems have an important role in the cities' life as well, as they are the base of local economy and provide defence from flooding. Another important aspect is the water supply, as rising sea level causes salt water intrusion and increases the salinity of ground water. The importance of these problems is so high that the EU issued the Communication from the Commission to the Council and the European Parliament on integrated coastal zone management: a strategy for Europe (COM/2000/0547).

The scale of the problem (109,000 km of coastline only in the EU 27 states) in itself limits the possibilities of adaptation. In most cases the only achievable solution is the revise of land use based on the modelling of sea level rise and erosion processes. This is not easy or cheap; the relocation of roads, electric lines, etc. even in an uninhabited area is very expensive. But, as the coast is a focus point of the European culture and human activity, there are regions, and of course the coastal cities, where we must find solutions to the challenge. This chapter aims to give some recommendations to this adaptation strategy.

The great complexity of human activity, land use, economy and nature reservation made the use of integrated planning obvious, as in almost every case in the water management. Plans have to consider that coast is a dynamic system, and the natural environment has far more greater influence on the coastal cities than their inland neighbours. It increases the uncertainty of the future and requires wider approach, more knowledge and creativity from the planners and municipalities. The preparation for unexpected changes needs the use of adaptive management approach. The plans and measures have to be flexible and renewable. As a management approach, it is based on implementation, monitoring, and periodic reassessment of adaptation measures.

The adaptation strategies are based on one of three general principles:
1. Protection: to avoid the occurrence of hazards in the protected area;
2. Accommodation: not to avoid, but at least to reduce the impacts of the hazard;
3. Retreat: moving away from the source of the hazard.

Coastal erosion
About 20% of the European coastline is considered to be posed to erosion. The higher share of erosion affecting coasts is at the Mediterranean Sea, while the Baltic Sea is the only region where the accumulation type coastline is longer than erosion type (EUROSION, 2004). So protection against demolition power of waves and currents is an important issue in European scale.

In the case of cities without a river estuary or bay, where the area can be completely closed off, a range of **flood protection and shore protection solutions** can be used to mitigate the effects of rising sea levels. These do not guarantee complete protection against rising sea levels but may be very useful as defence measures against ever more violent storms and storm surges. They fall into three categories:
- traditional efforts to reinforce and build sea walls, embankments, and dams;
- protecting and reinforcing offshore bars, dunes, and islands along the shoreline by regulating sedimentation (by building sea walls, hedges, and spur dikes) and by preserving the vegetation and by afforestation;
- reducing the erosive effects of the waves on the shoreline by reinstating saline lowlands and shoreline marshes (managed retreat, managed realignment).

The traditional solutions **(embankments, sea walls,** etc.) have been used for a long time with well-established practices of application; in fact, there is hardly any other option when it comes to built-in urban areas, rocky shorelines, and lowlands. This is the case in the ancient port cities of the Mediterranean Sea where there is no place to relocate buildings or build regional defence systems. At the same time, just as much experience has been accumulated about the disadvantages of these solutions. Hard structures are not economically viable in every case. No known material withstands the incessant, violent attacks of the waves forever; as a result, dams and sea walls require continuous systematic maintenance and development, something that makes them rather costly. As these solutions only deflect but do not dissipate the energy of the waves, erosion may in fact become stronger along unprotected shorelines in the immediate vicinity of the protected ones. This is why more sophisticated and, luckily, more natural solutions have had to be developed.

Sandbanks and islands along the shoreline are extremely important as far as **breaking the waves** is concerned. This has been very well known in the case of the Frisian Islands. Natural wave breaking structures consisting of loose sediment can only survive if the sediment supply is continuous; this is further supported by vegetation. Artificial wave breaking structures of the appropriate design make currents along the shoreline to be protected deposit their sediment, while protecting the vegetation and afforestation slow the erosion of the existing deposits of sediment. Planting and fertilising non-arboreal vegetation is an option, similarly to how the Dutch polders were reclaimed for agricultural cultivation. Of course, this solution can only be used in the case of shorelines where there is an ample supply of loose sediment matter, such as, for example, on the eastern shores of the North Sea or on the southern shores of the Baltic Sea. An advantage of the solution is that it helps preserve natural habitats while offering regional shoreline protection.

The most recent solution is rooted in the realisation that the energy of waves and wave surges is effectively reduced and dissipated by salt marshes stretching along the shoreline and crossed by wide channels. This is a type of protection that is different in its nature from any earlier system in that it does not stop water at the shoreline but gradually dissipates its energy as it runs ashore, even allowing some erosion. In actual practice, this is nothing else than an attempt at locally reinstating the balance of erosion and sedimentation by recreating the salt marshes and brackish flats that had existed but have been drained, or at creating similar landscapes artificially. The English term **managed retreat** is a poignant expression of how some areas are handed back, in a carefully planned manner, to the natural processes that shape the shoreline. If there is an ample source of sediment in the area, at least the extent of the protected land surface can be stabilised in the long run while allowing the shoreline to change continuously. At the very same time, this solution effectively reduces the erosive effect of storm surges and extremely violent waves, doing so without requiring any major investment or regular rebuilding. These salt marshes are valuable habitats even at the European level, especially for wading birds, wherefore they offer major advantages even in the context of nature protection. A disadvantage is that they may require giving up some cultivated, drained land, and in fact not every affected shoreline has areas that could be used for this purpose.

In the case of seashore cities situated on lowlands, flats, and in river estuaries most heavily exposed to rising sea levels, there is an increasing need to build **complex storm surge defence systems**. In these cases, the classic enclosure-type shoreline protection cannot be applied because river traffic and navigation must be maintained unaffected. These systems mostly serve the protection of the environment of a key settlement; however, they have regional or national significance as far as their dimensions and effects are concerned, wherefore they are far beyond the reach of municipal governments at the settlement level and their applicability remains extremely limited. The solution revolves around using permanent dams and movable surge gates to close off the protected bays and river estuaries during the time of storm surges. The largest such system is the *Deltawerken* in the Netherlands; it regulates the estuaries of the Rhine, the Meuse, and the Scheldt in a unified, regional approach. Other similar but smaller systems are to be seen on the Thames in London (*Thames Barrier*), in the estuary of the Neva in St. Petersburg, and the *MOSE project* implemented on the Adriatic Sea to protect Venice. For the time being, these systems are the only effective instruments against storm surges in the case of open river estuaries. Impressive as each one of these may be as a masterpiece of cutting-edge engineering, several problems also arise.

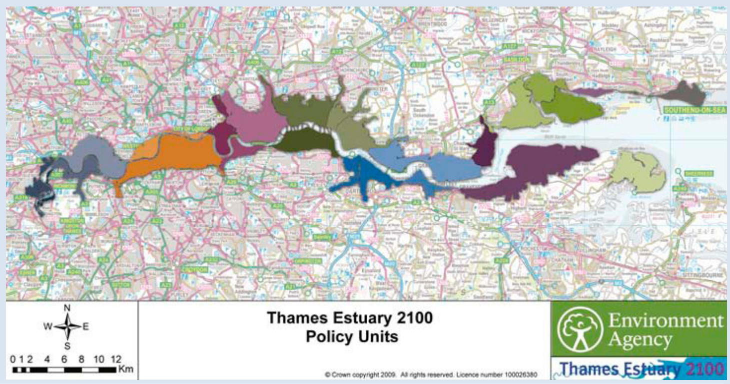
- Construction is extremely expensive and slow and a significant burden on the national economy.
- It follows from the basic principle of the system that it only allows closing the estuary temporarily, just for a few hours during the highest tides, wherefore it is unable to offer any protection against rising sea levels on its own; to this end, additional defence efforts are needed.
- It also follows from the nature of this system that it is not really suitable for regional defence because of the extraordinary scales and costs of investment. Just for the sake of comparison,

implementing the only truly regional defence system, the Deltawerken took nearly 50 years to complete, and its expansion is already underway because of the rising sea levels.

- Because of climate change, the actual permanent sea levels and flood levels can be higher than those envisioned at the time of adopting the plans, something that can easily render the entire system obsolete. Without further expansion, the Thames Barrier is expected to remain functional only until about 2030 if the current predictions concerning the expected rising sea levels prove to be accurate. If the dams are extended, the system may remain in use until the end of the century.
- It takes very thorough and extremely careful planning to prevent sea gate closing from causing major damage to the ecological systems of the area and to the environment in general.

Thames Estuary 2100 project - Managing flood risk through London and the Thames estuary

The Thames tidal floodplain is a low-lying corridor from Teddington in West London to the North Sea along the river. It covers 350 km^2, a home for 1,25 million people and vital institutional and business centres, heritage sites. The region is exposed to high tides and storm surges, so the defence of coast has been a permanent issue from centuries ago.



The existing flood walls, embankments and barriers were getting older and would need to be raised or replaced to manage rising water levels. It was time to make future plans and recommendations on what actions were needed to adapt to a changing estuary. The Thames Estuary 2100 project was established by the Environment Agency in 2002 with the aim of developing a strategic flood risk management plan for London and the Thames estuary through to the end of the century. The strategic aim is to develop a flood management plan for London and the Thames Estuary that is risk based, takes into account existing and future assets, is sustainable, includes the needs of stakeholders and addresses the issues in the context of a changing climate and varying socio-economic conditions that may develop over the next 100 years.

However the action plan does not include concrete infrastructural plans or technical details, it formulates strategic guidelines. This contributes to taking concrete measures in the changing circumstances. Based on risk assessment, the region was divided in 8 action zones and an estuary-wide zone to distinguish the different actions and to give the frame for synchronisation of the work of 23 policy units in the plan area. A public consultation on the plan ran in 2009 and the final plan was approved in March 2010.

The Plan: www.environment-agency.gov.uk/research/library/consultations/106100.aspx

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In addition to these large-scale protection systems, operating **observation and alarm systems** also significantly improves the safety of areas along the shoreline. These systems are inevitably necessary for effectively operating the dams and sluices to begin with; however, they also improve the safety of navigation and the protection of those living along the shoreline as they allow people to prepare for defence in due course of time. Such systems are in operation across Europe along the shorelines of countries like the United Kingdom, the Netherlands, and Spain. As in all cases of disaster management, it is very important to **prepare emergency plans**, communicate them and increase the awareness of citizens by education.

Although major floods and surges cannot be stopped by the homeowners' action, they can significantly reduce the damages in their own properties. The **preparation of private properties** to flood defence is an action in which the local municipalities can play a leading role. This can be achieved by the use of mobile walls, flood-proof architectural solutions (sealing of floors, walls, doors and windows, raising the electricity and air intakes, pipes above 1.5 m from the ground, use of water-resistant materials etc.). The local governance can provide advices, change the building regulations or buy/loan local flood protection equipments (e.g. mobile walls, as mentioned in Chapter 8.1.3.).

8.2. PREPARATION OF DRINKING WATER SUPPLY

As far as the supply of drinking water is concerned, once again, climate change is the greatest challenge both in terms of the quantity and the quality of potable water. Whether water is obtained from surface or underground sources, the amount of extractable water will decrease as a result of the dry and hot periods becoming more typical, right in those periods when, despite all efforts to save water, consumption is inevitably higher than normal. In the case of underground water bases, increased extraction and decreased precipitation create a situation in which the water reserves are not replenished, which leads to the emergence of a range of problems, the available quantity of water being just one of these. With changes in the system of underground currents, large volumes of non-potable or even polluted water may be mobilised; along shorelines, the balance between salt water and fresh water may be disrupted, and sea water may appear in the water base, resulting in the deterioration of water quality.

In most cases, the solutions proposed are based on existing, well known approaches. The first step is always **surveying the extent of the hazard** caused by the changing climate and soil conditions. Trends in available water quantities can be estimated based on expected future demand, water replenishment plans prepared on the basis of climate modelling (taking into account precipitation, natural infiltration, and outflow), and surveying ground water migration systems; and then the necessary steps may be planned.

In the case of underground water bases, **creating** or, as necessary, enlarging **protective areas** and **implementing more effective water use control** are obvious instruments. **Extraction from new water bases** may also be required. These solutions help solve not only quantity problems but also help improve the situation in terms of water quality. In the case of drinking water from surface water bodies, **sustainable water management** as described above in this document can be really useful in replenishing the water base even during periods of drought by building reserves of water stored in the soil and eventually discharged into water courses. **Retention basins** are especially useful in supporting water supply.

However, adaptation is always easier from the perspective of consumption, that is, demand and water use. This approach can partly help prevent the ever increasing water supply problems caused by climate change. At settlement level, the first step towards saving water is **surveying avoidable water consumption**. Examples may include the use of alternative water sources for certain purposes as described above, planting less water-intensive vegetation in public parks, and reducing evaporation and surface runoff by applying appropriate design solutions in public spaces (these include shading and more green areas instead of paved surfaces). Adopting similar measures can significantly reduce the water demand of public spaces.

The drinking water infrastructure has a number of technological solutions to choose from in adaptation.

Reducing losses within the system

Water supply networks go back to a history of several hundred years in many parts of Europe. Damage to old pipes and fittings and leaks can cause significant overconsumption or even water quality problems. Network loss may reach as much as 10 to 20% of the total volume of water supplied, and this water is mostly detrimental rather than neutral in its effect. Today, there are a number of fairly well-established solutions for renovating pipeline networks without fully dismantling the system. However, even a scheduled full replacement of the pipeline network, including the costs of excavation and reinstatement, can be a reasonable option as compared to the damage caused by a disastrous pipeline burst incident or an epidemic spreading along the water supply network. Large savings may also be achieved by operating a fast and efficient repair service as this leads to minimising leak time and water loss during pipe burst incidents and other network defects. Illegal water consumption must also be mentioned as part of the network loss; this can be rather significant in destitute, disadvantaged areas. Solving this problem is however a social policy challenge.

Creating larger storage capacities

Careful planning and water saving policies may not be enough to secure full water supply in all situations, for example, during times of lasting drought. However, the infrastructure may prepare for these periods by creating larger storage capacities. In addition to the customary water reservoirs, retention basins, underground precipitation water storage facilities, and underground natural water bodies may be filled in advance and then extracted as needed. This is a simple but rather costly way to survive the most severe periods in water supply, but it remains a temporary solution as the question of replenishing the water base remains open.

Producing drinking water from non-potable water sources

The above solutions may not be enough in the case of islands and extremely arid areas with very limited water reserves. However, a similar situation may arise in areas where the natural environment offers enough water in terms of quantity but most of it is not potable (such as in Békés county in Hungary). Territories richer in potable water are already more or less regular exporters of water to the arid regions of the Mediterranean. This is the least sustainable solution; however, it is unavoidable until other solutions become effective enough. The political, strategic, and economic risks are extraordinary. In these situations, the solution is converting non-potable water into drinking water. The best known and most widely applied solution is **the desalination of sea water**. An advantage of this approach is that it has been widely used for a long time, albeit mostly outside Europe. Currently, the best available solution is reverse osmosis desalination. Basically, reverse osmosis means that water is pressed through a semi-permeable membrane using high pressure. With pores of an adequate size, the membrane ‘filters out’ not only solid contaminants but also ions and molecules from the water. Using this method, most of the salt content of sea water can be removed. The salt removed leaves the system in the form of a concentrated saline solution. This system has quickly taken over the role of the traditional evaporation method because of its lower energy requirement and easier operation. The water obtained using this desalination method is completely free from salt. Accordingly, if the water is used for human consumption, some of the missing ions must be replenished in the form of minerals, for example by filtrating the water through limestone. This system may be suitable for supplying water even to cities with a large population. In Malta, 57% (!) of the water supplied is obtained from desalinated sea water using this method. The biggest disadvantages of this solution are the costs and the environmental impact of the salty water discharged. The desalination equipment itself is rather expensive as compared to simple water treatment solutions, and its operation is rather energy intensive. Partly because of greenhouse gas emissions, and partly because of the lack of energy, it is a fundamental interest to ensure that desalination methods be based on renewable energy sources. Desalination generates a concentrated saline solution as a by-product. With salt concentrations twice as high as that of normal sea water, it kills all marine life. As a result, the water directly discharged from desalination plants must be appropriately diluted and then discharged into the sea over a large expanse of sea surface.

A less frequently used solution for the removal of unwanted salts is **selective crystallisation**. In this case, appropriately selected reagents are used to induce crystallisation under circumstances ideally adjusted and additives carefully chosen to ensure the right speed of crystallisation of the unwanted ions into solid particles that are then easily filtered. The system cannot remove all cations; however, it has proven its worth in the treatment of very hard waters. There are water treatment plants operating on the basis of this system both in the Netherlands and in Hungary.

Collecting dew (air well)

Dry, cool seashore locations are ideally suited for installing large, appropriately designed condensation surfaces for extracting water from air humidity as a local solution. This technology is currently in the experimental stage; however, its cots are very low, and it operates without any energy systems or complicated purification or treatment methods. The greatest disadvantage is that its capacity is very limited; it is only a reasonable solution for supplying individual institutions or farmhouses. Also, it cannot be highly effective because of the prevalent European climate (specifically, the lack of cool shoreline desert climates) and only a handful of pilot projects have thus far been implemented. Using sea water as a cooling medium (seawater greenhouse) can improve condensation and water extraction significantly. In this scenario, using solar energy to evaporate sea water increases water production. However, even such a solution is inadequate for supplying water to a whole settlement, even though it may be useful as an added local water source to meet overall demand.

8.3. WASTEWATER TREATMENT

Sewage treatment infrastructure is affected by climate change in three areas. The most direct impact of these is the effect of exceptionally intensive precipitation on the sewer system. Sewage storage reservoirs must also prepare both for large amount of water suddenly appearing in the system and for dry periods. Questions related to disposing of and utilising the sewage sludge and the treated water discharged from the treatment plant are already part of active mitigation and adaptation in the context of efforts to reduce greenhouse gas emission and in terms of water replenishment. Reducing the overall energy consumption of sewage treatment (in transportation and in the operation of the purification systems) and the transition to renewable energy also contribute to the reduction of greenhouse gas emission.

In the context of activities generating greenhouse gas emissions, sewage treatment is important because of its production of methane gas. Based on 2002 Hungarian data, with a 60% rate of canalisation, approximately 9,800 tons of gas from communal waste water and 6,300 tons from industrial waste water contributed to the national methane emission. In CO_2 equivalent, this is approximately half a percent of the total national greenhouse gas emission. However, its importance is much greater at settlement level as it is the third most important source of greenhouse gas emission after waste management and public transport among activities managed by municipal governments.

Older, combined **sewer systems** (sewage transport and precipitation draining) are the most exposed to the effects of high-intensity precipitation. Separate systems may be prepared for climate change using sustainable precipitation channel systems as a solution, while sewage treatment in this case is unaffected by climate change. Like in other areas of water management, the first step is **surveying the expected increased load** on the basis of a climate model. Based on the results yielded by the climate model, the system can be designed to specifications appropriate for the expected increased load. Then, based on the updated capacity rating, all the **necessary expansions and reinforcement measures** can be implemented. Growing amounts of precipitation also increase the dimensions and ratings required in the case of almost all elements of the precipitation drainage infrastructure. Changes in the load may vary from one area to another because of differences in the local climate, with calculated new loads exceeding historical water quantity values by 30 to 50%. Several modelling software packages are available for calculating system loads; however, the reliability of the climate models serving as the foundation of these software calculations are not yet fully satisfying in respect of any given settlement. For this reason, it is a good idea to envision several possible scenarios and then opt for the safest and still economical solution. At the same time, modelling and surveying facilitate identifying the weakest points of the network, something that also helps increase the safety of the environment.

In city districts served by combined sewer systems (sewage transport and precipitation drainage) precipitation of unusual intensity or quantity does not only represent an increased load on the infrastructure. In fact, the sewer system may overflow and transport large amounts of polluted water into the reservoir, creating both flood protection and environmental problems. To prevent such a scenario, **retention basins** may be used. These should be constructed mostly at the terminal points of the sewer system, that is, as part of the sewage treatment plants. These are standard watertight pools used for storing the polluted water temporarily until the treatment plant is able to process the surplus. This solution is very simple, although it is relatively costly and it requires regular maintenance.

As wastewater normally only occupies a small portion, about 10%, of the total volume of the sewer system, precipitation water may also be stored temporarily within the sewer system itself. Implementing this requires **real-time control**. This system uses remote controlled sluices and pumps to enable the sewer system to actively manage the flow of water, ensuring that the flow direction and flow rate of water within the network can be controlled centrally. This requires the continuous observation and measurement of water quantities within the system and an appropriate algorhythm for controlling the system itself. A great advantage of the solution is that it can help avoid the need to build reservoirs; the total surplus water quantity of a downpour can be stored within the sewage network of a large city; and overflowing can be prevented, something that significantly improves the safety of the environment. Storage ensures that the sewage treatment plant itself receives regulated water quantities and thereby there is no compromise in the efficiency of purification. Currently, this represents the cutting edge in water control technology; as a result, only a handful of systems have so far been implemented.

Vienna, real-time control

Vienna, the capital of Austria has a population of approximately 1.7 million people.

Because of the city's climate, the number one problem for the city's sewage systems is managing the extraordinary outflows caused by unexpected high-intensity precipitation. In order to reduce the damage caused by the outflow, the city implemented a unified network in 2006 with the aim of preventing sewage, which is diluted by rainwater at times of extraordinary levels of precipitation, from surging back to the surface from the sewer system, thereby directly contaminating surface waters. Measuring 2,300 km in length, the sewer system has enough volume to temporarily retain excess water until it can be later discharged into the wastewater treatment plants.

To implement such a system, the loading of the sewer system must be monitored continuously and water levels and flows must be controlled in a sophisticated manner. The amount of water expected to appear within the sewer system and the temporary storage capacity remaining available can be modelled on the basis of surface runoff data and meteorological data, also relying on continuously measuring water levels within the sewer system. The system consists of 25 precipitation and temperature metering stations as well as 40 flow metering and 20 water level metering stations within the sewer system, with the data generated by the network being processed by the Channel Information System (KANIS). The ideal scenario for storing excess water may be determined by processing real data in a simulated model, while interventions are executed through centrally controlled sluices and pump stations. Accordingly, the real innovation of the solution was the implementation of the monitoring, modelling and controlling system.

Since its completion, contaminated water has never surged back. Currently, the system has a usable storage capacity of 361,000 m^3, but additional development projects may expand this to achieve as much as 600,000 m^3, which makes the system a global number one. The control system is applied to the entire sewer system of the city; with a 98% canalisation index, this practically means the total population of the city. Construction work started in 2001; after test operation in 2004, the system was commissioned in 2006.

The development project was managed by the MA30 working group of the municipal government (Vienna Sewer Company). The total cost was EUR 9.3 million. The system generated significant international interest and in 2006 received the best practice award of UN Habitat.

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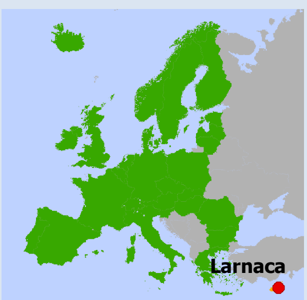
The preparation of **sewage treatment plants** for extreme weather conditions is especially important in the periods short of water. In case of the combined sewer system intense rains and intense rainwater can also be a problem; this can, however, be managed by inland water regulation and the establishment exploitation of the above storing capacities before the excess rainwater would reach the reservoir. The periods short in water may cause interruptions and defects in the ordinary course of water treatment as each treatment technology operates ideally only in case that there is a given degree of concentration, composition and quantity. In case of shortage of water or the increasing awareness of the population of the need to make economies of water, the sewage that is both more concentrated and more dense than expected. It is more difficult to treat or cannot be treated at all with the technology installed. Due to the smaller outflow than expected the contamination stays longer in the drainage network and, as a result, its decomposition can start in there, which may cause problems in the treatment plant. No special solutions are required for adaptation, the existing and widely known and used engineering solutions can be applied. The first step here is also modelling the expectable weather conditions and sewage quantity, based whereupon the predictable length and frequency of periods short of water can be projected with the effects of other measures aiming the making of economies of water, too. Based on these predictable changes the necessary sewage treatment capacities and solutions can be revised and the necessary projects completed. In case such is possible, the making of the technology more flexible can also greatly improve treatment efficiency in the critical periods.

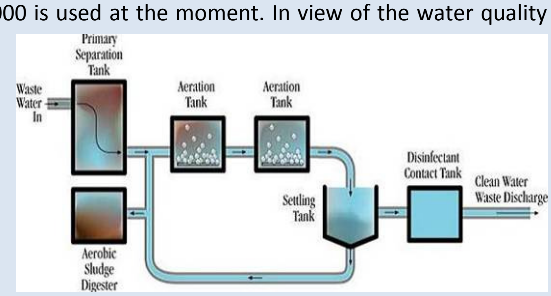


Larnaca, usage of sewage

Larnaca is a town in the Republic of Cyprus, on the South-Eastern bank of the island. Its population is approximately 70,000 people.

As a result of its climate and inadequate quantity of rainwater, a very deliberate water management policy had to be elaborated with the highest ratio of water recycling possible. According to data for 2007, only 3.5 per cent of the annual quantity of treated sewage (27.7 million m^3) was discharged into the sea, 9 per cent was led as supplement into the water bodies under the soil surface and 47 per cent was used for irrigation.

One of the most state-of-the-art of the significant sewage treatment plans operates in Larnaca. The plant has a capacity of 46,000 population equivalent of which 36,000 is used at the moment. In view of the water quality indispensable for re-use, treatment is of 3 stages. Following the completion of the second treatment phase water is sand filtered and then, chlorinated.



The plant annually treats and discharges 2 to 2.5 million m^3 water. The entire quantity is used for irrigation, mostly on the 250 ha arable land in the neighbouring village and in other gardens and green surfaces. No public health problem has been reported so far. In addition to recycled water sewage sludge is also used in agriculture in a quantity of approximately 5000 m^3 per annum.

EUR 9.3M corresponding to approximately 1/5th part of the total project cost was spent on setting up the conditions for the recycling of waste water, that is the construction of the stage 3 treatment facility, the pipe network and the pump station.

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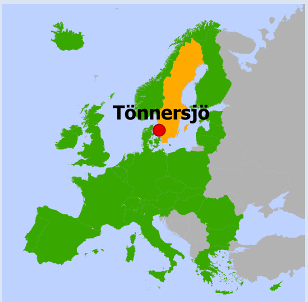

Tönnersjö, use of sewage in a nursery garden

Tönnersjö is situated in Halmstad Municipality in the south-western part of Sweden and has a population of 126 people.

Due to the geological situation of the area, the nutrition value of the soil here is lower than in the more southern or continental European regions. Therefore, to supplement the nutrition value of soil is of utmost importance here. A sewage utilisation project was completed between 2002 and 2006. The sewage with high phosphor and nitrogen contents from the municipal sewage plant was led into and used in the nursery garden, the latter being a regular user of artificial fertilisers. In order to deliver the sewage treated in the local sewage treatment plant to the nursery garden, underground pipelines were used to avoid odours. Irrigation with this water had an unambiguously favourable impact: much more intense leaf and head development was observed. Thanks to this method of irrigation, the nursery garden made use of approximately 20 kg of phosphorus and 100 kg of nitrogen per annum, and it was also a considerable advantage that the demand for artificial fertilisers and irrigation water was reduced.

No unexpected or harmful environmental or health effect was experienced either on the surface or in the subsoil water. The most important lesson, however, was proper communication, involvement of all concerned, and the setting up of an organisation uniting all participants. The expensive underground pipeline, for example, was selected for this reason.

The initiative was supported by the programme launched by the Swedish government under the title ‘Subsidising Local Developments’ (*lokala investeringsprogram* - LIP). The subsidy was awarded in 2000. The total project cost was SEK 850,000 and the share of the subsidy within it SEK 319,000. As the development is simple, efficient and it serves the interests of the environment from several points of view (nutrients, recycling of water, economies in materials and energy) the project was classified as ‘Best Practice (BP), in LIP.

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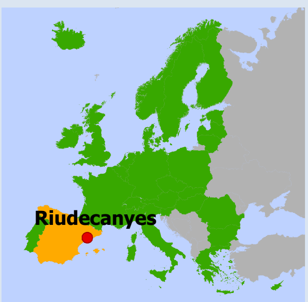
The **composting of sewage** is a process similar to the composting of organic solid waste. With the appropriate method, nutrients suitable to be used in agriculture can be produced from it, whereby artificial fertiliser consumption in agriculture can be cut. Adaptation to the effects of climate change is also assisted in an indirect manner, although this source of compost is not that rich in nutrients as communal waste. For its composting, the sludge discharged by the waste water treatment plant has to be first dried, which can be done with the help of renewable energy, for example, solar energy. Here as well, methane and carbon dioxide are produced during composting. The collection and use of gases released from sewage sludge is already relatively widespread and has a well established technology. In addition to electric power or heat energy obtained from the gas produced in this way, the quantity of sewage sludge is also reduced and, thereby, the costs of sludge treatment, too. Expenses are an important factor also because half of the costs of sewage treatment comes from the treatment of sludge. Odours are reduced, and a valuable and marketable product is made.

8.4. TRANSFORMATION OF WASTE MANAGEMENT IN LIGHT OF CLIMATE PROTECTION

Waste management in itself is little affected by climatic changes. It has, on the other hand, a very important role in the mitigation climate change effects, especially concerning the disposal of the collected waste. In countries with highly developed infrastructures, landfill gas generated from the waste in landfills accounts for approximately 4 to 5, while in Hungary, to 20 per cent of all the emission of greenhouse gases calculated in carbon dioxide equivalent. The carbon dioxide emitted by waste incinerators should also be added, which means another 2.6 M tons. The exhaust gases released from waste collection should also be taken into account, although those represent a much smaller quantity.

Preventive measures are possible to realise also during waste collection, although the emission of greenhouse gases can be reduced only indirectly in this field. **Selective collection of waste** is a typical solution for this; its favourable impacts manifest through recycling and energy savings in the manufacturing sector. In fact, the selective collection services in themselves can result in increased carbon dioxide emissions due to increased transport needs; and the recycling of paper and various types of plastic does not necessarily lead to a decrease in greenhouse gas emissions. Compared to simple deposition, it is much more favourable; however, compared to incineration, it is not always a better solution strictly from the greenhouse gas emission respect because the energy consumed by transport and cleaning has to be also considered.



Riudecanyes, selective communal waste collection

Riudecanyes, Tona and Tiana are settlements in Catalonia, in the north-eastern part of Spain.

The three municipalities initiated the setting up of a selective waste collection system to mitigate the harmful effects of climate change and to encourage the active participation of their communities. The system has been operating since 2000 and by now it has 80 members.

The essence of the system is that the selective collection of waste takes place at the very points of waste production, that is, individually at the different flats and houses. The residents may collect their waste in containers of sizes similar to those of the regular waste containers. Such selective containers are placed in front of the houses, or in case of condominium apartment houses, in the common premises. The waste types collected selectively are: compostable organic waste, paper, glass, packing materials and non-recyclable waste. To organise the collection of metals, PET bottles, dangerous waste, and electronic waste would not mean any technical problem either.

Transport, selection and recycling are simpler and more efficient than in the usual way. Investment and maintenance costs are also lower as no special public collection containers or special transport vehicles are needed; besides, processing is also cheaper and quicker. There is no need for selective waste collection points either, and an additional advantage of arranging collection on this individual level is that it raises awareness and increases the sense of responsibility in the citizens; furthermore, they receive immediate feedback if they do not collect the waste in the way required.

With this system introduced, the ratio of waste collected selectively reaches 70 to 80 per cent in the participating municipalities, which is an outstandingly good result, especially if we take into consideration that this rate used to be 10 to 20 per cent before. The greenhouse gas emissions associated with waste treatment also decreased by 55 per cent in Riudecanyes. The costs of the programme were covered by the participating municipalities.

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The use of hybrid collection vehicles to reduce the emission caused by waste transportation is not a widespread practice yet. However, it would be reasonable: taking into consideration the low speed, the number of repeated stops and starts and the fact that they work in a residential area, it would be ideal if the collection vehicles ran on electric power. This is a subject belonging to energy-conscious mitigation solutions in the field of public services, similarly to, for example, the modernisation of public transport. Supported by computerised **route planning,** the **transport routes and schedules as well as the transport capacities can be made optimal.** According to the experience so far, this may result in significant savings in fuel and, thereby in the costs, as well as cuts in greenhouse gas emissions. Savings can be realised at the border zones between the adjacent waste collecting areas, too, by harmonising transport tasks and by the co-operation between the different service providers.

From among the various methods of waste disposal, the less sustainable is, beyond doubt, the use of **landfills.** The same is true for the landfills regarding climate change as well. Even in the state-of-the-art landfills, anaerobe decomposition is the basis of all processes. As a result, the organic materials emit at a slow rate vast amounts of carbon dioxide (30 to 40% vol) and methane (40 to 55% vol) and, to a lesser degree, other gases. Under the conditions of the temperate climatic zone, following disposal, generation of the gas gradually increases for approximately half a year, and then, stabilised at the higher level, continues for even 20 to 25 years (E. Várkonyi, 2008). As the greenhouse effect of methane is approximately 23 times as much as that of carbon dioxide, such enormous amounts of it are critical from the point of view of climate change. Methane represents an increasingly precious energy resource, too; therefore, the **collection of landfill gas** is a must. This is of great importance especially if we take into consideration that by burning the methane content of the landfill gas, and thereby converting it by into carbon dioxide, the carbon dioxide equivalent of the emission of landfills can be reduced to its fifth. Collection and use of the landfill gas has to be an integral part of communal energy management, therefore, it is discussed in its technical details in the section about communal energy management.

Disposing of waste by incineration is a widespread method. It makes by the burning of gases generated by the landfills an opportunity for direct energy production, as opposed to the burning of landfill gases collected from the landfills. Generally, this energy is included in the figures of energy produced from biomass, although, due to the large quantities of plastic, a considerable part of it originates in fact, from fossil energy resources. Landfill gas, on the other hand, is generated rather from compostable waste. Due to the high proportion of non-combustible materials and water in the waste, incineration of waste is less efficient energetically than the burning of methane; also, the probability of emitting harmful substances is higher in the former case, too. Nevertheless, as increasing waste disposal into landfills is less and less possible, the only solution to dispose of the greatest part of communal waste is incineration. Consequently, this less advantageous solution is still widespread and has an important role. In Europe, due to its prevalence, this is the most important way to produce energy related to waste management.

Helsingborg, complex waste treatment

Helsingborg is situated in the southern part of Sweden, close to Denmark. Its population is about 95,500 people.

In an outskirt of Helsinborg, called Filborna there is a waste recycling facility including a biogas power plant that burns gases collected from the processed communal waste, sewage sludge and other organic materials, as well as a landfill site with a landfill gas collecting system.

The construction of the power station started in 1996. Waste is collected from the residential areas in special containers for each type of waste, and vehicles driven by biogas take them to the waste disposal facility. Here biogas is produced from the composted waste. Carbon dioxide and hydrogen-sulphide are extracted from the gas if it is to be used as fuel. The quantity of gas produced this way is enough to cover the regular fuel demand of 100 vehicles (buses, collection vans), while the rest is used to generate electricity or heat.

Because during the process special attention is paid to purifying the waste, the solid residue can be used as an organic fertiliser. It is delivered by a pipe network to the neighbouring lands saving thus 22,500 km of driving per year, which means also a decrease in carbon dioxide emissions by 40 tons. The power station has a waste processing capacity of 80,000 tons per year, and in 2001 it generated 12 000 MWh energy. The gas collection system, made in 1985, collects the gas emitted by the local landfill and, thus, this gas can be used for energy generation as well.

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Web: www.nsr.se

The most ideal solution both in terms of the economy and the environment is **recycling and composting,** whereby greenhouse gas emissions could also be cut. Recycling has already a relatively well developed and established mechanism and it spreads gradually. Composting in the towns is solved only in the case of organic wastes of big volumes (fallen leaves, horticultural refuse, Christmas trees, food residue from restaurants, etc.). The recycling of packaging material contaminated with large amount of food remains from households (which, in principle, is compostable material) is not yet solved, and causes continuous problem for the incineration plants. Methane and carbon dioxide are generated also during composting and it would be worthwhile to collect these gases. The compost produced could efficiently reduce the artificial fertiliser uptake of agriculture or parks; and if green urban surfaces are more productive, this could also, although indirectly, contribute to the improvement of the microclimate. Another indirect advantage is that energy and water consumption and the use of chemicals can drop, and the adaptability of settlements to intense rainstorms and heat waves can improve.

A special side of climate change adaptation, which is related to environmental security, is the **safety of the existing landfills** and their resistance to changing environmental conditions. Existing landfills were insulated in ways that suited the environmental conditions which existed then, or as were seen adequate based on the knowledge existing at that time about future perspectives. As a result of the changes in the climate, erosion caused by rainwater may increase, and the changes in underground water levels may also result in mechanical changes and movements in the soil; consequently, the insulations of these landfills can get injured. The rise of the sea level may result in the rise of the underground water levels at landfills close to the sea, which is again a phenomenon that poses a sudden risk to insulation. The solution in every case is to survey and map the hazards, to prepare the necessary interventions, and to improve physical protection. The best solution would be the liquidation of landfills along with a widespread recycling of waste, but for the time being, this is still a very expensive solution that can be used only in particularly justified cases.

BRIEF RECOMMENDATIONS

- Urging water consciousness, surveying which elements of water consumption can be avoided.
- Use of alternate water resources, utilization of sewage.
- Elaboration and construction of sustainable urban water management and a sustainable urban drainage system (Sustainable Urban Drainage System – SUDS).
- Use of integrated flood prevention and bank protection solutions on the basis of integrated water management.
- Elaboraton of special plans for the coastal regions.
- Preparation of the drinking water supply system and the sewage treatment plants for extreme weather conditions.
- Transformation of waste management in a way that supports the aims of climate protection.
- Consideration of environmental safety under the changing environmental conditions also with a special care to water management and infrastructure.

9. PREPARING FOR DISASTER MANAGEMENT AND HEALTH CARE

Settlement management – like the prevention of climate change – has many tools available with which to best prepare the city, its buildings, infrastructure and above all its inhabitants for the expected and already unavoidable harmful consequences of climate change. It has to be stated that prevention and adaptation are not separable. Numerous measures that aid adaptation to the consequences of climate change, at the same time help prevent a further increase in climate change. In the long term, only those adaptation measures can be efficacious which also serve prevention. Preventive measures include: publishing information on expected threats and the possibility of adaptation; securing the required financial background (e.g. elaboration of financial incentives for building insulation and expansion of green spaces in both private and public areas); strengthening urban utilities' technical capacity and infrastructure network; the establishment of a settlement structure better adapted to the expected climatic extremities. One of the main issues of the present Handbook covers proposals for climate adaptation measures, within the competence of settlement management; these are described in detail in other chapters. Here, we are dealing only with the adaptation of the urban institutional network, health care management and 'extreme weather events' caused by the climate change, as the decisive majority of the European Union member states will most likely be affected by the expectable consequences of climate change and will be increasingly burdened by this.

9.1. LOCAL HEALTH CARE INSTITUTION SYSTEM

Climate change has numerous consequences which pose a threat to human health and life. These impacts are expected to become more frequent in the future. At the same time, we have to be aware that climate change is not a problem existing in itself, but was generated by the transformation and mal-use of the natural environment. Destruction of the natural environment jeopardizes human health due to many phenomena, and not all as generated directly by climate change. This has to be mentioned because by restoration and protection of the natural environment, not only health problems caused by climate change, but many other illnesses referred to today as 'civilisation-illnesses' can be eliminated, However, while this problem exists, the health risks caused by climate change are only strengthened by the other risks resulting from the destruction of the natural environment.

The problem of climate change has evolved from systemic flaws in how society works, thus the lasting elimination of related health problems is not (only) the task of the health care system, but the whole institutional system, which affects all aspects of society.

Health risks posed by climate change

The probably most well-known consequence of climate change which directly influences human health are heat waves, and the accompanying high levels of UV-B radiation. Research proves that, for example in Hungary, the rate of sudden inflictions and mortality increases by 15% on days when the daily mean temperature exceeds 25°C. According to forecasts, an increase in mortality can be expected in the coming years due to heat waves. Similar to this is another climatic phenomenon, where extremely hot weather suddenly evolves from extremely cold weather (without a heat wave). Like heat waves, this poses a danger especially to the elderly and those with heart problems, as such changes place a considerable burden on the human body. The reason UV-B radiation is stronger is primarily because of the thinning of ozone layer; however, this is connected to climate change because of the increase in the proportion of clear, cloudless days, namely in summer months, which also increases the amount of UV-B radiation reaching the Earth's surface.

A further consequence of heat waves can be the occurrence of forest or bush fires, which also endangers human health and life. As a consequence of climate change, more and more pests are appearing in certain areas that were not found there before. A possible consequence of this process may be, for example, the spread of ticks or mosquitoes and the illnesses they cause. Changes in flowering time and the spread of allergen plants are also connected with climate change. To respond adequately to the new threats posed by climate change, such as the increased presence of emerging viruses and undetected pathogens, and therefore to implement new existing pathogen reduction technologies that decrease known and undetected viruses and other pathogens transmitted by blood are of a high importance. As extreme events become more frequent, weather-related diseases and deaths might rise. Climate change can also increase the spread of serious infectious vector-borne transmissible diseases including zoonosis. Climate change will threaten animal well-being and can also impact plant health, favouring new or migrant harmful organisms, which could adversely affect trade in animals, plants and other deriving products.

A further consequence of climate change is the incidence of more frequent and stronger storms; this results in occasional injuries, or even casualties and involves further health risks, too (e.g. infection from polluted drinking water). A similar situation arises in the case of floods following heavy rainfall, especially when the flood recedes quickly.

Mitigation of health risks

One of the keys to reducing the health risks caused by climate change and the efficient management of the fore-mentioned natural 'disasters' is ensuring that local society, including the healthcare services, are prepared accordingly; this leads to as few casualties as possible. Preparation of the local healthcare system must be included in the climate strategy for the settlement; its most important elements must be included in the integrated urban development processes, if required. The necessity of the latter is determined by the analysis of the situation; the relevant consequences of climate change's risks to human health, in a given settlement, must be assessed.

Today's healthcare system is further jeopardized by other changes that are expected in the near future – in addition to climate change – such as the growing energy crisis. Although primarily related to the energy crisis, the malfunction or interruption of the **major social provision systems** (e.g. in case of heat waves and strong storms) is a possible consequence of climate change. Consequently, institutions need their own energy supply systems relying on renewable energy resources. Providing these not only serves to reduce the impact on the environment, but also provides a base for secure healthcare provision (energy supply malfunctions may cause huge problems especially for in-patient care). Measures such as this will have ever more importance in the future, especially in those big cities in which a number of medical care institutions are operating, which are also responsible for the care of other settlements. Of course, the ownership structure of the given medical care institution is also a significant factor, as is the proportion that is owned by local government.

Adaptation to health risks

The energy efficiency, energy- and water saving, usage of renewable energy, installation of green areas, self-ventilation etc. are elements of the adaptation to climate change for the **medical institutions**. **These elements can compensate the otherwise necessary but harmful measures.** For example, the usage of the needed air conditioning in buildings releases emission which intensifies the effects of climate change. A health building that was built adequately implementing the aforementioned elements can counterbalance the damaging effects of such measures.

Local food production, whether home-grown or from a small producer, can play a very important role in mitigation but also has a role to play in health care. Consumption of food originating from local or neighbouring small producers causes less environmental impact (therefore it is more advantageous from a climate change perspective) and is mostly healthier when compared to food produced by industrialised large farms. If possible, local medical institutions providing in-patient care should ensure the catering for patients either partially or entirely with food originating from local or neighbouring small producers.

Pressure on medical care institutions and transportation can be reduced if the population knows as much as possible about healing certain illnesses and complaints. In this instance, the assistance of local doctors and natural therapists may be called upon. Due to energy and economic crises, in the future there may be limitations to the scope of **medication supplies**; therefore various local, natural therapies may become increasingly better valued. Learning and application of **natural therapies** is essential, since their application needs less energy use and thus the environmental impact is also lower. A further advantage of these therapies is that they play a significant role in strengthening the relationship between nature and society, something that has been weakened nowadays. The popularity of natural therapies is continuously increasing throughout the entire European Union, and today more and more doctors and medical care institutions are already using these methods. The local government can contribute to the increase in climate awareness by – recognising the population's interest– organising courses to teach natural therapies, combined with other information about climate change. All these steps can contribute to an improvement in the health of the population – again, regardless of climate change – and it should not be affected by unexpected, extraordinary situations and, should a serious disturbance occur in the healthcare system, the population will not remain without medical assistance.

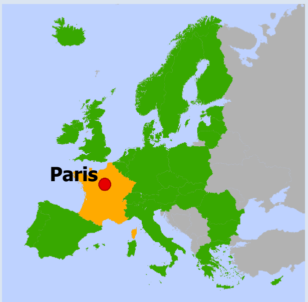
Awareness and communication

Beside expensive large investments, other possibilities are also available that enable the urban population to safeguard their health in extreme situations. Local medical care institutions and their employees can play a key role in this respect. An important step is **raising the population's awareness**, and providing an explanation of what action needs taken in certain actual circumstances (e.g. high UV-B radiation or heat waves). Besides personal counselling, it is useful to place advertisements and leaflets prepared by experts, for example, in waiting rooms. The local written and electronic press, as well as public forums, can also play a key role in passing on information regarding emergency situations and the modes for protection.

In extreme cases it may be important for the population to have basic **first-aid knowledge**, and are thus able to save lives in unexpected situations. An important step to achieve this objective is to include first-aid practice in local education, as well as local government courses, or even in the form of further or vocational training in work-places. Besides the local medical care institutions, initiatives like these can draw on the support of, for example, the local organisation of the Red Cross.

Besides informing the population, another important task is to provide **assistance in treating shock** following disaster situations and providing peace of mind. This is not necessarily the task of local government but it is much more effective if the local community can unite and help each other.

Due to the expected increase in the frequency of disaster situations, **communication** between local government, local disaster management institutions, local medical and social institutions, local training and educational institutions and the local population needs strengthened, in which the local press has a considerable role to play.



Paris, ‘Heat wave alert system’

Paris is one of the most populated metropolitan areas in Europe with its over 11 million inhabitants.

Summer 2003 brought to light the consequences of exceptionally long and abnormally intense heat-wave phenomenon and its impact on public health in France. The heat-wave between August 1 and 20, 2003 resulted in some 14,800 excess deaths in France, an increase of 55%. Paris was especially affected (an increase of 190%).

In 2003, 9 months after the catastrophic heat wave the City of Paris and the regional authorities have worked together out a plan to address and handle the impact of heat waves on the population. This plan includes the CHALEX register (abbreviation of ‘Chaleur Extrême’, extreme heat) that is a list of self-enrolled elderly and disabled people in the community. Those who consider themselves to be the most vulnerable are motivated via newsletters to register to the system (in 2010 19000 people have already registered). Thus the city administration can call them – using this list – on a regular basis during abnormally hot periods to verify their health status.

In case of any medical or other social irregularity the trained and authorised operators immediately call a sanitary unit located at the hospital that can alert emergency medical services (ambulance, fire brigade) to immediate intervention. They can also directly mobilise social workers if necessary.

MAIRIE DE PARIS

BULLETIN D’INSCRIPTION 2009
pour bénéficier d’un contact en cas d’événements exceptionnels

ATTENTION ! Ecrivez lisiblement en majuscules

A remplir soit :
- par la personne âgée ou handicapée ;
- par son (sa) représentant(e) légal(e) ;
- par un(e) parent(e) ou un(e) ami(e).

Et à renvoyer à :
Mairie de Paris - DASES - CHALEX
125 bis, rue de Reuilly, 75012 Paris

Vous pouvez vous inscrire plus facilement et rapidement en téléphonant au 3975
(coût d’un appel local depuis un poste fixe sauf tarif propre à votre opérateur).

Identification du bénéficiaire

M.☐ Mme☐ Mlle☐ Nom :

Année de naissance : Prénom :

IMPORTANT : précisez vos dates d’absences prévues en

Juin :

Juillet :

Août :

Personnes de votre entourage à prévenir :

1) Nom et Prénom :

2) Nom et Prénom :

Références du service médical, paramédical ou social in
ou en contact avec vous (médecin, kiné, aide ménagère,

Nom et Prénom :

Adresse :

Ville :

On July 17th 2006 the National Weather Institute issued a heat-wave warning. Until July 28, the Social Services Agency called all the registered individuals every other day to check on them. Those who needed it were examined once again, by doctors who determine their health status. Nearly 800 elderly people were examined by a medical team during these 11 days; 200 were called back. Most of the city’s interventions were limited to providing information on what to do and where to go during the heat wave. About 30 people were transported to air-conditioned adult day centres and 18 got urgent medical attention.

Contact:
Mairie de Paris - DASES - CHALEX
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Web: www.paris.fr/viewPDFileServlet?file_id=64737

9.2. LOCAL DISASTER MANAGEMENT

Extreme weather situations such as heat-waves, sudden and heavy precipitation, big storms, hail, etc., may occasionally result in disasters - unmanageable forest and bush fires, floods, and so on. During such events, damage or total destruction of buildings, flooding of basements or low-level apartments, uprooted trees and falling branches, or damage to vehicles may incur, jeopardizing human lives. Besides this, infrastructural damage can constitute a risk to the surrounding areas not directly affected by the disaster e.g. in the case of power failure.

In the future we may count upon the increased frequency and strength of extreme weather situations, and consequently the number of disaster situations may increase.

9.2.1. Civil defence authorities

In the future the concerned institutes will have to be prepared as well that the frequency of extreme weather patterns will probably grow. To be prepared for the most extreme case health monitoring networks should be established in the co-operation of health sector together with non-profit organisations. These would continuously follow the health condition of dwellers belonging to vulnerable social groups, whether through daily phone contact or – in ideal case – personally.

Urban disaster relief and management are fundamentally more difficult due to the features of the site, and require special preparation (e.g. flood protection, control of fires). It is a special challenge despite the fact that rescue services can reach affected urban sites earlier. Accordingly, **local disaster management** needs strengthening in urban areas. This may be achieved by strengthening local agencies responsible for disaster management (by technical-technological development, improved equipment or increase in staff) and by involving local residents as volunteers. It may prove necessary for disaster management organisations to develop new tactics in which the threat of fire, water and storm damage receives more emphasis than it has until now.

Besides dealing with the emergency situation itself, actual **disaster prevention** is an essential aspect of protection against climate change-related natural disasters; both the natural and built environment offer opportunities for this. Settlements can take many such measures within their own administrative area, by which the natural environment can be made more resistant to extreme weather events. An increasingly efficient tool to protect against these events and their consequences is planting trees and woodlands in peri-urban areas and if possible, within the city. Forest areas not only mitigate heat waves, but on hilly-mountainous surfaces play an important role in preventing landslides following heavy rain, and in controlling sudden, heavy run-off from the hill-sides.

Analysis of previous, weather-related local disasters can be a great help in preparing local disaster management organisations. Such events generally caught the community by surprise. As there events are so rare, the lessons which could be learnt have, in most cases, not been learnt – precisely because of their infrequency. However, with accelerating climate change a new situation has evolved. In many instances records which have held for centuries fall year after year, and other weather situations are occurring, which were thought to happen only once a century. Therefore, collecting the lessons of the past may greatly help prepare and protect against those disasters expected in the future.

The main objectives of climate-health prevention strategies are the inventory of diseases, the identification of their characteristics, as well as that the stakeholders take preventive measures. It is necessary to increase the weight of the prevention as opposed to the number of actual interventions, medical care or rehabilitation. However it requires the increase of resilience of health and social systems in order to follow the health impacts of climate change, the situation of the epidemiology and of the contagious diseases as well as the effects of extreme events, the preparation of disease surveillance and monitoring systems is an important requirement.

Preparation for disaster situations may be included in the **local education system** – perhaps along with first-aid tuition and basic health care knowledge, as proposed in the previous section. Local disaster management specialists can be called on to help. Awareness can be raised by organising, for example, fire-fighting competitions and obstacle-races for school-children. Besides school-children, the adult population must also be prepared through ongoing training and further education opportunities.

Shaping the riverbed of small streams crossing through urban areas and establishing emergency flood reservoirs decrease the risk of floods due to sudden rainfall. It is also important to prevent disaster situations by increasing the use of drainage and vegetation. These interventions are useful in both natural and urban environments (buildings, linear infrastructure), and help mitigate or eliminate climate change-related extreme weather events. Although such interventions are rather expensive in the short term, they are beneficial in the long term, since this avoids the potential costs of disaster management and protection; however, these impacts not only have a monetary value, as stress, injuries, and casualties may be prevented.

In general, environmental safety affects all members and levels of society. All adaptation solutions should make an effort to maintain and increase this as we prepare for new and continuously changing environmental conditions. The state or the local government can only partially cover the relevant costs, therefore widespread property insurance is necessary. This will cause differences in wealth to become strikingly clear, even to increase to a certain extent, simply because the people most in need will have fewer possibilities to prevent damage. That is why to assess the impacts of climate change and adaptation policies on employment and on the welfare of vulnerable social groups is of a high importance.

9.2.2. Health sector management for the extreme weather events

Health systems are vulnerable to extreme climatic events. Extraordinary situations due to climate change may incur primarily on the effect of extreme weather events. Most public health measures and systems are already in place but they need to be tuned to the new situation and demand. For these cases the **institutes of the health authorities** have to dispose of such plans that record the order of the necessary measures in case of the actual situation. Such cases may be e.g. ordering the distribution of protective drink during heat waves (e.g. in frequented traffic junctions, railway stations, etc.) or ordering disinfection subsequent to floods.
The White Paper (Adapting to climate change: Towards a European framework for action), the European Environment and Health Action Plan 2004-2010 and the EU Health Programme outline what the European Union can do to address these potential challenges. The European Parliament has called for enhanced multi-agency co-operation in order to boost the early warning system and thus to curb the harmful effects which climate change has on health.

Indeed, climate change might have an impact on health systems by increasing the demand for health services beyond the capacities of those systems. It may also interfere with their ability to cope with demand by undermining infrastructure, technology and the availability of workforce. This is linked to emergency preparedness and response.

The Health Security Committee (HSC) was set up by the Council as an informal committee to address preparedness for and responses to major health threats, such as CBRN events or pandemic influenza. It focuses on three areas, each assisted by a section consisting of representatives of the Member States. These areas are:

- generic preparedness and response for public health emergencies;
- response to chemical, biological and radionuclear (CBRN) attacks;
- influenza preparedness and response.

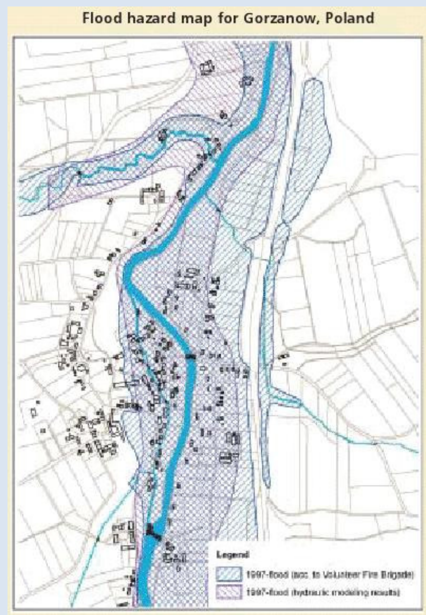
The JRC (Commission Joint Research Centre) supports the European Environment and Health Action Plan by providing the scientifically based information needed to help the EU and the Member States reduce adverse health impacts from environmental factors. In relation to climate change and health, the JRC was involved in the GAPCC (Global Air Pollution and Climate Change) Action contributing to scientific research on the linkages between air pollution and climate change, so that policy makers were made aware of the potential synergies and trade-offs in which the atmosphere and the climate system work. This action includes: the European Flood Alert System (EFAS), developed within the Weather Driven Natural Hazard (WDNH) project, which seeks to provide medium-range flood simulations across Europe with a lead-time of between 3 and 10 days, and which will provide information for the preparation and management of aid during a flood crisis; and the European Forest Fire Information System (EFFIS), which supports the services in charge of the protecting forests against fires in the EU and neighbouring countries, and which also provides information about forest fires in Europe.

The EU Health Programme supports projects and actions to improve health information and knowledge for the development of environmental health information systems. For example EuroHEAT which deals with actions at different levels: from health system preparedness coordinated with meteorological early warning systems to timely public and medical advice and improvement to housing and urban planning.

Gorzanów, flood mitigation plan

Gorzanów is a settlement in the south-west of Poland, near the Czech border, with a population of approximately 1,000 people.

Floods cause serious problems for the settlement. At the time of the 1997 flood, 81 homes and 100 farm houses were damaged, and 300 people had to be temporarily evacuated. Agricultural areas and roads were covered by water. The flood destroyed two bridges and damaged another two. The total damage amounted to 3.6 million EUR. A group was set up in 1997 in co-operation with the residents, to provide flood protection, coordinate flood preparation work and to perform other flood-related tasks.



The planning group includes teachers, volunteer fire-fighters, members of the Friends of Gorzanów Association, and local citizens. As a result of the group's activities, the following steps have been taken:

- a local flood warning organisation, operated by volunteers, has been set up;
- a questionnaire-based survey has identified to what extent the inhabitants were aware of their exposure to floods;
- the areas threatened by flooding have been surveyed and mapped;
- an emergency action plan has been created;
- educational activities have been carried out with the involvement of the local school and non-governmental organisation.

The members of the flood warning organisation are mostly local volunteer fire-fighters. Their task is to alert residents and to keep a regularly updated register of their telephone numbers. They also distribute informative flyers and offer advice to locals about how they can protect their assets should there be a flood. The action plan elaborated for flood emergency situations aims to secure the safety of the inhabitants within the shortest possible time. The plan includes an evacuation centre for humans (this is set up in the local school) and also one for livestock (this is designated in a flood-safe area) and also identifies evacuation routes. The municipal government provided funding for thE programme.

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BRIEF RECOMMENDATIONS

- Assessment of climate change impacts on human health.
- Preparation of health care system for related health risks.
- Reinforcing capacity to develop the modelling of health effects as a function of extreme weather and obtaining the data to define the needs for improved forecasting heat waves.
- Developing national, regional and local adaptation action plans to address the health impacts of the extreme weather situations and which will need to be integrated into the preparedness planning of health authorities and services in order to help assess their health-related vulnerabilities to climate change and develop health-related adaptation strategies.
- Reinforcement of public health policies and training, including effective surveillance and emergency response systems, and sustainable prevention and control programmes.
- Informing and preparing the local population for emergency situations and defensive measures.
- Raising awareness of local population.
- Development of guidance on surveillance, which will have to be matched by support for implementation and capacity development, such as microbiological support for food hazards detection and entomological knowledge and capacity.
- Disaster prevention interventions in the natural and built environment.
- Strengthening of organisations and institutions involved in health sector and disaster management.
- Improving the communication between the local governments, institutions, disaster management, health, social, and educational institutions and local residents.
- Further efforts towards identifying efficient health measures and public health response, including the strengthening of emergency medical services, early warning, education and outreach to vulnerable population groups, and better accessibility to key determinants of health, such as clean water, energy and sanitation.