ADAPTATION TO CLIMATE CHANGE

How does nature reflect/absorb heat?
How does nature store and cycle water?

Erasmus+

AGE RANGE

12–16

DURATION

Preparation:
60 min.

Activity:
445 min. / 10 lessons
A shorter version is offered in the Background for Teachers.

SUBJECT(S)

- Science – *Biology, Physics*
- Design, Engineering and Technology
- Mathematics

KEYWORDS

Evapotranspiration; albedo; water retention; plant cooling; experimental design; climate adaptation measures

SUMMARY

This module presents students with two challenges arising from the climate change: one exploring the effects of warming in towns, and the second flooding. Each challenge is designed for students to understand how nature deals with natural events, and how we can learn from this to address the climate change. They also learn that many of these events are deeply interconnected and require taking a holistic view. Each challenge can be delivered as a discrete lesson, or combined.

BIOMIMICRY PRINCIPLES

1 – Nature runs on sunlight
2 – Nature uses only the energy it needs
3 – Nature fits form to function
4 – Nature recycles everything
5 – Nature rewards cooperation
6 – Nature banks on diversity
7 – Nature demands local expertise

LEARNING OBJECTIVES

- Students are able to use observation skills to reach reasoned conclusions.
- Students can apply an inquiry-based science approach to problem solving.
- Students can apply analogical thinking.

LEARNING OUTCOMES

- Students use analogical thinking, critical thinking, making arguments and discussion.
- Students linked natural phenomena with adaptation to climate change.
- Students design climate change adaptation measures that are suitable for their locality.

BIOLEARN COMPETENCES

- Students are able to identify functional design in nature, develop greater awareness and appreciation for design excellence in nature, and appreciate how nature works as a system which is elegant and deeply interconnected.
- Students are able to use analogical creativity to innovate, using biological models to inspire solutions to design challenges.
- Students become more familiar with professions and research topics that relate to nature-inspired sustainability and technological innovation, which can inform their choices in post-secondary education and careers.

SUMMARY OF THE ACTIVITIES

	Activity Name	Description	Method	Duration	Location
CHALLENGE 1 – Cool town					
1	Challenge presentation 1.	Teacher presents the Cool Town challenge and leads a brainstorming on the topic	• Discussion • Brainstorming	20	Indoor/ outdoor
2	Effect of albedo on surface heating	Students measure the temperature of different objects and outside surfaces	• Experiment • Teacher presentation • Discussion	45	Indoor/ outdoor
3	Transpiration of plants	Students conduct an experiment on plant transpiration and study online resources about adaptation measures	• Experiment • Teacher presentation • Discussion • Research	15 + 30	Indoor
4	Plant cooling	Experiment on the cooling effect of water and vegetation	• Experiment • Teacher presentation • Discussion	45	Indoor/ outdoor
5	Field research	Students look outside for places endangered by urban heat island	• Observation	45	Outdoor
6	Design of adaptation measures	Students design suitable adaptation measures for their locality	• Design activity	45	Indoor/ outdoor
CHALLENGE 2 – Humid but not flooded					
7	Challenge presentation 2.	Teacher presents the Humid but Not Flooded challenge	• Discussion • Brainstorming	20	Indoor/ outdoor
8	Water retention in soil	Students conduct an experiment on the water retention capacity of different types of soil measures	• Experiment • Teacher presentation • Discussion • Research	15 + 30	Indoor/ outdoor

	Activity Name	Description	Method	Duration	Location
9	Water retention in the landscape	Students design a strategy to retain water in a model landscape	• Hands-on activity • Teacher presentation • Discussion	45	Indoor/ outdoor
10	Field research	Students explore outside for places endangered by flooding and drought	• Observation	45	Outdoor
11	Design of adaptation measures	Students design suitable adaptation measures for their locality	• Design activity	45	Indoor/ outdoor
12	Urban heat island (Extensions)	Students explore their neighbour-hood and together make a simple heat map	• Observation • Student presentation • Discussion	45	Indoor/ outdoor

BACKGROUND FOR TEACHERS

Introduction

This module aims to introduce natural phenomena and laws that, thanks to their understanding, we are better able to adapt to climate change. All the presented phenomena and laws are interconnected. The landscape must possess certain features to be able to retain water instead of losing it. But such features are almost useless when there is no soil with water binding capacity. So, there is need to understand what is essential to soil so it can retain as much water as possible. In a landscape saturated with water there is vegetation growing, which covers the soil and prevents water loss from excessive evaporation which happens when the soil is not covered and gets overheated. Plant transpiration has a cooling effect on the surroundings and thus makes it more pleasant for animals and humans especially in hot periods of a year. The water binding capacity of the soil and landscape, and the growth of vegetation are deeply interconnected. Discovering the principle of albedo helps to understand the role of colour in the heat absorption of objects which is helpful in adapting to raising ambient temperatures in urban areas and in the landscape too.

The adaptation of urban areas to climate change is a very current topic. A lot has been already done but it is still just the tip of the iceberg. Many projects have been realized on how to prepare and realize climate action plans, but there are significantly less adaptation measures actually realized than have been planned. In urban areas the main problem presents as urban heat islands, drought and how to manage an excess of water during climatic events like floods or storm-water. There are nice online sources that teachers and students can explore to get inspired about which adaptation measures would be the most suitable in their closest environment.

According to your time possibilities, you can choose one or both challenges. If you decide to do both of them, the online resources are the same for both challenges and also during the field research you can focus on both aspects of challenges – urban heat island and water retention and management.

Effect of albedo on surface heating

During a sunny day, will you be warmer in a black or white jacket? Colours have different reflective properties, i.e. the ratio of reflected to absorbed heat from the sun or *albedo*. Albedo is a measure of surface reflectivity. On a hot summer day, dark asphalt will become hot while a white facade will remain cooler. A dark house gets hotter than a light house, a black car gets very hot in the summer compared to white.

Transpiration of plants

Do you know why it is necessary to water plants? Plants need water because of two processes: (a) photosynthesis involving the fission of water, and (b) transpiration, which evaporates water from the leaves and creates a vacuum in the vascular system of the plant. Thanks to the vacuum, the plant is able to suck water together with nutrients from the soil and thus feed its cells. Transpiration drives the entire metabolism of the plant, which then functions as a solar pump. One tree can transpire hundreds of litres of water on a hot sunny day. One may ask how it is possible that trees are really helping to retain water in the landscape? Their important role is in soaking up water from deep layers that would otherwise remain unavailable for other organisms. They are also stopping water mechanically from running off thanks to their roots, especially on a hillside. A significant amount of water is also being condensed on the tree leaves before the sunrise or in the mist.

Reflecting sunlight using a mirror over vegetation and projecting it on a wall allows you to 'see' the evaporating water from the plants as shadows.

Plant cooling

On a hot summer day, taking a cool bath or sweating is the best way to cool yourself down. Water evaporates at temperatures above 0°C. This process consumes energy – heat, which leads to local cooling. Plants evaporate water from leaves during evapotranspiration, thereby cooling their surroundings. The sunnier it is, the warmer the day, the more the plant transpires (there has to be enough water available in the soil) and the greater the amount of thermal energy consumed. Think about the importance of plants in the city (you already know about albedo and transpiration). What cooling effect does a lawn, shrubs, separate trees or a forest have? Does a water surface (e.g. lake, stream, river, sea) cool as effectively as a tree / forest crown?; lake – water evaporates only from the surface, tree – huge surface area of all leaves, wind blowing through the crown enhances transpiration.

Water retention in soil

You may have heard the term humus. It is a partially or fully decomposed 'organic matter' or dead plant residue. Humus gives the soil a black colour, while light soil indicates a low content of 'organic matter' – the soil is mainly mineral. Organic matter, or humus, has many beneficial effects on soil and soil organisms, and is itself a source of energy for these creatures. In current agricultural systems it is not common to enrich the soil with organic matter such as dung but the farmers use mineral nutrients in very high doses to enable the plants' growth. As consequence there is almost no humus to retain water. In such a soil there is almost no life, the soil organisms have little to feed on, the soil tends to get dry. It is thus very important for plants to have symbiotic organisms in soil, fungi most of all, so they can grow better and be more resilient against drought, pests and diseases.

Water retention in the landscape

Imagine heavy rain and water flowing down a hillside. Why does the water sometimes not immediately soak up and instead drain away along the soil surface? The infiltration capacity of the landscape has a great influence on the amount of water that can be retained and can be used by plants or humans. Low absorption capacity of the soil surface can cause desert formation where a relatively high amount of precipitation falls. On the other hand, landscapes that hold water well and infiltrate easily are covered with healthy vegetation and provide rich harvests without irrigation. Natural processes often create bodies where the water stops and soaks, and these places soon become green islands. Understanding these natural processes is also very important in agriculture. If we have huge fields without barriers, the water flows away without stopping, sometimes bringing large quantities of soil along with it. There is also (in the Czech Republic) a huge drainage system that immediately drains the water out of fields. This results in a partially deserted areas in warmer regions the republic (where there are also situated the biggest fields). This is a very alarming situation. Soil is a precious resource, nature takes thousands of years to create several centimetres of soil. Nowadays we lose several centimetres every couple of years. Regulated watercourses cause two types of problems. First, they do not have a space for water outflow during heavy rains, the water just flows further in the landscape and damages the habitation further down the course. Second, the water flows away faster, does not soak in where it falls and may be unavailable during periods of drought. This is especially the case in urban areas, where people try to get rid of the water (river, rain) as fast as possible. Urban areas and their greenery then suffer from water scarcity.

ACTIVITY DETAILS

Preparation

Before the lesson starts, prepare the materials needed to perform the experiments and have the presentations at hand for the follow-up discussion (materials are listed with each individual exercise). There is a special presentation available for each topic, which will guide you through a series of ideas exploring the lesson subject. You are welcome to modify and update the presentation according to your needs and "best practice". It is advisable to prepare some ideas about the subject, for example by performing a short online search review, or at least write some ideas beforehand on a sheet of paper, so that you can contribute to the discussion.

There are three focal points in each lesson:

1. An exercise, which is a reduced model of real-world situation, and a discussion, where the analogies from the exercise are brought into a broader context, specifically adaptation to climate change.
2. A reflection part, during which students either share their experience with each other and multiply the learning effect, or think about possible applications of the experience into real-world problem solving and engage in a constructive discussion moderated by the teacher.
3. A presentation part, during which they are given some ideas and information which puts the exercise experience into broader context of real-world problem solving.

As a teacher, you should not act as a person who knows the answers, but rather as a guide (moderator), someone who has done some small research about the topic, but is as interested in exploring it during discussion and brainstorming as the students. Do not worry about not knowing enough about the topic; the aim is to engage the students in a constructive thinking process and provide an exciting learning experience, so the input should mainly come from them. You should focus mainly on building a bridge between the exercise and the topic of the presentation, where the bridge is built by the students, but guided by you.

Pre-prepare graphs for students for individual activities so they do not have to draw them by a hand. It might be time-saving during the lesson.

All experiments have a variation for distance learning (described after the description of each experiment) where students do not need any special equipment and do the experiments themselves at home.

CHALLENGE 1 – Cool Town

LOCATION
Indoor / Outdoor

1| CHALLENGE PRESENTATION 1.

» QUESTION

You need to present the challenge to students:
You will try several experiments that will teach you about the cooling possibilities in nature. With this knowledge we will go to explore your local environment and try to find out what places would benefit from additional natural cooling, especially during heat waves. You will suggest and design concrete measures that might help those places to cool down.

Brainstorming
Ask students to give their opinions on how it is possible to cool down the urban environment. You can write their opinions on a blackboard or give to each student few stickers (post-its) so they first think individually and later share their opinions.

TIP: *To save some time, split the students into groups (further divided into smaller subgroups of 3-4 students) – one makes the albedo experiment, the other (plant transpiration and) plant cooling experiment. The second part of albedo and plant cooling experiments takes place outside and can be carried out simultaneously.*

LOCATION
Indoor / Outdoor

2| EFFECT OF ALBEDO ON SURFACE HEATING

» DISCOVER

TOOLS AND MATERIALS

Each group of students will need:

- table lamp with a strong bulb (10 W) / sunny window
- a black and a white mug/cup
- 1 infrared thermometer
- paper and pencil to note the measured temperatures / student worksheet W2.1 (table) and W2.2 (graph)
- (if you are using computers to present the data – use the excel sheet albedo.xls)
- Albedo.ppt

PREPARATIONS

The activity takes place in the classroom, no special arrangements are required. Although, in case you use lamps, it is necessary to arrange connection to electricity.

It can also be delivered outdoors.

The goal of this activity is to measure the heating rate of two differently coloured mugs and measure the temperature of various surfaces outdoors. Students will oberve how heat is absorbed depending on the colours of objects.

Experiment
Place two mugs, one black and the other white, in front of a lamp (turned off). Measure the current temperature of mugs. Turn on the lamp/place the mugs in the lamplight and measure and note the temperature change every minute for 15 minutes. Plot the results in a graph. During sunny and warm/hot weather go outside with thermometers and let the students measure the surface temperature of various non-living objects – facade, sidewalk, car, stones, sand. They should notice their temperature as well as their colour.

Variation for distance learning https://www.youtube.com/watch?v=u7tdI5NdX44
Students need a black t-shirt and a white t-shirt, one-coloured mat and 20 ice cubes of the same size – big ones. On a sunny day they place the two t-shirts on the mat in a sunny place and place ice cubes on them. Then they measure how fast the ice cubes melt on those t-shirts.

Students can go outside during a warm and sunny day and compare with their bare hands the temperature of various objects of different colours and materials.

Presentation
Each group presents its results (graph drawn in the worksheet or in the excel file) from the experiment with mugs and students share their results from temperature measurements from outside surfaces.

Teacher presentation – as a base for your presentation use the one that is already prepared for you (Albedo.ppt), change it according to your needs.

Discussion
Think together about the likely impact of the albedo effect on the urban climate during a hot sunny day. Where would you feel hot and where less so? Think of the typical colour of Mediterranean houses (Greece for example). Why there are some places in town and in the landscape getting hotter than others? What might be the strategy to cool urban areas down – roofs and facades painted white, lighter reflective materials for building pavements and roads than asphalt and concrete? Why is the heat island effect such a problem when we have air-conditioning and swimming pools?

LOCATION
Indoor

3| TRANSPIRATION OF PLANTS

» DISCOVER

TOOLS AND MATERIALS

Every student will need:

- 2 plastic 0.5 l cups or two 1.5/2 l plastic bottles (not coloured, must see through) or two 0.7 l glass jars
- (knife to cut the bottles)
- piece of cardboard
- scissors
- Scotch tape
- live fern twig/or other available plant twig such as pine or yew
- 0.4 l water
- access to internet
- Plant transpiration.ppt

PREPARATIONS

This activity takes place in the classroom where every student prepares their own experiment.

RESOURCES

https://unalab.eu/system/files/2020-02/unalab-technical-handbook-nature-based-solutions2020-02-17.pdf

https://www.lifetreecheck.eu/en/Databaze

Students conduct an experiment presenting the transpiration of plants using a living twig in closed plastic cups. In the remaining time they study online resources to become familiar with nature-based solutions for adaptation of urban areas.

Preparations

In case you are using plastic bottles, cut them in two pieces at 15 cm height from the bottom to make a cup and "cap" for the twig. Fill the cup with water. Then cut a circular piece of cardboard so it fits the top of the plastic cup/bottle. Make a little hole in the middle of the cardboard so the twig stem can go through to the water. When you have one cup/bottle filled with water, covered with a piece of a cardboard and fern twig stuck in it and submerged, cover the twig with a second cup/bottle and seal the joint with tape so no water can evaporate from bottom up or outside. A cardboard ring in the middle holds the twig and ensures that water does not evaporate from the surface during the experiment. Draw a line on the bottom container to indicate the current water level.

Experiment

Place the plant under a lamp or in a sunny location. Let it 'work' for a few hours or wait until the following day. The upper container will have condensed water drops on the top. Measure and record the difference.

Variation for distance learning

This experiment can be done by students themselves in an unchanged version at home.

Presentation

Students present their results. It might be particularly interesting if students use twigs of different plants.

Discussion

Are there any differences in results? What might be the reason if everybody has the same species of fern? If students use different plant species, are there any differences in results? What is the cause of the difference other than species difference?

Teacher presentation and discussion – as a base for your presentation use the one that is already prepared for you (Plant transpiration.ppt), change it according to your needs.

How do people use plant transpiration in everyday life? Imagine you are an architect and you are designing a house where you would like to create a pleasant indoor climate – might plants be useful? If yes, how – green roofs and facades, indoor green walls – plants, mosses?

Indoors – plants give moisture in the air
How would you change the landscape so it can retain more water? Diversified landscape with natural water bodies, trees, hedges, soil covered with vegetation?

What would happen if all the trees from Earth disappeared? Brainstorming – we don't know the answer, it is up to students to use their imagination.

LOCATION
Indoor / Outdoor

4| PLANT COOLING

» DISCOVER

TOOLS AND MATERIALS

Each pair of students will need:

- hand-held infrared thermometer
- cup of water
- a piece of cloth/paper napkin
- paper and pencil for noting temperature data and drawing a chart
- houseplants if the activity is conducted indoors – suitable for the whole class
- Plant cooling.ppt

PREPARATIONS

This activity is recommended for outdoors, although it is possible to conduct it the classroom.

Preparations
If delivered outdoors, students take all listed tools and materials with them; and it is necessary to ensure the presence of different types of substrates such as for example – asphalt, concrete, metal, glass, soil, sand, stones, grass, shrubs, trees or water.

In case you stay indoors for this activity, bring some houseplants into the class or check where some in the corridor near the classroom are.

During the activity students will measure the temperature difference of their skin and various outdoor surfaces – man-made surfaces, natural surfaces and plants.

Experiment
Measure and note the skin temperature of a selected student with a hand-held infrared thermometer. Moist the area with water and keep measuring. The temperature of the skin drops, but gradually begins to rise again. Measure the temperature of a houseplant – in case of indoor activity, a lawn in front of the school, shrubs, a tree crown and a park garden. Then measure the temperature of the adjacent road, buildings, cars, etc. Subtract the surface temperature of the tree from the temperature of the bare soil – you have obtained a value that quantifies the *cooling capacity of vegetation* (note: road or dark surfaces become warmer; bare soil is better as a reference).

Cooling capacity of vegetation: how much more is the vegetation able to cool down the environment compared to a bare soil; different types of vegetation have different cooling capacities.

Variation for distance learning
Students walk outside and try to notice their thermal feelings (sensing) in different locations with and without vegetation. Example of an evaluation scale: 1 – the place is too hot to stay, 2 – the place is hot, 3 – the place is warm, 4 – I feel neutral, 5 – cool, 6 – cold.

Presentation
Add the measured data of skin temperature to a chart and present to the class as well as the cooling capacity of measured vegetation.

Discussion
What have you found when measuring different surfaces? Which were warmer and which colder? What might be the reason?

Teacher presentation: as a base for your presentation use the one that is already prepared for you (Plant cooling.ppt), change it according to your needs.

After presentation discussion:
- How would you feel during a hot day in a city where there is no vegetation?
- Do you know a place without vegetation in your town? How do you feel there?
- What has a better cooling capacity – a waterbody or a forest?
- How do you cool down buildings, or open urban spaces, with the help of plants?
- What role can plants play in reducing the greenhouse effect?
- Compare two indoor environments. Where would you prefer to work? Why?

LOCATION
Outdoor

5| FIELD RESEARCH

» DISCOVER

TOOLS AND MATERIALS

Map of the area you will survey

Go outside with students to explore the closest neighbourhood of your school and search for places potentially endangered by the heat island effect. Such places become hot during sunny weather and very unpleasant to stay in.

For this research the best will be hot weather so the students "feel" such places. Look for large areas with impermeable surfaces (concrete, asphalt), places without greenery, housing areas, city centre, frequented roads, industrial areas, large fields at the boarder of the town. In what type of buildings will be the indoor environment hotter? Mark those endangered placed into your map.

Variation for distance learning
Unchanged, students do the field research alone.

LOCATION
Indoor / Outdoor

6| DESIGN OF ADAPTATION MEASURES

» CREATE

TOOLS AND MATERIALS

W6.1 student worksheet

Once students have conducted all the experiments, studied resources and felt the outdoor environment, they are ready to suggest some adaptation measures to cool down the neighbouring environment. Let them work in newly created groups, endangered places split between them, so that every group can present one solution which they share in a final discussion. As a help for designing the measures, students can use the table W6.1.

Variation for distance learning
Students work online in teams, preferably in groups of students that have researched the same area (live nearby); they can present their results to the teacher as a home work.

CHALLENGE 2 – Humid but not flooded challenge

LOCATION
Indoor / Outdoor

7| CHALLENGE PRESENTATION 2.

» QUESTION

You need to present the challenge to students:
You will try several experiments that will teach you about water retention in nature. With this knowledge we will go to explore our closest environment and try to find out what places would benefit from additional water retention or water management changes, especially during floods and storm water. It will be up to you to suggest and design concrete measures that will help those places to stay safe during these events but sufficiently saturated with water for periods of drought.

Brainstorming
Ask students to give their opinions on how it is possible to retain water in urban environments and which places would benefit from water management change? Which change and how? You can write their opinions on a blackboard or give to each student few stickers (post-its) so they first think individually and later share their opinions.

LOCATION
Indoor / Outdoor

TOOLS AND MATERIALS

Every student will need:

- soil sample
- plant pot with holes
- a piece of paper napkin
- bottom part of a plastic bottle
- 0.5 l water for every sample
- (clock for measuring time)
- (paper and pencil for drawing the chart)
- internet access
- Water retention in soil.ppt

PREPARATIONS

Indoor/outdoor

Prepare a soil sample (0.5 litre of soil) in leaky container (plant pot) and place it on the other container – plastic bottle/glass jar (with volume marks).

No special arrangement of the classroom is needed for this experiment.

RESOURCES

https://unalab.eu/system/files/2020-02/unalab-technical-handbook-nature-based-solutions2020-02-17.pdf – Recommended from Chapter 5 on page 49 – Water sensitive urban design measure

https://www.lifetreecheck.eu/en/Databaze

8| WATER RETENTION IN SOIL

» DISCOVER

Tools and materials:

- Soil sample ▸ *at least 0.5 l, preferably the students bring their own samples; this provides a diversity of results and makes the experiment more interesting. Students should note where the soil comes from, provide a brief description of the sampling spot. IMPORTANT: the samples have to be absolutely dry (collected few days before the experiment and dried on the sun or in a kiln/oven).*
- Piece of paper napkin ▸ *in the bottom of each pot to cover the holes – prevents sand or fine soil from falling through.*
- Bottom part of a plastic bottle ▸ *fitting to plant pots to retain the water that comes through the soil / a glass jar with a wide neck into which will fit the plant pot.*

Description

We will be investigating the ability of humus to absorb and retain water like a sponge. Students will test how much water different soil samples absorb. In the remaining time they study online resources and get more familiar with nature-based solutions for adaptation of urban areas.

Experiment

Pour water on the soil. Measure the amount of water flowing out at different time intervals (e.g. every minute) and plot it. The class compares all results together.

Variation for distance learning

This experiment can be done by students themselves in an unchanged version at home. Let them study the websites resources.

Presentation

Students present their results to the class and interpret the results with respect to previous knowledge.

Discussion

Were there any differences in soil samples? What causes the differences?

Teacher presentation and following discussion: as a base for your presentation use the one that is already prepared for you (Water retention in soil.ppt), change it according to your needs.

Imagine soil without humus and with humus during a summer drought. In the event of rain, in which soil type will the plants have water available longer? Which plants are more vulnerable to drought and which are more resistant? How do we ensure the highest water-holding capacity of soils?

Alternative questions:

- How would you improve the soil quality on your own garden?
  - Compost, dung, fabaceous plants.
- What measures would you implement to retain as much water as possible in the soil?
  - Mulch, less weeding, no bare soil or shortly cut grass.
- Which plants suffer from drought and which plants are more resistant to drought?
  - Wetland plants, succulent plants.

LOCATION
Indoor / Outdoor

9| WATER RETENTION IN THE LANDSCAPE

» DISCOVER

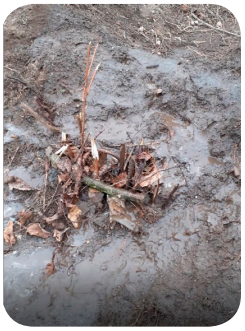
TOOLS AND MATERIALS

Every group will need:

- at least 2 l of sand/soil, preferably 10 l
- large plastic or metal container (with volume marks) – necessary only for indoor activity
- wooden sticks, skewers, stones, pebbles, leaves
- 1 l water
- watering can – one is sufficient for the whole class
- Water retention in landscape.ppt

Preparations:

This activity can take place indoors or outdoors. In the classroom we recommend to push two desks together to have enough place for the container. However, the activity will be more comfortable outdoors where no containers are needed.



In order to carry out the experiment, it will be necessary to prepare at least 2 l, preferably 10 l of sand (or soil) and containers where you will build a small hill. If you have the possibility, make the experiment outdoors where you can use some soil (a rural site after building), a sand playground or just a place with bare soil on a hill. Use the containers only when you wish to measure the amount of water which did not become absorbed; they are not something what should discourage you to make the activity.

Description:

With the aid of different natural materials students try to retain as much water as possible in a model landscape – sand/soil hill.

Experiment
You build the hill in a container so that you are throwing the sand/soil slowly and constantly in one place and the hill will rise by itself. Your goal is to ensure that when you later sprinkle the water, as much water as possible absorbs into the sand/soil and flows away as little as possible. There are some materials available such as skewers, pebbles and stones, sticks. Pour 0.5–1 l of water, depending on the height of the hill, from the watering can onto the finished hill. In the case of indoor activity, we recommend that every group has the same amount and type of soil/sand so the results are comparable. We recommend, for bigger learning impact, to sprinkle the water one after the other on the prepared hills so all the students can observe how the strategies of different groups work. We recommend it especially for outdoors when you do not use the containers and cannot measure the outflow. Measure how much water has run into the container after 5 minutes have elapsed.

Variation for distance learning
This experiment in the outdoor version can be done by students themselves in an unchanged version.

Presentation
Plot the results and present them to the class in case of using containers. If you haven´t used the containers (did not measure the outflow) the more successful groups explain their strategy of retaining water in the landscape to the others.

Discussion
Think about the importance of different techniques and their function in water retention. Some materials slow down the flow better (stones) and others allow seepage (ditches, ponds, dams). What other factors play a role in how the landscape functions? Try to include all the factors you explored in previous science lessons.

Teacher presentation and following discussion: as a base for your presentation use the one that is already prepared for you (Water retention in landscape.ppt), change it according to your needs.

Compare the current agricultural landscape with the landscape retaining water.
- What is the role of vegetation in the landscape in water retention (roots prevent water runoff, function as a dam = infiltration)?
- What functions do hedges have in the landscape? – slow down water flow, wind break, habitat and source of food for animals?

- What do you think of amelioration (drainage) of soils? Why is it done and what are its impacts today? – water drainage from wet fields so they can be "worked on" easily with mechanical techniques. Nowadays we severely miss this water which disappears through those drainage tubes and the landscape suffers from drought. Also, because it is not able to soak up the large amounts of water that comes from rainstorms. There are already people trying to bring water back to the landscape by "inactivating" those drainage tubes, recreating natural water bodies and natural waterways in the landscape. There is a will to change the style of agriculture from mechanised techniques that hardens the soil making it less permeable for water, rainwater runs away and flash floods are removing large amounts of soil (soil erosion is a serious long-term problem). Soil is a renewable source, but it takes thousands of years to create a few centimetres and we lose it in a couple of years.
- How to modify landscape so it can retain more water, lose less water through evapotranspiration? Smaller water bodies and revitalized regulated watercourses, spatially more diversified landscape.
- Compare the landscapes of the ppt: which one do you like the best and why?
- Which type of farming do you consider to be more adapted to extreme weather? What will the conditions be like in those two farms during a long period of hot and dry weather, strong winds or storm-water?

LOCATION
Outdoor

10 | FIELD RESEARCH

» DISCOVER

TOOLS AND MATERIALS

Map of the area you will survey

Go outside with students to explore the closest neighbourhood of your school and search for potentially endangered places by floods, storm-water and drought.

Look for large areas with impermeable surfaces (concrete, asphalt), places without greenery, housing areas, city centre, industrial areas, large fields uphill at the border of the town, regulated watercourses. Mark those endangered placed into your map.

Variation for distance learning
Unchanged, students do the field research alone.

LOCATION
Indoor / Outdoor

TOOLS AND MATERIALS

- W6.1 student worksheet

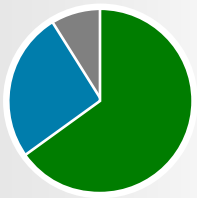
11 | DESIGN OF ADAPTATION MEASURES

» CREATE

Students that have made all experiments, studied resources and observed the outdoor environment are ready to suggest some adaptation measures to retain water and change its management in the neighbouring environment. Let them work in newly created groups, endangered places split between them so that every group can present one solution which they share in a final discussion. As a help for designing the measures, students can use the table W6.1.

Variation for distance learning
Students work online in teams, preferably in groups of students that have researched the same area (live nearby); they can present their results to the teacher as home work.

SENSATION PIE CHART:



- *good*
- *neutral*
- *hot*

12 | URBAN HEAT ISLAND (EXTENSIONS)

Have a walk in town and let students note how they feel in different places (comfortable, neutral, too hot). Visit the main square, central station, parking, place in front of supermarket, school entrance, bus/tram stop, playground, natural areas in the town, pond, river... the aim is to visit a variety of places preferably in the school neighbourhood, ideally as many places as there are students in the class. Visited places are distributed amongst students – every student picks one and students gather the data relevant for their chosen place. Once they have gathered data relevant for their place from all the students in the class, they create a "sensation" pie chart of the selected place; draw by hand or use Excel. If charts are created electronically, they can be copied into a map of the city. When made by hand, they can be stuck onto a board with a city map projected or stuck to/placed onto a paper map. Let students comment on the results. Are some of them unexpected? If there were some places where students felt uncomfortable what did they have in common? Do students find solutions how to improve such places to make them more pleasant to stay?

LITERATURE, ADDITIONAL INFORMATION

https://unalab.eu/en/documents/unalab-technical-handbook-nature-based-solutions
https://www.lifetreecheck.eu/en/Databaze
https://www.klimatickazmena.cz/cs/adaptace/

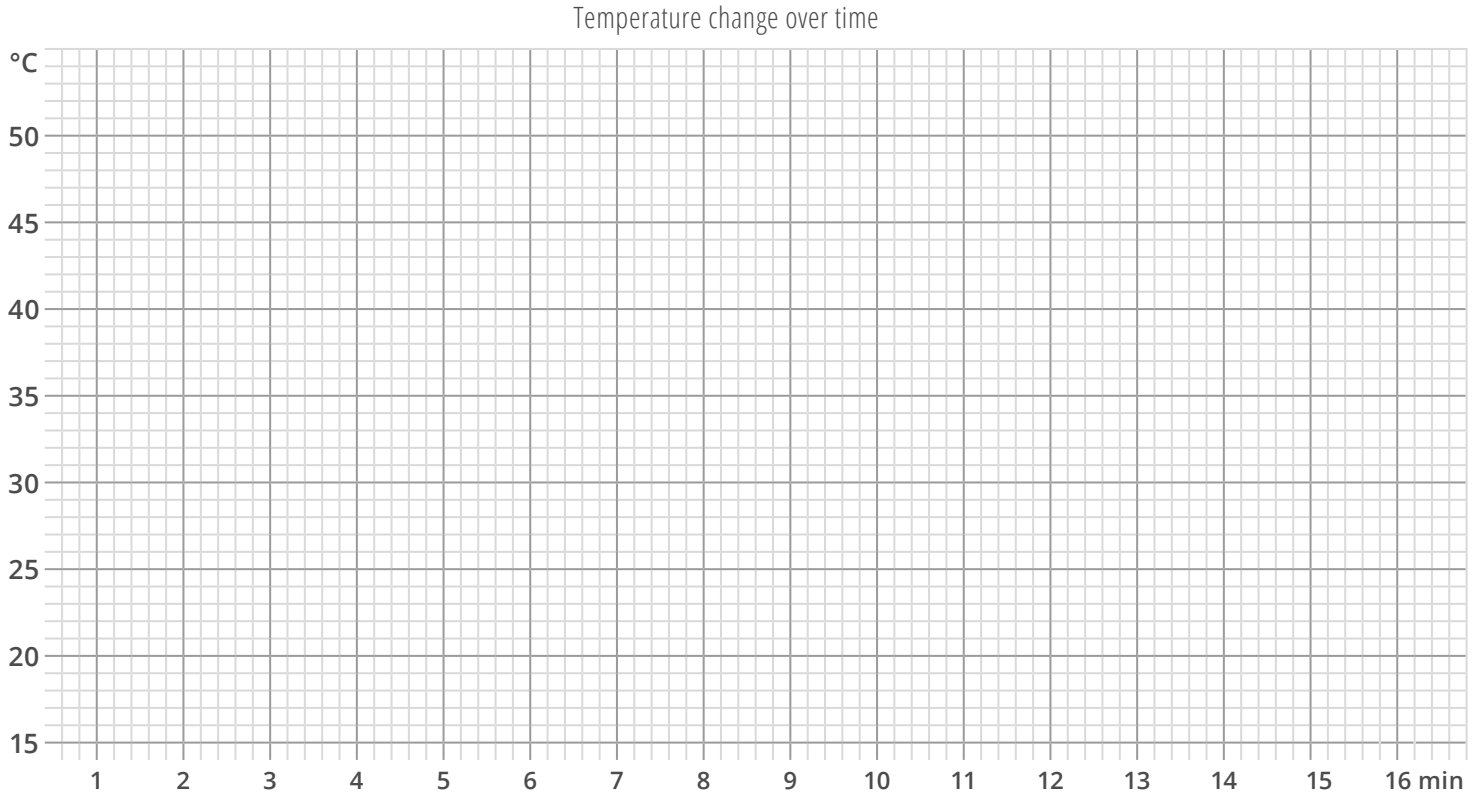
W2.1 EFFECT OF ALBEDO ON SURFACE HEATING

Table

time (min)	white cup (°C)	black cup (°C)
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

W2.2 EFFECT OF ALBEDO ON SURFACE HEATING

Graph



W6.1 DESIGN OF ADAPTATION MEASURES

Table of proposed adaptation measures

Proposed measure	Location	Rationale	Size/extent	Materials used	Desired effect