PROFF
Protection against flash floods

The series of 12 Workshops

Climate change and protection from natural disasters

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CONTENT

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Workshops overview

Any region or community can experience a range of direct and indirect impacts as a result of various disasters and shocks. Climate change affects all regions around the world and can affect our health, ability to grow food, housing, safety and work. Heavy rain and other extreme weather events are becoming more frequent. This can lead to floods and decreasing water quality, but also decreasing availability of water resources. Climate change has led to an increase in both the frequency and the intensity of extreme weather phenomena. Flash floods are a very common type of fluvial floods and are among the most fatal and detrimental natural disasters globally. The series of the workshops intend to enhance curricula with "popular" activities aiming at core concepts related to climate and flash floods.

Within this series of the workshops, the participants will have a chance to develop the skills of VET teachers on using innovative teaching methods and digital tools in the classroom. They will be able to examine the causes of flooding. They will also get an insight into the impact of climate change to natural disasters.

The workshops are devoted to the teachers from VET schools and organisations (teaching general or vocational theoretical subjects), who wish to incorporate sustainability and climate change subjects into their curricula.

The workshops will:

- raise awareness about climate change and its effects on natural disasters
- increased knowledge and skills of students on sustainability, climate change and protection from natural disasters
- increased capacity and modernisation of VET schools, on teaching climate change and sustainability issues
- improved communication and collaboration skills of students, on a transnational level

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[The series of 12 Workshops]

	Title of the workshops	Responsible partner
W1.	Climate change (causes - impacts - mitigation - adaptation)	PIT
W2.	Human activities (pollution - waste)	PIT
W3.	Geological hazards (landslides - earthquake - volcanos - soil erosion)	TUKE
W4.	Extreme weather (heat waves - wildfire - windstorms)	PIT
W5.	Hydrological risk (floods - droughts)	TUKE
W6.	Floods types (river - urban - flash)	KVK
W7.	Coastal flooding and coastal erosion	EKPA
W8.	Flood risk assessment (damages - losses)	KVK
W9.	Flood prediction (modelling - measurement - mapping)	EKPA
W10.	Flood risk management (activities before - during and after)	TUKE
W11.	Flash flood	EKPA
W12.	Flood protection measures (structural and nonstructural)	KVK

Workshop 1 Climate Change

W1.1 Instructor(s) name(s) and contact information

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W1.2 Workshop Description

This workshop will provide participants with a comprehensive overview of the causes and impacts of climate change, as well as strategies for mitigating its effects and adapting to the changing climate. Through interactive presentations, case studies, and group discussions, participants will gain a deeper understanding of the science behind climate change, including the role of greenhouse gas emissions, the impacts on ecosystems and human societies, and potential tipping points.

They will also learn about various mitigation strategies, including renewable energy, carbon capture, and sustainable agriculture, and explore the challenges and opportunities associated with their implementation. Additionally, participants will discuss adaptation measures, such as coastal protection, drought-resistant crops, and infrastructure improvements, and consider the social and ethical implications of these approaches.

Overall, this workshop will equip participants with the knowledge and tools needed to contribute to the urgent task of addressing the global climate crisis.

W1.3 Workshop goals and objectives

The goals of the workshop are to educate participants about the causes and impacts of climate change, to explore strategies for adapting to and mitigating its effects, and to encourage participants to take action to address the global climate crisis.

Specifically, the **workshop aims** to:

1. Increase awareness and understanding of the science behind climate change, including the role of human activities in driving global warming and the potential consequences for ecosystems and human societies.
2. Examine the various mitigation strategies that can be implemented to reduce greenhouse gas emissions, including the transition to renewable energy, energy efficiency, and carbon capture technologies.
3. Explore the challenges and opportunities associated with implementing mitigation strategies, including the economic, social, and political factors that influence their adoption.
4. Discuss adaptation measures that can help communities and ecosystems to cope with the impacts of climate change, including coastal protection, drought-resistant crops, and improved infrastructure.
5. Consider the social and ethical implications of different adaptation and mitigation strategies, including issues of justice and equity.
6. Encourage participants to take action on climate change, whether through individual lifestyle changes, community organizing, or advocacy efforts aimed at influencing policy at the local, national, or global level.

The **learning objectives** are designed to provide participants with a comprehensive understanding of the science behind climate change, the impacts of global warming on human societies and ecosystems, and the strategies for mitigating and adapting to its effects. Upon completion of the workshop, participants will be able to:

1. Understand the scientific concepts related to climate change, including the role of greenhouse gases, the carbon cycle, and feedback loops.
2. Recognize the different drivers of climate change, including human activities, natural factors, and socio-economic factors.
3. Identify the various impacts of climate change on ecosystems, biodiversity, agriculture, and human societies, including the effects of extreme weather events, sea-level rise, and food and water insecurity.
4. Evaluate the effectiveness of different mitigation strategies, including renewable energy, energy efficiency, and carbon capture, and understand the barriers to their adoption.
5. Understand the concept of adaptation and identify different measures that can be taken to prepare for and cope with the impacts of climate change.
6. Recognize the social and ethical dimensions of climate change, including issues of justice and equity, and the role of individual and collective action in addressing the problem.
7. Develop practical skills and knowledge to take action on climate change, including identifying opportunities for reducing emissions and building resilience in local communities.

W1.4 Pre-requisites

No prerequisites are required to participate in this workshop. It is open to all individuals regardless of prior experience or knowledge. So everyone is welcome to join this workshop without any prerequisites.

Anyway, some specific resources will be needed for the correct development of the activities:

- The ppt prepared for the theoretical explanation and the activities development
- Access to simulators such as NASA CLIMATE CHANGE MACHINE
- Internet access to use different Carbon footprint calculators

W1.5 Workshop methodology

STEAM activities can help engage participants in the science and technology behind climate change, while also incorporating elements of art, engineering, and mathematics. By participating in hands-on activities, participants can deepen their understanding of the causes and impacts of climate change and explore strategies for mitigating and adapting to its effects.

Here are the examples proposed:

Climate Data Analysis

Participants can use online tools like NASA's climate data portal to analyze temperature and precipitation data for their region over time. They can identify trends and patterns in the data and discuss the implications for local ecosystems and human societies.

Participants are organized in pairs so that they are able to use the required simulator and at the same time take note of the changes brought about by climate change.Explain how STEAM methodology and using AR will be applied in your workshop.

W1.6 Workshop Participation

Students will be asked to actively participate in a range of activities supervised by the teachers during the "Understanding Climate change" workshop. The workshop will have a mix of lectures, discussions, and hands-on activities that will help students learn more about the topic and get some experience in it.

Students will be required to attend carefully, take notes during the workshop and ask questions. The teachers will give a theoretical basis for comprehending the climate change process as well as the causes and effects of climate change on the planet. Students will engage in hands-on activities such as using NASA's online tool Climate change Machine.

Students will work in groups to develop the proposed STEAM activity. Students will observe simulations of various areas' change and will evaluate the effects of the climate in their lives.

At the conclusion of the session, students will be asked to reflect on what they have learned and apply their knowledge to real-world circumstances. They will be able to share their observations, thoughts and ideas with the group and will get feedback from the instructors and their peers.Describe how students will be expected to participate in the workshop.

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W1.7 Time outline

Activity	Time
Climate Change: basic information 1. Use the ppt to explain basic information about climate change: definition, causes, effects and Mitigation. 2. Explain how online simulators can help us to understand and see the effects of the climate change	30 minutes
Climate change Machine: Understanding the simulator 1. Join the NASA platform and familiarize with the tool in big group 2. give some example to see the scope of the tool	15 minutes
Activity 1: Climate Data Analysis 1. Develop the activity	30 minutes
Final assessment and feedback Students do the final test and the feedback of the workshops	10 minutes
Total	**90 minutes**

W1.8 Theoretical background

WHAT IS CLIMATE CHANGE?

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas.

Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures.

The main greenhouse gases that are causing climate change include carbon dioxide and methane. These come from using gasoline for driving a car or coal for heating a building, for example. Clearing land and cutting down forests can

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also release carbon dioxide. Agriculture, oil and gas operations are major sources of methane emissions. Energy, industry, transport, buildings, agriculture and land use are among the main sectors causing greenhouse gases.

Humans are responsible for global warming

Climate scientists have showed that humans are responsible for virtually all global heating over the last 200 years. Human activities like the ones mentioned above are causing greenhouse gases that are warming the world faster than at any time in at least the last two thousand years.

The average temperature of the Earth's surface is now about 1.1°C warmer than it was in the late 1800s (before the industrial revolution) and warmer than at any time in the last 100,000 years. The last decade (2011-2020) was the warmest on record, and each of the last four decades has been warmer than any previous decade since 1850.

Many people think climate change mainly means warmer temperatures. But temperature rise is only the beginning of the story. Because the Earth is a system, where everything is connected, changes in one area can influence changes in all others.

The consequences of climate change now include, among others, intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity.

People are experiencing climate change in diverse ways

Climate change can affect our health, ability to grow food, housing, safety and work. Some of us are already more vulnerable to climate impacts, such as people living in small island nations and other developing countries. Conditions like sea-level rise and saltwater intrusion have advanced to the point where whole communities have had to relocate, and protracted droughts are putting people at risk of famine. In the future, the number of “climate refugees” is expected to rise.

Every increase in global warming matters

In a series of UN reports, thousands of scientists and government reviewers agreed that limiting global temperature rise to no more than 1.5°C would help us avoid the worst climate impacts and maintain a livable climate. Yet policies currently in place point to a 2.8°C temperature rise by the end of the century.

The emissions that cause climate change come from every part of the world and affect everyone, but some countries produce much more than others.The seven biggest emitters alone (China, the United States of America, India, the European Union, Indonesia, the Russian Federation, and Brazil) accounted for about half of all global greenhouse gas emissions in 2020.

Everyone must take climate action, but people and countries creating more of the problem have a greater responsibility to act first.

We face a huge challenge but already know many solutions

Many climate change solutions can deliver economic benefits while improving our lives and protecting the environment. We also have global frameworks and agreements to guide progress, such as the Sustainable Development Goals, the UN Framework Convention on Climate Change and the Paris Agreement. Three broad categories of action are: cutting emissions, adapting to climate impacts and financing required adjustments.

Switching energy systems from fossil fuels to renewables like solar or wind will reduce the emissions driving climate change. But we have to act now. While a growing number of countries is committing to net zero emissions by 2050, emissions must be cut in half by 2030 to keep warming below 1.5°C. Achieving this means huge declines in the use of coal, oil and gas: over two-thirds of today’s proven reserves of fossil fuels need to be kept in the ground by 2050 in order to prevent catastrophic levels of climate change.

Adapting to climate consequences protects people, homes, businesses, livelihoods, infrastructure and natural ecosystems. It covers current impacts and those likely in the future. Adaptation will be required everywhere, but must be prioritized now for the most vulnerable people with the fewest resources to cope with climate hazards. The rate of return can be high. Early warning systems for disasters, for instance, save lives and property, and can deliver benefits up to 10 times the initial cost.

We can pay the bill now, or pay dearly in the future

Climate action requires significant financial investments by governments and businesses. But climate inaction is vastly more expensive. One critical step is for industrialized countries to fulfill their commitment to provide $100 billion a year to developing countries so they can adapt and move towards greener economies.

To get familiar with some of the more technical terms used in connection with climate change, consult the Climate Dictionary.

CAUSES OF CLIMATE CHANGE

Generating power

Generating electricity and heat by burning fossil fuels causes a large chunk of global emissions. Most electricity is still generated by burning coal, oil, or gas, which produces carbon dioxide and nitrous oxide – powerful greenhouse gases that blanket the Earth and trap the sun's heat. Globally, a bit more than a quarter of electricity comes from wind, solar and other renewable sources which, as opposed to fossil fuels, emit little to no greenhouse gases or pollutants into the air.

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Manufacturing goods

Manufacturing and industry produce emissions, mostly from burning fossil fuels to produce energy for making things like cement, iron, steel, electronics, plastics, clothes, and other goods. Mining and other industrial processes also release gases, as does the construction industry. Machines used in the manufacturing process often run on coal, oil, or gas; and some materials, like plastics, are made from chemicals sourced from fossil fuels. The manufacturing industry is one of the largest contributors to greenhouse gas emissions worldwide.

Cutting down forests

Cutting down forests to create farms or pastures, or for other reasons, causes emissions, since trees, when they are cut, release the carbon they have been storing. Each year approximately 12 million hectares of forest are destroyed. Since forests absorb carbon dioxide, destroying them also limits nature's ability to keep emissions out of the atmosphere. Deforestation, together with agriculture and other land use changes, is responsible for roughly a quarter of global greenhouse gas emissions.

Using transportation

Most cars, trucks, ships, and planes run on fossil fuels. That makes transportation a major contributor of greenhouse gases, especially carbon-dioxide emissions. Road vehicles account for the largest part, due to the combustion of petroleum-based products, like gasoline, in internal combustion engines. But emissions from ships and planes continue to grow. Transport accounts for nearly one quarter of global energy-related carbon-dioxide emissions. And trends point to a significant increase in energy use for transport over the coming years.

Producing food

Producing food causes emissions of carbon dioxide, methane, and other greenhouse gases in various ways, including through deforestation and clearing of land for agriculture and grazing, digestion by cows and sheep, the production and use of fertilizers and manure for growing crops, and the use of energy to run farm equipment or fishing boats, usually with fossil fuels. All this makes food production a major contributor to climate change. And greenhouse gas emissions also come from packaging and distributing food.

Powering buildings

Globally, residential and commercial buildings consume over half of all electricity. As they continue to draw on coal, oil, and natural gas for heating and cooling, they emit significant quantities of greenhouse gas emissions. Growing energy demand for heating and cooling, with rising air-conditioner ownership, as well as increased electricity consumption for lighting, appliances, and connected devices, has contributed to a rise in energy-related carbon-dioxide emissions from buildings in recent years.

Consuming too much

Your home and use of power, how you move around, what you eat and how much you throw away all contribute to greenhouse gas emissions. So does the consumption of goods such as clothing, electronics, and plastics. A large chunk of global greenhouse gas emissions are linked to private households. Our lifestyles have a profound impact on our planet. The wealthiest bear the greatest responsibility: the richest 1 percent of the global population combined account for more greenhouse gas emissions than the poorest 50 per cent.

EFFECTS OF CLIMATE CHANGE

Hotter temperatures

As greenhouse gas concentrations rise, so does the global surface temperature. The last decade, 2011-2020, is the warmest on record. Since the 1980s, each decade has been warmer than the previous one. Nearly all land areas are seeing more hot days and heat waves. Higher temperatures increase heat-related illnesses and make working outdoors more difficult. Wildfires start more easily and spread more rapidly when conditions are hotter. Temperatures in the Arctic have warmed at least twice as fast as the global average.

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More severe storms

Destructive storms have become more intense and more frequent in many regions. As temperatures rise, more moisture evaporates, which exacerbates extreme rainfall and flooding, causing more destructive storms. The frequency and extent of tropical storms is also affected by the warming ocean. Cyclones, hurricanes, and typhoons feed on warm waters at the ocean surface. Such storms often destroy homes and communities, causing deaths and huge economic losses.

Increased drought

Climate change is changing water availability, making it scarcer in more regions. Global warming exacerbates water shortages in already water-stressed regions and is leading to an increased risk of agricultural droughts affecting crops, and ecological droughts increasing the vulnerability of ecosystems. Droughts can also stir destructive sand and dust storms that can move billions of tons of sand across continents. Deserts are expanding, reducing land for growing food. Many people now face the threat of not having enough water on a regular basis.

A warming, rising ocean

The ocean soaks up most of the heat from global warming. The rate at which the ocean is warming strongly increased over the past two decades, across all depths of the ocean. As the ocean warms, its volume increases since water expands as it gets warmer. Melting ice sheets also cause sea levels to rise, threatening coastal and island communities. In addition, the ocean absorbs carbon dioxide, keeping it from the atmosphere. But more carbon dioxide makes the ocean more acidic, which endangers marine life and coral reefs.

Loss of species

Climate change poses risks to the survival of species on land and in the ocean. These risks increase as temperatures climb. Exacerbated by climate change, the world is losing species at a rate 1,000 times greater than at any other time in recorded human history. One million species are at risk of becoming extinct within the next few decades. Forest fires, extreme weather, and invasive pests

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and diseases are among many threats related to climate change. Some species will be able to relocate and survive, but others will not.

Not enough food

Changes in the climate and increases in extreme weather events are among the reasons behind a global rise in hunger and poor nutrition. Fisheries, crops, and livestock may be destroyed or become less productive. With the ocean becoming more acidic, marine resources that feed billions of people are at risk. Changes in snow and ice cover in many Arctic regions have disrupted food supplies from herding, hunting, and fishing. Heat stress can diminish water and grasslands for grazing, causing declining crop yields and affecting livestock.

More health risks

Climate change is the single biggest health threat facing humanity. Climate impacts are already harming health, through air pollution, disease, extreme weather events, forced displacement, pressures on mental health, and increased hunger and poor nutrition in places where people cannot grow or find sufficient food. Every year, environmental factors take the lives of around 13 million people. Changing weather patterns are expanding diseases, and extreme weather events increase deaths and make it difficult for health care systems to keep up.

Poverty and displacement

Climate change increases the factors that put and keep people in poverty. Floods may sweep away urban slums, destroying homes and livelihoods. Heat can make it difficult to work in outdoor jobs. Water scarcity may affect crops. Over the past decade (2010–2019), weather-related events displaced an estimated 23.1 million people on average each year, leaving many more vulnerable to poverty. Most refugees come from countries that are most vulnerable and least ready to adapt to the impacts of climate change.

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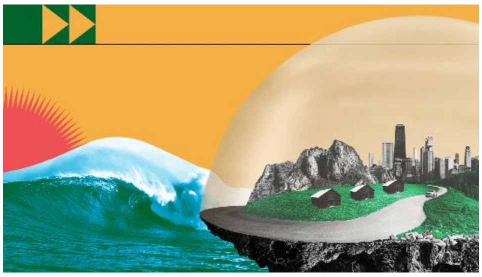
CLIMATE ADAPTATION



Climate change is here. Beyond doing everything we can to cut emissions and slow the pace of global warming, we must adapt to climate consequences so we can protect ourselves and our communities. The fallout varies depending on where you live. It might mean fires or floods, droughts, hotter or colder days or sea-level rise.

What can you do?

There are many ways to adapt to what is happening and what will happen. Individuals can take some simple measures. You can plant or preserve trees around your home, for instance, to keep temperatures cooler inside. Clearing brush might reduce fire hazards. If you own a business, start thinking about and planning around possible climate risks, such as hot days that prevent workers from doing outside tasks.

Everyone should be aware of the possibly greater potential for natural disasters where they live and what resources they have in case these happen. That might mean purchasing insurance in advance, or knowing where you can get disaster information and relief during a crisis.

Gearing up for big changes

Given the scale of climate change, and the fact that it will affect many areas of life, adaptation also needs to take place on a greater scale. Our economies and societies as a whole need to become more resilient to climate impacts. This will require large-scale efforts, many of which will be orchestrated by governments. Roads and bridges may need to be built or adapted to withstand higher temperatures and more powerful storms. Some cities on coastlines may have to establish systems to prevent flooding in streets and underground transport. Mountainous regions may have to find ways to limit landslides and overflow from melting glaciers.

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Some communities may even need to move to new locations because it will be too difficult to adapt. This is already happening in some island countries facing rising seas.

Spending now saves lives and reduces costs later on

If all of this sounds expensive, it is – but the important thing to remember is that we already know a lot about how to adapt. More is being learned every day. Further, investing in adaptation makes a lot more sense than waiting and trying to catch up later, as many countries have learned during the COVID-19 pandemic. Protecting people now saves more lives and reduces risks moving forward. It makes financial sense too because the longer we wait, the more the costs will escalate.

Think about this. Globally, a $1.8 trillion investment in early warning systems, climate-resilient infrastructure, improved agriculture, global mangrove protection along coastlines and resilient water resources could generate $7.1 trillion through a combination of avoided costs and a variety of social and environmental benefits. Universal access to early warning systems can deliver benefits up to 10 times the initial cost. And if more farms installed solar-powered irrigation, used new crop varieties, had access to weather alert systems and took other adaptive measures, the world would avoid a drop-off in global agricultural yields of up to 30 per cent by 2050. (Click here for more action facts on adaptation.)

Priority must go to the most vulnerable

While the case for adaptation is clear, some communities most vulnerable to climate change are the least able to adapt because they are poor and/or in developing countries already struggling to come up with enough resources for basics like health care and education. Estimated adaptation costs in developing countries could reach $300 billion every year by 2030. Right now, only 21 percent of climate finance provided by wealthier countries to assist developing nations goes towards adaptation and resilience, about $16.8 billion a year.

Wealthier countries are obligated to fulfill a commitment made in the Paris Agreement to provide $100 billion a year in international climate finance. They should make sure that at least half goes to adaptation. This would be an important symbol of global solidarity in the face of a challenge we can only solve if everyone in the world works together.

Watch leading Indian environmentalist Sunita Narain, who reminds us that we know how to make our communities safer, and we must act, as a matter of justice.

What have countries agreed to do?

All Parties to the Paris Agreement committed to strengthening the global response to climate change by increasing the ability of all to adapt and build resilience, and reduce vulnerability. See more details here.

At COP26, countries adopted the Glasgow Climate Pact, which calls for a doubling of finance to support developing countries in adapting to the impacts of climate change and building resilience. Glasgow also established a work programme to define a global goal on adaptation, which will identify collective needs and solutions to the climate crisis already affecting many countries.

Since 2011, under the UN Framework Convention on Climate Change, a number of countries have developed National Adaptation Plans. Check if your country has one and what it says. Or get the latest updates on how countries are elaborating plans as part of national development strategies.

W1.9 Bibliography or/and additional reading list for teachers

- EPA, United States Environmental Protection Agency (2022): "Basics of Climate Change". Retrieved from: https://www.epa.gov/climatechange-science/basics-climate-chang
- Gov.Uk (2019): "Guidance Climate change explained". Retrieved from: https://www.gov.uk/guidance/climate-change-explained

- NASA climate kids (2023): "What is Climate Change?" Retrieved from: https://climatekids.nasa.gov/climate-change-meaning/
- United Nations (2023): "What is Climate Change?". Retrieved from: https://www.un.org/en/climatechange/what-is-climate-change

W1.10 The recommended reading for VET students

It is recommended to watch these videos before the activity so that students fully understand the terms and processes explained during the workshop:

- National Geographic (2018): "National Geographic, climate causes and effects". Retrieved from: https://www.youtube.com/watch?v=G4H1N_yXBiA
- Smithsonian National Museum of Natural History (2018): "Climate clues hidden in ice". Retrieved from: https://www.youtube.com/watch?v=_8dzKWfAcwM&t=1s)
- The US Environmental protection Agency (2015) :"Greenhouse effect". Retrieved from https://www.youtube.com/watch?v=VYMjSule0Bw
- Smithsonian National Museum of Natural History" (2020): "How carbon affects everything on earth". Retrieved from: https://www.youtube.com/watch?v=lWEvBLlUa2E
- IPCC (2022) "Climate Change 2022: Impacts, adaptation and vulnerability". Retrieved from:https://www.youtube.com/watch?v=SDRxfuEvqGg

W1.11 Recommended assessment of student knowledge and skills

1. How does the greenhouse effect work?

   - Greenhouse gases directly warm oceans and cause dramatic weather.
   - Greenhouse gases reflect the sun's energy, causing it to warm the Earth.
   - Greenhouse gases absorb the sun's energy, slowing or preventing heat from escaping into space.
   - Oceans absorb greenhouse gases, which cause the Earth's temperature to rise.

2. Wasting less food is a way to reduce greenhouse gas emissions. Explain why.

   - **True**

- False

Why? More than a third of food produced globally never makes it to the table. Some of this wasted food spoils in transit, while consumers throw some of this food out. Approximately 8-10% of the world's greenhouse gas emissions relate to food waste.

3. Which activities are the largest contributors of greenhouse gases? Explain why.

- Deforestation
- **Electricity generation**
- Industry
- **Transportation**
- Landfills
- Agriculture

Why? Although all of the activities on the list cause greenhouse gas emissions, transportation and electricity generation are the biggest causes.

> In the USA, greenhouse gas emissions from electricity are falling as coal burning is slowly declining. Thus, the proportion of emissions from transportation has grown, and it accounted for 29% of total USA´s emissions in 2019, according to EPA data.

4. How has the global average temperature changed since the Industrial Revolution?

- Cooler by 0.1 degree
- The temperature has gone up and down, but remains overall the same
- Warmer by 0.1 degree
- **Warmer by more than 1 degree**
- Warmer by almost 2 degrees

5. When was the last time in Earth's history that CO2 was as high as it is now?

- This is the highest it's ever been
- CO2 was at least this high during the warm periods between the ice ages
- CO2 has not been this high for almost one million years.

- **The last time CO_2 was this high was 3 million years ago.**

6. What are the major causes of sea level rise? (there is more than one correct answer)

- Melting sea ice
- **Melting glaciers and ice sheets**
- Rivers accelerating
- Seawater expanding as it gets warmer
- Rocks and soil washing into the sea

7. What causes ocean acidification?

- **CO_2 dissolved in ocean water**
- Sunscreen in the water
- Ocean pollution
- Warm water
- Sediment stirred up by extreme storms

8. Which of the following actions could you take to help lessen the impacts of climate change?

- Sealing and insulating your windows and doors to save energy.
- Biking, walking, carpooling, and using public transportation when possible.
- Saving water by using low-flow fixtures or taking shorter showers.
- Reducing your food waste by buying only what you need, composting food scraps, and donating unused food to food banks.
- Getting involved with your community, local governments, and neighborhood councils.
- **All of the above.**

9. What is a feasible method to reduce the release of the greenhouse gases without decreasing the production of these gases?

- **Sequestering**
- Eliminating industry
- Adopting new technologies that do not use fossil fuels
- Mitigating

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10. What statement best describes what the majority of climate scientists believe about climate change?

- Climate change is irreversible, and there is no hope we can change what has already occurred
- Climate change is not really happening, and the media are to blame for getting everyone worked up
- Climate change is not inevitable, and there is still time to undo everything that has happened already
- **Climate change is inevitable, and the best we can do is to try to adapt to its effects**

To prepare self-assessment questions and specific tasks.

W1.12 Workshop feedback

To prepare a short questionnaire for students

W1.13 Summary of the Workshop

The workshop "Climate change issues" is a 90-minute workshop aiming to introduce participants (students, as well as VET teachers) basic concepts about climate change, so they have a clear idea about the process, their causes and their main effects on the planet and the society. Also, some ways to adapt and mitigate climate change are presented.

A NASA's online simulator known as Climate Change Machine is going to be used so the students can see that the change is real and how it is affecting different áreas all over the world. During the workshop, the students will have the chance to decide where they want to see the effects of climate change and also in which period of time. This way they will be motivated about the activity and also watch different scenarios to become aware of the change.

W1.14 Glossary

Adaptation Action that helps cope with the effects of climate change - for example construction of barriers to protect against rising sea levels, or conversion to crops capable of surviving high temperatures and drought.

Anthropogenic climate change Man-made climate change - climate change caused by human activity as opposed to natural processes.

Atmospheric aerosols Microscopic particles suspended in the lower atmosphere that reflect sunlight back to space. These generally have a cooling effect on the planet and can mask global warming. They play a key role in the formation of clouds, fog, precipitation and ozone depletion in the atmosphere.

Biofuel A fuel derived from renewable, biological sources, including crops such as maize and sugar cane, and some forms of waste.

Black carbon The soot that results from the incomplete combustion of fossil fuels, biofuels, and biomass (wood, animal dung, etc.). It is the most potent climate-warming aerosol. Unlike greenhouse gases, which trap infrared radiation that is already in the Earth's atmosphere, these particles absorb all wavelengths of sunlight and then re-emit this energy as infrared radiation.

Carbon capture and storage The collection and transport of concentrated carbon dioxide gas from large emission sources, such as power plants. The gases are then injected into deep underground reservoirs. Carbon capture is sometimes referred to as geological sequestration.

Carbon dioxide (CO2) Carbon dioxide is a gas in the Earth's atmosphere. It occurs naturally and is also a by-product of human activities such as burning fossil fuels. It is the principal greenhouse gas produced by human activity.

Carbon dioxide (CO2) equivalent Six greenhouse gases are limited by the Kyoto Protocol and each has a different global warming potential. The overall warming effect of this cocktail of gases is often expressed in terms of carbon dioxide equivalent - the amount of CO2 that would cause the same amount of warming.

Carbon footprint The amount of carbon emitted by an individual or organisation in a given period of time, or the amount of carbon emitted during the manufacture of a product.

Carbon neutral A process where there is no net release of CO2. For example, growing biomass takes CO2 out of the atmosphere, while burning it releases the gas again. The process would be carbon neutral if the amount taken out and the amount released were identical. A company or country can also achieve carbon neutrality by means of carbon offsetting.

Carbon sequestration The process of storing carbon dioxide. This can happen naturally, as growing trees and plants turn CO2 into biomass (wood, leaves, and so on). It can also refer to the capture and storage of CO2 produced by industry. See Carbon capture and storage.

Carbon sink Any process, activity or mechanism that removes carbon from the atmosphere. The biggest carbon sinks are the world's oceans and forests, which absorb large amounts of carbon dioxide from the Earth's atmosphere.

CFCs The short name for chlorofluorocarbons - a family of gases that have contributed to stratospheric ozone depletion, but which are also potent greenhouse gases. Emissions of CFCs around the developed world are being phased out due to an international control agreement, the 1989 Montreal Protocol.

Deforestation The permanent removal of standing forests that can lead to significant levels of carbon dioxide emissions.

Fossil fuels Natural resources, such as coal, oil and natural gas, containing hydrocarbons. These fuels are formed in the Earth over millions of years and produce carbon dioxide when burnt.

Global average temperature The mean surface temperature of the Earth measured from three main sources: satellites, monthly readings from a network of over 3,000 surface temperature observation stations and sea surface temperature measurements taken mainly from the fleet of merchant ships, naval ships and data buoys.

Global warming The steady rise in global average temperature in recent decades, which experts believe is largely caused by man-made greenhouse gas emissions. The long-term trend continues upwards, they suggest, even though the warmest year on record, according to the UK's Met Office, is 1998.

Global Warming Potential (GWP) A measure of a greenhouse gas's ability to absorb heat and warm the atmosphere over a given time period. It is measured relative to a similar mass of carbon dioxide, which has a GWP of 1.0. So, for example, methane has a GWP of 25 over 100 years, the metric used in the Kyoto Protocol. It is important to know the timescale, as gases are removed from the atmosphere at different rates.

Greenhouse gases (GHGs) Natural and industrial gases that trap heat from the Earth and warm the surface. The Kyoto Protocol restricts emissions of six greenhouse gases: natural (carbon dioxide, nitrous oxide, and methane) and industrial (perfluorocarbons, hydrofluorocarbons, and sulphur hexafluoride).

Greenhouse effect The insulating effect of certain gases in the atmosphere, which allow solar radiation to warm the earth and then prevent some of the heat from escaping. See also Natural greenhouse effect.

IPCC The Intergovernmental Panel on Climate Change is a scientific body established by the United Nations Environment Programme and the World Meteorological Organization. It reviews and assesses the most recent scientific, technical, and socio-economic work relevant to climate change, but does not carry out its own research. The IPCC was honored with the 2007 Nobel Peace Prize.

Kyoto Protocol A protocol attached to the UN Framework Convention on Climate Change, which sets legally binding commitments on greenhouse gas emissions. Industrialised countries agreed to reduce their combined emissions to 5.2% below 1990 levels during the five-year period 2008-2012. It was agreed by governments at a 1997 UN conference in Kyoto, Japan, but did not legally come into force until 2005. A different set of countries agreed a second commitment period in 2013 that will run until 2020.

Methane Methane is the second most important man-made greenhouse gas. Sources include both the natural world (wetlands, termites, wildfires) and human activity (agriculture, waste dumps, leaks from coal mining).

Mitigation Action that will reduce man-made climate change. This includes action to reduce greenhouse gas emissions or absorb greenhouse gases in the atmosphere.

Natural greenhouse effect The natural level of greenhouse gases in our atmosphere, which keeps the planet about 30C warmer than it would otherwise be - essential for life as we know it. Water vapor is the most important component of the natural greenhouse effect.

Ocean acidification The ocean absorbs approximately one-fourth of man-made CO2 from the atmosphere, which helps to reduce adverse climate change effects. However, when the CO2 dissolves in seawater, carbonic acid is formed. Carbon emissions in the industrial era have already lowered the pH of seawater by 0.1. Ocean acidification can decrease the ability of marine organisms to build their shells and skeletal structures and kill off coral reefs, with serious effects for people who rely on them as fishing grounds.

Weather The state of the atmosphere with regard to temperature, cloudiness, rainfall, wind and other meteorological conditions. It is not the same as climate, which is the average weather over a much longer period.

W1.15 The presentations

Power Point presentation is available as an annex.

Workshop 2: Human activities

W2.1 Instructor(s) name(s) and contact information

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W2.2 Workshop Description

This workshop will provide participants with a deeper understanding of the environmental impact of human activities and the types of waste and pollutants generated by various sectors such as transportation, manufacturing, and agriculture. This knowledge can help them to identify and quantify the impact

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of their actions on the environment, and to take steps towards reducing their waste and pollution footprint.

Secondly, the workshop can equip participants with practical skills and strategies for waste reduction and pollution prevention. Through case studies, interactive activities, and presentations, participants can learn about effective waste management practices, sustainable consumption habits, and the use of alternative materials and technologies.

By the end of the workshop, participants can be empowered to take concrete actions to reduce their waste and pollution footprint and contribute to a more sustainable future.

W2.3 Workshop goals and objectives

The goals of the workshop are to educate participants about the impacts of human activities on the planet and the society, and to encourage participants to take action to address the global climate crisis.

Specifically, the **workshop aims** to:

1. Increase awareness and understanding: One goal of the workshop could be to increase participants' awareness and understanding of the types of human activities that generate waste and pollutants, the impact of these activities on the environment, and the importance of reducing waste and pollution.
2. Promote behaviour change: Another goal could be to promote behavior change among participants by providing them with the knowledge and skills necessary to reduce their waste and pollution footprint. This could include practical strategies for waste reduction, sustainable consumption habits, and environmentally responsible behavior.
3. Foster community engagement: A goal of the workshop could be to foster community engagement and collaboration around waste reduction and pollution prevention. This could involve encouraging participants to share their experiences, ideas, and challenges related to waste and pollution reduction and to work together to develop solutions.
4. Empower participants to take action: The workshop could also aim to empower participants to take action by providing them with the tools, resources, and networks necessary to make a positive impact on the

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environment. This could include advocacy and activism skills, access to sustainable products and services, and connections to local environmental organizations.

The **learning objectives** are designed to provide participants with a comprehensive understanding of the impacts caused by human activity. Upon completion of the workshop, participants will be able to:

1. Understanding the sources and impacts of waste and pollutants: Participants can learn about the different sources and types of waste and pollutants generated by human activities, and the impacts they have on the environment and public health.
2. Developing knowledge of sustainable waste management practices: Participants can learn about effective waste management practices, such as reducing, reusing, and recycling, and how to apply them in their daily lives.
3. Developing knowledge of sustainable consumption habits: Participants can learn about sustainable consumption habits, such as reducing meat consumption, buying locally-sourced products, and using public transportation, and how to apply them in their daily lives.
4. Developing skills for environmental advocacy and activism: Participants can develop skills and knowledge to engage in environmental advocacy and activism, such as how to write a letter to a legislator or organize a community event to promote waste reduction and pollution prevention.

W2.4 Pre-requisites

No prerequisites are required to participate in this workshop. It is open to all individuals regardless of prior experience or knowledge. So everyone is welcome to join this workshop without any prerequisites.

Anyway, some specific resources will be needed for the correct development of the activities:

- The ppt prepared for the theoretical explanation and the activities development
- Internet access to use different Carbon footprint calculators
- Some sector-related waste materials

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W2.5 Workshop methodology

STEAM activities can help engage participants in the science and technology behind climate change, while also incorporating elements of art, engineering, and mathematics. By participating in hands-on activities, participants can deepen their understanding of the causes and impacts of climate change and explore strategies for mitigating and adapting to its effects.

Here are the examples proposed:

Carbon footprint calculators

Participants can use online calculators or worksheets to calculate their carbon footprint and identify areas where they can reduce their emissions, such as transportation, food choices, and energy use. They can discuss the impact of individual actions on global emissions and the need for collective action to address climate change

Here are some links and examples that are easy to use.

Greenly (N.D): "Start your climate journey measuring your GHG emissions". Retrieved from: **Greenly's carbon calculator**

- Cool Climate Network (N.D): "The CoolClimate Approach Retrieved from: **CoolClimate**
- Conservation International (N.D): "Conservation international protects nature like this". Retrieved from: **Conservation International**
- Carbon Footprint Ldt (2023). Retrieved from: **Carbon Footprint Ltd**
- Footprint calculator (N.D): "How big is your environmental footprint". Retrieved from: **WWF Carbon Footprint Calculator**
- UCAR- Center of Science Education (2023): "The Very Simple Climate Model Activity". Retrieved from: **Center of science education**

Climate Art

Participants can create climate-themed art using a variety of materials, such as recycled paper, clay, or paint. They can reflect on their personal connection to the environment and how art can be used to raise awareness about climate change.

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It would be enriching to use different materials of the students professional sector such as cables of electronic waste for electronic students or test tubes, glassware or bottles for chemistry related students.

Participants can create something individually with the material facilitated and then work in groups (4-5 people), trying to do something coherent but at a group level.

W2.6 Workshop Participation

Students will be asked to actively participate in a range of activities supervised by the teachers during the "Human activities" workshop. The workshop will have a mix of lectures, discussions, and hands-on activities that will help students learn more about the topic and get some experience in it.

Students will be required to attend carefully, take notes during the workshop and ask questions. The teachers will give a theoretical basis for comprehending human activities' effects as well as the pollutants and waste effects on climate change on the planet. Students will engage in hands-on activities such as using the Carbon Footprint Calculators, such as:

Students will work in groups to develop the proposed STEAM activity. Students will observe simulations of various areas' change and will evaluate the effects of the climate in their lives.

At the conclusion of the session, students will be asked to reflect on what they have learned and apply their knowledge to real-world circumstances. They will be able to share their observations, thoughts and ideas with the group and will get feedback from the instructors and their peers.

W2.7 Time outline

Activity	Time
Introduction 1. Welcome to the students and introduction to the topic and objectives of the workshop. 2. Brief overview of the workshop structure and activities.	5 minutes
Human activities: Pollution 1. Use the ppt to explain basic information about human activities and the pollution created. 2. Explain the variety of tools that can allow us to calculate the carbon footprint.	15 minutes
Activity 1: Carbon footprint calculation 1. Join the CoolClimate or WWF Calculator and explain the dashboard of the tool. 2. Each student calculates his footprint .	30 minutes
Human activities: Waste 1. Use the ppt to explain basic information about human activities and the pollution created.	10 minutes
Activity 2: Climate Art 1. Explain the activity and the resources needed. 2. Develop the activity.	30 minutes
Final assessment and feedback Students do the final test and the feedback of the workshops.	10 minutes
Total	**90 minutes**

W2.8 Theoretical background

<u>INTRODUCTION</u> - HUMAN ACTIVITIES AND THEIR IMPACT ON THE ENVIRONMENT

Human activities have a profound impact on the environment. These impacts are often negative, contributing to environmental degradation, loss of biodiversity, and climate change. Human activities that have negative

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environmental impacts include **industrial production, transportation and urbanization, and agricultural practices**.

One of the most significant impacts of human activities on the environment **is climate change**. As humans continue to burn fossil fuels and release greenhouse gases into the atmosphere, the planet's climate is changing rapidly, with severe consequences for ecosystems and human societies. Rising temperatures are causing ice caps and glaciers to melt, sea levels to rise, and oceans to become more acidic. These changes are causing severe weather events, heatwaves, and droughts, and threaten food security and human health.

See this video to understand this: It´s us

Earth: The Operators' Manual (2012): It´s us. Retrieved from: https://www.youtube.com/watch?v=-PrrTk6DqzE&t=13s

Another major impact of human activities on the environment is **pollution**. Human activities such as industrial production, transportation, and agriculture generate a range of pollutants, including greenhouse gases, nitrogen and phosphorus compounds, toxic chemicals, and plastics. These pollutants can have serious effects on human health, including respiratory and cardiovascular diseases, and can also have negative impacts on wildlife and ecosystems. Pollution can also contribute to climate change, which can have widespread impacts on natural systems, including rising sea levels, more frequent and severe weather events, and changes in precipitation patterns.

Deforestation and **habitat destruction** are also significant impacts of human activities on the environment. As humans expand their urban and agricultural footprint, forests and other natural habitats are destroyed, threatening biodiversity and the ecosystem services they provide. Deforestation also contributes to climate change, as forests act as carbon sinks, absorbing and storing carbon dioxide from the atmosphere. When forests are destroyed, this carbon is released, contributing to rising atmospheric concentrations of greenhouse gases.

In conclusion, human activities have a profound impact on the environment, with significant negative consequences for natural systems and human societies. It is important that we take steps to mitigate and reduce these

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impacts, including through sustainable production and consumption practices, waste reduction, conservation of natural habitats, and policies that promote renewable energy and low-carbon transportation. By working together to address the environmental challenges we face, we can ensure a healthy and sustainable future for ourselves and future generations.

MAIN SOURCES OF POLLUTION

Industrial activities

Industrial activities are a source of pressure on the environment, mainly in the form of emissions to the atmosphere and water ecosystems, waste generation and resource consumption.

The biggest industries in Europe are the manufacture of food, beverages and tobacco products, the manufacture of motor vehicles and other transport equipment and the manufacture of basic metals and fabricated metal, according to Eurostat. In 2021, the value of industrial products sold in the European Union amounted to €5,209 billion.

In Europe, a small number of industrial facilities are responsible for a significant share of the damage caused by air pollution, mostly emitted from within Germany, Poland, Spain and Italy.

People living in large industrial cities or regions typically experience more air pollution from industry than rural communities. For other pollutants, such as heavy metals, the pathway is more complex. It can be through inhalation, but also through the consumption of contaminated food and drink.

In addition to harming human health, industrial pollutant emissions also harm plants, animals and their habitats, altering breeding cycles and biodiversity. Pollutants can also deposit on buildings and monuments and corrode vital infrastructure, requiring costly repairs.

Heavy metals: Cadmium, mercury, lead...

Heavy metals accumulate in ecosystems and damage human health. In line with the EU's commitments under international conventions, specific legislation led to reductions in emissions of heavy metals across Europe from 1990 levels.

Between 2005 and 2020, emissions have continued to decline, with lead emissions decreasing by 49%, mercury emissions by 51% and cadmium emissions by 39% across the EU-27 Member States. In 2020, Germany, Italy and Poland contributed most to heavy metal emissions in the EU.

European Environment Agency (2022): "Heavy metal emissions in Europe". Retrieved from: **See EEA indicator in heavy metal emissions**

Phasing out ozone-depleting substances

The EU continues to actively phase out ozone-depleting substances (ODS), in line with its commitment under the Montreal Protocol.

In 2021, the EU's consumption of controlled substances amounted to 1,176 metric tonnes, up from a negative consumption level of -2,688 metric tonnes in 2020. The consumption of controlled substances, when expressed in metric tonnes, was largely driven by large quantities of carbon tetrachloride that were stockpiled before export.

European Environment Agency (2022):"Consumption of ozone-depleting substances''. Retrieved from: See our indicator in ozone depleting substances

Check industrial pollution in your country

Country profiles are available for each of the 33 EEA member countries individually as well as one profile on all 33 EEA member countries and another one for all EU-27 Member States as a group.

These profiles summarise key data related to industry: its relevance with respect to economic contributions, energy and water consumption, as well as air and water emissions and waste generation.

European Environment agency (2020): "EEA-33 – Industrial pollution profile 2020".Retrieved from: See country reports and data

Transportation

One of the main environmental impacts of transportation is air **pollution**. Vehicles emit a range of pollutants, including nitrogen oxides, particulate matter, and carbon monoxide, which can have negative impacts on human

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health, including respiratory and cardiovascular diseases. Air pollution from transportation can also contribute to climate change, as some of the pollutants emitted by vehicles, such as carbon dioxide, are greenhouse gases that trap heat in the Earth's atmosphere.

Transportation also contributes to **climate change** by emitting large quantities of greenhouse gases into the atmosphere. The burning of fossil fuels in vehicles releases carbon dioxide, methane, and other gases that trap heat in the atmosphere, leading to rising temperatures, melting ice caps and glaciers, and rising sea levels. Climate change has severe impacts on ecosystems and human societies, including more frequent and severe weather events, droughts, and food and water scarcity.

Another impact of transportation on the environment is **noise pollution**. Vehicles, particularly those that use gasoline or diesel engines, can produce significant amounts of noise, which can have negative impacts on wildlife and human health. Noise pollution can cause stress, hearing damage, and sleep disturbance, and can also interfere with communication between animals.

Finally, transportation can also contribute to **habitat destruction** and biodiversity loss. As roads and highways are built to accommodate vehicles, natural habitats such as forests, wetlands, and grasslands are often destroyed. This can result in the loss of important plant and animal species, affecting the overall health and functioning of ecosystems.

In conclusion, transportation has a significant impact on the environment, contributing to air pollution, climate change, noise pollution, and habitat destruction. It is important that we take steps to reduce the environmental impacts of transportation, including by using more sustainable modes of transportation, such as public transit, biking, or walking, and by using vehicles that have lower emissions, such as electric or hybrid vehicles. By working together to address these challenges, we can ensure a healthier and more sustainable future for ourselves and future generations.

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Agricultural practices

Agricultural practices have a significant impact on the environment. They can contribute to soil degradation, water pollution, greenhouse gas emissions, and habitat destruction.

One of the main environmental impacts of agricultural practices is **soil degradation**. Intensive farming practices, such as overuse of fertilizers, pesticides, and herbicides, can lead to soil erosion, nutrient depletion, and loss of soil fertility. This can result in decreased crop yields and reduced soil biodiversity, which can ultimately impact the overall health of ecosystems.

Agricultural practices also contribute to **water pollution**. Agricultural runoff containing fertilizers, pesticides, and other chemicals can enter waterways, contaminating them and causing eutrophication, which can lead to algal blooms, oxygen depletion, and the death of aquatic life. This can have far-reaching consequences for ecosystems and human health.

Furthermore, agricultural practices contribute to **greenhouse gas emissions**. Livestock farming, for example, is a significant contributor to greenhouse gas emissions, particularly methane, which is a potent greenhouse gas that traps heat in the atmosphere. Additionally, the use of fossil fuels for farm machinery, transportation, and production can also contribute to greenhouse gas emissions.

Finally, agricultural practices can also contribute to **habitat destruction** and biodiversity loss. As agricultural land expands, natural habitats, such as forests and wetlands, are often destroyed to make way for crops and livestock. This can result in the loss of important plant and animal species, affecting the overall health and functioning of ecosystems.

In conclusion, agricultural practices have a significant impact on the environment, contributing to soil degradation, water pollution, greenhouse gas emissions, and habitat destruction. It is important that we take steps to reduce the environmental impacts of agriculture, including by implementing sustainable farming practices, reducing the use of chemicals and fertilizers, and promoting conservation of natural habitats. By working together to address

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these challenges, we can ensure a healthier and more sustainable future for ourselves and future generations.

WASTE

Waste generation

Virtually every resident, organization, and human activity in the UE generates some type of waste. Many different types of waste are generated, including municipal solid waste, hazardous waste, industrial non-hazardous waste, agricultural and animal waste, medical waste, radioactive waste, construction and demolition debris, extraction and mining waste, oil and gas production waste, fossil fuel combustion waste, and sewage sludge (see Glossary for detailed descriptions of these wastes).

The amount of waste produced is influenced by economic activity, consumption, and population growth. Developed societies, such as the EU, generally produce large amounts of municipal solid waste (e.g., food wastes, packaged goods, disposable goods, used electronics) and commercial and industrial wastes (e.g., demolition debris, incineration residues, refinery sludges). Among industrialized nations, the EU is one of the largest generators of municipal solid waste per person on a daily basis.

Waste generation, in most cases, represents inefficient use of materials. Tracking trends in the quantity, composition, and effects of these materials provides insight into the efficiency with which the nation uses (and reuses) materials and resources and provides a means to better understand the effects of wastes on human health and ecological condition.

Waste Management

Once generated, wastes must be managed through reuse, recycling, storage, treatment, energy recovery, and/or disposal or other releases to the environment. Most municipal solid wastes and hazardous wastes are managed in land disposal units. For hazardous and industrial wastes, land disposal includes landfills, surface impoundments, land treatment, land farming, and underground injection.

Modern landfill facilities are engineered with containment systems and monitoring programs. Waste management practices prior to Resource Conservation and Recovery Act (RCRA) regulations left legacies of contaminated lands (see Contaminated Land).

Current approaches to waste management evolved primarily due to health concerns and the need to control odors. In the past, waste often was deposited on land just outside developed areas. Land disposal created problems such as groundwater contamination, methane gas formation and migration, and disease vector hazards.

Effects

The effects associated with waste vary widely and are influenced by the substances or chemicals found in waste and how they are managed. Although data do not exist to directly link trends in waste with effects on human health and the environment, the management of waste may result in waste and chemicals in waste entering the environment.

Hazardous waste, by definition, has the potential to negatively affect human health and the environment, which is why it is so strictly regulated. Hazardous wastes are either specifically listed as hazardous by EPA or a state, or exhibit one or more of the following characteristics: ignitability, corrosivity, reactivity, or toxicity. Generation and management of hazardous wastes can contaminate land, air, and water and negatively affect human health and environmental conditions.

Chemical wastes, as reported to EPA's Toxics Release Inventory (TRI), may or may not also be considered RCRA hazardous waste, but they are toxic chemicals. TRI reporting is based on how chemicals are used and not on the characteristics of the wastes generated. While the quantity of TRI chemicals released to the air, water, or land does not indicate their health risks, the information can be used as a starting point to evaluate the potential for human exposure to TRI chemicals and whether their releases may pose risks to human health and the environment.

Municipal solid waste landfills are the third-largest source of human-related methane emissions in the, accounting for approximately 16 percent of these

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emissions in 2016. Methane is one of several non-CO2 gases that contribute to global climate change. Methane gas is released as wastes decompose, and emissions are a function of the total amount and makeup of the wastes as well as management facility location, design, and practices.3 EPA is interested because gas emissions can be affected by recycling and changing product use. For example, recycling office paper or aluminum can reduce environmental effects (e.g., by reducing the need to harvest trees or mine bauxite to produce aluminum), and it will also create positive environmental benefits, such as reductions in energy consumption and greenhouse gases (e.g., emissions associated with the production of products from virgin materials).

W2.9 Bibliography or/and additional reading list for teachers

- Committee to climate and energy education (2023): "Clean network". Retrieved from: https://cleanet.org/clean/community/index.html
- European Environment Agency (2023): "Pollution". Retrieved from: https://www.eea.europa.eu/en/topics/in-depth/pollution
- National geographic (2023): "Pollution" Retrieved from: https://education.nationalgeographic.org/resource/pollution/
- United States environmental protection agency (2023): "Waste - What are the trends in wastes and their effects on human health and the environment?" Retrieved from: https://www.epa.gov/report-environment/wastes

W2.10 The recommended reading for VET students

It is recommended to watch these videos before the activity so that students fully understand the terms and processes explained during the workshop:

Exploratorium (2023): "Our changing Atmosphere". Retrieved from: https://www.exploratorium.edu/snacks/our-changing-atmosphere

Here students use data from the NOAA carbon dioxide monitoring sites, such as Mauna Loa, to graph the Keeling Curve for themselves on large sheets of paper. Each group graphs one year, and the graphs are joined at the end to reveal the overall upward trend. The explanation describes the carbon cycle and how human activities are leading to the overall trend of rising carbon dioxide.

NASA (N.D): "Deforestation of Rondonia Brazil 1975 to 2009". Retrieved from: http://svs.gsfc.nasa.gov/vis/a000000/a003600/a003637/index.html

This NASA animation on land cover changes zooms into Rondonia, Brazil. It starts with a Landsat satellite image taken in 1975 and dissolves into a second image of the same region taken in 2009 that illustrates a significant amount of land use change.

Earth observatory (N.D): "World of Change: Amazon Deforestation". Retrieved from:
http://earthobservatory.nasa.gov/Features/WorldOfChange/deforestation.php

This is a series of NASA Moderate Resolution Imaging Spectroradiometer (MODIS) satellite images taken over a 10 year period, 2000-2010, showing the extent of deforestation in the State of Rondonia in western Brazil over that period of time.

Earth: The Operators' Manual (2012): "It's us". Retrieved from: https://www.youtube.com/watch?v=-PrrTk6DqzE&t=13s

This video segment from 'Earth: The Operators' Manual' explores how we know that today's increased levels of CO2 are caused by humans burning fossil fuels and not by some natural process, such as volcanic out-gassing. Climate scientist Richard Alley provides a detailed step-by-step explanation that examines the physics and chemistry of different "flavors," or isotopes, of carbon in Earth's atmosphere.

Video length: 2:75 min

KCVS. ca (N.D): "Heating it Up: The Chemistry of the Greenhouse Effect". Retrieved from: https://www.explainingclimatechange.ca/lesson3/lesson3.html

This lesson explores the chemistry of some of the greenhouse gases that affect Earth's climate. Third in a series of 9 lessons from an online module entitled 'Visualizing and Understanding the Science of Climate Change'.

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[The series of 12 Workshops]

W2.11 Recommended assessment of student knowledge and skills

1. What is one cause of air pollution?

- Industrial activities
- Transportation
- **Both are correct**

2. Habitat destruction is causes directly by:

- Human waste
- Human pollution
- Agricultural and urban footprint

3. The main pollutants in the atmosphere are

- Greenhouse gases, nitrogen and phosphorus compounds, toxic chemicals, and plastics
- Greenhouse gases
- Heavy metals

4. The major manufacture in Europe are

- **Manufacture of food, beverages and tobacco products, the manufacture of motor vehicles and other transport equipment and the manufacture of basic metals and fabricated metal**
- Manufacture of food, beverages and tobacco products, the manufacture of airplanes and other transport equipment and the manufacture of basic chemistry products
- Manufacture of textile products, the manufacture of motor vehicles and other transport equipment and the manufacture of basic metals and fabricated metal

5. The countries emitting more pollutants, are:

- **Germany, Poland, Spain and Italy.**
- Germany, United Kingdom, Poland and France
- Germany, France, Poland and Spain

6. **Heavy metals (Cadmium, mercury, lead...) have their worst effects on:**

- **Human's health**
- Ecosystem's health

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- Waste generation

7. The only pollutant with negative increase in the last years, is:

- Carbon dioxide
- **ODSs**
- Nitrogen compounds

8. Soil degradation and water pollution, are mainly caused by:

- Transportation
- **Agricultural sector**
- Industries

9. Land disposal created problems such as:

- groundwater contamination,
- methane gas formation and migration
- **Both are correct**

10. The third-largest source of human-related methane emissions is:

- Hazardous waste
- Chemical wastes
- **Municipal solid waste landfills**

W2.12 Workshop feedback

W2.13 Summary of the Workshop

The workshop “Climate change issues” is a 90-minute workshop aiming to introduce participants (students, as well as VET teachers) basic concepts about human activities, so they have a clear idea about the variety of pollutants and types of waste produced due to that and their main effects on the planet and the society.

A Carbon footprint calculator is going to be used so the students can see that their effects on climate change are direct and real.

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Also during the workshop, the students will have the chance to get creative and make art using some resources understood as waste so they do their part in contributing to the circular economy.

W2.14 Glossary

Acidification - Change in an environment's natural chemical balance caused by an increase in the concentration of acidic elements.

Aerosol - System of solid or liquid particles suspended in a gaseous medium, having a negligible falling

Biodegradable - Capable of decomposing rapidly by microorganisms under natural conditions (aerobic and/or anaerobic). Most organic materials, such as food scraps and paper are biodegradable.

Biomass - The biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste.

CFCs (chlorofluorocarbons) - Gases formed of chlorine, fluorine and carbon whose molecules normally do not react with other substances; they are therefore used as spray can propellants because they do not alter the material being sprayed.

Diffuse pollution - Pollution from widespread activities with no one discrete source, e.g. acid rain, pesticides, urban run-off, etc.

Ecosystem - A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

Emission - Direct release of a pollutant to air or water as well as the indirect release by transfer to an off-site waste water treatment plant

European Environment Agency (EEA) - The European Environment Agency (EEA) was established by Regulation (EEC) No 1210/1990, amended by Regulation (EEC) No 933/1990, and has been operational since 1994. The EEA aims to support sustainable development and to help achieve significant and

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measurable improvement in Europe's environment through the provision of timely, targeted, relevant and reliable information to policy-making agents and the public. The Agency processes data from the member countries to knowledge at European level, and co-operates with the European environment information and observation network (Eionet) and other international partners to gather, process and distribute data and information.

Eutrophication - Excessive enrichment of waters with nutrients, and the associated adverse biological effects.

Food chain - Sequence of organisms each of which uses the next lower member of the sequence as a food source.

Fossil fuel - Coal, natural gas and petroleum products (such as oil) formed from the decayed bodies of animals and plants that died millions of years ago.

Fugitive emission - Emissions not caught by a capture system which are often due to equipment leaks, evaporative processes and windblown disturbances.

Global Warming - Changes in the surface-air temperature, referred to as the global temperature, brought about by the greenhouse effect which is induced by emission of greenhouse gases into the air.

Greenhouse gas - A gas that contributes to the natural greenhouse effect. The Kyoto Protocol covers a basket of six greenhouse gases (GHGs) produced by human activities: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. Annex I Parties' emissions of these gases taken together are to be measured in terms of carbon dioxide equivalents on the basis of the gases' global warming potential. An important natural GHG that is not covered by the protocol is water vapour.

Hazard - A threatening event, or the probability of occurrence of a potentially damaging phenomenon within a given time period and area.

Herbicide - A chemical that controls or destroys undesirable plants.

Incineration (of waste) - The process of burning solid waste under controlled conditions to reduce its weight and volume, and often to produce energy.

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Landfill - A waste disposal site for the deposit of the waste onto or into land (i.e. underground).

Municipal waste - Waste from households, as well as other waste, which, because of its nature or composition, is similar to waste from households.

Municipal waste water - Discharge of effluent from wastewater treatment plants, which receive wastewater from households, commercial establishments, and industries. Combined sewer/separate storm overflows are included in this category.

Nutrient removal - Elimination of nutrients from wastewater in order to prevent water eutrophication.

Ozone - Ozone, the triatomic form of oxygen (O3), is a gaseous atmospheric constituent. In the troposphere, it is created both naturally and by photochemical reactions involving gases resulting from human activities (photochemical smog). In high concentrations, tropospheric ozone can be harmful to a wide range of living organisms. Tropospheric ozone acts as a greenhouse gas. In the stratosphere, ozone is created by the interaction between solar ultraviolet radiation and molecular oxygen (O2). Stratospheric ozone plays a decisive role in the stratospheric radiative balance. Depletion of stratospheric ozone, due to chemical reactions that may be enhanced by climate change, results in an increased ground-level flux of ultraviolet radiation.

Ozone-depleting substance - A compound that contributes to stratospheric ozone depletion. Ozone-depleting substances (ODS) include CFCs, HCFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. ODS are generally very stable in the troposphere and only degrade under intense ultraviolet light in the stratosphere. When they break down, they release chlorine or bromine atoms, which then deplete ozone.

Pesticide - Substances or mixture thereof intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

Pollutant - Individual substance or group of substances as listed in Annex A 1 of the EPER Decision.

Recycling - (1) A resource recovery method involving the collection and treatment of a waste product for use as raw material in the manufacture of the same or a similar product. (2) the EU waste strategy distinguishes between: reuse meant as a material reuse without any structural changes in materials; recycling meant as a material recycling, only, and with a reference to structural changes in products; and recovery meant as an energy recovery only.

Reuse - Material reuse without any structural changes in materials.

Risk - Expected losses (of lives, persons injured, property damaged and economic activity disrupted) due to a particular hazard for a given area and reference period. Based on mathematical calculations, risk is the product of hazard and vulnerability.

Waste - Materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded.

Waste disposal - The collection, sorting, transport and treatment of waste as well as its storage and tipping above or underground.

W2.15 The presentations

Power Point presentation is available as an annex.

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[The series of 12 Workshops]

Workshop 3 Geological hazards

W3.1 Instructor(s) name(s) and contact information

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W3.2 Workshop Description

The Geological Hazards workshop describes in more detail the emergence of geological hazards as a consequence of climate change, which is related to the main objective of the project, to address natural disasters due to climate change. The content of the workshop is designed to provide participants with information on geological hazards that are influenced by climate change, but also those that are themselves influencing climate change. The knowledge gained will help them to navigate the consequences of geological risks and suggestions for mitigation measures.

Through an introductory presentation of the subject by the lecturer and recommended activities to be carried out in groups, participants will get an introduction to the subject and learn the principles of teamwork.

After completing Workshop3, the student will gain an overview of the interplay between climate change and geological hazards. Studying the above mentioned issues and getting a brief overview of the defined problem will be beneficial for the student personally, especially for the awareness of threats for the future, but also a motivation for his/her further professional activity in the spirit of climate change mitigation. The application of innovative STEAM and AR digital tools in the form of practical tasks and activities will help him/her to master the issue and meet the main objective of raising awareness about the environment and the effects of climate change on natural disasters.

W3.3 Workshop goals and objectives

In the formulation of the educational objectives of the Workshop3 and in the planning (selection) of activities that will ensure the fulfilment of the educational objective, the principles of Bloom's taxonometry were used. According to this taxonomy, the highest cognitive processes are creative and evaluative thinking. Knowledge is no longer the most important goal of education and training; the attitudes on which people act and the abilities that make them capable of acting in professional and everyday life are of much greater importance for their lives.

Learning goals

The general objective of the seminar is to Identify geological risks in the process of climate change. As part of the process, it is also to familiarize participants with the causes and consequences of geological risks, and to provide a basis for exploring mitigation strategies.

Specific goals of the workshop:

1. Explain the meaning of basic terms, processes and principles related to geological risks in the context of climate change (relief, seismic and volcanic activity, soil erosion, slope stability), which will be served by the lecturer's presentation, glossary and discussions on the topic during the lesson.
2. Identify locations of potential geological risks, their risk factors, while monitoring the situation in the field. Students will gain this ability after completing the chosen activities.
3. Improve the educational skills of teachers in the field of applying the STEAM methodology, which will be supported by a guide for teachers.
4. Propose measures to mitigate the consequences of climate change on the geomorphology of the terrain. The proof of this will be the completion of the activity and the discussion of the proposal.
5. Support critical thinking and the ability to assess the information obtained about real geological risks and consequences, which will enable discussions in the team and work with the lecturer.
6. Apply STEAM to the specific described situation, thereby supporting the use of innovative digital tools in teaching.
7. Visualize the geological risk in the form of an experiment that will simulate a landslide and soil erosion as part of team activities.
8. Calculate and evaluate slope stability and measures to reduce the causes of failures.
9. Increase awareness of the impact of human activity on the formation of geological risks.

Learning objectives

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The student will know / be able to after completing this workshop:

1. define the main causes and effects of geological risks,
2. categorize geological risks into groups,
3. recognize different factors of climate change, including human activities, natural factors that produce geological risks,
4. analyze situations arising from volcanic and seismic activity,
5. assess the effectiveness of measures against soil erosion and landslides,
6. choose an appropriate risk reduction measure, identify a measure for a specific situation,
7. create a simple model simulating a landslide according to STEAM principles,
8. define the main signs warning of slope instability,
9. summarize knowledge from past extreme events, discuss your experiences in the team and class, highlight successful solutions and learn from these negative events.

Closely related to the objectives are recommended activities and tasks, which are detailed in chapter W3.5 and W3.6.

W3.4 Pre-requisites

Pre-requisites for successful completion of the W3 workshop are summarized in the following points.

Basic knowledge that students should have:

1. Knowledge of the causes and consequences of climate change - it is ideal to complete workshop 1 and/or 5 before W3.
2. Knowledge of basic terminology from the field of geology and geomorphology (specific words, symbols, signs, images, ...),

Basic skills that students should have:

1. Ability to search, process and analyze information from various sources.
2. Ability to work independently as well as in a team.
3. Ability to identify, present and solve problems.
4. Ability to apply knowledge in practical situations.

Basic equipment that must be available to students:

Participants should also have access to a computer or laptop with a graphics card capable of processing 3D visualization. Internet access.

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Other necessary material and tools are listed in the experiments.

W3.5 Workshop methodology

The workshop will use a variety of approaches to teaching. The main tasks will use the STEAM method, an experiential method that is based on creating an experience, emotionally experiencing a real situation first hand. This way of learning often leads to powerful experiences and spontaneous learning. Already Cicero proclaimed that experience is the best teacher. According to research, up to 80% of our knowledge comes from our own experiences, which we then process rationally into the form of general knowledge that guides us. This knowledge is stored in long-term memory and is quickly 'recalled' when we are faced with a specific situation. Applying the STEAM method involves using science, technology, engineering, art and mathematics together to solve problems.

The essence of the STEAM method is participation in hands-on activities that will help participants to better understand the causes and consequences of geological hazards. STEAM as a tool will be used to apply theoretical knowledge and model a real situation simulating a landslide.

In selecting the tasks that will fulfil the educational objective, according to Bloom's taxonomy, the variety of tasks was taken into account so that they are formulated for different types of students' intelligence, which is closely related to certain abilities of the students. We distinguish between linguistic, spatial, logical-mathematical, motor, musical, intrapersonal and interpersonal intelligence.

The tasks are divided into two groups, compulsory and optional. The compulsory tasks are formulated in such a way that in each case the specific objective of the Workshop is fulfilled. Participants are organized in teams of 4-5 members. The educator assigns one mandatory task to each group.

Design of mandatory tasks:

1. In Iceland there is the feared volcano Katla, try to look up the available information about it, describe why it is risky and make a short presentation about it for about 5 minutes. Draw information from available websites.

http://eyjafjallajokull.cestovanie.biz/iceland-katla.htm

https://youtu.be/1A_3O8zLiEs

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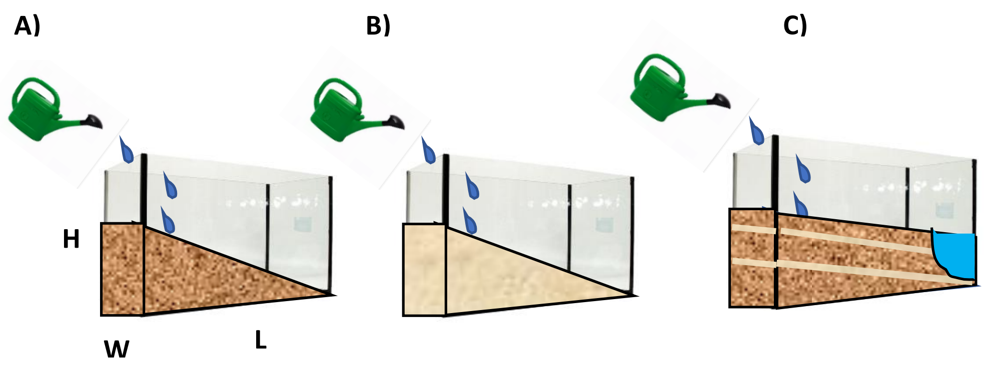
2. **Experiment 1** - A simple experiment to demonstrate the behavior of soils under the action of water - the occurrence of surface erosion and landslides.

Necessary material:

- 1 or 2 pc glass/plastic container: dimensions (LxWxH)=cca(30x20x15) cm
- soil (sand and clay) cca 4 kg
- water – 500 to 1000 ml
- small watering jug, or plastic cup

Procedure: Place the soil in the container so that it is tilted (see picture) and gradually pour water.

A) There is sand in the container,
B) There is clay in the container,
C) We will put the soil in the container in layers alternately - sand, clay, sand, clay, sand. We make a pit in the lowest place and pour water there (it represents a water flow).



Evaluation: We observe different behavior of soils:

A) Sand - absorbs water and slowly begins to slide - surface erosion occurs.
B) In case of clayey soil, water flows over the surface and erosion occurs gradually.
C) We observe that the sand gradually absorbs water (the clay remains dry), after the sand is saturated with water and the constant pouring of water (rain), the sand begins to slide slowly - a landslide occurs.

Objective: To point out the different behaviour of different soils. We usually do not have one soil under the surface of the terrain, but different layers of soils alternate. Each of them has a different ability to receive / not receive water, and

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that is why the most sensitive areas to landslides are those that are characterized by an alternation of layers (sand, clay, gravel, clay, etc.).

3. **Experiment 2** - A simple experiment to demonstrate the influence of water and different shear strength of soils for the occurrence of a landslide.

Necessary material:

- 3 ks boards with different surfaces, size, rozmer (LxWxH)=cca (30x20x2) cm

  (1 board with a smooth surface, 1 board with a slightly rough surface - e.g. with fine sandpaper on the surface, or with small drilled holes), and 1 board with a rough surface - e.g. with thicker sandpaper on the surface, or with larger drilled holes),

- container with water – 500ml,
- 2 pc plastic cup,
- pad under the board (to achieve the slope of the boards),
- cloth,
- glue or pushpins (for attaching the sandpaper to the plate).

Procedure: Place the boards with different surfaces on the table and insert a mat between the board and the table so that the board is inclined (see picture). Prepare two glasses, pour water into one and make a small hole in the bottom of the other. First, we place a glass of water on the prepared board and observe what happens.

Then put a glass with a hole in the bottom on the board, hold it with your hand and pour water into it. We drop the glass slowly and observe what happens. (Attention, if the glass will approach the end of the board, it is necessary to catch it, otherwise the water will spill on the table).

We repeat the procedure for all 3 boards and observe the differences.

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Board

Sandpaper (fine, thicker)

Any pad under the board to create an inclination of the board (e.g. hockey puck)

Placing the sandpaper on the board (with glue or pushpins around the edges)

Plasic cups

Container with water

Preparation of the experiment

Evaluation: We observe how different surfaces of the boards (representing different types of soil) affect the displacement of the cup:

A) A board with a smooth surface represents fine-grained soil (clay, silt) on a slope. If you put a cup of water without a hole in the bottom on it, nothing happens and the cup stays where you put it. If you put a cup with a hole in the bottom on it, pour water and let go of the cup, the cup will easily slide on the plate. A micro-layer of water gets between the cup and the plate, which accelerates the downward movement of the cup. (After fine-grained soil, a landslide of other soil (represented by a cup) occurs if water gets between them.

B) A board with a slightly rough surface (e.g. with fine sandpaper or with small drilled holes) represents sandy soil (sand with pores in which there is air). If you put a cup of water without a hole in the bottom on it, nothing happens and the cup stays where you put it. If you put a cup with a hole in the bottom on it, pour water and let go of the cup, the water from the cup will gradually fill the "gaps" (in the sandpaper or the holes in the plate) and the cup will

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slowly move downwards, where the water will already be in the gaps of the pad. So water gets between the "gaps", which when they are filled, the glass will slide. The gaps rebuild the pores in the soil. In the case of sandy soil, when the pores of the soil become saturated with water, another layer can slide over it (the cup with water represents the next layer of soil).

C) A board with abrasive surface (e.g. with thicker sandpaper on the surface, or with larger drilled holes) represents gravelly soil. The course of the experiment and evaluation is the same as in case B). The only difference is that when the pores are larger, the time to fill them will be longer and the shift will come later.

Objective: To point out that the landslide is affected not only by precipitation, but also by the shear strength of soils. The shear strength is primarily dependent on the friction of the soil (therefore different surfaces with different abrasiveness), if water gets into the soil, the friction of the soil and thus its shear strength will decrease. The ground thus becomes unstable and a landslide can occur. The shear strength is not the same for all soils, and therefore a different course is observed with a smooth surface, i.e. for fine-grained soil (clay, silt) and another for abrasive surfaces of coarse-grained soil (sand, gravel). It also follows from the above that coarse-grained soils (sand, gravel) have greater shear strength.

These simple experiments can help participants use the action of water to create erosion and landslides in the production of different types of landscapes. At the same time, it will help them to increase their awareness of the impact of water on the earth's surface, which is made up of different types of land and rocks.

The second group consists of the optional tasks available in the table. The tasks are designed to pursue the fulfilment of Bloom's taxonomy (fulfilment of the higher cognitive goals) - to understand the topic, to be able to apply the acquired knowledge, to analyse the problem, to use synthesis, to evaluate and to produce outputs. In selecting tasks from this category, students have a choice of preferred types/abilities. Each group of students chooses from a selection of 1-2 tasks. These tasks should lead to the fulfilment of the learning requirements. The project is aimed at VET students, which implies a certain competence resulting from the focus of the school attended by the target group. For this reason, language, mathematics and spatial tips were preferred in the design of the tasks. The result of the student's active activity is a specific product that is measurable, controllable, and facilitates feedback.

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Table of optional learning tasks:

Types of intelligence/cognitive levels		Cognitive processes			
		Apply	**Analyze**	**Evaluate**	**Create**
	Linguistic	Based on your knowledge of slope stability, explain how it is affected by climate change - prepare a short overview and discussion materials.	Design a questionnaire (6 questions) to collect information about the causes / symptoms of landslides.	Develop criteria (signs) (4 points) for assessing the situation - a landslide.	Write a short report for the newspaper using the given words - causes and consequences of landslides, climate change.
	Mathematical-logical	Calculate the degree of stability (Fs) and determine whether the slope is stable if it is given that: Fa = 1285kN, Fp = 1850kN Calculate the value of the active forces Fa if it is given that Fp = 1850kN and the degree of stability is Fs = 0.85. Indicate whether the slope is stable or unstable. Calculate the value of the pasive forces Fp if it is given that Fa = 1425kN and the degree of stability is Fs = 1,35. Indicate whether the slope is stable or unstable.	Organize information / an overview of current volcanic activity in the world into a table, graph, diagram, ...	Based on the available photos, assess which solution is the most effective for the given situation.	Design a landslide monitoring / rehabilitation procedure.
	Spatial	Draw the shear surface and explain how active and passive forces affect slope stability.	The table contains data on the number of landslides and climate change - analyze how it is related.	Process an information leaflet with 4 arguments why we should influence climate change in relation to geological risks.	Create a puzzle (7 pairs), match the cause and effect of geological hazards.

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W3.6 Workshop Participation

After completing the introductory formalities, the workshop continues with a presentation by the lecturer on the theoretical knowledge of the impact of climate change and its relation to volcanic and seismic activity. Participants will also be introduced to geotechnical hazards in the form of consequences. The most common manifestations of these, namely soil erosion and slope failures, will be highlighted. The lecture will also include guidance on how to identify their causes and suggest measures.

After a theoretical introduction, students will divide themselves into groups of up to five. If they are unable to do this on their own, a random selection will be chosen. At this stage it is advisable to inform the participants about the division of learners according to learning styles-types/cognitive abilities-knowledge.

> *Cognitive style is the way a person prefers to receive and process information. It is mostly innate, difficult to change and is only minimally tied to content. Learning style is the sum total of the practices that an individual prefers to learn at a particular time. In educational practice, learning styles according to sensory preferences are the most applied and used. Types of intelligence and derived learning styles according to H. Gardner (2011), which are applicable in dealing with W3, others are more artistic.*

Student with intelligence	He prefers	It is typical for him	It suits him
Logical-mathematical	likes counting, puzzles, chess, logic and number games	s good at mathematics, likes to solve problem situations,	learning that has logical connections, counting with numbers,
Linguistic	writing, reading, has a good memory, plays with words, solves crossword puzzles,	easy rote learning, it suits him classical teaching - memory,	rote learning, listening to the teacher and classmates, communication,
Spatial	drawing, modelling, easily navigates in maps, sketches, graphs,	careful perception, imagination,	activity, material handling, comparing,

Once the activities have been chosen, the students will have to actively participate in solving them in teams, with the teacher assisting them during the preparation. The final session will be devoted to a presentation of the activities in order to share their observations with the other workshop participants and a discussion to get feedback from the teacher and classmates.

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W3.7 Time outline

The recommended procedure for the lecturer in preparing the time-thematic plan of the workshop appears to be:

1. prepare the teaching material (topic-problem) - it is available in chapter W3.8,
2. set objectives, for the chosen issue, are provided in chapter W3.3,
3. think about the outcomes that will demonstrate the achievement of the objectives,
4. design/select from the recommended tasks the means by which the outcomes can be achieved, remembering to prepare the tools that will be needed for each task,
5. during the development of the tasks, if necessary, help, cooperate, guide, so that the development of the task achieves what we want/need,
6. allocate time for the different activities that will be used in the lesson - total time is 90 minutes.

Each teacher manages the lesson in his/her own way, but in the final analysis, he/she has to monitor the achievement of the chosen objectives!!!

Suggested timings for the recommended activities:

Activity	Time
Information about content, lesson organization, cognitive types, “rules of the game”	5 minutes
Presentation - topic, problem – theoretical background	10 -15 minutes
Dividing into groups, assigning tasks, selecting tasks.	5 minutes
Work on solving tasks	40 minutes
Presentation of tasks, discussion	15 - 20 minutes
Conclusion, summary, repetition, evaluation	5 - 10 minutes
Total	**90 minutes**

W3.8 Theoretical background

Climate is the only force on our planet that has been able to influence human history globally. A small change in climatic processes could have had a fatal impact on human societies on different continents. "Drought affected the beginnings as well as the demise of ancient Egypt. The expansiveness of the Roman Empire, in turn, was helped immeasurably by a favourable climatic period. Climate also had an impact on the development of medieval China. The emergence of global pandemics has also been linked to some historical climate changes," explains Climate Change, published by the Slovak Academy of Sciences.

Climate change in the form of warming is the most serious global problem. Students currently attending primary and secondary schools will be affected by the effects of climate change throughout their lives and will one day bring up their own children in conditions that will be even more affected by climate change.

We consider **global warming** to be the most important indicator of climate change ever. Its cause lies primarily in the concentration of greenhouse gases in the atmosphere. The more greenhouse gases there are in the atmosphere, the more the energy of the Earth's heat radiation is trapped, warming the atmosphere and returning this radiation back, increasing the ground temperature. With rapid changes, ecosystems become unstable, leading to severe storms with lots of lightning and torrential rain.

Manifestations of climate change:

Specific manifestations of climate change that can be discussed in detail in Workshop1 include floods, heat waves and droughts, melting glaciers, hurricanes, sea and ocean level rise, and air pollution.

Geological hazards

The quality of the geological and environmental environment is influenced by its characteristics and the processes that take place within it. Those that have a negative impact on the quality of the natural and environmental environment and cause extraordinary events pose a threat to man and the results of his work.

A geological hazard or geohazard is an adverse geological condition that can cause widespread damage or loss of property and life. Geohazards can be relatively small, but can also reach enormous proportions (e.g. submarine or surface landslide) and affect the local and regional socio-economic situation on a large scale (e.g. tsunami). In other cases, particularly in mountainous areas, natural processes can cause catastrophic events of a complex nature, such as the formation of a lahar, a mudflow caused by volcanism, or, for example, a debris flow triggered by an avalanche that hits a lake, with consequences that can be felt hundreds of kilometres away.

Threats (sources of negative activity) can be:

1. natural - earthquakes, volcanic activity, landslides, heavy rains, subsequent floods, erosion, etc,
2. man-made - pollution of surface and groundwater, soil erosion, disturbance of slope stability, hazardous substances deposited in landfills, etc.

Volcanoes play an important role in shaping the global climate picture, and in particular its variability. The material in the form of dust and gas particles that they eject into the upper atmosphere during their periodic activity can influence the chemical, radiative and dynamic properties of the Earth's atmosphere. How significantly a particular volcano actually affects the climate depends on several factors. In addition to the strength of the volcanic eruption itself and the geographical location of the volcano, these are primarily the chemical composition and quantity of particles produced, as well as their vertical distribution and concentration in the different layers of the atmosphere. The presence of volcanic aerosols at altitudes above 15-20 km can affect the climate for several years.

What climate effect is produced by volcanic eruptions?

After extremely powerful eruptions, dust and ash particles remain in the atmosphere for only a few weeks or even months. It is the gases that reflect or absorb some of the direct solar radiation at stratospheric altitudes and thus cool the ground layers of the troposphere sufficiently significantly. Of particular interest is sulphur dioxide (SO_2), which in the free atmosphere reacts very readily with water vapour to form tiny aerosol droplets of sulphuric acid (H_2SO_4), which very effectively prevents the short-wave and visible part of the solar radiation from reaching the Earth's surface, which is subsequently cooled. Conversely, the layer itself warms up due to the increased absorption of solar energy and thermal radiation from the Earth's surface and clouds. It follows that the more strongly sulphur gases are present in volcanic aerosols, the more significant the impact on global climate can be. The effect of volcanic eruptions is to cool the tropics significantly, with continental areas at higher latitudes temporarily warmer, especially in winter. This is the result of a stronger flow of warm ocean air along the parallels over the continents of the hemisphere.

It depends not only on the nature of the volcanic products, their chemical composition and the strength of the eruption, but also on the geographical location of the active volcano. In order for a volcano to have a major impact on global climate, it should be located in the tropics, close to the equator, where the atmospheric flow can very efficiently disperse volcanic aerosols almost uniformly across the Earth, effectively reducing the intensity of incoming solar radiation. However, if a volcano is located at higher latitudes and its eruption is not exceptionally strong, its influence is limited to the hemisphere in which it is located.

In March 2010, a massive eruption of the Eyjafjallajökull volcano in southern Iceland was recorded. As a result of its activity, airspace was closed to air traffic in most of Western and Central Europe, tens of thousands of flights were cancelled and, last but not least, there was considerable chaos at airports and large masses of disgruntled passengers waiting impatiently in departure lounges.

If you are interested, you can watch her behaviour in the attached videos.
https://www.youtube.com/watch?v=1A_3O8zLiEs
https://www.youtube.com/watch?v=PrD0PfSQJwg

The real danger is the 'glacial' volcanoes in Iceland, which is a land of volcanoes. Many of them are dangerous because they lie beneath massive glaciers, which can cause devastating floods if they erupt. Volcanologists are currently worried about the tall Katla volcano, which is covered by a vast glacier, up to 500 metres thick in places, the fourth largest in Iceland. Increased volcanic activity in Iceland and Greenland is triggered by melting ice, followed by a rise in the ground of about three centimetres or more a year, which can reduce the pressure under the glacier, provoking volcanoes to act.

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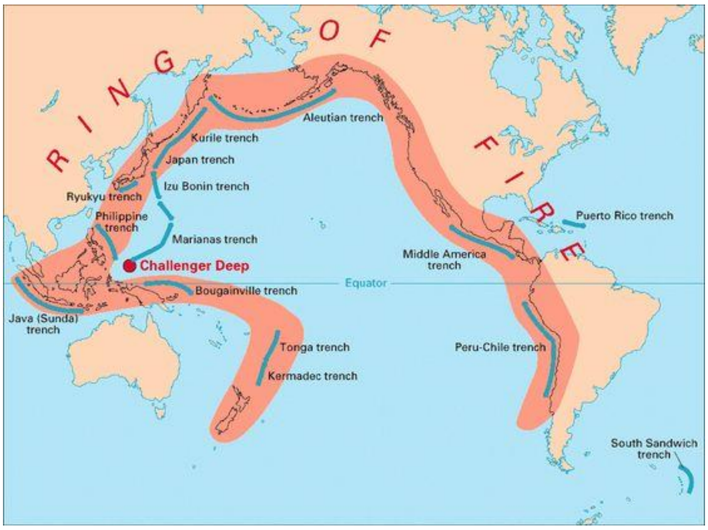
Areas of active volcanoes are not evenly distributed on the Earth's surface, but neither are they random. With some exceptions, their occurrence is confined to the contact zones of lithospheric plates. One of the most prominent such lines bounds the Pacific Ocean and is also called 'The Pacific Ring of Fire'. A large amount of earthquake and volcanic activity has been recorded in this horseshoe-shaped area, rather than a complete circle.



Earthquakes are caused by the accumulation and release of energy between plates. The Ring of Fire is the one that concentrates 75% of the active volcanoes of the entire planet. It is also where 90% of earthquakes occur. This makes the area even more dangerous because of the potential for catastrophe. This ring stretches from New Zealand to the entire west coast of South America, with a total length of more than 40,000 kilometers. This belt marks the edge where the Pacific plate coexists with other smaller tectonic plates, forming what is known as the crust. According to the US agency, which has the world's most advanced network of seismic sensors, there have been 16 earthquakes of magnitude greater than seven in the world in the past year (from 21 March 2022 to 20 March 2023), five of which were greater than 7.5. The strongest were the Turkish tremors (7.8). In total, more than 20,000 earthquakes occur annually - about 55 per day. Unless these geological processes result in human casualties, the mass media generally do not pay attention to them.

The plates are not fixed, but are constantly moving. When the plates move, they tend to separate and crash into each other. This movement and collision of the plates triggers strong geological activity at the edges of the plates. The earthquake that struck Turkey and Syria in 2023 was shallow (17 km below the surface) with a magnitude of 7.8 and had large effects over an area of 190 km by 25 km. The area around Turkey is geologically very active, with three

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boundary plates: the Arabian, the Anatolian (on which most of Turkey is located) and the African.

Visit https://www.usgs.gov/programs/VHP to keep up to date with the latest information on earthquakes and volcanic activity. There is an interactive map that allows you to determine the hazard/risk level of a given volcano by the colour of the marker. If the volcano is active at that particular time, it is possible to find out up-to-date information about it through sites such as the Alaska Volcano Observatory's (AVO) https://avo.alaska.edu/ site.

As mentioned earlier, ballast can also take the form of water. Earthquakes in the Himalayas have been linked to heavy rainfall in the region. During the monsoon season, the addition of water weight reduces microseismic activity and increases in the dry season. The extra weight causes the plates to move both horizontally and vertically.

Does the climate crisis also affect the occurrence of earthquakes and volcanic activity?

In fact, there is evidence to support the idea that weather and global warming may be influencing seismic activity beneath the Earth's surface. However, none of the evidence is concrete, so experts cannot say for sure, but there is a link. While the climate crisis does not directly cause earthquakes, it does bring more extreme weather, which in turn can trigger earthquakes. All this activity causes stress on fault lines, which is the basis for earthquakes.

In the tectonic play of irresistible forces, eventually something will loosen, break or move sideways. The earth begins to shake. How and when the pressure is released depends in part on the load the plate is carrying. The load can take different forms, such as rocks, water or ice. The effects of climate change can contribute to changes in pressure on tectonic plates. One such manifestation is a decrease in the amount of ice and an increase in the amount of water (e.g. from oceans, precipitation) as a result of warming.

Does this mean we are in for a more geologically active, hotter and meteorologically violent future? No one is saying that there will be a big increase in earthquakes and volcanic eruptions. These will, as always, depend to a large extent on local geological conditions. However, where an earthquake or volcano is prepared, climate change may provide an extra helping hand to speed up the timing of an earthquake or eruption that would have happened eventually anyway.

Can earthquakes cause catastrophic landslides?

Earthquakes are triggering factors that can activate slope movements, also referred to as "co-seismic" landslides. Ground failure is usually rapid and sudden, making such landslides dangerous to human civilization. The effects of an earthquake on a particular slope depend on the energy that arrives at that location, which is mainly influenced by the magnitude of the earthquake, the epicentral distance, the amplification of the topography, and the stratigraphy.

Conversely, can landslides trigger earthquakes?

As part of the research of the German Research Centre for Geosciences (GFZ), the earthquakes in Taiwan in 2009 were monitored and analysed, when a typhoon brought about 3 m of rainfall to the south of the country, causing exceptional landslides and erosion. These earthquakes were found to have occurred after heavy rainfall. Scientists estimate that 1.2 km3 of soil and rock material was displaced as a result of approximately 100,000 landslides. This amount is equivalent to 4 800 000 Olympic swimming pools. Seismic activity was recorded immediately after the rains and landslides and lasted for about 2.5 years.

Researchers explain this as a reaction after the removal of soil and rock material, which caused a local slight upward displacement of the Earth's crust. As a result, stress changes occurred in the crust, which may have triggered the earthquakes. The authors of the study also commented that it is not landslides that trigger these earthquakes, but the redistribution of material at the site that leads to changes in internal stresses. For this reason, it is better to characterize these phenomena as erosion-induced earthquakes.

Knowledge of these geological processes is currently limited because similar events are relatively rare and have not been widely documented. However, it appears that erosion-induced earthquakes will occur more frequently as a result of extreme weather events caused by climate change.

<u>What is a landslide and when does it happen?</u>

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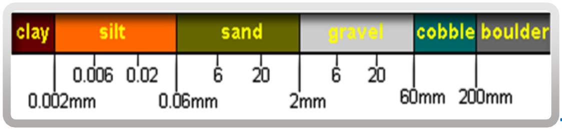
At the beginning, some general information. The earth's crust is made up of rocks. Rock is a diverse inorganic natural substance, composed of one or more minerals, which were created by natural forces without human intervention. Soils, are most often found in the surface layers of the earth's crust. Soils, from a physical point of view, they are a very complex environment, because they are created as a product of the breakdown of rocks during mechanical and chemical weathering. Moreover, the breakdown rock may remain in place, or may be subject to transport down the slopes by gravity, or by the action of water and wind.

On the basis of grain size and some properties, we divide soils into:



4. **non-cohesive** (coarse-grained) - consist of individual unrelated, non-interacting fragments - **(gravel and sand)**,

5. **cohesive** (fine-grained) - in which cohesion is caused by molecular bonds between soil particles and water **(silts and clays).**

Soils are characterized by their physical and mechanical properties.

Physical properties - characterize quantitative solid particles, water and air in the soil and their mutual ratio (grain size - derived naming, bulk and specific weight, porosity and void ratio, density of coarse-grained soils, degree of saturation, plasticity and consistency of cohesive soils).

Mechanical properties - characterize the behavior of soils in water seepage, deformation and failure (shear strength, permeability, compressibility).

Among the most important mechanical properties of soils that affect their resistance to landslides is the shear strength of soils, because soil failure occurs when it is exceeded. The shear strength of soils is not constant and depends on several influences, including changes in soil moisture.

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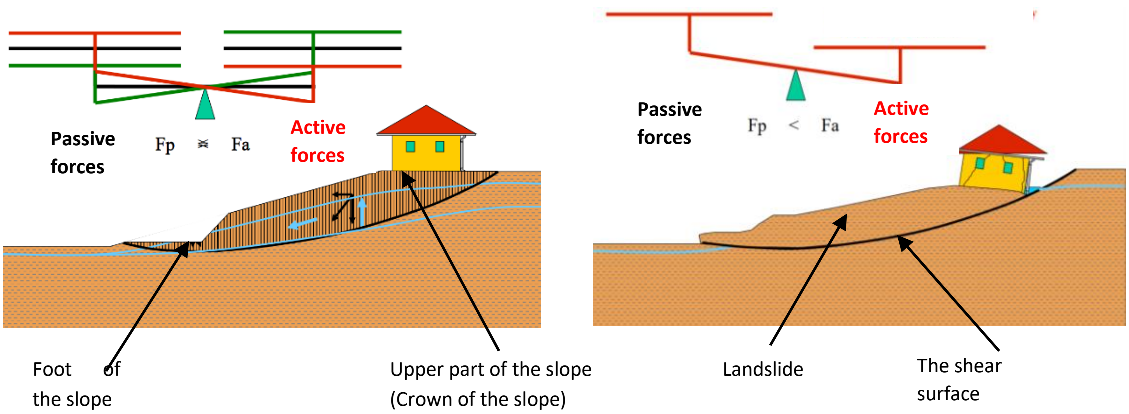
Slope stability is the ability of a natural or artificial slope to maintain a certain slope. A slope slide occurs as a result of a violation of the stability of the slope. Factors that affect slope stability include:

- natural conditions:
  - climatic conditions,
  - hydrogeological conditions,
  - geomorphological and geological conditions,
- anthropogenic impacts:
  - in terms of previous activity (territory formed by overburden, mined territories, landfills, etc.)
  - and processes currently underway - soil erosion, change of slope, slope load, offloading of the slope foot, seismic effects, increase in groundwater pressure etc.

The slope stability is usually evaluated by the degree of stability (Fs), which is given as the ratio of passive forces (Fp) to active forces (Fa) acting on the slope.

$$F_S = F_P / F_a$$



If the passive forces are greater than the active ones (i.e. the degree of stability is greater than 1), we consider the slope to be stable. If the value of the degree of stability is less than 1, we consider the slope to be unstable and a slope movement occurs, in a geodynamic process during which rock masses move along the slope due to gravity. The result of slope movements is slope deformation (slope failure). Landslide is a type of slope failure that occurs precisely as a result of the gravitational movement of rocks on one or more slip surfaces.

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Landslides caused by climatic factors

A very significant factor that affects the slope stability is primarily rainwater, which reaches the slope and causes, especially in fine-grained soils (clays, silts), an increase in the water pressure in the pores, which decreases their shear strength.

It is generally true that periodically recurring landslides occur precisely in years when there is high-intensity rainfall. A substantial part of landslides currently occurs as a result of rainfall anomalies that occur in the spring after the melting of the snow cover or after longer rains. An illustrative example of the described situation is the 2st **mandatory task (Experiment 1A) a 1B)).**

Landslides caused by changes in hydrogeological conditions

Change in hydrogeological conditions, i.e. the change in the level of groundwater is significantly influenced by climatic factors (see WP 5) The height of the groundwater level is related to the height of the water level in the surrounding watercourse.

If the water in watercourses rises due to heavy rainfall, the level of the underground water also rises and as a result not only floods but also landslides caused by floods occur.

Water that gets below the ground surface, especially in fine-grained soils (clays, silts), causes an increase in the water pressure in the pores, which decreases their shear strength. An illustrative example is experiment 1.C) offered as a mandatory task. A model example describing the effect of water on the shear strength of the soil is offered as **mandatory task 2.**

Landslides caused by the influence of geomorphological and geological factors

Geomorphological conditions characterize the shape of the terrain surface (relief), which can be created by the interaction of several factors (volcanism, tectonic movements, weathering, etc.). The shape of the relief, as well as the factors involved in its creation, influence and create a prerequisite for the occurrence of landslides.

Geological conditions characterize the territory in terms of geological structure, i.e. they describe the rocks and soils that are below the surface of the terrain, their thickness, arrangement and properties.

Information on geomorphological, geological and hydrogeological conditions, supplemented by the properties of soils and rocks, as well as the obtained of additional relevant information about a specific location, is obtained by geotechnical survey.

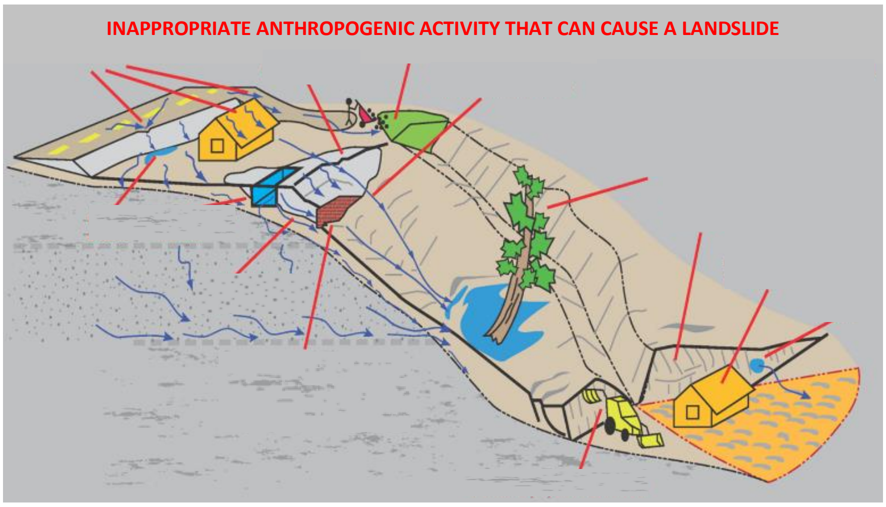
Landslides caused by anthropogenic activity

As already mentioned, precipitation and temperature changes are among the most common causes of rock weathering on slopes and slope movements (landslides).

A large part of the disturbances caused by the violation of the balance of natural and artificially created slopes and earth bodies is caused by anthropogenic activity, i.e. the activity of man.

Such activities include change of slope, slope load, offloading of the slope foot, extraction of mineral raw materials and the associated creation of mined areas, inappropriate drainage of water from constructions, etc.

The following picture shows inappropriate anthropogenic activity that can cause a landslide.



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Rehabilitation and protection of slopes

We can use two options to prevent the occurrence of landslides or to rehabilitate existing landslides. We mentioned that the stability of the slope is evaluated by the degree of stability (Fs), which is given as the ratio of passive forces (Fp) to active forces (Fa) acting on the slope.

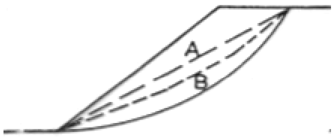
Active forces (weight of the soil on the slope, groundwater pressure, external loading of the slope, offloading of the slope foot) cause the landslide, and passive forces (cohesion of the soil, friction on the shear surface, loading of the slope foot) act against the landslide. From the above, it follows that for the rehabilitation and protection of slopes we can:

- <u>reduce active effects</u> (e.g. reduce the slope, offloading of the slope - upper part of the slope (crown of the slope), by reducing water from the slope (e.g. horizontal drilling through which water will flow from the slope, etc.),
- <u>increase passive effects</u> (e.g. by loading of the slope foot various structures - retaining wall, anchoring, pile wall, reinforcing the slope, etc.).

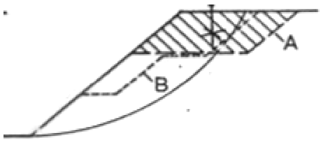
Examples are shown in the following pictures.

- Reduce active effects

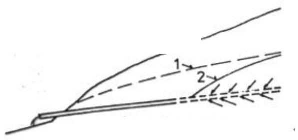
Reduce of the slope



Offloading of the slope - upper part of the slope (crown of the slope)



Horizontal drilling through which water will flow from the slope



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- Increase passive effects






"Slope deformations, especially landslides, represent such a negative phenomenon that they are ranked third in the world, after earthquakes and floods."

W3.9 Bibliography or/and additional reading list for teachers

1. Gardner H. (2003), Multiple Intelligences after 20 Years. Paper Presented at the Meeting of the American Educational Research Association, http://www.pz.harvard.edu/PIs/HG_MI_after_20_years.pdf.
2. Gardner H. (2011), Frames of Mind: The Theory of Multiple Intelligences, Basic Books, NY.
3. Causes of climate change, An official website of the European Union https://climate.ec.europa.eu/climate-change/causes-climate-change_en
4. What do volcanoes have to do with climate change, NASA, Global climate change, https://climate.nasa.gov/faq/42/what-do-volcanoes-have-to-do-with-climate-change/
5. Stephen MacAvoy (2023), To the Point: What Causes Earthquakes, and Is Climate Change Involved?, American University, Washington, DC, https://www.american.edu/cas/news/to-the-point-what-causes-earthquakes-and-is-climate-change-involved.cfm

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6. Bill McGuire (2016), How climate change triggers earthquakes, tsunamis and volcanoes, The Guardian, Climate crisis, https://www.theguardian.com/world/2016/oct/16/climate-change-triggers-earthquakes-tsunamis-volcanoes

7. Peter Sousounis (2022), Can climate change cause more earthquakes and volcanic eruptions?, PreventionWeb, the platform for disaster risk reduction and resilience https://www.preventionweb.net/news/can-climate-change-cause-more-earthquakes-and-volcanic-eruptions

W3.10 The recommended reading for VET students

1. Climat Emergency: Feedback Loops (2021) https://feedbackloopsclimate.com/wp-content/uploads/Climate-Emergency-Curriculum-Guide.pdf

2. Ring of Fire (2022), https://en.wikipedia.org/wiki/Pacific_Ring_of_Fire?oldid=251682734

3. Peter Sousounis (2021), How Climate Change May Influence Earthquakes Around the World, Verisk, https://www.preventionweb.net/news/can-climate-change-cause-more-earthquakes-and-volcanic-eruptions

4. Volcano Hazard Assessments are based on the geologic record, Volcano Hazards Program, The U.S. Geological Survey, https://www.usgs.gov/programs/VHP

5. https://www.usgs.gov/programs/VHP/volcano-hazard-assessments-are-based-geologic-record

W3.11 Recommended assessment of student knowledge and skills

Recommended questions for the final discussion:

- What sources of negative geohazard-inducing activities are you familiar with?
- How does the effect of volcanic eruptions on global climate manifest itself?

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- Why are numerous earthquakes and volcanic activity concentrated in "The Pacific Ring of Fire" region?
- Can intense precipitation activity trigger an adverse geological condition?
- Is there evidence that redistribution of rock material has activated seismic activity?
- List at least 3 ways in which the hillslope can be secured against landslide by reducing active effects.
- Give at least 3 options on how the slope can be secured against landslide by increasing passive effects.

W3.12 Workshop feedback

A form for feedback on the workshop will be distributed to all participants to assess the workshop (attachement-2).

W3.13 Summary of the Workshop

The Workshop “Geohazards” (W3) is designed as a guide for VET teachers on how to deal with the issue of geohazards in relation to climate change. W3 is designed to provide teachers with information on volcanic and seismic activity. Based on the information gathered, it provides answers to the questions of whether these geological phenomena influence climate or, conversely, whether climate change initiates them. As part of their learning, students are asked to solve one teacher-provided problem and can choose two from a list provided. During the problem solving, students work in teams of their choice, whichever is most appropriate for their learning type. The tasks are designed to introduce them to the STEAM methodology and the use of augmented reality in the classroom. Teachers will be involved in discussions during the interactive learning sessions, especially while working on the chosen tasks and during the presentation of the results of each team. The active participation of students in solving the tasks will foster their creativity, expand their knowledge of modelling real situations. The authors tried to prepare the syllabus in such a way as to give the opportunity to understand the issues in a more engaging and attractive way.

The prerequisite for easy mastery of this 90-minute workshop is completion of workshops W1 and W5. Using online information about current volcanic activity will introduce students to the scientific exploration. Simple experiments will help them to increase their awareness of the impact of water on the earth's surface, which is made up of different types of land and rocks.

W3.14 Glossary

Anthropogenic influences are the effects of human activity.

Avalanche is the rapid descent of masses (powdery, wet or slabby snow, fine- or coarse-grained firn, rocks or combinations of these down a steep, usually bare slope.

Climate (climate) is the long-term state of the atmosphere - a period of about 30 years. It is the result of the interaction of the energy of solar radiation, the relief of the earth's surface, the circulation of the atmosphere, the currents of the sea and, last but not least, the influence of human activities.

Earth's atmosphere or Earth's air is the gaseous envelope surrounding the Earth.

Earth's crust is the uppermost geological layer of the Earth. It is divided into continental and oceanic crust.

Earth's Hemisphere - the northern hemisphere refers to the northern half of the Earth from the Earth's equator, while the southern half is the half south of the equator.

Epicentre of an earthquake is the point on the Earth's surface that is formed by the perpendicular projection of the hypocentre (the focus of the earthquake) onto the Earth's surface.

Equidistant in geography means a circle on the earth's surface with the same latitude. Perpendicular to the parallels run the meridians.

Geographic location is the position of an object (point) in geographic space (on the Earth).

Geomorphological conditions - characterize the shape of the terrain surface (relief), which can be formed by the interaction of several factors

Groundwater is water that is found outside the earth's surface in the rock environment, unconsolidated sediments, weathered rock cover and soil.

Hydrogeological conditions - characterise the type and height of the water table.

Internal stress is the stress in a body that remains after a loading process even when no external force is acting on the body.

Lahar is a massive congealed mudflow that was formed by mixing volcanic material with water and then flowing down into the valley.

Landfill is a place with waste disposal facilities where waste is permanently deposited on the surface of the ground or in the ground.

Landslide is a sudden downward movement of soil.

Layers of the atmosphere - the troposphere is also referred to as the "lower atmosphere", the mesosphere and stratosphere also as the "middle atmosphere", and the thermosphere and exosphere as the "upper atmosphere". Above an altitude of 500/600 km, the thermosphere (ionosphere) gradually transitions into the exosphere, which extends towards space to an altitude of several thousand kilometres.

Lithospheric plate, tectonic plate or lithospheric plate is a massive covering of the Earth's solid crust and part of the upper mantle (lithosphere). The Earth's surface is covered by 12 larger and a number (about 40) of smaller plates (microplates).

Magnitude of an earthquake is a physical quantity (a single number) characterizing the absolute size (strength) of an earthquake.

Meteorology is the science that deals with the atmosphere. It studies its composition, structure, properties, phenomena, and the processes taking place in it, such as weather.

Seismicity is the activity of an earthquake at a particular location

Slope stability is the ability of a natural or artificial slope to maintain a certain slope.

Soil erosion - the gradual erosion of soil and the transport of soil particles to other locations, usually caused mainly by water or wind.

Solar radiation is an important meteorological variable used to determine the amount of "heat" we receive from the sun at the earth's surface. This amount of

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solar radiation varies with changes in climate and the retention of greenhouse gases.

Stratigraphy is the branch of geology that deals with layers of sediments or even layered igneous rocks.

Stratosphere is the second main layer of the Earth's atmosphere after the troposphere.

Surface water is the water of streams, creeks, rivers, ponds, lakes, reservoirs. Generally speaking, it is the water we encounter on the surface of our earth.

Thermal radiation of the Earth's surface - Radiation or radiation is a heat transfer mechanism that involves the emission and absorption of thermal radiation, the exchange of heat between the air and the Earth's surface.

Topographic amplification is the extension of geographic and geodetic methods to explore and describe the shapes, distribution, and properties of objects.

Tropical zone is typical of areas that have warm and dry weather throughout the year. Due to the low cloud cover, the surface is intensely irradiated by the sun.

Troposphere is the lowest layer of the atmosphere, and is where the most significant weather phenomena occur.

Tsunami is one or more successive waves at sea level that are generated by a strong earthquake beneath the sea surface, after an underwater landslide, or after a meteorite strikes the sea.

Volcanic aerosol is a mixture of solid or liquid particles, in suspension in a gaseous environment, that is released into the air during volcanic activity.

Volcanic eruption is a geological volcanic event during which magma is ejected onto the surface of a volcanic body.

Volcano is a geomorphological formation formed by magma rising to the Earth's surface (where it is called lava), possibly under water or ice.

W3.15 The presentations

Power Point presentation is available as an annex.

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[The series of 12 Workshops]

Workshop 4: Extreme weather

W4.1 Instructor(s) name(s) and contact information

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W4.2 Workshop Description

This workshop will provide participants with a deeper understanding of the environmental impact of human activities and the types of waste and pollutants generated by various sectors such as transportation, manufacturing, and agriculture. This knowledge can help them to identify and quantify the impact of their actions on the environment, and to take steps towards reducing their waste and pollution footprint.

Secondly, the workshop can equip participants with practical skills and strategies for waste reduction and pollution prevention. Through case studies, interactive activities, and presentations, participants can learn about effective waste management practices, sustainable consumption habits, and the use of alternative materials and technologies.

By the end of the workshop, participants can be empowered to take concrete actions to reduce their waste and pollution footprint and contribute to a more sustainable future.

W4.3 Workshop goals and objectives

The goals of the workshop are to educate participants about the science behind the extreme weather and how it affects the planet or our society. The workshop will try to encourage participants to take action to address the global climate crisis.
Specifically, the **workshop aims** to:

1. Increasing awareness and understanding of the impacts of extreme weather events: The workshop may aim to educate participants about

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the various types of extreme weather events and the potential impacts they can have on communities, infrastructure, and the environment.

2. Developing preparedness and response strategies: The workshop may focus on identifying and discussing strategies for preparing for and responding to extreme weather events, such as developing evacuation plans, enhancing communication systems, and establishing emergency shelters.
3. Identifying vulnerabilities and risk factors: The workshop may aim to identify areas and populations that are particularly vulnerable to extreme weather events, such as low-income communities or areas prone to flooding, and discuss ways to address these vulnerabilities.
4. Sharing best practices and lessons learned: The workshop may provide an opportunity for participants to share their experiences and knowledge of dealing with extreme weather events, highlighting successful strategies and lessons learned from past events.

The learning objectives are designed to provide participants with a comprehensive understanding of the extreme weather and the processes involved. Upon completion of the workshop, participants will be able to:

1. Understand the causes and impacts of extreme weather events: Participants should be able to identify the causes and drivers of extreme weather events, and understand the potential impacts on communities, infrastructure, and the environment.
2. Recognize the different types of extreme weather events: Participants should be able to identify and distinguish between different types of extreme weather events, such as heat waves, wildfires, and windstorms.
3. Identify vulnerable populations and areas: Participants should be able to identify populations and areas that are particularly vulnerable to extreme weather events, and understand the social and environmental factors that contribute to this vulnerability.
4. Develop preparedness and response strategies: Participants should be able to develop strategies for preparing for and responding to extreme weather events, such as developing evacuation plans, enhancing communication systems, and establishing emergency shelters.
5. Learn from past experiences: Participants should be able to learn from past experiences and identify best practices and lessons learned from past extreme weather events.

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W4.4 Pre-requisites

No prerequisites are required to participate in this workshop. It is open to all individuals regardless of prior experience or knowledge. So everyone is welcome to join this workshop without any prerequisites.

Anyway, some specific resources will be needed for the correct development of the activities:

- The ppt prepared for the theoretical explanation and the activities development
- Internet access to use Global Forest Watch
- Materials for the Building activity

W4.5 Workshop methodology

STEAM activities can help engage participants in the science and technology behind climate change, while also incorporating elements of art, engineering, and mathematics. By participating in hands-on activities, participants can deepen their understanding of the causes and impacts of climate change and explore strategies for mitigating and adapting to its effects.

Here are the examples proposed:

Global Forests Watch (see fire alerts)

One of the most important effects of the increase in temperature in relation to climate change is the increase in the frequency and virulence with which uncontrolled forest fires occur around the world. Many of them are intentional, others, due to the effect of high temperatures, all of them contribute negatively to the conservation of biodiversity and have a positive feedback on climate change, destabilizing even more the climate in our times.

The proposed tool gives us the possibility to see in real time which are the fire alerts that are occurring globally, as well as various other data related to forest fires that will help participants to see in a real way what is explained to them theoretically.

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The tool also allows the visualization of other types of data related to forests and deforestation that are closely related to the theme of the activity.

Students can be asked to do some research using the tool. They can monitor fires in an area, explore recent trends in fire alerts, view cumulative fire alerts, view fire alerts on the map…

Global Forest watch (2023): "Incendios - Fires". Retrieved from: **https://www.globalforestwatch.org/topics/fires/#footer**

Building activity

A simple experiment to demonstrate the effects of wind on buildings involves building a small structure out of paper or cardboard and placing it in front of a fan. By gradually increasing the speed of the fan, participants can observe how wind can cause structures to bend, break, or collapse. This can help to illustrate the importance of building design and construction in areas prone to windstorms.

To add some variables, we can simulate a dust storm: A simple experiment to demonstrate the effects of dust storms involves filling a clear container with sand or dirt and placing it in front of a fan. By gradually increasing the speed of the fan, participants can observe how wind can pick up and move large amounts of dust and debris, leading to reduced visibility and other hazards.

These simple experiments can help participants become aware of the action of wind on human infrastructure as well as the abrasive effect of sand and dust storms. It is a simple and fun way for students to unleash their creativity while raising awareness of the effects of wind on society.

W4.6 Workshop Participation

Students will be asked to actively participate in a range of activities supervised by the teachers during the "Extreme weather" workshop. The workshop will have a mix of lectures, discussions, and hands-on activities that will help students learn more about the topic and get some experience in it.

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Students will be required to attend carefully, take notes during the workshop and ask questions. The teachers will give a theoretical basis for comprehending the extreme weather events, their causes, their relation with Climate Change and other related consequences such as wildfires or windstorms. Students will engage in hands-on activities such as using Global Forests Watch tool for doing some Building activities.

Students will work in groups to develop the proposed STEAM activity. They will use the visualizer to find information related to fire alerts, and they will be asked to reflect on what they have learned and apply their knowledge to real-world circumstances.

They will also do the Building activity working in 4/5 people groups. They can be creative and build an infrastructure with the same material as their peers to create the most resistant construction to strong winds and sandstorms

At the conclusion of the session, students will be asked to reflect on what they have learned. They will be able to share their observations, thoughts and ideas with the group and will get feedback from the instructors and their peers.

W4.7 Time outline

Activity	Time
Introduction 1. Welcome to the students and introduction to the topic and objectives of the workshop. 2. Brief overview of the workshop structure and activities"	5 minutes
Extreme weather 1. Use the ppt to explain basic information about human activities and the pollution created. 2. Explain the variety of tools that can allow us to calculate the carbon footprint	20 minutes
Activity 1: Global forest watch 1. Join the Global forest watch and explain the dashboard of the tool 2. Each student find the data asked for the professor 3. Share general thoughts and ideas	30 minutes

Activity 2: Building activity 1. Explain the activity and the goals 2. Develop the activity	30 minutes
Final assessment and feedback Students do the final test and the feedback of the workshops	5 minutes
Total	**90 minutes**

W4.8 Theoretical background

EXTREME WEATHER

HEATWAVES

What is a heatwave?

A heatwave is 'an extended period of hot weather relative to the expected conditions of the area at that time of year, which may be accompanied by high humidity'. It is deemed to have occurred when temperatures exceed or meet the regional threshold temperature for three or more consecutive days in a particular location. The thresholds are based on average temperatures from 1991 to 2020 and vary by county.

What causes heat waves?

High pressure at ground level, most common in the summer months, creates heat waves. When high pressure accumulates over an area it results in the sinking of air through the atmosphere. The air compresses and heats up as it sinks. For every 100 metres the air is pushed downward, the temperature increases by 1°C.

High pressure can also result in a heat dome, exacerbating the heatwave. A heat dome is created when an area of high pressure stays over the same area for several days, trapping very warm air underneath. The dome traps air that would otherwise rise and cool before circulating back to the surface, resulting in the continual build-up of heat and reducing the chance of precipitation.

Longer periods of high pressure are more likely in summer when weather patterns are slower moving. When high-pressure systems take longer to leave

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an area, they have knock-on effects on other weather systems. Cloud cover can be reduced and winds minimised, making the air stuffier and more humid.

Cities and heat waves

Cities are usually hotter than rural environments, a phenomenon known as the 'urban heat island' effect. According to the Environmental Protection Agency, cities of more than one million people can be between 1-3 degrees Celsius warmer in the day than the countryside, and as much as 12 degrees warmer in the evening.

Many researchers believe that the biggest contributor to the urban heat island effect is the use of concrete and the replacement of natural surfaces such as grass. Natural surfaces have a larger surface albedo than unnatural materials, which means they reflect more of the sun's radiation back out to the atmosphere, reducing the heat felt near the surface of the Earth. Vegetation also releases water vapour which contributes to cooling. In contrast, man-made surfaces such as concrete are made of water-resistant and non-reflective materials which increase the absorption of solar radiation.

Other factors also contribute to the effect, including heat given off by appliances, people, vehicles and buildings. Heat tends to be stored during the day by man-made structures and released at night.

Heatwaves and climate change

Heatwaves do occur naturally in summer, but man-made climate change is increasing their length, intensity and frequency.

Climate attribution science is the process of determining the extent to which climate change has impacted a particular extreme weather event. To calculate this, scientists run simulations of today's climate and compare them to simulations of a climate without human-caused greenhouse gas emissions. Attribution science is revealing the significant impact of global warming on heatwaves.

Climate attribution researchers have calculated that the heatwaves in India and Pakistan in May 2022 were made 30 times more likely due to global warming, while the 2019 European heatwave has been deemed one hundred times more likely in France and The Netherlands. That same year, the record heat scorched the Pacific Northwest is considered to have been one hundred and fifty times more likely due to climate change.

Climate change is also impacting heatwaves in the UK. A scientific study by the Met Office into the Summer 2018 heatwave in the UK showed that the likelihood of the UK experiencing another summer as hot or hotter is 30 times more likely now than before the industrial revolution because of the higher concentration of carbon dioxide in the atmosphere (the chance is now one in ten). Heatwaves of similar intensity are projected to become even more frequent, perhaps occurring as regularly as every other year by the 2050s.

This is all taking place because the excess greenhouse gases (such as carbon dioxide), released since the Industrial Revolution, trap heat in the Earth's atmosphere. Since the late 1800s, this effect has warmed the Earth's average temperature by around 1°C. This is enough warming of the average temperature to cause a disproportionately large jump in extreme heat.

If All the Ice Melted

The following resource is purely informative. In it, you will be able to visualize the continents and the areas that will be submerged under water if the poles continue to melt at the same rate as they are melting.

National Geographic (2023): "What the World Would Look Like if All the Ice Melted". Retrieved from:
https://www.nationalgeographic.com/magazine/article/rising-seas-ice-melt-new-shoreline-maps

WILDFIRES

What Causes Wildfires?

In recent years, stories of widespread wildfires are impossible to miss in climate change-related news. Unprecedented fires have destroyed millions of hectares of land, displaced hundreds of thousands of people, and eliminated entire

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habitats across the world. We take a look at what causes wildfires and what we can do to prevent them.

Even if you don't closely follow the news, you would have heard of the unprecedented and record-breaking fires that have hit several regions across the globe in recent years. Between 2019 and 2021, immense wildfires burned down more than 1 million hectares of land in Siberia, killed nearly 3 billion animals in southeastern Australia, and took hundreds of buildings down across the US state of California.

As we reflect on the consequences of these extreme events and study solutions to mitigate their impact and prevent them from happening on such a large scale, it is important that we understand what causes wildfires in the first place.

How Do Wildfires and Bushfires Start?

The risk of a fire developing is driven by three main factors:

- Dry fuel such as leaves, grass, branches, and other organic materials
- Oxygen in the air
- Heat to ignite and burn

The latter can be a natural event, such as lightning strikes or spontaneous ignition, or it can be directly linked to human activities, such as vehicle fires, cigarette butts, or campfires. But what are the most common ignition sources of wildfires around the world?

Natural Causes of Wildfires

Lightning is the most common ignition source that causes the vast majority of wildfires. There are two types of lightning: cold and hot. Cold lightning is usually of short duration and thus rarely a cause of wildfires. The same cannot be said of hot lightning: currents in hot lightning have less voltage but occur for a longer period of time. Because of the intense heat it generates, hot lightning accounts for the majority of natural fires. While this natural phenomenon is completely unpredictable, adequate land management and landscape fire management planning can significantly diminish the intensity of wildfires and prevent unnecessary deaths and the displacement of people and animals.

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Climate change is undoubtedly the biggest trigger of extreme lightning storms. Warmer and longer summers heat up the land surface. This, coupled with an increase in carbon emissions, causes stronger updrafts that are more likely to produce more powerful and frequent lightning. A 2014 study estimates a 12% increase in the frequency of lightning strikes with every one degree Celsius increase in temperature.

The month of July 2022 was the second-hottest ever recorded in Europe (and the third hottest globally). The south of the continent has been the focus of this extreme heat, with temperatures in Greece this week expected to peak at 47 degrees Celsius (117 degrees Fahrenheit).

Greece and neighboring Turkey are in the midst of a heat wave that could be the worst in 30 years — invoking memories of the nightmarish 1987 fire season that claimed more than 1,500 victims in Greece alone.

In Turkey, almost 200 separate wildfires have raged through the country in just over a week, forcing some coastal residents and tourists to flee into the Aegean for safety.

So while arson and natural causes such as lightning are equally to blame for starting the fires, extreme heat has increased their intensity and is the real culprit for the destruction wreaked across fire-hit regions. This is why at least 55% more area has burned across Europe by August 5 than the average over the previous 12 years.

Human-Induced Wildfires

Humans are also often responsible for initiating wildfires, either accidentally or intentionally. Human-related events that can ignite fires range from open burning such as campfires, equipment failure, and the malfunction of engines to debris burning, negligent discarding of cigarettes on dry grounds as well as other intentional acts of arson. The latter accounts for one of the most common causes of wildfires.

In Europe, more than nine out of 10 fires are ignited by human activities, such as arson, disposable barbecues, electricity lines, or littered glass, according to EU data.

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The European Commission's Joint Research Centre (JRC) published the latest edition of its Annual Report on Forest Fires in Europe, the Middle East and North Africa in 2021. It concludes that last year's fire season was the second worst in the EU territory in terms of burnt area (since records began in 2006), after 2017 when over 10,000 km² had burnt. More than 5,500 km² of land burnt in 2021 – more than twice the size of Luxembourg – with over 1,000 km² burnt within protected Natura 2000 areas, the EU's reservoir of biodiversity.

The report does not yet cover this year's fires, which have been even more destructive than the ones in 2021. The annual reports allow having past fire seasons as a reference when analysing preliminary data on the impact of wildfires in the current year. With this perspective, 2022 is even worse, confirming the worrying destructive trend of recent years. In fact, an area covering 8,600 km² already burnt down this year. This is one of the largest areas scorched by wildfires in Europe by the end of October, setting new burnt records in nine EU countries. In total, since the worst fire season on records in 2017, 35,340 km² – an area larger than Belgium – have been scorched by wildfires. About 35% of the total area burnt, more than 11,600 km², was in the Natura 2000 network area.

Although the area burnt by wildfires has been remarkably extensive in 2022, the number of human casualties has been contained thanks to prevention measures implemented by EU Member States and the EU Civil Protection Mechanism (UCPM). In 2021, the EU further strengthened this mechanism's capacity by increasing aerial firefighting means to assist countries during that fire season. This support was extensively used during the fires that hit the Mediterranean region in 2021 and in 2022.

How Can We Solve the 'Wildfire Pandemic'?

While almost all human-made wildlife fires are preventable, predicting Mother Nature is more complicated. However, every action to mitigate climate change and slow down global warming can effectively reduce the risk of extreme weather events such as lightning strikes and thus decrease the chances of wildlife fires. Furthermore, steady temperatures and rainfall can drastically reduce the amount of dry vegetation.

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The EU Civil Protection Mechanism coordinates pan-European assistance and ensures that all EU Member States and participating states to the Mechanism receive timely information in times of crises and emergencies. Upon its activation by any country worldwide, the Mechanism ensures the rapid deployment of resources and personnel that are tailor-made to fit the needs of each emergency.

At the operational heart of the Mechanism lies the European Commission's Emergency Response Coordination Centre (ERCC). The Centre monitors forest fire risks and emergencies across Europe, supported by national and European monitoring services such as the European Forest Fire Information System (EFFIS).

So far this year, the ERCC has channelled assistance to Czechia, France, Germany, Portugal, Slovenia and Albania, with 33 planes and 8 helicopters deployed and over 360 firefighters on the ground.

Furthermore, the Copernicus Emergency Management Service (EMS) regularly produces satellite maps on demand to help national authorities respond to forest fires. In 2022, Copernicus has produced 322 maps of areas affected by forest fires across our globe.

As the burning of vegetation related to deforestation practices is among the leading causes of wildfires, environmental laws and policies that can provide critical backstops for ecosystems at risk, including forests, are also necessary. The Deforestation Pledge of more than 100 countries at the 26th annual United Nations Climate Change Conference (COP26) is certainly a step in the right direction. However, promising to end deforestation is not enough. Now, countries need to step up their efforts by lining up funding and quickly strengthening forest protection laws.

Keeping fires under control is crucial if we want to preserve wildlife and vegetation and avoid undesirable health problems and diseases caused by air pollution from smoke and ash.

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WINDSTORMS

What are extreme wind storms?

In this workshop we focus on windstorms which have hit Europe. Most of the damaging windstorms in Europe are extra-tropical cyclones: low pressure systems, which grow from unstable frontal waves. In order for these systems to grow, a strong north-south temperature gradient is needed, and a strongly baroclinic atmosphere. During the months October to March the North Atlantic Ocean satisfies these conditions, allowing extra-tropical cyclones to form (cyclogenesis) which travel eastwards towards Europe.

The path that these storms follow (storm track) tends to curve northwards, and so Iceland and northern European countries (e.g. the Faroe Islands, Ireland, the UK, and Scandinavia) are frequently hit. However, occasionally the storms can travel further southwards, for example when the jet stream is in a more southerly position, affecting countries such as France, Portugal, and Spain.

High winds in Europe can also be a result of convective storms (the most severe of which are tornadoes) and cyclones formed in the Mediterranean basin (medicanes). However, these types of windstorm tend to be on a smaller scale and are not well captured by re-analysis data, so are not considered in this version of the catalogue.

Windy

This is a full colour, worldwide, animated weather map using GIS interface showing current and projected wind and other weather conditions for any location in the world. Data can be viewed at different spatial scales.

Windy. com (2023). Retrieved from: ***https://www.windy.com/?43.298,-3.002,5***

Windstorms are amongst the most damaging natural hazards in Europe. Annual losses are approximately 5 €billion in the EU+UK. Although windstorm intensity and frequency is not projected to increase significantly in the EU+UK with climate change, the absolute damages caused by windstorms will increase in the future due to rising asset values as the economy grows.

Current effects of windstorms

Over the last few decades a number of damaging windstorms have had considerable human and economic impacts in Europe, ranging from human fatalities and injuries to damage to roads, power plants, the agriculture sector, forests, infrastructure, and private properties. The estimated annual losses for the EU+UK amount to 5 €billion/year (in 2015 values), or approximately 0.04% of total GDP (of 2015). The highest absolute losses are in Germany (850 €million/year), France (680 €million/year), Italy (540 €million/year) and the UK (530 €million/year). Each year approximately 16 million EU citizens are exposed to windstorms with an intensity that happens only once every 30 years in the present climate, resulting in nearly 80 deaths every year on average. While in tropical regions an increase in the frequency and intensity of cyclones has been observed in recent decades, in Europe there is no robust trend.

Wind hazard across Europe in a warmer climate

Climate model projections suggest little change in wind hazard with global warming in Europe. With 3°C warming, maximum wind speeds will reduce over 16% of the land area, increase over nearly 10%, and remain relatively stable over the rest of Europe. Regionally, Southern Europe is the region with the largest area share that will see an increase in wind extremes (17% of the area with 3°C warming). The number of windy or stormy days is not projected to change significantly across Europe. For most of Europe there is a robust tendency towards more calm days with global warming, defined as when the daily maximum wind speed is below 3.5 m/s, particularly for central, western and eastern Europe.

Economic losses from windstorms assuming no future socioeconomic change

The lack of a significant trend in wind hazard with global warming across Europe implies that human and economic impacts in the EU will remain stable, when assuming current socioeconomic conditions continue into the future. For most countries, impacts remain stable, although losses could grow to 0.08% of national GDP (of 2015) in Hungary, Romania and Slovakia with 3°C global warming, compared to 0.06% in the present climate.

Economic losses from windstorms with future socioeconomic change

The projected losses in absolute terms are larger when future socioeconomic change is accounted for, compared to when current socioeconomic conditions are assumed to continue into the future. This is because the size of the economy grows in the future, and as a result, exposed assets have higher values. The absolute annual damages due to windstorms in the EU+UK could grow from 4.6B€ in 2015 to 11.3B€ (1.5 °C) and 11.4B€ (2 °C and 3 °C) in 2100 without adaptation.

W4.9 Bibliography or/and additional reading list for teachers

- Committee to climate and energy education (2023): "Clean network". Retrieved from: https://cleanet.org/clean/community/index.html
- Global Forest watch (2023): "Incendios - Fires". Retrieved from: https://www.globalforestwatch.org/topics/fires/#footer
- National ocean service (2023). Retrieved from: http://oceanservice.noaa.gov/education/lessons/katrina.html
- Trop Icsu (2023): "Lesson Plan: Climate Change and Risks of New Pandemics". Retrieved from: https://tropicsu.org/lesson-plan-risks-of-new-pandemics/
- Windy. com (2023). Retrieved from: https://www.windy.com/?43.298,-3.002,5

W4.10 The recommended reading for VET students

It is recommended to watch these videos before the activity so that students fully understand the terms and processes explained during the workshop:

1. National Geographic: Extreme Weather - This video from National Geographic explores some of the world's most extreme weather events, including hurricanes, tornadoes, and wildfires. The video provides stunning footage and explanations of how these events occur and the impacts they can have.
2. NASA: Wildfires - This resource from NASA provides information on wildfires, including how they start and spread, and the impacts they can

have on the environment and climate. The resource includes videos, images, and interactive maps that allow students to explore the science behind wildfires.

3. PBS LearningMedia: Windstorms - This resource from PBS LearningMedia provides videos, activities, and lesson plans related to windstorms. The resource includes information on how windstorms are formed, their impacts on the environment and infrastructure, and ways to prepare for and respond to these events.
4. The Weather Channel: Extreme Weather Videos - This collection of videos from The Weather Channel includes footage of some of the most extreme weather events, including hurricanes, tornadoes, and wildfires. The videos provide stunning visuals and insights into the science of extreme weather events.

W4.11 Recommended assessment of student knowledge and skills

1. A heatwave is:

- **Deemed to have occurred when temperatures exceed or meet the regional threshold temperature for three or more consecutive days in a particular location**
- Deemed to have occurred when temperatures exceed or meet the regional threshold temperature for five or more consecutive days in a particular location
- Deemed to have occurred when temperatures exceed or meet the regional threshold temperature for one week or more consecutive days in a particular location

2. Mark the correct answer:

- **Cities are usually hotter than rural environments, a phenomenon known as the 'urban heat island' effect.**
- Rural environments are usually hotter than, a phenomenon known as the 'rural heat island' effect
- Rural environments are usually hotter than, a phenomenon known as the 'urban heat island' effect

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3. Scientists say increased frequency of heat waves is closely linked to climate change, and:

- But no higher intensity heatwaves are projected to happen regularly as every other year by the 2050s.
- **And that heat waves of intensity are projected to become even more frequent, perhaps occurring as regularly as every other year by the 2050s.**
- And that heat waves of the same intensity are projected to happen with the same frequency until now, for now on.

4. What factors are needed to start a fire?

- Dry fuel such as leaves, grass, branches, and other organic materials
- Oxygen in the air
- **Both are correct**

5. A hot lightening:

- Is usually of short duration and thus rarely a cause of wildfires.
- **Have less voltage but occur for a longer period of time**
- Generates de minority of wildfires

6. Natural wildfires

- Are completely unpredictable
- **An adequate management and landscape fire management planning can significantly diminish the intensity of wildfires**
- Wildfires al always intentioned

7. When is more likely to happen wind storms in Europe

- **During the months October to March**
- During the months March to October
- During the months of summer

8. Wind storms are more likely to happen in these countries:

- France, Spain and Germany
- **Ireland, the UK, and Scandinavia**

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- Denmark, Sweden and Norway

10. Mark the correct answer:

- **For most of Europe there is a robust tendency towards more calm days with global warming**
- For most of Europe there is a robust tendency towards more windy days with global warming
- For most of Europe there is a robust tendency towards more stormy days with global warming

W4.12 Workshop feedback

W4.13 Summary of the Workshop

The workshop "Extreme weather" is a 90-minute workshop on extreme weather, wildfires, and windstorms designed to educate participants on the impacts of these natural disasters and how to prepare for and respond to them. The workshop will cover the science behind these events and explore their impacts on the environment and society. Participants will also learn about the latest technology and tools used to monitor and predict these events.

Global Forest Watch (GFW) is a powerful tool that can be used in a workshop to provide participants with an interactive and engaging way to explore data related to forests, deforestation and wildfires. So the tool is going to be key in the learning path.

Also during the workshop, the students will have the chance to get creative and make windstorm prepared buildings, so they can notice how sensible the human infrastructure can be facing extreme events such as windstorms, sand and dust storms.

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W4.14 Glossary

Adiabatic - changes in temperature caused by the expansion (cooling) or compression (warming) of a body of air as it rises or descends in the atmosphere.

Anemometer - An instrument that measures wind speed.

Anticyclone - A large area of high pressure around which the winds blow clockwise in the Northern Hemisphere.

Arctic air - a mass of very cold, dry air that usually originates over the Arctic Ocean north of Canada and Alaska.

Barometer - An instrument for measuring atmospheric pressure

Blowing dust or sand - Small particles of dust or sand which are caused by strong winds blowing over dry ground that has little or no vegetation.

Breezy - Sustained winds of 15 to 25 mph.

Broken clouds - Clouds which cover between 6/10 and 9/10 of the sky.

Cirriform - High altitude ice clouds with a very thin wispy appearance.

Cirrocumulus - Cirrus clouds with vertical development.

Cirrostratus - Cirrus clouds with a flat sheetlike appearance.

Cirrus (CI) - High clouds, usually above 18,000 feet, composed of ice crystals.

Climate - The historical record of average daily and seasonal weather events.

Closed low (cut off low) - A low pressure centre having a closed circulation, which is used in reference to systems in the upper levels of the atmosphere. Closed lows that become cut off from the main flow pattern are called cut-off lows.

Continental air mass - A dry air mass originating over a large land area.

Convection (CNVTN) - the transfer of heat within a gas or liquid by their movement.

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Cumulonimbus - A vertically developed cumulus cloud, often capped by an anvil shaped cloud. Also called a thunderstorm cloud, it is frequently accompanied by heavy showers, lightning, thunder, and sometimes hail or gusty winds.

Cumulus cloud (CU) - A cloud in the shape of individual detached domes, with a flat base and a bulging upper portion resembling cauliflower.

Diurnal effects - A reference to an effect that has its origins due to daytime heating, such as afternoon cumulus cloud development or the formation of a lake/sea breeze. These phenomena dissipate once the sun goes down and surface heating is lost.

Dry slot - Refers to a influx of dry air (especially toward a mid-latitude cyclone)

Dust storm - an area where high surface winds have picked up loose dust, reducing visibility to less than one-half mile.

EL NINO - A major warming of the equatorial waters in the Pacific Ocean. El Nino events usually occur every 3 to 7 years, and are characterized by shifts in "normal" weather patterns.

ENSO - El Nino-Southern Oscillation.

Flash flood - A flood that occurs within a few hours (usually less than six) of heavy or excessive rainfall, dam or levee failure.

Flood - High flow, overflow or inundation of a normally dry area which causes or threatens damage.

Foehn - A warm dry wind on the lee side of a mountain range. The heating and drying are due to adiabatic compression as the wind descends downslope.

Freeze - When the temperature at or near the surface is expected to be 32 or below, during the growing season. Adjectives, such as "killing,' "severe," or "hard," are used when appropriate. A freeze may or may not be accompanied by the formation of frost.

Humidity -The amount of water vapor in the atmosphere.

Ice storm - liquid rain falling and freezing on contact with cold objects creating ice build-ups of 1/4th inch or more that can cause severe damage.

Isobar - A line of equal barometric pressure on a weather map. W1.15 The presentations

Jet stream - Strong winds concentrated within a narrow band in the atmosphere. The jet stream often "steers" surface features such as fronts and low pressure systems.

Lightning - An electrical discharge from a thunderstorm.

Macroburst - Large downbursts with 2.5 miles or larger outflow diameter and damaging winds lasting 5 to 20 minutes. Intense macrobursts could cause tornado-force damage.

Measurable- Precipitation of 0.01" or more.

Mesocyclone -The rotating updraft in a supercell thunderstorm

Meteorology - The study of the atmosphere and atmospheric phenomena.

Overcast - Sky condition when greater than 9/10 of the sky is covered

Precipitation (PCPN) -Liquid or solid water molecules that fall from the atmosphere and reach the ground.

Pressure -The force exerted by the interaction of the atmosphere and gravity. Also known as atmospheric pressure.

Radar - An instrument used to detect precipitation by measuring the strength of the electromagnetic signal reflected back. (RADAR= Radio Detection and Ranging)

Radiation fog - See ground fog.

Scattered clouds - Sky condition when between 1/10 and 5/10 are covered.

Sea surface temperature (SST) - Surface temperature data collected using IR satellite imagery, buoy and ship data.

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Severe thunderstorm - A thunderstorm with winds of 58 mph or more or hail 3/4-inch diameter or larger. Structural wind damage may imply the occurrence of a severe thunderstorm.

Smog - Pollution formed by the interaction of pollutants and sunlight (photochemical smog), usually restricting visibility, and occasionally hazardous to health.

Snow - Unless qualified by such words as " occasional" or " intermittent" , a prediction of snow indicates a steady fall of a few hours or more.

Subsidence- Sinking air that is associated with warming air and little cloud formation.

Subtropical jet - The branch of the jet stream that is found in the lower latitudes.

Thunder- The sound wave produced as a lightning stroke heats the air causing it to rapidly expand.

Thunderstorm (TS, TSRA, TSTM) - A shower accompanied by thunder. It is always accompanied by lightning and thunder, and occasionally by strong gusty winds, hail, and or heavy rain.

Tornado - A violent rotating column of air, usually forming a pendant from a cumulonimbus cloud with the circulation reaching the ground. It nearly always starts as a funnel cloud and may be accompanied by a loud roaring noise. On a local scale, it is the most destructive of all atmospheric phenomena.

Trace -Precipitation amounts less than 0.01".

Tropical depression - Tropical mass of thunderstorms with a cyclonic wind circulation and winds between 20 and 34 knots.

Tropical disturbance - An organized mass of tropical thunderstorms, with a slight cyclonic circulation, and winds less than 20 knots.

Tropical storm - An organized cyclone in the tropics with wind speed between 35 and 64 knots.

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Upwelling - The rising of cold water from the deeper areas of the ocean to the surface. This phenomenon often occurs along the California coast during the summer.

Warm front - A boundary between a warm air mass that is replacing a cooler air mass.

Warning - is issued when severe or hazardous weather has already developed and has been reported by spotters or indicated by radar. Warnings are statements of imminent danger and are issued for relatively small areas near and downstream from the severe storm or flood. For example, Tornado Warning, Severe Thunderstorm Warning, Flash Flood Warning, Winter Storm Warning.

Wind - air in motion relative to the surface of the earth.

Wind chill - The apparent temperature that describes the cooling effect on exposed skin by the combination of temperature and wind, expressed as a loss of body heat. An increase in wind speed or decrease in temperature will accelerate the effect. A wind chill factor of 30 degrees or lower on exposed skin will result in frostbite in a short period of time.

Windy - Sustained winds of 20 to 30 mph.

W4.15 The presentations

Power Point presentation is available as an annex.

Workshop 5; Hydrological risks (flood-drought)

W5.1 Instructor(s) name(s) and contact information

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hany.abdelhamid@tuke.sk, +421 944190359

W5.2 Workshop Description

The workshop will focus of hydrological risk (flood - drought). First, the main natural hazards will be presented to the participants including. Then, participants will get basic information on hydrological risks including flood and drought. The workshop will include power point presentation and some videos related to the topic. Also, participants will do some activities during the workshop. The participants will get an introduction for hydrological risk focusing on floods and droughts. They will get information about the definitions, types, causes, impacts, adaptation measures for both floods and drought. Then some activities on flood and drought will be conducted.

W5.3 Workshop goals and objectives

This workshop for hydrological risks (flood - drought) will provide students with basic information about Hydrological risks including floods and droughts through power point presentation, some videos related to the topic and activities done by participants.

Learning goals

- Understand the different types of hydrological risks,
- Recognize the difference between flood and drought,
- Identify the main causes of flood and drought,
- Explain the impacts of flood and drought on environment and communities, and
- Identify methods for predicting both flood and drought, and
- Describe the methods of protection from flood and drought.

Learning objectives

- Analyze the climate data that may lead to flood or drought,
- Create flood physical model to simulate flood,
- Evaluate the impact of flood and drought on environment and community,
- Test methods for predicting both flood and drought, and
- Apply different measures to adapt with flood.

The participating teachers are also concerned with these learning goals objectives. Participating teachers will learn more about the above subjects and their experience will increase. Additionally, they will learn how to use various

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STEAM tools and AR in the classroom which could help students in understanding such topics.

W5.4 Pre-requisites

The student should be aware of the following pre-requests and workshops before admitting this workshop:

- Familiarity with components of hydrologic cycle
- Basic knowledge of flood and drought
- Familiarity with the climate and precipitation data
- Completion of a workshop on Climate change (causes - impacts - mitigation - adaptation)

W5.5 Workshop methodology

STEAM methodology will be applied in this workshop through the use of stream table that will be used for simulating flood risks and management in urban and rural areas. In addition to other activities that depend on thinking, share data and discussions. However, drought will be presented by different methods of explanation, discussions and vidios.

The main activity in this workshop will focus on using stream table for simulating different flood types, different basins morphology and different human activities. They will be able simulate different soil types, flood plains, mountains, agriculture areas, settlements, roads and bridges. In addition to some flood protection measures such as alignment of revers, dams, leaves.

Participants in this workshop will do simulation of flood themselves and apply different scenarios and different cases. Also, the will; discuss the results of experiments which will help them for prediction of some phenomena. Finally, applying STEAM approach and AR will help participants in understanding and analysis of natural phenomena such as flood and drought.

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W5.6 Workshop Participation

The students will participate in the workshop in present in classroom and interactive laboratory. First, they will get presentation for hydrological risks including flood and drought. During the presentation they will participate in discussions and some activities. Then they will do an experiment for simulating flood using stream table. They will apply different cases for flood, different basins characteristics, different human activities and different protection measures. They will observe the flood impacts and discuss the results which will help in understanding the flood phenomena, causes, types, impacts and mitigations measures. Also, drought will be simulated through some activities and discussions.

W5.7 Time outline

Activity		Time	Type of Activity	Necessary materials
1	Introduction to hydrological risks	20	Presentation	Data show and computer
2	Hydrologic cycle components	5	Discussion	Sheets of paper, pencils
3	What are the main natural risks?	5	Discussion	Sheets of paper, pencils
4	What are the main differences between flood and drought (definition, types, causes, impacts, prediction, mitigation methods)	10	Think, pair and share	Sheets of paper, pencils
5	What are the main impacts of drought?	10	Role-play	Sheets of paper, pencils
6	Flood simulation	30	Case study	A map of flood plain, Stream table
7	Discussion	10		
Total		**90 minutes**		

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[The series of 12 Workshops]

W5.8 Theoretical background

This part provides the theoretical background of hydrological risks focusing on flood and drought.

5.8.1 Hydrological risks

The natural hazard may lead to natural disaster, so it is important to know the difference between natural hazard natural disaster. Natural hazard is the threat of an event that will have a negative impact. Natural disaster is the negative impact subsequent to the natural hazard that significantly harms the community. The Major natural hazards include: coastal flooding, river flooding, drought, avalanche, earthquake, volcanic activity, heat wave, cold wave, hail, hurricane, ice storm, landslide, lightning, strong wind, tornado, tsunami, wildfire, winter weather. However, the hydrological risks are defined as extreme events associated with the occurrence, movement, and distribution of water, resulting in floods and droughts (Fig. 1b).

(a) (b)

Fig. 1. Photo for flood and drought

Flood and drought are natural phenomena that probability of occurrence increases with changing weather conditions. Climate change is increasing as a result of global warming may affect the hydrologic cycle's parameters, such as temperature and precipitation patterns, increasing the likelihood of floods and droughts. Climate change could enormously affect many regions and many countries will suffer from drought and others from floods which makes a hydrological risk that should be considered carefully.

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5.8.2 Flood

Hydrological risks include both flood and drought. Flood is an overflow of water that submerges land that is usually dry (not normally covered by water), it caused by overflow from a river, wind-induced surges, tides, tsunamis, or other factors (Fig. 2). Flood is the maximum rate of rainfall and usually conjugates with the highest level in water streams.

Fig. 2. Photo for urban flood

Causes of flood

Flood may occur due to different reasons as shown in (Fig. 3).

Heavy rainfall: long periods of heavy rainfall will lead to an increase in surface runoff and increase in river level.

Snow melt: water in storage is often freed by Spring melts increasing surface runoff.

Deforestation: cutting trees leads to a reduction in interception rates and an increase in surface runoff.

Urbanization: concrete surfaces are impermeable and lead to an increase in surface runoff.

Others: severe winds over water, unusual high tides, tsunamis, failure of dams, levees, retention ponds, or other structures that retained the water.

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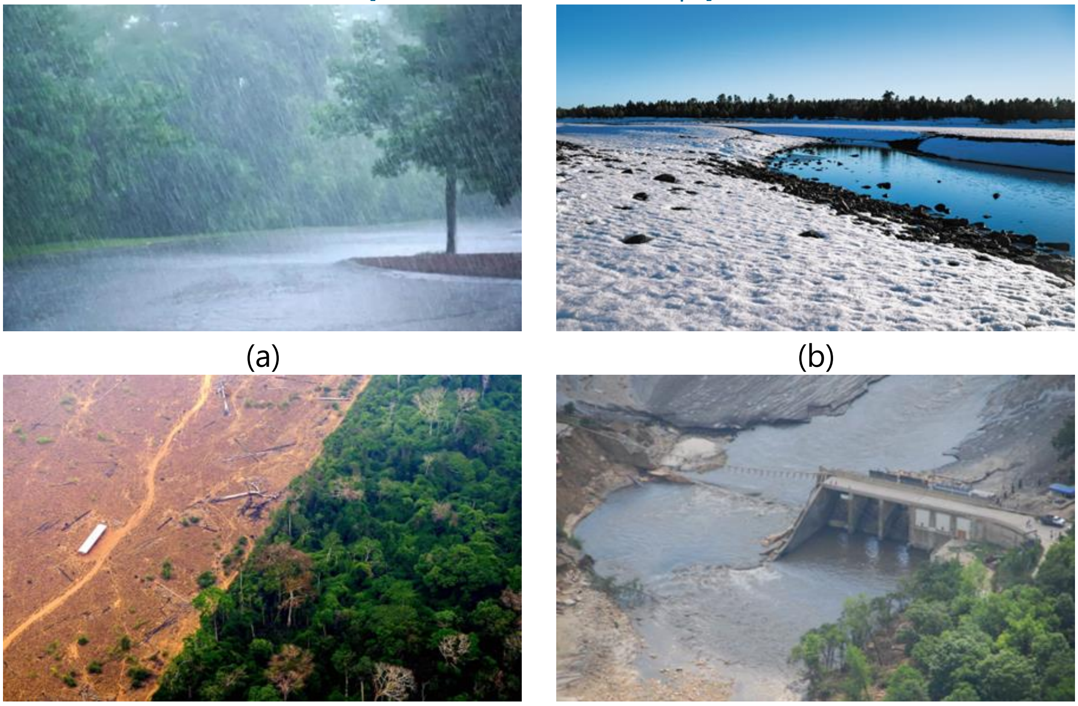

(a) (b) (c) (d)

Fig. 3. Photos for different causes of flood

Types of flood

Different typed of flood can be defined as following (Fig. 4):

River Flooding: occurs due to long rainfall or snowmelt and resulting in the overflow of rivers and their banks.

Coastal Flooding: is the inundation of low-lying coastal lands due to storm surges or tsunamis.

Flash Floods: is caused by heavy rain falling in a short time and resulting in rapid runoff.

Urban Flooding: occurs due to incapability of urban drainage systems to handle intense rainfall and resulting in flooding of streets and buildings.

Agricultural floods: is the inundation of agricultural lands and damage crops and livestock due to heavy rainfall or river overflows.

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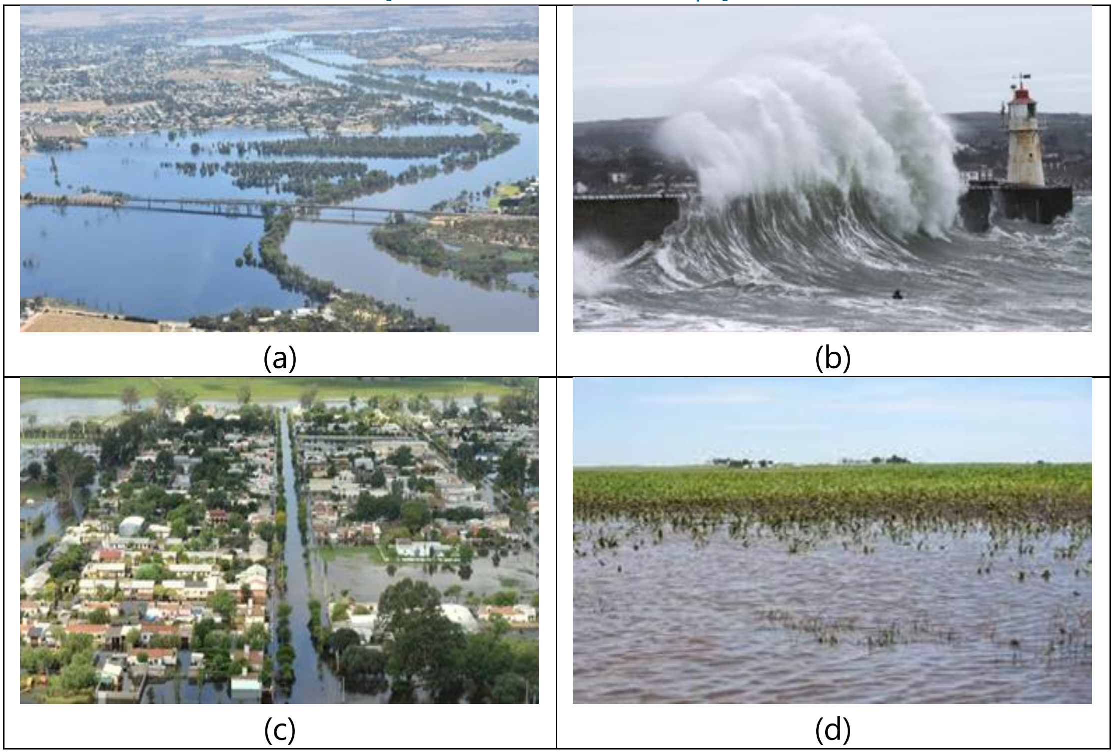


Fig. 4. Photos for different types of flood

Impacts and damages caused by flood

Flood could have many effects on the short term and long term on both environment and community:

Short term impacts of flood:

- Loss of life
- Damages of property
- Soil erosion
- Crop damage
- Loss of communication
- Fresh water pollution
- Loss of power
- Structural damage can occur in bridges, bank lines, sewer lines, and other structures within floodway's

  Fig. 5, shows some examples of damages caused by flood.

Long term impacts of flood:

- Replacing what is lost or damaged (rebuilding costs)
- Many poorer people could not afford insurance.

- Crop destruction can lead to famine.
- Governments have to provide funds to rebuild the infrastructure (e.g. roads, structures, water treatment etc…) this may take long time with high cost.


(a)


(b)


(c)


(d)

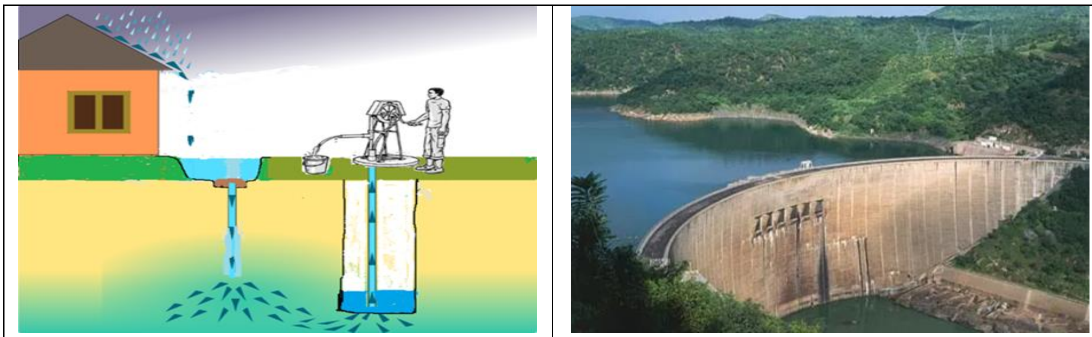
Fig. 5. Photos for damages caused by flood

Benefits of flood

Flood could have some benefits if it is probably predicted and controlled such as:

- Recharging groundwater
- Making soil more fertile and increasing nutrients in some soils
- Flood water provide water resources in arid and semi-arid regions
- Freshwater floods play an important role maintaining floodplain biodiversity
- For some fish species, an inundated flood plain may form a highly suitable location for spawning with few predators and enhanced levels of nutrients or food
- Fish, such as the weather fish, make use of floods in order to reach new habitats

- Bird populations may also profit from the boost in food production caused by flooding



(a) (b)

Fig. 6. Photos for some benefits of flood

Flood prediction and modeling

Flood mitigation involves the management and control of flood water movement. The prevention and mitigation of flooding can be studied on three levels: on individual properties, small communities, and whole towns or cities. Prediction of flood is important step for mitigating and protection, and it can help in different topics as following:

- It can provide early warning that could reduce the damage caused by floods
- It can enable people to take measures to protect themselves and their properties.
- It helps emergency responders to prepare and respond to floods.
- It can help in planning of land use and infrastructure in flood areas
- It could prevent loss of life and minimize the economic losses.

Simulating flood events can be done using mathematical models and computer programs and could help in prediction and mitigation of flood as following:

- It can help decision-makers for putting flood risk management plans, response planning, and land-use planning
- It can be done using different types of models, including hydrological, hydraulic, and hydrodynamic models.
- These models depend on collecting and analyzing data for the catchment area including, topography, land use, drainage systems and precipitation.

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- Then the models can help estimate the probability and magnitude of floods, and to identify risk areas.
- Examples of Models: WMS, HEC-WMS, HEC-RAC, MIKE, ArcHydro

Flood safety planning

The flood safety planning includes different actions as following:

- Planning for flood safety involves many aspects of analysis and engineering, including:
- Observation of previous and present flood heights and inundated areas,
- Statistical, hydrologic, and hydraulic model analyses,
- Mapping inundated areas and flood heights for future flood scenarios,
- Long-term land use planning and regulations,
- Engineering design and construction of structures to control flooding,
- Monitoring, forecasting, warning, and response operations

Flood Control methods

Flood control refers to all methods used to reduce or prevent the detrimental effects of flood water.

- *Flood control on rivers* (detention basins, levees, dams, reservoirs and weirs)
- *Coastal flooding* (coastal defences such as sea walls, nourishment and barrier)
- *Flood control on watershed*

- Dams: these hold back and regulate the flow of water.
- Forestation: planting trees increases interception rates and reduces runoff.
- Diversion Canals: built canals which in turn divert the water to temporary holding ponds or other bodies of water where there is a lower risk or impact to flooding.
- Culverts: semi circular, smooth channels increase velocity and gets water away from urban areas as quickly as possible.
- Water-Gate: water-gate flood barrier is a rapid response barrier
- Self-closing flood barrier
- Restricted use of flood-plains
- Co-ordinated flood warning
- Revetments, Gabions and Culverts

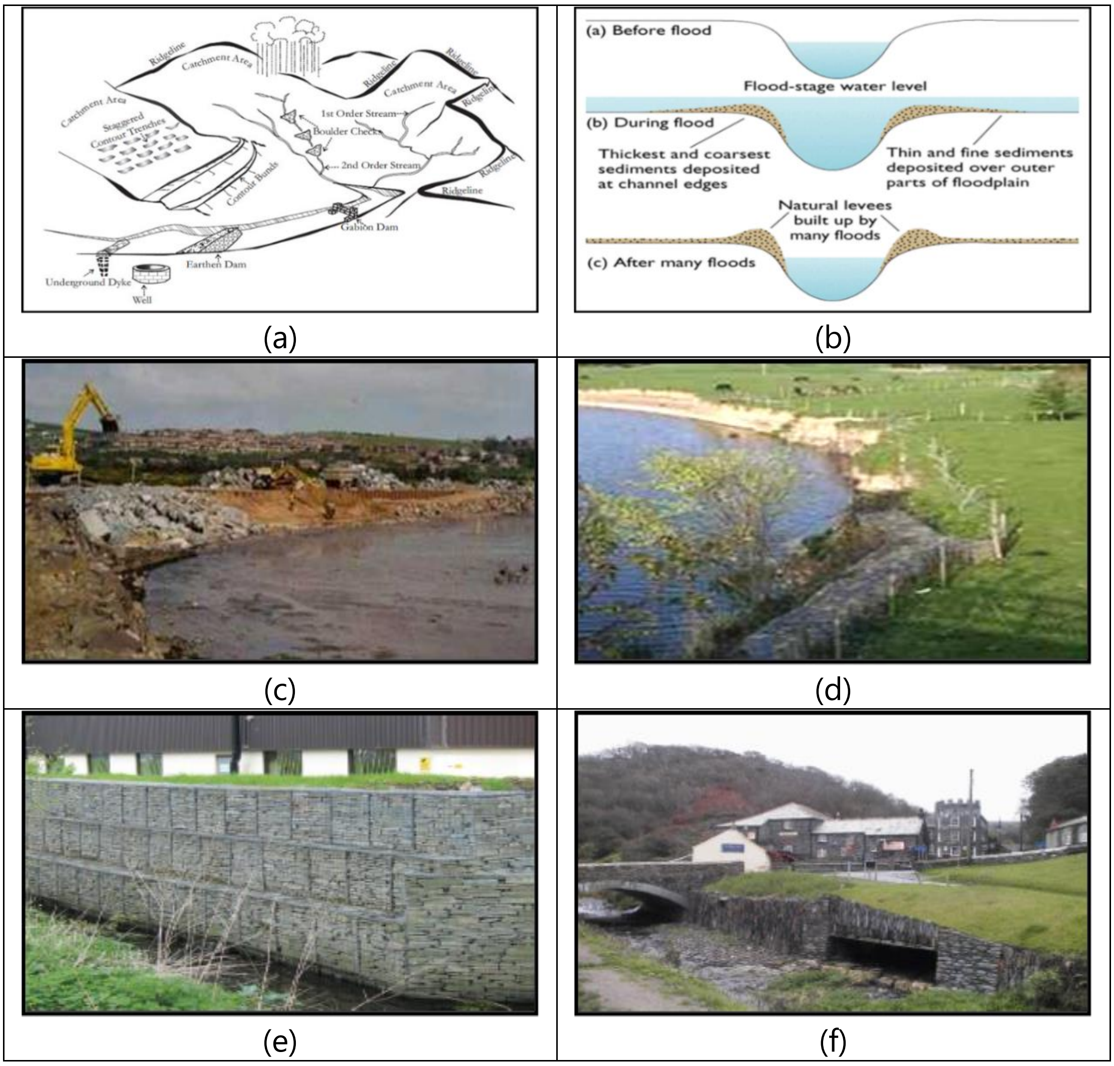

Fig. 7. Photos for some protection measures of flood

5.8.3 Drought

Drought is a prolonged dry period in the natural climate cycle that can occur anywhere in the world. It is a slow-onset disaster characterized by the lack of precipitation, resulting in a water shortage. Drought could have many damages impacts for both environment and community.

Causes of drought

Drought may occur due to some reasons such as:

- Rising temperatures caused by climate change are making already dry regions drier.

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- In dry regions, this means that when temperatures rise, water evaporates more quickly, and thus increases the risk of drought or prolongs periods of drought.

Fig. 8. Photos for drought

Types of drought

The different types of droughts can be listed as following:

- ***Meteorological drought*** occurs when there is a prolonged time with less than average precipitation. Meteorological drought usually precedes the other kinds of drought
- ***Hydrological drought*** is brought about when the water reserves available in sources such as aquifers, lakes and reservoirs fall below a locally significant threshold.
- ***Agricultural or ecological droughts*** affect crop production or ecosystems in general. This can arise independently from any change in precipitation levels when either increased irrigation or soil conditions and erosion triggered by poorly planned agricultural endeavors cause a shortfall in water available to the crops.

(a) (b) (c)

Fig. 9. Photos for some benefits of flood

Impacts of drought

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Drought could have different impacts on environment and community as following:

- Drought causes water shortages
- People health
- Livelihoods
- Increases the disease and death
- Agriculture
- Energy
- Economies
- Environment
- Severe drought can also affect air quality by making wildfires and dust storms more likely, increasing health risks

(a)

(b)

(c)

(d)

Fig. 10. Photos for some benefits of flood

Drought control methods

Drought cannot be prevented but adaptation measures can be considered. WHO works to reduce the impacts of these effects through coordination with aid agencies and governments

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- Early warning and response programs and preventative immunization efforts to mitigate the effects of disease in drought-stricken areas
- Coordinating emergency funding to support health
- Ensure appropriate food supplementation is available to the affected areas,
- Support for child, maternal and mental health services.

W5.9 Bibliography or/and additional reading list for teachers

This is a list of references of sources that could help to increase the knowledge about the workshop topic [hydrological risks (flood – drought)].

- K Subramanya "Engineering Hydrology", 3rd edition, McGraw-Hill, (2008).
- Johnston, DON, and Cross, W.P. "Elements of Appliedc Hydrology," Ronald, New York, 1949.
- Chow, V.T. "Handbook of Hydrology," McGraw-Hill, New York, 1964.
- Larry W Mays, "Water Resources Engineering", 2nd edition, John Wiley & Sons, (2011).
- Eagleson, P. "Dynamic Hydrology," McGraw-Hill, New York, 1970.
- Zevenbergen, C. et al. (2010) Urban flood management. Boca Raton, Florida, U.S.A.: CRC Press.
- Kazmann, R.G. "Modern Hydrology," 2d ed., Harper & Row, New York, 1972.
- Linsley, R.K, Kohler, M.A. and Paulhus, J.L.H.: "Applied Hydrology," McGraw-Hill, New York, 1949.
- Mead, D.W. "Hydrology," 1st ed., McGraw-Hill, New York, 1919; 2d ed., rev.by H.W. Mead, 1950.
- Smith, K. and Ward, R. (1998) Floods: Physical Processes and Human Impacts. London, U.K.: John Wiley & Sons Ltd.
- Ward, R. C. and Robinson, M. (2000) Principles of Hydrology. 4th edn. London: McGraw-Hill.
- Bedient, P. B., Huber, W. C. and Vieux, B. E. (2013) Hydrology and floodplain analysis. Pearson.
- Kron, W. (2012) Floods: From risk to opportunity. Springer.
- Schüttrumpf, H. (2016) Flood Risk Assessment and Management. John Wiley & Sons.
- Disaster, planning and development: managing natural hazards to reduce loss. Washington, D.C.: Organization of American States. 1990. http://www.oas.org/dsd/publications/Unit/oea54e/oea54e.pdf.

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- IPCC (2021). Masson-Delmotte, V.; Zhai, P.; Pirani, A.; Connors, S. L.; et al. (eds.). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf
- Douville, Hervé; Raghavan, Krishnan; Renwick, James A.; Allan, Richard P.; et al. (2021). "Chapter 8: Water cycle changes". IPCC AR6 WG1 2021. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_08.pdf
- Gergelova M. B., Kovanič L., Abd-Elhamid H. F., Cornak A., Garaj M., Hilbert R. (2023), "Evaluation of Spatial Landscape Changes for the Period from 1998 to 2021 Caused by Extreme Flood Events in the Hornád Basin in Eastern Slovakia" Land, 12(2), 405. https://doi.org/10.3390/land12020405
- Ramadan E. M., Shahin H. A., Abd-Elhamid H. F., Zelenakova M., and Eldeeb H. M. (2022) "Evaluation and Mitigation of Flash Flood Risks in Arid Regions: A Case Study of Wadi Sudr in Egypt" Water 2022, 14(19), 2945; https://doi.org/10.3390/w14192945.
- Zeleňáková M., Abd-Elhamid H. F., Krajníková K., Smetanková J., Alkhalaf I. (2022), "Spatial and temporal variability of rainfall trends in response to climate change, A case study: Syria" Water, 14 (10), 1670, https://doi.org/10.3390/w14101670
- Zeleňáková M., Sol'áková T., Purcz P., Abd-Elhamid H. F. (2023), "Analysis of Hydrological Drought in the Eastern Part of Slovakia Using Standardized Precipitation Index", Water Resources Management and Sustainability: Solutions for Arid Regions, Springer Nature Switzerland, Vol 121: 119-128, https://doi.org/10.1007/978-3-031-24506-0_8
- Soľáková T., Zeleňáková M., Mikita V., Hlavatá H., Simonová D., Abd-Elhamid H. F. (2022). "Assessment of meteorological and hydrological drought using drought indices: SPI and SSI in eastern Slovakia", Acta Hydrologica Slovaca, 23(2), 267–272. DOI: 10.31577/ahs-2022-0023.02.0030
- Zeleňáková M., Soľáková T., Purcz P., and Abd-Elhamid H. F. (2022), "Analysis of hydrological drought using Standardized Stream flow Index" Public recreation and landscape protection – with the environment hand in hand (9-11May, 2022), Brno, Czech Republic.

- Hlinková M., Zeleňáková M. and Abd-Elhamid H. (2022), "Comparison between flood damages evaluation methods and selection of the appropriate method for application in Slovakia", CEC, TUKE
- Šoltész A., Zeleňáková M., Čubanová L., Šugareková M. and Abd-Elhamid H. F. (2021) "Environmental Impact Assessment and Hydraulic Modelling of Different Flood Protection Measures", Water, MDPI, 13(6): 786.
- Fathy I., Ahmed A. and Abd-Elhamid H. F. (2021), "Integrated Management of Surface Water and Groundwater to mitigate flood risks and water scarcity in Arid and Semi-Arid Regions", Flood Risk Management, 14(3): 1-18.
- Fathy I., Zeleňáková M. and Abd-Elhamid H. F. (2020), "Highways protection from flood hazards, a case study: New Tama road, KSA", Natural Hazards, Springer, 103:479-496.
- Abd-Elhamid H. F., Zeleňáková M., Vranayová Z. and Fathy I. (2020), "Evaluating the Impact of Urban Growth on the Design of Storm Water Drainage Systems", Water, MDPI, 12 (6), 1572.
- Fathy I., Abd-Elhamid H. F., Negm A., (2020), "Prediction and Mitigation of Flash Floods in Egypt", Flash Floods in Egypt. Advances in Science, Technology & Innovation (IEREK Interdisciplinary Series for Sustainable Development). Springer, 349-368. https://doi.org/10.1007/978-3-030-29635-3_15,
- Fathy I., Abd-Elhamid H. F., , Zelenakova M., Kaposztasova D. (2019), "Effect of Topographic Data Accuracy on Watershed Management", International journal of environmental research and public health, MDPI, 16(21): 4245
- Zeleňáková M., Harabinová S., Mésároš P., Abd-Elhamid H. F., Purcz P. (2019), "Modelling of Erosion and Transport Processes", Water, MDPI 11 (12), 2604.
- Zeleňáková M., Repel A., Vranayová Z., Kaposztasová D., Abd-Elhamid H. F. (2020), "Impact of land use changes on surface runoff in urban areas-Case study of Myslavsky Creek Basin in Slovakia", Acta Montanistica Slovaca, EBSCO, 24 (2), 129-139
- Abd-Elhamid H. F., Fathy I. and Zeleňáková M. (2018), "Flood prediction and mitigation in Hurghada, Egypt", Natural Hazards 93 (2), 559-576.

W5.10 The recommended reading for VET students

This is a list of references of sources that could help to increase the knowledge about the workshop topic [hydrological risks (flood – drought)].

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- Larry W Mays, "Water Resources Engineering", 2nd edition, John Wiley & Sons, (2011).
- Chow, V.T. "Handbook of Hydrology," McGraw-Hill, New York, 1964.
- Mead, D.W. "Hydrology," 1st ed., McGraw-Hill, New York, 1919; 2d ed., rev.by H.W. Mead, 1950.
- K Subramanya "Engineering Hydrology", 3rd edition, McGraw-Hill, (2008).
- Johnston, DON, and Cross, W.P. "Elements of Appliedc Hydrology," Ronald, New York, 1949.
- Eagleson, P. "Dynamic Hydrology," McGraw-Hill, New York, 1970.
- Zevenbergen, C. et al. (2010) Urban flood management. Boca Raton, Florida, U.S.A.: CRC Press.
- Kazmann, R.G. "Modern Hydrology," 2d ed., Harper & Row, New York, 1972.
- Linsley, R.K, Kohler, M.A. and Paulhus, J.L.H.: "Applied Hydrology," McGraw-Hill, New York, 1949.
- Smith, K. and Ward, R. (1998) Floods: Physical Processes and Human Impacts. London, U.K.: John Wiley & Sons Ltd.
- Ward, R. C. and Robinson, M. (2000) Principles of Hydrology. 4th edn. London: McGraw-Hill.
- Bedient, P. B., Huber, W. C. and Vieux, B. E. (2013) Hydrology and floodplain analysis. Pearson.
- Kron, W. (2012) Floods: From risk to opportunity. Springer.
- Schüttrumpf, H. (2016) Flood Risk Assessment and Management. John Wiley & Sons.
- Disaster, planning and development: managing natural hazards to reduce loss. Washington, D.C.: Organization of American States. 1990. http://www.oas.org/dsd/publications/Unit/oea54e/oea54e.pdf.
- IPCC (2021). Masson-Delmotte, V.; Zhai, P.; Pirani, A.; Connors, S. L.; et al. (eds.). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf
- Douville, Hervé; Raghavan, Krishnan; Renwick, James A.; Allan, Richard P.; et al. (2021). "Chapter 8: Water cycle changes". IPCC AR6 WG1 2021. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_08.pdf

- Fathy I., Abd-Elhamid H. F., Negm A., (2020), "Prediction and Mitigation of Flash Floods in Egypt", Flash Floods in Egypt. Advances in Science, Technology & Innovation (IEREK Interdisciplinary Series for Sustainable Development). Springer, 349-368. https://doi.org/10.1007/978-3-030-29635-3_15,
- Soľáková T., Zeleňáková M., Mikita V., Hlavatá H., Simonová D., Abd-Elhamid H. F. (2022). "Assessment of meteorological and hydrological drought using drought indices: SPI and SSI in eastern Slovakia", Acta Hydrologica Slovaca, 23(2), 267–272. DOI: 10.31577/ahs-2022-0023.02.0030
- Zeleňáková M., Soľáková T., Purcz P., and Abd-Elhamid H. F. (2022), "Analysis of hydrological drought using Standardized Stream flow Index" Public recreation and landscape protection – with the environment hand in hand (9-11May, 2022), Brno, Czech Republic.
- Šoltész A., Zeleňáková M., Čubanová L., Šugareková M. and Abd-Elhamid H. F. (2021) "Environmental Impact Assessment and Hydraulic Modelling of Different Flood Protection Measures", Water, MDPI, 13(6): 786.
- Fathy I., Zeleňáková M. and Abd-Elhamid H. F. (2020), "Highways protection from flood hazards, a case study: New Tama road, KSA", Natural Hazards, Springer, 103:479-496.
- Abd-Elhamid H. F., Zeleňáková M., Vranayová Z. and Fathy I. (2020), "Evaluating the Impact of Urban Growth on the Design of Storm Water Drainage Systems", Water, MDPI, 12 (6), 1572.
- Zeleňáková M., Harabinová S., Mésároš P., Abd-Elhamid H. F., Purcz P. (2019), "Modelling of Erosion and Transport Processes", Water, MDPI 11 (12), 2604.
- Abd-Elhamid H. F., Fathy I. and Zeleňáková M. (2018), "Flood prediction and mitigation in Hurghada, Egypt", Natural Hazards 93 (2), 559-576.
- Ramadan E. M., Shahin H. A., Abd-Elhamid H. F., Zelenakova M., and Eldeeb H. M. (2022) "Evaluation and Mitigation of Flash Flood Risks in Arid Regions: A Case Study of Wadi Sudr in Egypt" Water 2022, 14(19), 2945;

W5.11 Recommended assessment of student knowledge and skills

Assessment will be done using different methods including, discussions during the workshop, evaluation to activities done by participants and short assessment will be submitted by participants (attachement-1).

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W5.12 Workshop feedback

A form for feedback on the workshop will be distributed to all participants to assess the workshop (attachement-2).

W5.13 Summary of the Workshop

The workshop [hydrological risks (flood – drought)] was prepared to VET students and teachers to be familiar with the main natural hazards and hydrological risks. The workshop focuses on flood and drought and aims to provide participants with basic knowledge of their definitions, types, causes, impacts, and adaptation measures for both floods and drought. The workshop includes power point presentation, some videos, and some activities done by participants. STEAM approach is applied in the workshop through using stream table to simulate flood event including different scenarios and cases of flood basin morphology, different drainage network, and different human interventions. Also, flood protection measures such as roads, bridges, buildings, cities etc.). The participants can observe the impact of changing these parameters on the flooded area and can propose some protection measures to protect such areas from flood risks. Also, drought causes and impacts were discussed in details. Finally, the activities and discussions during the workshop could help participants to increase their knowledge or the workshop topic.

W5.14 Glossary

Agricultural or ecological droughts affect crop production or ecosystems in general. This can arise independently from any change in precipitation levels when either increased irrigation or soil conditions.

Drought is a prolonged dry period in the natural climate cycle that can occur anywhere in the world.

Evapotranspiration: the water that returns to the atmosphere through the processes of evaporation and transpiration (combined).

Flash flood: a flood that occurs rapidly, mainly in small, mountainous drainage basins, due to short, but intense rainfall or storm events.

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Flood control: refers to all methods used to reduce or prevent the detrimental effects of flood water.

Flood: the overflow of a river's banks and the inundation of areas that would normally be dry.

Floodplain: a plain created by successive floods of a river.

Hydrological cycle: the cycle of water within a drainage basin.

Hydrological drought is brought when water reserves available in sources such as aquifers, lakes and reservoirs fall below a locally significant threshold.

Hydrological risks: are extreme events associated with the occurrence, movement and distribution of water, resulting in floods and droughts

Infiltration: the flow of water from the surface to the underground.

Meteorological drought occurs when there is a prolonged time with less than average precipitation. Meteorological drought usually precedes the other kinds of drought

Natural hazard: is the threat of an event that will have a negative impact

Precipitation: the liquid or frozen water that forms in the atmosphere and falls back to the Earth.

Runoff: the superficial flow of the water.

Transpiration: the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers.

Urban floods: floods occurring in large urban centers.

Valley: a concave area between two mountains that leans downstream

Watershed: an imaginary line connecting the areas of the highest altitude around the basin.

W5.15 The presentations

Power Point presentation is available as an annex.

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[The series of 12 Workshops]

Workshop 6 Flood types

W6.1 Instructor(s) name(s) and contact information

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W6.2 Workshop Description

Floods are the most common and most costly natural disasters in Europe. They are becoming more frequent due to climate change and have devastating effects, endangering lives and leading to heavy economic losses. Floods can also release pollutants stored in the ground and spread them even more widely. Floods may also destroy wetland areas and reduce biodiversity. It is expected that the coming decades are likely to see a higher flood risk in Europe and greater economic damage.

While studying, participants' get to know the types of floods, their causes and consequences. You learn to understand what makes one flood different from another. Through a presentation, a Kahoot test, a discussion, and an augmented reality app, students will be able to understand the meaning of floods and their impact on life.

W6.3 Workshop goals and objectives

Learning goal

To enhance participants' understanding of different types of floods and their characteristics, causes, impacts, and mitigation measures.

Learning objectives

- Identify and describe the main types of floods, including river floods, urban floods, flash floods.
- Understand the unique characteristics, triggers, and patterns associated with each flood type.
- Examine the causes and contributing factors that lead to the occurrence of different types of floods.

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- Analyze the impacts of floods on the environment, infrastructure, communities, and individuals.
- Identify the role of climate change, land use, and urban development in influencing flood risks.
- Engage in scenario-based exercises to apply knowledge and propose appropriate response strategies for different flood situations.
- Foster collaboration and knowledge-sharing among participants to exchange experiences, challenges, and ideas related to flood types.

W6.4 Pre-requisites

The pre-requisites for the participating students include none.

For Kahoot test, group work must have mobile phones, access to the internet.

W6.5 Workshop methodology

In the workshop on flood types the STEAM methodology will be incorporated by the use of Augmented Reality (AR) technology to enhance the workshop's effectiveness and engagement.

Science: The science component of the workshop will focus on understanding the scientific principles behind different types of floods, such as flash floods, river floods, or urban floods. Participants will learn about the causes, effects, and characteristics of each type through interactive discussions, case studies, and data analysis.

Technology: AR technology will play a crucial role in the workshop. Using AR, participants will be able to visualize and simulate flood scenarios in a realistic and immersive manner. They can explore virtual environments depicting various flood types, observe water flow patterns, and understand how different factors contribute to flooding.

Mathematics: Mathematics will come into play during data analysis and problem-solving exercises. Participants will analyze flood-related data, such as rainfall patterns, water levels, or flood frequency, to identify trends and make predictions.

By integrating AR technology, participants will be able to visualize complex concepts and immerse themselves in interactive learning experiences. AR can provide real-time feedback, enabling participants to make informed decisions and understand the consequences of their actions in simulated flood scenarios. This combination of STEAM and AR methodologies creates an engaging and comprehensive learning environment that fosters critical thinking, collaboration, and a deeper understanding of flood types and their implications.

W6.6 Workshop Participation

Participants in the Flood Types Workshop will be expected to actively engage with the material and participate in all aspects of the workshop. During the workshop, participants will work in small groups to apply their knowledge and skills. Participants should be prepared to collaborate, share ideas, learn from each other and to participate in the discussion. Participants should also come prepared with the necessary resources. This may include mobile phone, access to the internet.

W6.7 Time outline

Activity	Time
Introduction Introduce the workshop topic and goals Review of the workshop prerequisites and required resources	5 minutes
Presentation Theoretical background of flood types	15 minutes
Kahoot (or other) test about flood types	15 minutes
Group work (with AR app**)**	30 minutes
Overall discussion	25 minutes
Total	**90 minutes**

W6.8 Theoretical background

Each flood type has its unique characteristics, causes, and impacts. Understanding these differences is crucial for effective flood management, preparedness, and mitigation strategies.

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A RIVER FLOOD occurs when a river or stream overflows its banks and inundates the surrounding areas. Here is some additional information about river floods:

1. Causes: River floods can be triggered by various factors, including heavy rainfall, snowmelt, ice jams, or a combination of these factors. Prolonged or intense rainfall can lead to increased water volume in rivers, exceeding their capacity and causing flooding.

2. Factors influencing severity: The severity of a river flood can depend on several factors. These include the amount and duration of rainfall or snowmelt, the size and slope of the river basin, the presence of dams or reservoirs upstream, and the condition of the river channel (e.g., sediment buildup, channel width).

3. Duration and aftermath: River floods can last for days or even weeks, as water slowly recedes back into the river channel. After the floodwaters subside, affected areas may experience significant damage to infrastructure, agriculture, and natural habitats. Cleanup and recovery efforts can be extensive and require substantial resources.

4. Floodplain impact: River floods primarily affect areas within the floodplain, which is the flat or low-lying land adjacent to the river channel. Floodplains provide valuable ecosystem services, such as nutrient deposition and habitat for aquatic species. However, human settlements and infrastructure located in flood-prone areas are at risk during flood events.

5. Flood forecasting and warning systems: River flood forecasting involves monitoring river water levels, rainfall patterns, and weather forecasts to estimate potential flood risks. This information is crucial for issuing timely flood warnings to communities downstream, allowing for evacuation and other preparedness measures.

6. Mitigation measures: To reduce the impacts of river floods, various mitigation measures can be employed. These include constructing levees and floodwalls to contain or divert floodwaters, implementing river channelization projects to improve water flow, and creating floodplain zoning regulations to limit development in high-risk areas. Additionally, land and water management practices, such as afforestation, wetland restoration, and soil conservation, can help retain water and reduce runoff.

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7. Climate change and river floods: Climate change can influence river flooding patterns. Rising global temperatures can lead to more intense rainfall events, increased snowmelt, and altered precipitation patterns, affecting river flow and flood frequency. It is essential to consider climate change projections when assessing future flood risks and implementing adaptation strategies.

Understanding the characteristics and impacts of river floods is crucial for effective flood risk management, including land-use planning, early warning systems, and infrastructure design. By adopting integrated approaches, communities can reduce the vulnerability and enhance the resilience of riverine areas to flooding events.

URBAN FLOODS occur when an urban area experiences excessive water accumulation due to heavy rainfall or inadequate drainage systems. Here is some additional information about urban floods:

1. Causes: Urban floods can be caused by intense or prolonged rainfall, rapid snowmelt, blocked or overwhelmed drainage systems, inadequate infrastructure, urbanization-induced changes in land use and surface runoff, and the lack of green spaces that can absorb water.

2. Impervious surfaces: Urban areas often have extensive impervious surfaces such as roads, parking lots, and buildings, which prevent water from infiltrating into the ground. Instead, the water quickly runs off into storm drains, leading to higher volumes of water overwhelming drainage systems and causing flooding.

3. Drainage system overload: Urban floods can occur when the capacity of drainage systems, such as storm sewers and culverts, is exceeded. This can happen due to the sheer volume and intensity of rainfall, blockages caused by debris or garbage, or inadequate maintenance of the drainage infrastructure.

4. Flash floods: In urban areas, heavy rainfall can lead to flash floods, which occur when intense rainfall overwhelms drainage systems within a short period. Flash floods can be particularly dangerous as they can occur suddenly, with little time for warning or evacuation.

5. Impact on infrastructure and communities: Urban floods can result in significant damage to infrastructure, including roads, bridges, buildings, and utilities. Floodwaters can also pose risks to public health, contaminate water supplies, and disrupt essential services. Additionally, urban floods can cause displacement, economic losses, and psychological distress for affected communities.

6. Urban planning and flood management: Effective urban planning and flood management strategies can help mitigate the impacts of urban floods. This includes implementing green infrastructure solutions such as rain gardens, permeable pavement, and green roofs to absorb and manage stormwater. Adequate stormwater management practices, including the design and maintenance of drainage systems, can help reduce flood risks in urban areas.

7. Community resilience and preparedness: Building community resilience to urban floods involves raising awareness about flood risks, educating residents about emergency response procedures, and promoting individual and community preparedness. This can include developing flood response plans, establishing early warning systems, and implementing evacuation strategies.

8. Climate change and urban floods: Climate change can exacerbate the risks of urban flooding. Increasingly intense rainfall events, rising sea levels, and changing weather patterns can amplify the frequency and severity of urban floods. Adapting to climate change requires integrating climate considerations into urban planning, improving infrastructure resilience, and implementing sustainable drainage systems.

Addressing urban floods requires a multidimensional approach that includes improving infrastructure, implementing sustainable urban planning practices, enhancing emergency response capabilities, and increasing community engagement. By adopting comprehensive flood management strategies, cities can become more resilient and better prepared to cope with urban flood events.

A FLASH FLOOD is a sudden and rapid onset of flooding that typically occurs within a short period, often within a few hours or even minutes. Here is some additional information about flash floods:

1. Causes: Flash floods are commonly caused by intense rainfall, particularly in areas with steep terrain or poor drainage. Heavy rainfalls can overwhelm the capacity of rivers, streams, and drainage systems, leading to the rapid accumulation of water.

2. Weather conditions: Flash floods are often associated with severe thunderstorms, tropical storms, or hurricanes. These weather events can produce high-intensity rainfall over a localized area, resulting in rapid runoff and flash flooding.

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3. Rapid water rise: Flash floods are characterized by a sudden and dramatic rise in water levels. The rapid influx of water can catch people off guard and cause significant damage to infrastructure, property, and even loss of life.

4. Affected areas: Flash floods can occur in both urban and rural areas. However, they are particularly hazardous in urban environments due to the abundance of impervious surfaces, which can cause rapid runoff and overwhelm drainage systems.

5. Danger of swift currents: Flash floods often generate swift currents that can sweep away vehicles, debris, and even people. The force of the rushing water poses a significant risk to anyone caught in a flash flood.

6. Limited warning time: Unlike some other types of floods, flash floods provide little to no advance warning. The rapid onset and short duration of these floods make it challenging to issue timely alerts and evacuate vulnerable areas.

7. Flood-prone regions: Flash floods are more common in certain regions, such as arid or semi-arid areas with low vegetation cover, mountainous terrains, or regions prone to thunderstorms. However, they can occur in any location where conditions favor rapid and localized rainfall accumulation.

8. Mitigation measures: Mitigating the impacts of flash floods involves a combination of measures. These may include improving weather forecasting and early warning systems, implementing effective land-use planning to avoid construction in flood-prone areas, constructing flood control structures such as detention basins or flood walls, and educating the public about flash flood risks and safety precautions.

9. Personal safety during flash floods: It is crucial to stay informed about weather conditions and heed evacuation orders or warnings issued by local authorities. If caught in a flash flood, it is recommended to seek higher ground immediately and avoid walking or driving through floodwaters.

10. Climate change and flash floods: Climate change can influence the frequency and intensity of rainfall events, potentially impacting flash flood occurrences. Warmer atmospheric temperatures can lead to more moisture in the air, increasing the likelihood of intense rainfall. Changes in weather patterns and increased extreme weather events can contribute to flash flood risks.

Understanding the characteristics and risks associated with flash floods is vital for individuals, communities, and authorities to develop appropriate emergency

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response plans, improve infrastructure resilience, and promote public safety in flood-prone areas.

W6.9 Bibliography or/and additional reading list for teachers

1. Di Baldassarre, G. et al. (2013) "Socio-hydrology: conceptualising human-flood interactions," Hydrology and Earth System Sciences, 17(8), pp. 3295–3303. Available at: https://doi.org/10.5194/hess-17-3295-2013.
2. Flood (no date). Available at: https://www.nationalgeographic.org/encyclopedia/flood/.
3. Floods | Ready.gov (no date). Available at: https://www.ready.gov/floods
4. Merz, B. et al. (2021) "Causes, impacts and patterns of disastrous river floods," NATURE REVIEWS EARTH and ENVIRONMENT, 2(9), pp. 592–609. Available at: https://doi.org/10.1038/s43017-021-00195-3
5. Nunez, C. (2021) "Floods 101," Environment, 3 May. Available at: https://www.nationalgeographic.com/environment/natural-disasters/floods/
6. Water (2023). Available at: https://ec.europa.eu/environment/water/flood_risk/understanding_risks_en.htm

W6.10 The recommended reading for VET students

1. Di Baldassarre, G. et al. (2013) "Socio-hydrology: conceptualising human-flood interactions," Hydrology and Earth System Sciences, 17(8), pp. 3295–3303. Available at: https://doi.org/10.5194/hess-17-3295-2013
2. Flood (no date). Available at: https://www.nationalgeographic.org/encyclopedia/flood/
3. Floods | Ready.gov (no date). Available at: https://www.ready.gov/floods
4. Merz, B. et al. (2021) "Causes, impacts and patterns of disastrous river floods," NATURE REVIEWS EARTH and ENVIRONMENT, 2(9), pp. 592–609. Available at: https://doi.org/10.1038/s43017-021-00195-3
5. Nunez, C. (2021) "Floods 101," Environment, 3 May. Available at: https://www.nationalgeographic.com/environment/natural-disasters/floods/

6. Water (2023). Available at: https://ec.europa.eu/environment/water/flood_risk/understanding_risks_en.htm
7. The Great Flood of 1993 | U.S. Geological Survey (2004). Available at: https://www.usgs.gov/centers/cm-water/science/great-flood-1993
8. Taylor, A. (2017) "The Unprecedented Flooding in Houston, in Photos," The Atlantic, 8 September. Available at: https://www.theatlantic.com/photo/2017/08/hurricane-harvey-leaves-houston-under-water/538215/
9. Gray, J. (2023) "Different types of flash flooding and what causes it," CNN, 24 March. Available at: https://edition.cnn.com/2023/03/24/weather/what-causes-flash-flooding-xpn/index.html

Presenter: National Geographic Title: Floods 101 | National Geographic URL: https://www.youtube.com/watch?v=4PXj7bOD7IY
Presenter: TED-Ed Title: Why do floods happen? - Athanasios Nenes URL: https://www.youtube.com/watch?v=eUKd5K4E6mM
Presenter: Bureau of Meteorology Title: Understanding floods URL: https://www.youtube.com/watch?v=ivUKLr8q4sE

W6.11 Recommended assessment of student knowledge and skills

These questions will help the student review and evaluate their knowledge of flood types and their impacts. They will also encourage further research and exploration of the topic.

- What are the main types of floods?
- What factors contribute to the occurrence of each type of flood?
- How do urban floods differ from river floods?
- What are the environmental and societal impacts of floods?
- How can floods affect infrastructure and residential areas?
- How can climate change influence flood risk?
- How can geographical location affect flood types?

W6.12 Workshop feedback

Rating scale from 1 to 10 (1 - the lowest, 10 - the highest rating).

How do you assess the organization of training?

Participant service (registration, time management, etc.).

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

Training environment (communication, audience, tools, etc.).

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

How do you assess the training content?

Benefits and applicability of training content.

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

The novelty and relevance of the training content.

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

Lecturer competencies (knowledge, experience, teaching methods).

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

Would you recommend this training to others?

Yes	No	I have no opinion

What training would you be interested in?

Your suggestions

W6.13 Summary of the Workshop

The "Flood Types" workshop was conducted with the aim of enhancing participants' knowledge and awareness of different types of floods. The

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workshop provided a comprehensive overview of various flood types, their causes, impacts. It served as an interactive platform for learning and exchanging insights on flood-related topics.

During the workshop, participants were introduced to the main types of floods, including river floods, urban floods, flash floods. The characteristics, triggers, and unique features of each flood type were discussed in detail. Case studies and real-life examples were presented to illustrate the diverse nature of floods and their consequences.

The workshop emphasized the importance of understanding the causes and contributing factors behind each flood type. Participants learned about the role of weather patterns, topography, climate change, land use, and urban development in influencing flood occurrences. The discussion also touched upon the impact of human activities, such as deforestation and improper infrastructure planning, on exacerbating flood risks.

In addition to theoretical knowledge, the workshop incorporated practical exercises and group discussions. Participants engaged in scenario-based activities to analyze different flood situations and propose appropriate response strategies. The workshop fostered an interactive learning environment, allowing participants to exchange their experiences, challenges, and ideas regarding flood types.

W6.14 Glossary

Coastal Flood: Flooding that occurs along coastal areas due to high tides, storm surges, or a combination of wind, waves, and sea-level rise. Coastal floods can cause erosion and damage to infrastructure.

Flash Flood: A sudden and rapid onset of flooding, usually caused by intense rainfall in a short period. Flash floods can occur with little or no warning.

Flood: An overflow of water onto normally dry land, often caused by heavy rainfall, snowmelt, or dam/levee failures.

Floodplain: The flat or low-lying area adjacent to a river or stream that is subject to flooding during high-water events. Floodplains serve important ecological functions but can also pose risks to human settlements.

River Flood: Flooding that results from a river or stream exceeding its capacity and overflowing its banks. It can be caused by heavy rain, snowmelt, or a combination of factors.

Seasonal/Monsoon Flood: Flooding that occurs during specific seasons characterized by heavy rainfall or monsoon climates. These floods are influenced by weather patterns and can be predictable to some extent.

Urban Flooding: Flooding that primarily affects urban areas due to inadequate drainage systems, impervious surfaces, and heavy rainfall. It often leads to water accumulation on streets and in basements.

W6.15 The presentations

Flood types_KVK.ppt

Kahoot (or other) test:

1. What is the cause of a flood? a) Prolonged rainfall b) Storm c) Earthquake d) All of the above

Answer: d) All of the above

2. What are the types of floods? a) Flash flood b) Coastal flood c) River flood d) All of the above

Answer: d) All of the above

3. What is a characteristic of a flash flood? a) Rapid rise and fall of water b) Standing water above the ground c) Small flood waves d) Water rise due to prolonged storm

Answer: a) Rapid rise and fall of water

4. What is a characteristic of a coastal flood? a) Rapid rise and fall of water b) Standing water above the ground c) Small flood waves d) Water rise due to cyclone or hurricane

Answer: d) Water rise due to cyclone or hurricane

5. What is a characteristic of a river flood? a) Rapid rise and fall of water b) Standing water above the ground c) Small flood waves d) Water rise due to moon phase and astronomical forces
Answer: b) Standing water above the ground
6. Which factors can influence the intensity of a flood? a) Wind b) River currents c) Atlantic currents d) All of the above
Answer: d) All of the above
7. How can you protect against floods? a) Build flood barriers b) Follow flood warnings and evacuation orders c) Improve city drainage systems d) All of the above
Answer: d) All of the above

Flood types_discussion.ppt

Workshop 7 Coastal flooding and coastal erosion

W7.1 Instructor(s) name(s) and contact information

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W7.2 Workshop Description

The workshop's topic is coastal erosion and coastal floods. The participants will become familiar with the primary processes that affect the coastal zone (waves, longshore currents, surge/storm waves, tide etc.), as well as their potential negative results (such as coastal erosion and flooding). They will also become familiar with the main morphological features of the coastal zone (e.g., beaches, rocky coasts, rocky cliffs etc.).

Moreover, they will understand what natural factors cause and affect these phenomena (coastal erosion and flooding), as well as how human interventions bear an impact on their properties. What is more, they will get to know the most common measures for their mitigation and critically assess their efficiency compared to their advantages and disadvantages.

The workshop on coastal erosion and coastal flooding is a laboratory and its primary tool will be the wave tank, which can be used to simulate the wave action based on the wave energy the users choose to apply (see section 5). During the workshop, several parameters will be altered by the instructors, so that students can view the different impacts of these parameters on the coastal zone. Additionally, during the workshop's different phases, simulations of different protective measures will be defined, such as breakwaters, sea walls, jetties etc., so that students can view which measures offer protection from coastal erosion and flooding in the most efficient way, also relevant to their cost and other benefits and drawbacks. Moreover, nature-based solutions will be discussed, so that students comprehend the benefits of applying these measures instead of hard engineering methods.

W7.3 Workshop goals and objectives

Learning goals

The learning goals of this workshop include the following:

- Students will learn the basic physiographical/geomorphological terms regarding the coastal zone (beach, rocky coast, coastal cliff, sediments etc.) and how they are connected to each other.
- Students will become familiar with the main natural processes that affect the coastal zone (wave activity, storms and wind, tide, sediment production etc.).
- Students will learn what natural factors cause coastal flooding and erosion and what natural and anthropogenic parameters affect their properties and consequences.
- Students will learn which protective measures are frequently used for coastal management, their benefits, drawbacks and their efficiency.
- Students will learn what nature-based alternatives there exist, their benefits over the usage of hard engineering methods, as well as their efficiency and the extent to which they are applicable in coasts with different wave, tide and current regime.

These learning goals will be also extended to the participating teachers, who will also become familiar with the aforementioned, in case they are unaware, or enrich their pre-existing knowledge regarding the various aspects of the coastal zone.

Learning objectives

The learning objectives of this workshop include:

- Students will comprehend the impacts of coastal erosion and flooding on the human societies and, more specifically, coastal settlements, coastal constructions, as well as activities that take place on the coast.
- Students will comprehend in which cases and under which circumstances should protective measures be applied on the coast to ensure proper coastal management.
- Students will understand the multiple benefits of nature-based solutions compared to hard engineering methods, as well as in which case they can actually be applied.
- Students will learn to respect nature and be in accordance with the natural processes. In this way, they will become sensitised in coastal issues and contribute themselves to its proper management.
- Because the workshops consists of teaching in an interactive and entertaining way, students will restrain the obtained knowledge and will also be able to apply it whenever it is considered necessary.
- Students will develop their critical thinking, as they will participate actively in the fruitful discussions that will follow every phase of the workshop.

These learning objectives will also be extended to the participant teachers, as they will obtain all the aforementioned knowledge, in case they do not already, or enrich it. Moreover, they will obtain valuable skills regarding education, as they will learn to utilise various STEAM tools (in this case, the wave tank, but other tools by extension as well) in order to teach their students effectively and in an entertaining way.

W7.4 Pre-requisites

The pre-requisites for the participating students include:

- Familiarity with the morphology of a typical beach and a typical rocky coast (not necessarily the terminology)

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- Familiarity with the primary effects of waves, currents etc. on the coastal floods and erosion

A wave tank will be used during the workshop's implementation (see section 5).

W7.5 Workshop methodology

The workshop on coastal erosion and flooding may be improved by using a STEAM approach and Augmented Reality (AR) technology. STEAM is a teaching approach that encourages interdisciplinary learning and critical thinking abilities by combining science, technology, engineering, arts, and mathematics. In contrast, augmented reality (AR) is a technology that superimposes digital material onto the real-world environment to provide an immersive and engaging learning experience.

During the workshop, a wave tank will be used. The wave tank is essentially a tub filled with water, in which waves are artificially generated. The properties of the waves, such as duration, intensity, frequency, height and direction, can be controlled by the instructors, allowing students to observe and analyze the effects of different wave characteristics on the coastal zone.

Students may examine how various kinds of waves influence the coastal zone differently by changing the features of the waves. They may, for example, investigate how long-period waves that travel longer distances affect the beach morphology versus short-period waves that travel shorter distances. Users may also see how variations in wave height and frequency impact the stability of coastal infrastructure like sea walls and breakwaters.

The wave tank may also be used to model wave behaviour in various conditions, such as storm surges or tsunamis, allowing students to see the effects of major occurrences on the coastal zone. Additionally, the wave tank may be utilised to investigate wave behaviour in various coastal environments, such as sandy beaches, rocky coastlines and cliffs.

Students may also obtain a better understanding of the underlying processes that impact the coastal zone and how these processes interact with human interventions and natural causes. This hands-on learning exercise may help students build critical thinking skills and equip them to face real-world coastal erosion and flooding concerns.

In conclusion, the wave tank, as a STEAM methodology can assist students in developing a deeper understanding of the scientific and engineering principles underlying the phenomena of coastal erosion and flooding, as well as allowing them to critically evaluate different mitigation measures based on their efficiency, cost, and other benefits and drawbacks.

W7.6 Workshop Participation

Students will be asked to actively participate in a range of activities supervised by the teachers during the coastal erosion and flooding workshop. The workshop will have a mix of lectures, discussions, and hands-on activities that will help students learn more about the topic and get some experience in it.

Students will be required to attend carefully, take notes during the workshop and ask questions. The teachers will give a theoretical basis for comprehending coastal zone dynamics as well as the effects of coastal erosion and floods. Students will engage in hands-on activities such as using the wave tank to model the impact of waves on the coastal zone.

Students will work in groups to tweak the wave parameters and study how these changes influence the wave behaviour and consequently the coastal zone. Students will also observe simulations of various coastal erosion and flooding mitigation methods, such as breakwaters, sea walls, and jetties. Students will evaluate the effectiveness of these measures and critically examine their benefits and drawbacks.

At the conclusion of the session, students will be asked to reflect on what they have learned and apply their knowledge to real-world circumstances. They will be able to share their observations, thoughts and ideas with the group and will get feedback from the instructors and their peers.

W7.7 Time outline

Activity	Time
Introduction 1. Welcome of the students and introduction to the topic and objectives of the workshop. Brief overview of the structure and activities.	2-5 minutes
2. Lecture on coastal flooding and coastal erosion 3. Introduction to the primary processes affecting the coastal zone, including waves, currents, tides, surge/storm waves etc.	5-20 minutes

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4. Overview of the main morphological features of the coastal zone (e.g., beaches, rocky coasts, cliffs etc.). Discussion of natural factors that cause and affect coastal erosion and flooding, as well as human interventions that impact these phenomena.	
Wave tank simulation 1. Demonstration of the wave tank and how it will be used during the workshop. 2. Students work in small groups to adjust wave parameters and observe their effects on the coastal zone. 3. Discussion on different types of waves and their impact. 4. Introduction to different protective measures, such as breakwaters, sea walls etc. 5. Students will simulate these measures using the wave tank and they will observe their effectiveness in mitigating coastal erosion and flooding. Discussion of the advantages and disadvantages of these measures.	6-50 minutes
Workshop summary 1. Summary of the main points covered in the workshop. 2. Reflection on what students have learned and how they can apply their knowledge to real-world situations. Questions and Answers	15 minutes
Total	**90 minutes**

W7.8 Theoretical background

Coastal flooding

One of the regions most commonly inhabited by humans, even in ancient times, is the coastal zone. The reason for this is that it offers multiple benefits. Initially, in several cases, the coasts have a flat morphology, which facilitates dwelling and other human activities. Even in areas where this is not the case, however, there are still other benefits offered by the coastal zone. The short distance from the sea entails easy access to abundant food resources (through fishing). Moreover, the coastal zone facilitates several other human activities, such as transportations, trading etc. Another example includes the deltas of large rivers,

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which are known to have fertile soils due to the fine-grained sediments (clay, silt) transported by the rivers and deposited in their deltaic plains.

All these benefits have rendered the coastal zone one of the most preferred sites of human habitation (Chelleri et al., 2015) and the development of human activities since Antiquity (Ewing and Synolakis, 2011). A further value of the coasts has been more recently acknowledged. The coastal zone's aesthetic value has been widely recognised and thus it attracts a significant amount of tourists. Beach-related tourism contributes to a significant extent to many countries' economy.

However, as important as the coastal zone has been proved to be regarding human activities in general, it is very important to comprehend that it is not something stable, but instead it undergoes continuous changes, both long and short-term. It is also of primary significance to understand the different drivers of these changes, i.e. natural versus anthropogenic ones.

To begin with the natural drivers, it is worth mentioning that the sea-level itself is continuously changing in different time intervals. In the last two and a half million years, the Earth's climate is periodically shifting from glacial to interglacial periods. During glacial periods, the global climate is cold and dry. Due to the very low temperatures prevailing at a global scale, glaciers are formed in most parts of the planet. The water of which these glaciers consist is the sea water. In other words, water from the sea is accumulated in the mainland to form glaciers. As a result, the sea-level falls. This fall, however, is global (Shackleton and Opdyke, 1976). Moreover, it is generally of high magnitude. In the last glacial period, for example, the sea-level was roughly 120 meters lower than today.

During interglacial periods, the glaciers melt and the water returns to the sea. As a result, the sea-level rises anew, also at a global level. It is worth mentioning that glacial periods are longer-lasting than interglacial ones. These sea-level changes are generally of high magnitude. For instance, the Last Glacial Maximum, which took place approximately 18 to 20 thousand years ago, the sea-level was roughly 120 meters lower than today. The last 18,000 years until today are an interglacial period. After the melting of the glaciers, the global sea-level started rising rapidly, with a rate of approximately 1 cm per year, until 6,000 years ago, when it remained relatively stable, only rising by 1-2 mm per year (Chappel, 1990; Church *et al.*, 2001; Church and White, 2011; Church *et al.*, 2013).

Based on that, we can comprehend that the global sea-level rise at such rates is a natural process, which occurred in the past, occurs at present and will also occur in the future. However, it has been shown that currently, the sea-level is rising at higher rates, due to a global and rapid change in the global climate (Bindoff et al., 2007), which in turn has been shown to be provoked by human interventions. It may not seem obvious, but humans have been affecting the climate since ancient times. The primary activity included the combustion of fossil fuels, which still takes place today. This causes the augmentation of the global temperature due to emanated gasses. The global rise in the temperature has become more intense during the last two centuries, after the industrial revolution, as the amount of the emanated gasses has exponentially increased.

This human-induced rise in the temperature, besides that which would anyway be caused during any interglacial period, has led to a proliferation of the amount of glaciers melting. Therefore, based on the above described processes, the global sea-level is rising at higher rates than normal. Several measures have shown that during the last decades, the sea-level is no longer rising at such low rates. In fact, based on observations from satellite images, it has been estimated that during the last two decades, the global sea-level is rising by 3 mm per year.

Given that human activities on the coastal zone have been very well-developed nowadays, as described above, it is obvious that many communities will face severe problems in the future due to the rising sea-level (Lantz *et al.*, 2020; Neumann *et al.*, 2015). Mathematically, the quoted increase in the sea-level rise (from rates of 1-2 mm to 3 mm per year) may not seem very significant. Yet, it is worth mentioning that in a coastal area of flat morphology, 1 mm of sea-level rise results in the progradation of the sea water by 100 mm, or 10 cm, towards the mainland. Therefore, within a time period of a few years, settlements that are hosted in areas of low altitude, flat morphology and adjacent to the sea will face severe inundation issues (Chappell, 1990; Pethick, 2001; Schuerch *et al.*, 2018).

Coastal flooding is one of the most important results of the global sea-level rise. Of course, as a phenomenon, it is not independent on natural processes that always occur on the coast. Coastal flooding, for example, can be a result of storm waves, tsunamis etc. Tsunamis are phenomena that are owed to natural processes that take place below the sea-level, such as earthquakes and volcanic eruptions. These phenomena are not related to the climate and have therefore not been affected by the human activities. Some of the most devastating tsunamis have occurred in the broader area of Japan, the Philippines and Indonesia. Regarding Europe, tsunamis are relatively common in the Eastern Mediterranean (Greece, Italy, Croatia etc.), but also on the Atlantic coasts (Spain, Portugal, Great Britain, Ireland etc.).

The other two primary causes of coastal flooding are highly affected by the climate. They include storms and the global sea-level rise. Storms, just like tsunamis, may potentially cause a temporary inundation of low-lying coastal areas. Surging waves due to storms (or strong winds) are generally less damaging than tsunamis, but they still cause significant infrastructure damages and property losses.

The man's influence on the effects of coastal flooding due to surging waves is associated with his impacts on the global climate. Besides the global rise in the sea-level, the rainfall patterns have also been altered due to human interventions. In many regions, the total amount of rainfall has been reduced, whereas in others it has been increased (Nakaegawa et al., 2013; Santini and di Paola, 2015). The precipitation types have also been altered. For instance, in many areas, the highest amount of the annual precipitation falls during short periods and with a high intensity. This is related to the observed increase in both the frequency and intensity of extreme weather phenomena, such as storms. It is thus obvious that temporary coastal flooding has also been increased in many areas globally.

Regarding permanent coastal inundation, this is owed to the global rise in the sea-level. As mentioned above, the sea-level is rising at higher rates than normally and it will continue rising even further. Unfortunately, permanent coastal inundation is not merely an upcoming danger, as it has already been initiated.

According to a recent report by the Intergovernmental Panel on Climate Change (IPCC, 2019), the predominant sources of freshwater supply leading to global

Mean Sea Level (GMSL) are glaciers and ice caps. From tide gauge observations and satellite altimeter observations, GMSL has increased from 1.4 mm/year in the period 1901-1990, to 2.1 mm/year in the period 1970-2005, to 3.2 mm/year in the period 1993-2015 and to 3.6 mm/year in the period 2006-2015. GMSL in 2019 was the highest ever measured. Representation of GMSL based on tidal observations shows an increase of 19.0 cm from 1900 until today.

Estimates of projected future changes in this report are largely based on the predictions of the CMIP5 climate model using Representative Concentration Pathways (RCPs). RCPs are scenarios that include time series of emissions and concentrations of the full range of greenhouse gases (GHGs), aerosols and chemically active gases, as well as land use / land cover. RCPs provide only a set of many possible scenarios that would lead to different levels of global warming. The future increase of GMSL caused by thermal expansion, melting of glaciers and ice caps and changes in water storage, largely depends on which scenario is followed. At the end of the century, sea level rise is expected to be faster in all scenarios, including those that are compatible with achieving the long-term temperature target set by the Paris Agreement.

One of the areas globally where coastal flooding has become extreme is the Netherlands. It is a low-lying country exposed to the open Atlantic Ocean. Over the 20th century, the Dutch coasts have shown a 50% increase in the rates of sea-level rise compared to previous centuries. Moreover, it has been estimated that by 2071-2100, the sea-level will rise by 25 to 80 cm (Van Koningsveld and Mulder, 2004; Climate Change Post, 2023).

This phenomenon does not only take place in the Dutch shorelines, but affects almost all coastal areas. And there are many types of human activities that are jeopardised. Coastal settlements are the most common, as many coastal communities will be forced to move to the mainland in order to be protected by the coastal floods. What is more, trading activities and sites of cultural and natural heritage are also in high danger of being submerged.

Several flood-proofing measures have been taken to mitigate coastal flooding, either as a result of surging waves and tsunamis or due to the global sea-level rise. Sea or rock walls, for instance, have been typically used to prevent the sea

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water due to waves to reach adjacent settlements. They are constructed parallel to the shoreline from rocks, boulders or cement (FEMA, 1992, 2007, 2008).

Flood-proofing measures have also been applied in the buildings themselves besides directly on the coast. they are applied both to houses and other important constructions or facilities (e.g., electricity stations). They are grouped into two categories: wet and dry ones. Dry methods include the construction of buildings in such a way that they are impermeable by the sea water. Wet methods allow the entrance of the sea water into the structures (e.g. buildings) and cause it to exit them without causing any, or at least significant, damages (FEMA, 1992, 2007, 2008; Zhu *et al.*, 2010).

A significant advantage of flood-proofing measures applied on constructions is that they do not require the constructions to be relocated, whereas they are generally effective in most cases. Additionally, they do not further affect the coastal zone. Wet measures have further advantages, as they render buildings more resistant to flood-induced damages and, when structures are damaged, their repairing is cheaper and easier. Their main disadvantage compared to dry methods is that they are inhabitable during coastal floods (FEMA, 1992, 2007, 2008; Powell and Ringler, 2009).

Coastal erosion

The coastal zone is a natural system that is directly affected by the interaction between the lithosphere, the hydrosphere, and the atmosphere, as well as by the action of terrestrial, aerial and marine processes. It is an environment which constantly changes over time through slow-moving phenomena, the duration of which may vary from as long as a thousand years to a rapid action within even twenty-four hours. Apart from its unique physical characteristics, the coastal zone is also of great interest for the plethora of resources it offers.

About 41.0% of Europe's population lives near the coast, leading to increasing urbanization rates (Collet and Engelbert, 2013). The coastal zone hosts a number of tourism businesses and activities, making, therefore, the tourism industry one of the most important sectors of the economy at local and national level. Among the various types of coasts, sandy coasts are more encumbered by this type of activity (Davenport and Davenport, 2006) and they are among the most geomorphologically complex coasts, with the coastline constantly changing under the interaction between natural and anthropogenic factors (Mentaschi *et al.*, 2018; Vousdoukas *et al.*, 2020).

Apart from the natural factors that contribute to the evolution of the coastal zone such as eustatism, tectonics and isostasy, the climate change in recent decades is capable of causing significant changes in coastal areas, mainly due to rising sea levels, with the coastline being the main receiver of these changes. Coastal environments are in a dynamic interaction with marine processes where coastal sediments are constantly moving, either resulting in the formation of a new coastline or the erosion of an existing coastline. The phenomenon of erosion is intensified by rising sea levels, as well as by anthropogenic interventions, thus increasing the vulnerability of the coastal zone (Briguglio, 2004).

Sediment transport, wave dynamics and coastline morphology are some of the major concepts and principles connected to coastal erosion (Dean and Dalrymple, 2002; Masselink and Hughes, 2003).

- The transportation of sediment along the coast caused by wave and current action is referred to as "sediment transport." The driving factors of sediment transport are waves, whose strength, direction, and frequency determine the direction and pace of sediment flow.
- The physical features of the coastal zone, such as beach slope, profile, and sediment size and composition, may impact wave energy dissipation and sediment movement.

A 13.6–15.2% (36,097–40,511 km) of sandy coasts worldwide could be severely eroded by 2050, with these figures rising to a percentage of 35.7%-49.5% (95,061–131,745 km) by the end of the century (Vousdoukas *et al.*, 2020). In the case of Greece, the coastline reaches 18,400 km for the mainland and 9,835 km for the islands (Poulos and Chronis, 1997).

Since the end of the 19th century, global sea levels have risen by about 1.6 mm/year (Church and White, 2011), while its rate has not exceeded 0.6 mm/year over the past two millennia (Kemp *et al.*, 2011). In time scales ranging from decades to centuries, sea levels vary, mainly due to anthropogenic climate change and its effects on the melting of glaciers and ice caps and the thermal expansion of the oceans (Milne *et al.*, 2009; Church *et al.*, 2011). As sea levels are expected to rise further in the future (0.5 to 1.0 m by 2100 and possibly more (Church *et al.*, 2013)), concerns about its future impact on coastal areas are also increasing (Hinkel *et al.*, 2012; Hallegatte *et al.*, 2013; Mimura, 2013).

Protective measures are often implemented to mitigate coastal erosion and provide protection to the coastline and coastal infrastructure. Breakwaters, seawalls, groynes and revetments are some of the most commonly used protective measures (Reeve and Chadwick, 2019; Zhang *et al.*, 2021; Zhu *et al.*, 2010).

- Breakwaters are offshore constructions meant to lessen the intensity of oncoming waves while also protecting the coastline from erosion. They are often composed of concrete, rock, or steel and may be submerged or visible.
- Seawalls are vertical constructions constructed along the coast to guard against storm surges and waves. They are often utilized in places with strong wave energy and steep coastal slopes and are composed of concrete, masonry, or rock.
- Groynes are structures constructed parallel to the shoreline to trap sediment and stabilize the beach. They are usually composed of wood, concrete or rock and may help to reduce coastal erosion. Revetments are sloping structures placed along the beach to absorb wave energy and prevent erosion. They are often constructed of concrete or rock and are intended to fit in with the natural coastline.

Although these protective measures may be beneficial in decreasing erosion and floods, they can also have unanticipated negative consequences for the surrounding coastal ecosystem, such as changes in sediment movement and beach morphology. As a result, it is critical to carefully weigh the benefits and drawbacks of various preventive measures before applying them.

W7.9 Bibliography or/and additional reading list for teachers

- Bindoff, N.L. et al. (2007) Observations: Oceanic Climate Change and Sea Level Coordinating, Climate Change 2007: The Physical Science

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Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by S. Solomon et al. Available at: https://eprints.soton.ac.uk/id/eprint/50391

- Briguglio, L. (2004) Small Island Developing States and their Economic Vulnerabilities. International Workshop on 'Vulnerability and Resilience of Small States'. The Global Development Research Center Programme, Partner of UN Ocean Atlas, The Ocean Project, GIN Global Island Network, World Ocean Network. Malta.
- Chapel, J. (1990) 'Some effects of sea level rise on riverine and coastal lowlands', Geological Society of Australia, Special publication, 1, pp. 37–45.
- Chelleri, L. et al. (2015) 'Resilience trade-offs: addressing multiple scales and temporal aspects of urban resilience', Environment and Urbanization, 27(1), pp. 181–198. Available at: https://doi.org/10.1177/0956247814550780
- Church, J. A. and White, N. J. (2011) 'Sea-Level Rise from the Late 19th to the Early 21st Century', Surveys in Geophysics, 32(4), pp. 585–602. doi: 10.1007/s10712-011-9119-1.
- Church, J. A. et al. (2011) 'Revisiting the Earth's sea-level and energy budgets from 1961 to 2008', Geophysical Research Letters. John Wiley & Sons, Ltd, 38(18). doi: 10.1029/2011GL048794.
- Church, J. A. et al. (2013) 'Sea-level rise by 2100', Science. American Association for the Advancement of Science, 342(6165), p. 1445. doi: 10.1126/SCIENCE.342.6165.1445-A/ASSET/D6472434-3494-48D2-BC42-036EF82E48E6/ASSETS/SCIENCE.342.6165.1445-A.FP.PNG.
- Church, J.A. et al. (2001) 'Changes in sea level', in J.T. Houghton et al. (eds) Climate Change 2001: The Scientific Basis: Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel, pp. 639–694.
- Climate Change Post (2023) Coastal flood risk The Netherlands. Available at: https://www.climatechangepost.com/netherlands/coastal-floods/ (Accessed: 24 March 2023)
- Collet, I. and Engelbert, A. (2013) 'Coastal regions: People living along the coastline and integration of NUTS 2010 and latest population grid', EUROSTAT Stat. Focus, 30, pp. 2–12.

- Dangendorf, S. et al. (2019) 'Persistent acceleration in global sea-level rise since the 1960s', Nature Climate Change. Springer US, 9(9), pp. 705–710. doi: 10.1038/s41558-019-0531-8.
- Davenport, J. and Davenport, J. L. (2006) 'The impact of tourism and personal leisure transport on coastal environments: A review', Estuarine, Coastal and Shelf Science, 67(1), pp. 280–292. doi: https://doi.org/10.1016/j.ecss.2005.11.026.
- Dean, R. G. and Dalrymple, R. A. (2002) Coastal processes with engineering applications. Cambridge University Press.
- Evelpidou, N. (2020) Sea-level changes. Athens, Greece (In Greek): DaVinci.
- Ewing, L., et al. (2011) Coastal resilience: Can we get beyond planning the last disaster? Solutions to Coastal Disasters, 2011.
- FEMA (1992) Repairing your flooded home. Washington D.C., U.S.A.
- FEMA (2007) Selecting Appropriate Mitigation Measures for Floodprone Structures. Washington D.C., U.S.A.
- FEMA (2009) Floodplain Management Bulletin: Historic Structures. Washington D.C., U.S.A.
- Hallegatte, S. et al. (2013) 'Future flood losses in major coastal cities', Nature Climate Change. Nature Publishing Group, 3(9), pp. 802–806. doi: 10.1038/nclimate1979.
- Harada, K., Imamura, F. and Hiraishi, T. (2002) 'Experimental Study on the Effect in Reducing Tsunami by the Coastal Permeable Structures', in Proceedings of the International Offshore and Polar Engineering Conference. San Fracisco, California, U.S.A., pp. 652–658.
- Hinkel, J. et al. (2012) 'Sea-level rise impacts on Africa and the effects of mitigation and adaptation: An application of DIVA', Regional Environmental Change, 12(1), pp. 207–224. doi: 10.1007/s10113-011-0249-2.
- IPCC (2019) Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities, The Ocean and Cryosphere in a Changing Climate. doi: 10.1017/9781009157964.012.
- Kemp, A. C. et al. (2011) 'Climate related sea-level variations over the past two millennia', Proceedings of the National Academy of Sciences of the United States of America. National Academy of Sciences, 108(27), pp. 11017–11022. doi: 10.1073/PNAS.1015619108/SUPPL_FILE/PNAS.1015619108_SI.PDF.

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- Lantz, T.C. et al. (2020) 'Mapping Exposure to Flooding in Three Coastal Communities on the North Slope of Alaska Using Airborne LiDAR', Coastal Management, 48(2), pp. 96–117. Available at: https://doi.org/10.1080/08920753.2020.1732798
- Masselink, G. and Hughes, M. G. (2003) Introduction to coastal processes and geomorphology. Hodder Arnold.
- Mentaschi, L. et al. (2018) 'Global long-term observations of coastal erosion and accretion', Scientific Reports, 8(1), p. 12876. doi: 10.1038/s41598-018-30904-w.
- Milne, G. A. et al. (2009) 'Identifying the causes of sea-level change', Nature Geoscience, 2(7), pp. 471–478. doi: 10.1038/ngeo544.
- Mimura, N. (2013) 'Sea-level rise caused by climate change and its implications for society', Proceedings of the Japan Academy Series B: Physical and Biological Sciences, 89(7), pp. 281–301. doi: 10.2183/pjab.89.281.
- Nakaegawa, T., Kitoh, A. and Hosaka, M. (2013) 'Discharge of major global rivers in the late 21st century climate projected with the high horizontal resolution MRI-AGCMs', Hydrological Processes, 27(23), pp. 3301–3318. Available at: https://doi.org/10.1002/hyp.9831
- Neumann, B. et al. (2015) 'Future coastal population growth and exposure to sea-level rise and coastal flooding - A global assessment', PLoS ONE, 10(3). Available at: https://doi.org/10.1371/journal.pone.0118571
- Pethick, J. (2001) 'Coastal management and sea-level rise', Catena, 42(2–4), pp. 307–322. Available at: https://doi.org/10.1016/S0341-8162(00)00143-0
- Poulos, S. E. and Chronis, G. T. H. (1997) 'The importance of the river systems in the evolution of the Greek coastline by', Transformations and evolution of the Mediterranean Coastline, (January 1997), pp. 75–96.
- Powell, M. and Ringler, R. (2009) 'Yorklin, DE, and other cities adopt plans to protect buildings in floodplains from water', in R.L. Kemp (ed.) Cities and Water: A Handbook for Planning. Jefferson, North Carolina, U.S.A.: McFarland and Company, pp. 180–184.
- Reeve, D. E. and Chadwick, A. (2019) Coastal engineering: processes, theory and design practice. Routledge.

- Santini, M. and di Paola, A. (2015) 'Changes in the world rivers' discharge projected from an updated high resolution dataset of current and future climate zones', Journal of Hydrology, 531, pp. 768–780. Available at: https://doi.org/10.1016/j.jhydrol.2015.10.050
- Schuerch, M. et al. (2018) 'Future response of global coastal wetlands to sea-level rise', Nature, 561(7722), pp. 231–234. Available at: https://doi.org/10.1038/s41586-018-0476-5
- Shackleton, N.J. and Opdyke, N.D. (1977) 'Oxygen Isotope and Palaeomagnetic Stratigraphy', Nature, 270(m), pp. 216–219.
- Van Koningsveld, M. and Mulder, J.P.M. (2004) 'Sustainable coastal policy developments in the Netherlands. A systematic approach revealed', Journal of Coastal Research, 20(2), pp. 375–385. Available at: https://doi.org/10.2112/1551-5036(2004)020[0375:SCPDIT]2.0.CO;2
- Vousdoukas, M. I. et al. (2020) 'Sandy coastlines under threat of erosion', Nature Climate Change, 10(3), pp. 260–263. doi: 10.1038/s41558-020-0697-0.
- Zhang, J. et al. (2021) 'Beach erosion, restoration, and protection', in Esteban, M., Takagi, H., and Shibayama, T. (eds) Handbook of Coastal Disaster Mitigation for Engineers and Planners . Springer, pp. 297–328.
- Zhang, K. (2016) 'Regime shifts and resilience in China's coastal ecosystems', Ambio, 45(1), pp. 89–98. Available at: https://doi.org/10.1007/s13280-015-0692-2
- Zhu, X., Linham, M.M. and Nicholls, R.J. (2010) Technologies for climate change adaptation: coastal erosion and flooding. Roskilde, Denmark. Available at: http://www.uneprisoe.org/%5Cnhttp://tech-action.org/

W7.10 The recommended reading for VET students

- Brown, S. et al. (2007) 'The management of coastal erosion in Australia: key institutional responsibilities, policy options and the role of insurance', Marine Policy, 31(2), pp. 139–151.
- Dean, R. G. and Dalrymple, R. A. (2002) Coastal processes with engineering applications. Cambridge University Press.
- Evelpidou, N. et al. (2023) 'GIS-Based Assessment of Fire Effects on Flash Flood Hazard: The Case of the Summer 2021 Forest Fires in Greece', GeoHazards, pp. 1–22. doi: 10.3390/geohazards4010001.

- Farhan, Y. and Anaba, O. (2016) 'Flash Flood Risk Estimation of Wadi Yutum (Southern Jordan) Watershed Using GIS Based Morphometric Analysis and Remote Sensing Techniques', Open Journal of Modern Hydrology. Scientific Research Publishing, Inc, 06(02), pp. 79–100. doi: 10.4236/OJMH.2016.62008.
- Karkani, A. et al. (2021) 'Flash Flood Susceptibility Evaluation in Human-Affected Areas Using Geomorphological Methods—The Case of 9 August 2020, Euboea, Greece. A GIS-Based Approach', GeoHazards 2021, Vol. 2, Pages 366-382. Multidisciplinary Digital Publishing Institute, 2(4), pp. 366–382. doi: 10.3390/GEOHAZARDS2040020.
- Kjerfve, B. (2017) 'Coastal lagoons and climate change: ecological and social ramifications in the 21st century.', Ocean & Coastal Management, 136, pp. 1–13.
- Masselink, G. and Hughes, M. G. (2003) Introduction to coastal processes and geomorphology. Hodder Arnold.
- Reeve, D. E. and Chadwick, A. (2019) Coastal engineering: processes, theory and design practice. Routledge.
- Reeve, D. E. and Chadwick, A. (2019) Coastal engineering: processes, theory and design practice. Routledge.
- Vousdoukas, M. I. et al. (2020) 'Sandy coastlines under threat of erosion', Nature Climate Change, 10(3), pp. 260–263. doi: 10.1038/s41558-020-0697-0.
- Zhang, J. et al. (2021) 'Beach erosion, restoration, and protection', in Esteban, M., Takagi, H., and Shibayama, T. (eds) Handbook of Coastal Disaster Mitigation for Engineers and Planners . Springer, pp. 297–328.
- Zhang, K. et al. (2017) 'A review of coastal protection strategies: case study of China's coastline', Ocean & Coastal Management, 149, pp. 53–60.

W7.11 Recommended assessment of student knowledge and skills

1. **Explain the primary processes that affect the coastal zone and their potential negative results?**

Answer: The primary processes that affect the coastal zone include waves, longshore currents, surge/storm waves, tides and sea level rise. These processes can cause coastal erosion, shoreline retreat and flooding, which can lead to property damage, loss of infrastructure and harm to coastal ecosystems.

2. **How do natural factors cause and affect coastal erosion and flooding, and what human interventions impact their properties?**

Answer: Natural factors such as sea level rise, storm surges and wave action can cause coastal erosion and flooding. Human interventions such as coastal development, sand mining and the construction of hard structures like seawalls and breakwaters can also impact the coastal zone, altering natural sediment transport processes and exacerbating erosion and flooding.

3. **What are the main morphological features of the coastal zone, and how do they contribute to the effects of coastal erosion and flooding?**

Answer: The main morphological features of the coastal zone include beaches, rocky coasts, cliffs and estuaries. These features can influence the sediment transport and erosion processes, which can cause changes in the shoreline position and affect the potential for flooding and erosion.

4. **Can you identify the most common measures for mitigating coastal erosion and flooding, and critically assess their efficiency compared to their advantages and disadvantages?**

Answer: The most common measures for mitigating coastal erosion and flooding include beach nourishment, dune restoration and the construction of hard structures such as seawalls, breakwaters and groynes. Each measure has its own advantages and disadvantages, and their efficiency depends on the specific coastal area and its characteristics.

W7.12 Workshop feedback

1. On a scale of 1 to 5, how useful did you find the workshop in understanding coastal erosion and coastal floods?
    a. Not useful at all
    b. Somewhat useful
    c. Moderately useful
    d. Very useful
    e. Extremely useful
2. Which protective measure against coastal erosion and coastal floods did you find most effective?
    a. Breakwaters

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   b. Sea Walls
   c. Jetties
   d. Nature-based solutions
3. Were the tasks and activities provided during the workshop helpful in reinforcing your understanding of the concepts taught?
   a. Yes
   b. No
4. What did you like most about the workshop?

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W7.13 Summary of the Workshop

The workshop "Coastal flooding and coastal erosion" is a 90-minute workshop aiming to introduce participants (students, as well as VET teachers) to these two major issues that threaten many coastal communities and activities. A wave tank will be used, simulating extreme waves (e.g., tsunami-induced waves, storm surges etc.) and their impacts on the coastal zone itself, as well as human constructions. It also simulates various coastal mitigation measures and participants can observe their efficiency towards different types of waves. More specifically, during the workshop, different combinations of wave types and human interventions will be simulated, so that participants can comprehend the intersection between the coastal processes and the anthropogenic activities, as well as the increased sensitivity of the coastal zone compared to other natural environments.

W7.14 Glossary

Beachrocks: hard coastal rocks made from beach material, cemented naturally.

Breakwaters: structures parallel to the coastline, partly or wholly submerged; the incoming waves are broken on them, loosing part of their energy and thus bearing a lesser impact on the coastal zone.

Coast: the interface between the marine and the terrestrial environment.

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Coastal erosion: the breaking down and carrying away of coastal materials by the marine processes, mainly waves and long-shore currents.

Coastal flooding/inundation: a relatively intense and often sudden rise in the local sea-level due to surging/tsunami waves (temporary), as well as due to the global sea-level rise.

Coastal sediments: pieces of solid material that can be removed by the motion of the sea water (waves or currents).

Coastal zone: the part of the land affected by its proximity to the sea and that part of the sea affected by its proximity to the land.

Coastline/Shoreline: the line separating the land and the sea.

Dry flood-proofing measures: flood-proofing measures based on making the coastal constructions (e.g. buildings) impermeable to the sea water.

Flood-proofing measures: measures applied on coastal constructions (e.g. buildings) to mitigate the impacts of coastal flooding.

Gabions/Bulkheads: large boulders stacked up in coastal areas and confined in steel cages; used for mitigating coastal erosion and preventing landslides.

Glacial period: period during which there is extended development of glaciers and a consequent fall in the sea-level at a global scale.

Gravel: sediments with a grain diameter larger than 2 mm.

Groynes: constructions perpendicular to the coastline, permeable or impermeable by the sea water, partly blocking the coastal currents, preventing the coastal sediments from being removed, and trapping incoming sediments.

Hard-engineering measures: protection measures on the coastal zone, based on the construction of various structures using several materials.

Interglacial period: period during which there is extended melting of glaciers and a consequent rise in the sea-level at a global scale.

Last Glacial Maximum: the peak of the glacier development in the most recent glacial period; occurred 18-20 thousand years ago.

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Long-shore currents: currents parallel to the coastline, which offen result in the redistribution of coastal sediments.

Long-shore currents: currents parallel to the coastline, which offen result in the redistribution of coastal sediments.

Mud (silt and clay): sediments with a grain diameter lesser than 0,063 mm.

Revetments: constructions similar to the sea walls, but inclined rather than upright and bearing either a smooth or a rough surface.

Rock walls/rock armour: series of rocks and boulders that are placed along a shoreline to intercept the wave actions and protect the coast from coastal erosion.

Sand: sediments with a grain diameter between 0,063 mm and 2 mm.

Sand bypassing: soft-engineering method for coastal erosion mitigation; transportation of sand, either hydraulically or mechanically, from an accretion zone of a shoreline to an erosion zone.

Sand dune stabilisation: soft-engineering method for coastal erosion mitigation; artificial stabilisation through structural controls and also using local vegetation.

Sand dunes: coastal ridges formed by sand transported and deposited by the wind.

Sand nourishment: soft-engineering method for coastal erosion mitigation; artificial enrichment of a beach or other type of shoreline with sand to increase its width and elevation.

Sea walls: vertical or near-vertical walls, mainly from concrete, built to intercept the wave actions and protect the coast from coastal erosion.

Sea wave: a moving ridge or swell of water occurring close to the surface of the sea, characterised by oscillating and rising and falling movements, often as a result of the frictional drag of the wind.

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Sea-level: the level of the oceans and seas; the base level for measuring the elevation and depth on Earth. Because the ocean is one continuous body of water, its surface tends to be at the same level globally.

Soft-engineering measures: protection measures on the coastal zone, based on the usage of natural material and/or the natural rehabilitation of the coastal zone.

Storm waves/surges: high waves caused by extreme weather phenomena such as storms, cyclones or very strong winds.

Tsunamis: series of high waves in a water body (mainly ocean) caused by the displacement of a large volume of water due to earthquakes, submarine volcanic eruptions or submarine landslides.

Wet flood-proofing measures: flood-proofing measures allowing the sea water to enter and exit a construction (e.g. building), reducing its potential damages.

W7.15 The presentations

Power Point presentation is available as an annex.

Workshop 8 Flood risk assessment

W8.1 Instructor(s) name(s) and contact information

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W8.2 Workshop Description

The workshop on Flood Risk Assessment (Damages - Losses) equipped participants with the knowledge, skills, and practical tools necessary to assess and evaluate the impacts of floods on different elements. By understanding the complexities of flood risk and the associated damages and losses, participants are better prepared to contribute to effective flood risk management strategies, enhance community resilience, and minimize the negative impacts of future flood events.

W8.3 Workshop goals and objectives

Learning goals

- Enhance participants' understanding of flood risk assessment with a specific focus on evaluating damages and losses associated with floods. Participants will gain knowledge about the various factors, methodologies, and tools involved in assessing flood risks.
- Develop participants' skills in conducting flood risk assessments related to damages and losses. They will learn practical techniques for quantifying and analyzing the impacts of floods on infrastructure, property, the economy, and the environment.
- Promote a risk-informed approach to decision-making related to flood management and planning. Participants will gain insights into how flood risk assessments can contribute to better decision-making processes, including mitigation strategies, emergency response planning, and land-use management.

Learning objectives

- Understand the concept of flood risk assessment: Participants will grasp the fundamental concept of flood risk assessment, including the components of damages and losses. They will learn about the interplay between hazard, exposure, and vulnerability in assessing flood risks.
- Explore methodologies for assessing damages: Participants will explore various methodologies used to assess damages caused by floods, including direct physical damages to infrastructure, property, and the environment. They will understand the importance of collecting data, utilizing remote sensing and GIS technologies, and employing damage assessment models.

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- Analyze economic losses: Participants will learn how to assess economic losses resulting from floods, such as business interruptions, infrastructure repair costs, and impacts on agriculture and livelihoods. They will delve into techniques for quantifying these losses and understanding their broader socio-economic implications.
- Evaluate environmental and ecological impacts: The workshop will address the assessment of environmental and ecological damages caused by floods. Participants will explore the effects on ecosystems, water quality, biodiversity, and natural habitats, and understand the value of incorporating ecological considerations into flood risk assessments.
- Apply risk assessment tools and frameworks: Participants will have hands-on opportunities to apply risk assessment tools and frameworks specific to evaluating damages and losses. They will gain practical experience in utilizing software, conducting simulations, and interpreting results to inform decision-making.
- Foster collaboration and knowledge exchange: The workshop will provide a platform for participants to collaborate, share experiences, and learn from one another. Group activities, case studies, and discussions will facilitate the exchange of knowledge and best practices in flood risk assessment for damages and losses.

W8.4 Pre-requisites

The pre-requisites for the participating students include none.

For group work must have mobile phones, access to the internet.

W8.5 Workshop methodology

In the workshop on Flood Risk Assessment (Damages - Losses), the STEAM methodology (Science, Technology, Engineering, Arts, and Mathematics) and the use of Augmented Reality (AR) can be effectively applied to enhance the learning experience and engagement of participants. Here's how these elements can be incorporated:

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Science: Participants will explore the scientific principles underlying flood risk assessment and understand the factors contributing to damages and losses.

Technology: AR technology can be utilized to provide an interactive and immersive learning experience. Participants can use AR applications or tools to visualize and simulate flood scenarios, assess damages in real-time, and explore the potential consequences of different flood events on the built environment and natural systems.

Arts: The arts component can be incorporated to encourage creativity and foster innovative thinking. Participants can engage in artistic activities, such as creating visual representations or sketches depicting the impacts of floods on communities and the environment. They can also use art to communicate their findings and recommendations to a wider audience.

Mathematics: Mathematics plays a crucial role in flood risk assessment, including statistical analysis, data modeling, and quantitative evaluation of damages. Participants will utilize mathematical concepts and tools to analyze flood data, calculate losses, and assess the probability of future flood events. AR can assist in visualizing complex mathematical models and data patterns.

Participants can collaborate in multidisciplinary teams, bringing together diverse perspectives and expertise. They can engage in group projects, where they apply their knowledge and skills to develop innovative solutions for flood risk assessment and mitigation.

W8.6 Workshop Participation

To evaluate the knowledge and skills of students participating in the workshop on Flood Risk Assessment (Damages - Losses), it is important to assess their understanding of key concepts and their ability to apply relevant methodologies. Here are some recommended assessment methods:

Pre-Workshop Survey (test): Prior to the workshop, administer a pre-workshop survey to assess participants' baseline knowledge and familiarity with flood risk assessment, damages, and losses. This can include multiple-choice questions, true/false statements, or short-answer questions to gauge their understanding of fundamental concepts.

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Case Study Analysis: Provide participants with real or hypothetical case studies involving flood events and ask them to analyze the associated damages and losses. They should identify the key elements at risk, assess the impacts, and propose appropriate risk mitigation strategies. This assessment method evaluates participants' ability to apply theoretical knowledge to practical scenarios.

Data Analysis Exercise: Present participants with a dataset related to a specific flood event and ask them to analyze the data to quantify damages and losses. They should apply statistical analysis techniques, use appropriate modeling tools, and interpret the results. This assessment method tests their skills in data analysis and their understanding of quantitative approaches.

Group Discussion and Presentation: Divide participants into groups and assign each group a specific aspect of flood risk assessment, damages, or losses. They should conduct research, discuss their findings, and prepare a group presentation summarizing their understanding and recommendations. This assessment method evaluates their ability to collaborate, communicate effectively, and synthesize information.

Post-Workshop Assessment: Conduct a post-workshop assessment to evaluate participants' knowledge and skills after completing the workshop. This can include a mix of multiple-choice questions, short-answer questions, and scenario-based exercises to measure their learning outcomes and the application of workshop content.

W8.7 Time outline

Activity	Time
Introduction Introduce the workshop topic and goals Review of the workshop prerequisites and required resources. Pre-Workshop Survey (test)	7 minutes
Presentation Theoretical background of flood types	20 minutes
Group work	35 minutes

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Case Study Analysis Data Analysis Exercise AR app	
Discussion with presentations after group work	25 minutes
Post-Workshop Assessment (test)	3 minutes
Total	**90 minutes**

W8.8 Theoretical background

The workshop on Flood Risk Assessment (Damages - Losses) is grounded in several key theoretical concepts and approaches related to flood risk management. Here are some foundational elements that inform the theoretical background of the workshop:

Risk Assessment: The workshop builds upon the concept of risk assessment, which involves the systematic evaluation of the likelihood and potential impacts of floods. Risk assessment integrates three components: hazard (the probability of a flood occurrence), exposure (the elements at risk, such as infrastructure and communities), and vulnerability (the susceptibility of exposed elements to damage).

Losses and Damages: The workshop focuses specifically on understanding and assessing losses and damages caused by floods. Losses refer to the negative consequences or impacts resulting from a flood event, encompassing economic, social, and environmental aspects. Damages refer to the physical harm or destruction to infrastructure, property, and natural systems. Participants will explore different types of losses and damages, including direct and indirect impacts, and learn methods for quantifying and evaluating their extent.

Spatial Analysis: Spatial analysis is a critical component of flood risk assessment. It involves examining the spatial distribution of hazards, exposure, vulnerability, and damages. Participants will learn about Geographic Information Systems (GIS) and remote sensing techniques that facilitate spatial analysis. They will understand how to integrate spatial data, generate flood hazard maps, identify high-risk areas, and assess the spatial patterns of damages and losses.

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Data and Modeling: The workshop emphasizes the importance of data collection, analysis, and modeling in flood risk assessment. Participants will learn about different data sources, including historical records, hydrological data, and socio-economic data. They will explore statistical methods, flood modeling techniques, and simulation tools that aid in predicting flood behavior, estimating damages, and evaluating potential scenarios. Theoretical concepts such as return periods, flood frequency analysis, and damage assessment models will be covered.

Decision-Making and Adaptation: The workshop acknowledges the need for risk-informed decision-making and adaptive management in flood risk assessment and management. Participants will understand the importance of incorporating risk assessment outcomes into decision-making processes, such as land-use planning, emergency response planning, and infrastructure design. They will explore approaches to adapt and build resilience in the face of changing flood risks, considering future climate change scenarios and socio-economic developments.

Losses and damages are significant consequences of floods that can have wide-ranging impacts on various aspects of society, the economy, and the environment. Understanding and assessing losses and damages are crucial components of flood risk assessment. Here are further details on losses and damages:

Economic Losses: Economic losses refer to the financial impacts resulting from a flood event. These can include direct costs, such as damage to buildings, infrastructure (e.g., roads, bridges), and utilities (e.g., power lines, water supply systems). Indirect costs may also arise, such as business interruption, loss of productivity, and disruptions to supply chains. Economic losses can have both short-term and long-term implications for local economies, businesses, and industries. When conducting a flood risk assessment, several factors contribute to the estimation of economic losses:

- Property Damage: This includes damage to residential, commercial, and industrial buildings, as well as infrastructure such as roads, bridges, and utilities. The assessment takes into account the replacement or repair costs of damaged structures.

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- Contents Damage: The assessment also considers the damage to the contents within buildings, including furniture, appliances, inventory, and personal belongings.
- Business Interruption: Floods can disrupt business operations, leading to revenue losses and additional costs for temporary relocations, equipment replacement, and loss of productivity. Economic losses related to business interruption are evaluated based on the duration of the disruption and the financial impact on the affected businesses.
- Agricultural Losses: Floods can devastate agricultural lands, leading to crop damage or loss, livestock casualties, and disruption of farming activities. Economic losses in agriculture consider the reduced yields, replacement costs, and potential long-term effects on the sector.
- Infrastructure Damage: Floods can damage critical infrastructure such as dams, levees, water treatment plants, and transportation systems. The assessment evaluates the costs of repairing or replacing damaged infrastructure components.
- Emergency Response and Recovery Costs: This category includes the expenses associated with emergency operations, search and rescue efforts, medical services, temporary shelters, and debris removal.
- Environmental Damage: Floods can cause ecological damage, including contamination of water bodies, destruction of habitats, and loss of biodiversity. The economic assessment accounts for the costs of environmental restoration and remediation.

Property Losses: Property losses encompass the physical damage to buildings, homes, and other structures caused by floods. This includes structural damage, destruction of contents, and loss of valuable possessions. Property losses can lead to financial burdens for individuals, communities, and insurance companies, and may require significant resources for repair, reconstruction, or relocation. Here are some key aspects of property losses in flood risk assessments:

- Structural Damage: This includes the physical damage to buildings due to floodwaters. It involves the evaluation of various components such as foundations, walls, roofs, floors, electrical systems, plumbing, and HVAC (heating, ventilation, and air conditioning) systems. The assessment considers the extent of damage, repair or replacement costs, and depreciation of the structures.

- Building Content Damage: Floodwaters can also cause damage to the contents within buildings, including furniture, appliances, electronics, inventory, and personal belongings. The assessment takes into account the replacement or repair costs of damaged contents.
- Loss of Functionality: Property losses also consider the loss of functionality of affected buildings. This refers to the inability to use the premises for their intended purposes due to flood damage. For example, a flooded retail store may need repairs and restoration before it can resume operations, leading to financial losses during the downtime.
- Depreciation: Flood damage can impact the value of properties even after repairs are made. The assessment considers the potential decrease in property value due to the history of flooding and the associated risks. Properties in flood-prone areas may experience diminished market value, affecting property owners and the real estate market.
- Cost of Mitigation Measures: In some cases, property losses assessment also includes the cost of implementing flood mitigation measures to reduce future flood damages. These measures can include raising buildings, installing flood barriers or levees, waterproofing, and other resilience-enhancing actions.

Human Losses: Human losses refer to the impacts on human life resulting from a flood event. This includes fatalities and injuries caused by drowning, physical trauma, or health-related issues related to flooding (e.g., waterborne diseases, injuries during evacuation). Human losses can have profound emotional, social, and economic implications for affected communities and families. Here are some key considerations in assessing human losses in flood risk assessments:

- Casualties: This involves estimating the number of fatalities resulting from floods. It considers factors such as the population density in flood-prone areas, evacuation rates, warning systems, response time, and the severity and duration of the flood event. Historical data on previous flood events can provide insights into potential casualty rates.
- Injuries: Floods can cause a range of injuries, including cuts, fractures, respiratory issues, and waterborne diseases. The assessment evaluates the probability and severity of injuries based on factors such as floodwater depth, flow velocity, debris, and exposure duration. It considers the availability and effectiveness of emergency medical services and healthcare infrastructure.

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- Displacement and Evacuation: Flood risk assessments also consider the number of people displaced or evacuated from their homes due to flooding. This includes temporary relocation to shelters or other safe areas. The assessment takes into account the duration of displacement, the needs of vulnerable populations such as the elderly, children, and individuals with disabilities, and the resources required for their support.
- Mental Health Impacts: Flood events can have significant psychological and emotional impacts on individuals and communities. These include post-traumatic stress disorder (PTSD), anxiety, depression, and other mental health issues. Assessments may incorporate the potential long-term effects on mental well-being and the need for psychological support services.
- Vulnerable Populations: Certain groups may be more susceptible to the adverse effects of floods, such as the elderly, children, pregnant women, individuals with disabilities, and low-income communities. The assessment considers the specific vulnerabilities and needs of these populations in terms of evacuation, access to healthcare, and social support.

Social and Community Impacts: Floods can have social and community impacts that extend beyond economic and property losses. These include the displacement of individuals and families from their homes, disruption of community services (e.g., schools, healthcare facilities), and psychological stress. Communities may experience a loss of social cohesion, increased vulnerability, and long-term social challenges in the aftermath of floods. Here are some key aspects of social and community impacts in flood risk assessments:

- Disruption of Daily Life: Flood events can disrupt the normal routines and activities of individuals and communities. People may be unable to go to work or school, access essential services, or engage in social and recreational activities. The assessment takes into account the duration and extent of disruption, which can have social and economic ramifications.
- Community Cohesion and Social Networks: Floods can affect the social fabric of communities, disrupting social networks and cohesion. Displacement, relocation, and damage to community spaces and infrastructure can strain social connections. The assessment considers the potential impacts on community resilience, social support systems, and the ability of communities to recover and rebuild after the flood event.
- Community Health and Well-being: Floods can have both immediate and long-term impacts on community health and well-being. Immediate impacts

include injuries, waterborne diseases, and mental health issues. Long-term impacts may involve the loss of healthcare facilities, increased vulnerability to diseases, and the displacement of vulnerable populations. The assessment evaluates the potential consequences on community health and the need for healthcare resources and services.

- Socio-economic Disparities: Flood events can exacerbate existing socio-economic disparities within communities. Low-income communities may face greater challenges in coping with floods due to limited resources, inadequate infrastructure, and a lack of access to insurance or financial assistance. The assessment considers the differential impacts on different socio-economic groups and helps identify measures to address inequalities.
- Cultural and Heritage Losses: Floods can damage cultural and heritage sites, including historical buildings, artifacts, and cultural landscapes. These losses can have significant cultural and emotional impacts on communities. The assessment considers the value of cultural heritage and the need for preservation, restoration, and community engagement in the recovery process.
- Community Resilience and Adaptive Capacity: Assessing social and community impacts also involves evaluating the resilience and adaptive capacity of communities in the face of flooding. This includes the effectiveness of early warning systems, community preparedness, communication strategies, and the ability to recover and adapt to future flood events.

Environmental and Ecological Damages: Floods can cause significant damage to ecosystems and the environment. This includes erosion of soil, contamination of water bodies, destruction of habitats, and loss of biodiversity. Floodwaters can carry pollutants and sediment, impacting water quality and the health of aquatic ecosystems. Environmental damages can have long-term consequences for ecosystem services, such as water purification, wildlife habitat, and recreational opportunities. Here are some key considerations in assessing environmental and ecological damages in flood risk assessments:

- Habitat Destruction: Floods can cause the destruction or alteration of natural habitats, including wetlands, forests, grasslands, and coastal ecosystems. The assessment evaluates the extent of habitat loss and the associated impacts on biodiversity, wildlife populations, and ecological processes.

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- Water Quality Impacts: Floodwaters can carry sediments, pollutants, and contaminants from various sources, including agricultural lands, industrial areas, and urban environments. These pollutants can enter water bodies, leading to water quality degradation and ecological damage. The assessment considers the potential impacts on aquatic ecosystems, including fish, invertebrates, and plant communities.
- Soil Erosion and Sedimentation: Flood events can result in soil erosion, leading to the loss of topsoil, nutrient depletion, and sedimentation in rivers, streams, and lakes. The assessment evaluates the magnitude of soil erosion and the subsequent impacts on soil fertility, agricultural productivity, and downstream ecosystems.
- Impact on Flora and Fauna: Floods can directly affect plant and animal species, including those that are adapted to specific habitats and flood regimes. The assessment considers the potential impacts on native species, including changes in population dynamics, habitat fragmentation, and the introduction of non-native species.
- Disruption of Ecological Processes: Floods can disrupt important ecological processes, such as nutrient cycling, pollination, seed dispersal, and hydrological regimes. The assessment evaluates the potential consequences of these disruptions on ecosystem functioning and resilience.
- Coastal and Marine Impacts: Coastal areas and marine ecosystems are particularly vulnerable to the impacts of flooding, including storm surges and sea-level rise. Assessments in these areas consider the effects of flooding on coastal habitats, coral reefs, mangrove forests, and marine biodiversity.
- Long-Term Ecological Effects: The assessment also takes into account the long-term ecological effects of flooding. These may include changes in species composition, altered ecosystem dynamics, and potential cascading effects on ecosystem services, such as water purification, flood regulation, and carbon sequestration.

Cultural and Historical Losses: Floods can also result in the loss or damage of cultural heritage sites, historical buildings, artifacts, and documents. These losses can have a profound impact on the preservation of cultural identity, heritage tourism, and the understanding of local history. Here are some key considerations in assessing cultural and historical losses in flood risk assessments:

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- Damage to Historical Buildings and Sites: Floods can cause physical damage to historical buildings, monuments, archaeological sites, and other cultural heritage structures. This includes structural damage, erosion, and the loss of architectural features. The assessment evaluates the extent of damage and the potential impacts on the historical and architectural value of these sites.
- Loss of Artifacts and Collections: Floodwaters can damage or destroy artifacts, museum collections, archives, libraries, and other cultural materials. These losses can include irreplaceable historical documents, artworks, photographs, and other valuable cultural objects. The assessment considers the significance and uniqueness of the lost items and the implications for cultural heritage preservation.
- Cultural Landscapes: Floods can impact cultural landscapes, which include areas that bear cultural, historical, or aesthetic significance. These landscapes may consist of features such as traditional farming systems, sacred sites, traditional settlements, or landscapes shaped by cultural practices. The assessment evaluates the damage or alteration of these landscapes and the associated impacts on cultural values and identity.
- Intangible Cultural Heritage: Floods can also affect intangible cultural heritage, which includes practices, rituals, knowledge, and expressions that are transmitted from generation to generation within communities. This can include traditional crafts, music, dance, oral traditions, and social practices. The assessment considers the potential loss or disruption of intangible cultural heritage due to the displacement or disruption of communities.
- Cultural and Community Identity: Floods can have profound impacts on the cultural and community identity of affected populations. The loss or damage of cultural heritage can result in a sense of loss, disconnection, and diminished cultural vitality. The assessment evaluates the potential impacts on community well-being, social cohesion, and the preservation of cultural identity.
- Cultural Heritage Management and Restoration: Assessing cultural and historical losses also involves considering the capacity for cultural heritage management and restoration. This includes evaluating the availability of resources, expertise, and infrastructure for the preservation and restoration of damaged cultural heritage sites and artifacts.

Assessing losses and damages involves quantifying and evaluating these impacts using various methods, including data collection, surveys, valuation techniques, and damage assessment models. These assessments provide

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essential information for decision-makers, policymakers, and planners to prioritize resources, develop mitigation strategies, and allocate funding for recovery and reconstruction efforts.

Overall, a comprehensive understanding of losses and damages is crucial for effective flood risk management, enabling stakeholders to prioritize investments, develop resilient infrastructure, and implement measures that mitigate the impacts of future flood events.

W8.9 Bibliography or/and additional reading list for teachers

- Luu, C. et al. (2020) "Framework of Spatial Flood Risk Assessment for a Case Study in Quang Binh Province, Vietnam," Sustainability, 12(7), p. 3058. Available at: https://doi.org/10.3390/su12073058
- Flood Risk Assessment and Management (no date). Available at: https://link.springer.com/book/10.1007/978-90-481-9917-4
- Shrestha, B.M. and Kawasaki, A. (2020) "Quantitative assessment of flood risk with evaluation of the effectiveness of dam operation for flood control: A case of the Bago River Basin of Myanmar," International Journal of Disaster Risk Reduction, 50, p. 101707. Available at: https://doi.org/10.1016/j.ijdrr.2020.101707
- Flood Map Products (no date). Available at: https://www.fema.gov/flood-maps/products-tools/products
- UNDRR - Homepage (2023). Available at: https://www.undrr.org/
- Topics (no date). Available at: https://www.worldbank.org/en/topic
- All News - European Commission (no date). Available at: https://drmkc.jrc.ec.europa.eu/events-news/all-news#news/432/details/21180/current-practice-in-flood-risk-management-in-the-eu
- Netherland's flood management is a climate adaption model for the world (2021). Available at: https://www.preventionweb.net/news/netherlands-flood-management-climate-adaption-model-world
- Dutch Masters: The Netherlands exports flood-control expertise (no date). Available at: https://www.earthmagazine.org/article/dutch-masters-netherlands-exports-flood-control-expertise/

- EUR-Lex - 32007L0060 - EN - EUR-Lex (no date). Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32007L0060
- Wright, Daniel B. (2015). Methods in flood hazard and risk assessment (English). Advances in Probabilistic Flood Hazard Assessment (CAPRA) technical notes Washington, D.C.: World Bank Group. Available at: http://documents.worldbank.org/curated/en/395541467991908801/Methods-in-flood-hazard-and-risk-assessment
- European Union, 1995-2023 (no date) Map of EMS Risk and Recovery Mapping Activations. Available at: https://emergency.copernicus.eu/mapping/map-of-activations-risk-and-recovery?title_op=contains&title=&field_event_type_tid%5B%5D=17&field_event_time_utc_value%5Bmin%5D%5Bdate%5D=&field_event_time_utc_value%5Bmax%5D%5Bdate%5D=&field_activation_status_value=All#title_op=contains&title=&field_event_type_tid%5B%5D=17&field_event_time_utc_value%5Bmin%5D%5Bdate%5D=&field_event_time_utc_value%5Bmax%5D%5Bdate%5D=&field_activation_status_value=All&zoom=2&lat=8.52448&lon=-6.58136&layers=BT00
- Map | National Risk Index (no date). Available at: https://hazards.fema.gov/nri/map
- Potvynių grėsmės ir rizikos žemėlapiai (no date). Available at: https://potvyniai.aplinka.lt/map

W8.10 The recommended reading for VET students

- Luu, C. et al. (2020) "Framework of Spatial Flood Risk Assessment for a Case Study in Quang Binh Province, Vietnam," Sustainability, 12(7), p. 3058. Available at: https://doi.org/10.3390/su12073058
- Flood Risk Assessment and Management (no date). Available at: https://link.springer.com/book/10.1007/978-90-481-9917-4
- Shrestha, B.M. and Kawasaki, A. (2020) "Quantitative assessment of flood risk with evaluation of the effectiveness of dam operation for flood control: A case of the Bago River Basin of Myanmar," International Journal of Disaster Risk Reduction, 50, p. 101707. Available at: https://doi.org/10.1016/j.ijdrr.2020.101707
- Flood Map Products (no date). Available at: https://www.fema.gov/flood-maps/products-tools/products
- UNDRR - Homepage (2023). Available at: https://www.undrr.org/

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- Topics (no date). Available at: https://www.worldbank.org/en/topic
- All News - European Commission (no date). Available at: https://drmkc.jrc.ec.europa.eu/events-news/all-news#news/432/details/21180/current-practice-in-flood-risk-management-in-the-eu
- Netherland's flood management is a climate adaption model for the world (2021). Available at: https://www.preventionweb.net/news/netherlands-flood-management-climate-adaption-model-world
- Dutch Masters: The Netherlands exports flood-control expertise (no date). Available at: https://www.earthmagazine.org/article/dutch-masters-netherlands-exports-flood-control-expertise/
- EUR-Lex - 32007L0060 - EN - EUR-Lex (no date). Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32007L0060
- Wright, Daniel B. (2015). Methods in flood hazard and risk assessment (English). Advances in Probabilistic Flood Hazard Assessment (CAPRA) technical notes Washington, D.C.: World Bank Group. Available at: http://documents.worldbank.org/curated/en/395541467991908801/Methods-in-flood-hazard-and-risk-assessment
- European Union, 1995-2023 (no date) Map of EMS Risk and Recovery Mapping Activations. Available at: https://emergency.copernicus.eu/mapping/map-of-activations-risk-and-recovery?title_op=contains&title=&field_event_type_tid%5B%5D=17&field_event_time_utc_value%5Bmin%5D%5Bdate%5D=&field_event_time_utc_value%5Bmax%5D%5Bdate%5D=&field_activation_status_value=All#title_op=contains&title=&field_event_type_tid%5B%5D=17&field_event_time_utc_value%5Bmin%5D%5Bdate%5D=&field_event_time_utc_value%5Bmax%5D%5Bdate%5D=&field_activation_status_value=All&zoom=2&lat=8.52448&lon=-6.58136&layers=BT00
- Map | National Risk Index (no date). Available at: https://hazards.fema.gov/nri/map
- Potvynių grėsmės ir rizikos žemėlapiai (no date). Available at: https://potvyniai.aplinka.lt/map

W8.11 Recommended assessment of student knowledge and skills

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Self-evaluation is an essential component of the learning process, allowing participants to reflect on their progress, identify areas of improvement, and consolidate their understanding. Here are some self-evaluation questions for participants in the workshop on Flood Risk Assessment (Damages - Losses):

Conceptual Understanding:

- Have I gained a clear understanding of the fundamental concepts related to flood risk assessment, damages, and losses?
- Can I explain the interplay between hazard, exposure, vulnerability, and the resulting damages and losses?
- Have I grasped the key theories and principles underlying flood risk assessment in the context of damages and losses?

Knowledge Application:

- Am I able to apply the learned methodologies and tools to assess damages and losses caused by floods?
- Have I successfully utilized data analysis techniques, modeling tools, or spatial analysis methods to evaluate flood impacts?
- Can I demonstrate my ability to quantify and assess economic, property, human, and environmental losses?

Critical Thinking:

- Have I developed critical thinking skills to analyze and interpret the consequences of floods on different elements, such as infrastructure, communities, and ecosystems?
- Can I identify the factors contributing to vulnerabilities and understand their role in determining the extent of damages and losses?
- Have I explored various risk mitigation strategies and considered their effectiveness in reducing damages and losses?

Practical Skills:

- Have I gained practical skills in conducting flood risk assessments related to damages and losses?
- Can I effectively use software, models, or tools to analyze flood data, simulate scenarios, and estimate impacts?
- Have I developed proficiency in data collection, data analysis, and interpretation techniques relevant to assessing damages and losses?

Collaboration and Communication:

- Have I actively participated in group activities, discussions, and presentations related to flood risk assessment?
- Can I effectively communicate my findings, recommendations, and the rationale behind my assessments?
- Have I demonstrated the ability to collaborate with others, exchange knowledge, and contribute to the collective learning experience?

Future Learning and Development:

- What are the areas where I need further improvement or additional learning?
- How can I apply the knowledge and skills gained in the workshop to real-world scenarios or future projects?
- What steps can I take to continue expanding my understanding of flood risk assessment, damages, and losses beyond the workshop?

By engaging in self-evaluation and reflecting on these questions, participants can assess their progress, identify areas for growth, and develop a plan for further learning and skill development in the field of flood risk assessment and management.

W8.12 Workshop feedback

Rating scale from 1 to 10 (1 - the lowest, 10 - the highest rating).

How do you assess the organization of training?

Participant service (registration, time management, etc.).

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

Training environment (communication, audience, tools, etc.).

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

How do you assess the training content?

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Benefits and applicability of training content.

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

The novelty and relevance of the training content.

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

Lecturer competencies (knowledge, experience, teaching methods).

1	2	3	4	5	6	7	8	9	10

Comments and wishes.

Would you recommend this training to others?

Yes	No	I have no opinion

What training would you be interested in?

Your suggestions

W8.13 Summary of the Workshop

The workshop provided participants with a comprehensive understanding of the assessment and evaluation of damages and losses resulting from floods. Through a combination of theoretical knowledge, practical exercises, and hands-on activities, participants gained valuable insights into the complex nature of flood risk and its impact on various aspects of society, the economy, and the environment.

The workshop began by exploring the fundamental concepts of flood risk assessment, including the interplay between hazard, exposure, vulnerability, and the resulting damages and losses. Participants learned about the different types of losses, such as economic, property, human, social, environmental, and cultural, and their significance in flood risk management.

Theoretical discussions were complemented by practical exercises and case studies that allowed participants to apply their knowledge and skills in assessing damages and losses.

The workshop emphasized the importance of risk-informed decision-making and adaptive management in flood risk assessment and management. Participants explored strategies for mitigating damages and losses, including the implementation of resilient infrastructure, land-use planning, and emergency response measures. They gained insights into the integration of flood risk assessment outcomes into decision-making processes to enhance community resilience and reduce future vulnerabilities.

Collaboration and communication were key components of the workshop, with participants engaging in group activities, discussions, and presentations. This fostered knowledge exchange, critical thinking, and the development of practical skills. Participants learned to effectively communicate their findings, recommendations, and the rationale behind their assessments, enabling them to convey complex information to stakeholders and decision-makers.

Throughout the workshop, participants also had the opportunity to apply augmented reality (AR) technology, enhancing their learning experience and understanding of flood risk assessment.

W8.14 Glossary

Cultural Heritage Losses: The loss or damage of cultural heritage sites, historical buildings, artifacts, and documents due to floods, impacting the preservation of cultural identity and heritage tourism.

Damages: The physical harm or destruction caused by floods, including the impact on infrastructure, buildings, property, and natural systems.

Decision-Making: The process of making informed choices and selecting appropriate actions based on the outcomes of flood risk assessment and the evaluation of damages and losses. In flood risk management, decision-making involves considering multiple factors, stakeholders, and potential trade-offs.

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Economic Losses: The financial impacts resulting from a flood event, including direct costs (e.g., infrastructure damage, business interruption) and indirect costs (e.g., loss of productivity, supply chain disruptions).

Environmental Damages: The harm caused to ecosystems and the natural environment as a result of floods, including soil erosion, contamination of water bodies, destruction of habitats, and loss of biodiversity.

Exposure: The elements at risk that are exposed to potential flood impacts, including buildings, infrastructure, communities, ecosystems, and cultural heritage sites.

Flood Risk Assessment: The process of evaluating the probability and potential consequences of flooding, including the assessment of hazards, exposure, vulnerability, and potential damages and losses.

Hazard: The probability of a flood occurrence or the potential threat posed by a flood event. Hazards can be categorized based on the likelihood and magnitude of floods, such as low, moderate, or high hazards.

Human Losses: The impacts on human life resulting from a flood event, including fatalities, injuries, and health-related issues (e.g., waterborne diseases) associated with flooding.

Losses: The negative consequences or impacts resulting from floods, encompassing economic, social, and environmental aspects. Losses can include financial losses, human casualties, displacement, environmental degradation, and cultural heritage loss.

Property Losses: The physical damage or destruction to buildings, homes, and structures caused by floods, including structural damage and loss of valuable possessions.

Risk Mitigation: Strategies and measures aimed at reducing the impacts of floods, minimizing damages and losses, and increasing community resilience. Risk mitigation can involve structural measures (e.g., flood barriers, drainage systems), non-structural measures (e.g., land-use planning, early warning systems), and community preparedness.

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Social Impacts: The consequences of floods on communities and society, including displacement of individuals, disruption of community services (e.g., schools, healthcare facilities), and psychological stress.

Spatial Analysis: The examination and analysis of geographic data and spatial relationships to understand the distribution and patterns of flood hazards, damages, and losses. Spatial analysis involves the use of Geographic Information Systems (GIS) and remote sensing techniques.

Vulnerability: The susceptibility of exposed elements to damage or harm caused by floods. Vulnerability is influenced by various factors, such as the structural integrity of buildings, the resilience of communities, and the sensitivity of ecosystems.

W8.15 The presentations

Power Point presentation is available as an annex.

Flood risk assessment_kvk.ppt

Flood risk assessment_test.ppt

Flood risk assessment_casestudy.ppt

Workshop 9 Flood Prediction, Modelling, Measurement and Mapping

W9.1 Instructor(s) name(s) and contact information

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W9.2 Workshop Description

Floods are among the most catastrophic natural disasters, having a devastating impact on society, the economy, and the environment. Flood prediction, modeling, measurement and mapping are critical methods for assessing and controlling flood hazards. This workshop will introduce the teachers to the essential ideas, theories and methods used in flood forecasting, modeling, measurement and mapping.

Students, via a mix of lectures, demonstrations, experiments, and case studies, will learn the causes and effects of flooding, how data on rainfall, streamflow, and other flood-related factors should be collected and analysed, how to model flood processes and map flood risks using software tools such as ArcGIS Pro and ArcGIS Online, how to assess the efficacy of flood control and management strategies and how to inform stakeholders on flood hazards and mitigation methods. Finally, they will provide hands-on supervision and assistance to learners as they develop practical knowledge and tackle real-world flood prediction, modeling, measuring and mapping challenges.

W9.3 Workshop goals and objectives

The goal of the Flood Prediction, Modeling, Measurement and Mapping Workshop is to give students an in-depth look at ideas, theories and methods for flood prediction, modeling, measurement and mapping in order to train them. The workshop also seeks to teach them how to use software tools like ArcGIS Pro and ArcGIS Online in order to simulate flood processes and map flood dangers. Students should be able to assess the efficacy of flood control and management methods, as well as convey flood risks and mitigation strategies to stakeholders.

The workshop will help teachers reach a wide range of learning goals, from remembering basic ideas to planning and carrying out projects in the real world.

Learning goals

- Improve learners' critical thinking abilities in assessing and understanding data linked to floods.
- To offer a thorough overview of the principles, theories and procedures behind flood prediction, modeling, measurement and mapping.

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- To educate on how to use software tools like ArcGIS Pro and ArcGIS Online to simulate flood processes and map flood hazards.
- Participants will be able to assess the efficacy of flood control and management techniques as well as convey flood risks and mitigation solutions.
- Generate ideas that combine flood prediction, modeling, measuring and mapping topics.
- Understand the role of technology, such as AR, in enhancing the learning experience for students.
- Encourage participation and teamwork in tackling real-world flood-related issues.

Learning objectives

- Define the primary causes and effects of flooding.
- Describe the variables that lead to flood hazards.
- Data on rainfall, streamflow and other flood-related factors will be analysed.
- Several flood predictions, modeling, measuring and mapping approaches will be compared.
- Assess the efficacy of flood control and management strategies.
- Software tools like ArcGIS Pro and ArcGIS Online can be used to model how floods happen and map flood risks.
- Collaborate with peers to solve real-world flood-related concerns.
- Examine the reliability, validity and accuracy of flood forecasting, modeling, measuring and mapping outcomes.

W9.4 Pre-requisites

To participate successfully in the workshop, participants must attend prepared, having fulfilled any essential prerequisites.

Participants should have a basic understanding of Geographic Information System (GIS) and mathematical concepts and principles. Prior experience with GIS software is not required.

Participants should also have access to a computer with the required software and hardware specifications. The required software may include GIS software

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such as ArcGIS, and any required hardware may include a laptop with a minimum of 8GB of RAM, a graphics card capable of handling 3D visualization and a mouse.

Additionally, completion of a prior workshop or course on related topics is recommended but not required. This may include courses or workshops on GIS, modeling, or statistical analysis, as well as the workshop on flash floods.

Overall, participants of the workshop should have a basic understanding of the concepts and principles related to flooding, including the types of floods, causes and effects of flooding, as well as the methods used to measure and map floodplains. This knowledge will enable them to effectively apply the STEAM methodology and use AR in their work related to flood prediction and management.

W9.5 Workshop methodology

The workshop will use a variety of teaching approaches to offer participants a thorough learning experience. A large part of the program will be the STEAM approach, which focuses on how science, technology, engineering, art and mathematics can be used together to solve problems. By combining these fields, participants will learn more about flood prediction, modeling, measurement and mapping, as well as how these ideas are used to solve problems in the real world.

The course starts with a review of flood science, covering flood origins and impacts, the hydrologic cycle and the fundamentals of water management. Participants will learn about flood prediction and modeling tools and methods such as weather monitoring systems, computer modeling software and satellite images. They will also investigate the use of Geographic Information Systems (GIS) technology in flood mapping and analysis.

Participants will be able to use their newly acquired knowledge and abilities in their own classrooms by the end of the workshop. Students will get a better knowledge of the science underpinning flood prediction and mapping, as well as STEAM teaching ideas and how to use AR technology into their courses. Teachers will also have access to a variety of resources and tools, including online software, datasets and lesson plans, to assist them in developing interesting and successful STEAM courses for their pupils.

Overall, the Flood Prediction Workshop offers educators a one-of-a-kind and dynamic learning experience that integrates the most recent advances in science, technology and teaching. It is intended to inspire and motivate educators to incorporate STEAM learning into their classrooms, as well as to assist students comprehend the science and technology underpinning flood prediction and mapping.

W9.6 Workshop Participation

Participants in the Flood Prediction, Modeling, Measurement and Mapping Workshop will be expected to actively engage with the material and participate in all aspects of the workshop.

To ensure that participants are adequately prepared for the workshop, any required pre-requisites should be completed before attending. This may include basic knowledge of GIS, familiarity with mathematical concepts and principles, and completion of a prior workshop on related topics.

During the workshop, participants will work in small groups to apply their knowledge and skills to real-world flood-related problems. Participants should be prepared to collaborate with their peers, share ideas and perspectives, and learn from each other.

In addition to attending all scheduled sessions, participants should also come prepared with the necessary resources. This may include a laptop with the required software and hardware specifications, access to the internet and any required reading materials.

By actively engaging with the material and collaborating with their peers, participants will be able to develop the necessary knowledge and skills to effectively address real-world flood-related problems.

W9.7 Time outline

Activity	Time
Introduction 1. Introduce the workshop topic and goals 2. Review of the workshop prerequisites and required resources. 3. Provide an overview of the workshop methodology	5 minutes
Theory and Background 1. Briefly introduce the concepts and principles related to flood prediction, modelling, measurement, and mapping. 2. Discuss the importance of STEAM methodology and AR in flood prediction and management	20 minutes
Modeling a Flood in ArcGIS Software 1. Provide a demo of using GIS software to create a flood model. 2. Participants will work on their own computers to create their own flood model using sample data and guided instructions. 3. Instructors will be available to answer questions and provide support as needed.	45 minutes
Flood Mapping	15 minutes
Conclusions	5 minutes
Total	**90 minutes**

W9.8 Theoretical background

The term flood refers to a situation in which water covers (inundates) areas that would normally be dry. Flooding can occur when the water level rises over the natural breaks of a river or when large sea waves flood the shore. The specific rise in water level and the increase in water volume are primarily due to the influence of weather phenomena. Floods are divided into riverine floods, coastal floods, floods due to the rise of groundwater and urban floods (Smith and Ward, 1998; Martini and Loat, 2007; Eleuterio, 2012). Weather conditions are responsible for increasing the volume of water in a geological system (e.g., hydrographic network, coastal system). The added water in the case of a river comes in the form of precipitation, especially rainfall, while large waves on the beach are created by storm surges, which are related to cyclonic weather systems.

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Riverine floods (hereinafter: “floods”) are an important social issue as they actively contribute to the total of human losses and economic impacts (Kundzewicz and Kundzewicz, 2005; Barrero, 2009). They are a significant factor in hydrological processes in a drainage basin and occur on occasion in a natural channel or in an artificial chute that drains an area that cannot provide the amount of water that flows, resulting in overflowing its banks and the waters occupying sections of the land. The size, shape, cross section, longitudinal profile and pattern of the river basin are all the result of erosion, sediment transport and deposition happening within the limits of geology and basin relief. The rivers continuously adapt and change in terms of the sequence of normal flow, flood flow and drought conditions connected to the regional climate, local weather and basin hydrology. The existence of the phenomena is dependent on a vast number of natural (Ward and Robinson, 2000) and manmade (Smith and Ward, 1998) causes.

Long-lasting heavy rainfall, melting ice and failures in flood prevention infrastructures (e.g., dams) cause floods in river areas (Smith and Ward, 1998; Martini and Loat, 2007). In contrast, intense rainfall with a short duration causes flash floods and as a result have intense corrosion, rushing waters, mudslides, etc. Rainfall combined with urban infrastructure failure contributes to flooding in urban areas (Smith and Ward, 1998; Martini and Loat, 2007). Intense rainfall combined with high tide contribute to the occurrence of coastal floods causing a recession of the coastline and accumulation of water in coastal areas.

The flood hazard threatens mainly the plain areas and those located near the stream mouth. The degradation of the natural environment, such as deforestation or the lack of wooded land in river basins, is a primary source of increased flood risk. The materials carried by the rivers are quickly deposited in the plains and delta areas when the rivers flood. This increases the likelihood of flooding in certain places, resulting in widespread tragedies. Risk is defined as the ratio of the probability of a natural catastrophe occurring to the magnitude of the harm inflicted. Natural phenomena are required for the production of natural hazards and human exposure to them transforms them into danger and the prospect of devastation.

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The objective of hazard assessment is to create conclusions that can be utilised again in diverse areas. After the risk hazard has been identified and assessed, choices on how to manage it should be made. Management consists of administrative, political and financial activities carried out to determine if and how a certain kind of hazard should be minimised to a given level and at what cost.

There are several methods for assessing flood hazard, depending on the case (e.g., type of flood, area of study, as well as the available data) (Martini and Loat, 2007; van Alphen et al., 2009). The most common and usually most reliable approach is the geomorphological, which is the study of the aforementioned natural parameters and how they influence flooding hazards (geomorphology and geology of the basin, combined with its climatic and meteorological characteristics) (Kochel and Baker, 1988; Fernández-Lavado, Furdada and Marqués, 2007; Baker, 2008; Lastra et al., 2008; Díez-Herrero, Huerta and Llorente-Isidro, 2009).

Geological and geomorphological approaches use the types of landforms created during or after the occurrence of the flood event. By estimating certain parameters like depth, speed and sediment load, this method delimits geomorphologically active areas, or areas that are vulnerable to flooding in the context of the river's natural dynamics (Ayala, 1985; Baker, Kochel and Patton, 1988; Díez and Pedraza, 1996; Díez-Herrero, 2002; Marquínez, Fernández and Lastra, 2006a, 2006b; Ortega and Garzón, 2006; Lastra et al., 2008). More specialised approaches calculate and identify the hydrological conditions that make the occurrence of a flood more likely, having as input data the precipitation characteristics (Martini and Loat, 2007; Golian et al., 2011).

Another method is the comparative study of historical flood events, i.e. floods that occurred in earlier periods. The availability and analysis of information on existing flood phenomena help to estimate the frequency of the phenomena and focus on their spatial and time distribution for the studied area (Benito, 2002; Francés, 2004; Brázdil, Kundzewicz and Benito, 2006; Díez-Herrero, Huerta and Llorente-Isidro, 2009). This methodology is based on the study of historical documents (handwritings and printed documents, archives of newspapers and libraries e.tc.), technical structures (buildings, road networks, public works etc.)

and human testimonies (oral and written testimonies) with the aim of reconstructing the area that flooded during the given historical period. A simple application of this methodology is the assumption that "if the water has already reached certain levels in the past, it may also reach them in the not-too-distant future", making this area a "historic flood zone."

More sophisticated are the studies that convert historical data into models that attribute a specific probability, so that these data can be introduced as complementary data in the frequency analysis of the phenomenon or in geomorphological studies (Barriendos and Coeur, 2004; Barnolas and Llasat, 2007; Lastra et al., 2008; Marquínez et al., 2008). How to incorporate historical events into the flood frequency analysis has been described in detail by Francés (2004). The analysis of the flood history reaches as far back in time as is possible with the existing data, while as input data, not only qualitative and descriptive but also quantitative characteristics (where available) are used. This method is useful because, on the one hand, it makes it possible to determine the locations with the greatest susceptibility to flooding and, on the other hand, it quantifies their frequency and intensity (Benito, 2002; Francés, 2004; Brázdil, Kundzewicz and Benito, 2006; Díez-Herrero, Huerta and Llorente-Isidro, 2009).

Another method is the hydraulic, which is based on the use of mathematical models in order to quantify the hydrological characteristics of the basin (e.g., supply, flood peaks, delay times etc.) (Horritt and Bates, 2002; Díez-Herrero, Huerta and Llorente-Isidro, 2009). In addition, the vegetation indicators (Sigafoos, 1964; Gottesfeld, 1996; Stoffel and Bollschweiller, 2008; Díez-Herrero, Huerta and Llorente-Isidro, 2009; Stoffel et al., 2010) contribute to calculating the physical characteristics and age of earlier flood events by analysing plants.

Flood hazard maps are created to illustrate crucial flood-related information and prepare citizens by providing useful information about future floods. Such maps can show catastrophic events that have taken place in the past, simulate areas where floods have occurred, show open spaces, disaster management centers, danger points, channels and communication systems.

The effectiveness of flood hazard maps depends on both the accuracy of the information and the extent to which it is understood. Experience has shown that local authorities and residents are aware of the risks and dangers of their area.

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They are therefore able to prepare and follow the proposed response plan in the event of an imminent disaster. Information on flood risk is also intended to assist authorities and communities in urban development, i.e. how buildings are constructed, defining land uses as well as identifying potential risks associated with flooding.

International attention is paid to the mapping of flood hazards. The research conducted by the United Nations Environment Program (UNEP) and the University of Grenoble has shown that worldwide flood hazard mapping is carried out with increasing availability of data on the basins, which in combination with available altitude data provide predictions of flood frequency. Thus, these data can be used to map events associated with floods over the past 100 years. Studies have already been completed for North and South America as well as Mozambique. In addition, the increasingly edited satellite images are combined with historical events and Geographic Information Systems spatial databases to highlight areas vulnerable to flood hazards caused by catastrophic events such as storm waves, tsunamis and heavy rainfall events.

In Europe, the Flood Directive 2007/60/EC has been developed due to the increasing social and economic impacts. The Directive sets out the requirements for mapping of flood zones. The competent authorities shall use these zones to identify preventive measures against the risk of flooding. The probability of flooding is linked to these zones and is used as a starting point for evaluating flood prevention measures. The areas on flood hazard maps are:

- Low probability floods or emergency events.
- Moderate probability of flooding (recurrence period ≥ 100 years).
- High probability of flooding.

For each of the above scenarios, the following points should be listed:

- Predicted depth of water.
- Flow velocity.
- Areas where there may be phenomena corrosion and deposition of material.

Also, flood hazard maps should be combined with flood risk maps that show: (a) an estimate of the number of people who will be affected; (b) an estimate of the economic activity in the area that will be affected; (c) a list of facilities that could be a source of pollution in the event of a flood and are likely to affect protected areas; and (d) an estimate of the possible environmental effects.

An integrated hydrological forecasting system should contain four main axes:

- Data recovery in real time.
- Meteorological and hydrological forecasting models.
- Analysis of predictions.
- Spread the warning.

The system's ability to convert the rainfall forecast into a hydrological model in real-time results in early warning of a potential hazard exposure, providing a reasonable time between the precipitation and the subsequent flood to protect the population.

The study of the statistics of the occurrence of a flood in a particular area, the use of flood models, in relation to the monitoring of the precipitation in a given area, provide the data to make a short-term forecast of the event of a flood event. Once this information is available, the local-scale warning system becomes crucial in conjunction with flood response measures.

The study of the statistics of the occurrence of a flood in a particular area and the use of flood models in relation to the monitoring of the precipitation in a given area provide the data necessary to make a short-term forecast of the event of a flood. Once this information is available, the local-scale warning system becomes crucial in conjunction with flood response measures.

In many cases, the timing of an early flood warning ranges from a few minutes to hours or even days and is related to adequate knowledge of the conditions in the upper areas of the basin.

W9.9 Bibliography or/and additional reading list for teachers

- Ayala, F. J. (1985) Geología y prevención de daños por inundaciones. Madrid.

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- Baker, V. R. (2008) 'Paleoflood hydrology: Origin, progress, prospects', Geomorphology, 101(1), pp. 1–13. doi: https://doi.org/10.1016/j.geomorph.2008.05.016
- Baker, V. R., Kochel, R. C. and Patton, P. C. (1988) Flood Geomorphology. United Kingdom: John Wiley and Sons, Chichester.
- Barnolas, M. and Llasat, M. C. (2007) Metodología para el estudio de inundaciones históricas en España e implementación de un SIG en las cuencas del Ter, Segre y Llobregat. Monografías CEDEX, M-90, Centro de Estudios Hidrográficos. Madrid.
- Barrero, J. I. (2009) 'Normalised flood losses in Europe: 1970–2006', Natural Hazards, 9, pp. 97–104.
- Barriendos, M. and Coeur, D. (2004) 'Flood data reconstructions in historical times from non-instrumental sources in Spain and France', in Benito, G. and Thorndycraft, V. R. (eds) Systematic, palaeoflood and historical data for the improvement of flood risk estimation: Methodological guidelines . Madrid: CSIC and European Commission, pp. 29–42.
- Benito, G. (2002) 'La paleohidrología en el análisis de inundaciones', in Ayala, F., Carcedo, J., and Olcina Cantos, J. (eds) Riesgos Naturales . Barcelona: Ariel Ciencia, pp. 953–967.
- Brázdil, R., Kundzewicz, Z. and Benito, G. (2006) 'Historical hydrology for studying flood risk in Europe', Hydrological Sciences Journal. Taylor & Francis, 51(5), pp. 739–764. doi: 10.1623/hysj.51.5.739.
- Díez-Herrero, A. (2002) 'Condicionantes geomorfológicos de las avenidas y cálculo de caudales y calados', in Ayala-Carcedo, F. J. and Olcina Cantos, J. (eds) Riesgos Naturales . Barcelona: Ariel Ciencia.
- Díez-Herrero, A., Huerta, L. L. and Llorente-Isidro, M. (2009) A handbook on flood hazard mapping methodologies. Spain: Publications of the Geological Survey of Spain (IGME).
- Díez, A. and Pedraza, J. (1996) 'Procesos fluviales', in de Pedraza, J. (ed.) Geomorfología: Principios, Métodos y Aplicaciones . Madrid: Rueda, pp. 199–257.
- Eleuterio, J. (2012) Flood risk analysis: impact of uncertainty in hazard modeling and vulnerability assessments on damage estimations. University of Strasbourg.
- Fernández-Lavado, C., Furdada, G. and Marqués, M. A. (2007) 'Geomorphological method in the elaboration of hazard maps for flash-

floods in the municipality of Jucuarán (El Salvador)', Natural Hazards and Earth System Sciences, 7(4), pp. 455–465. doi: 10.5194/nhess-7-455-2007.
- Francés, F. (2004) 'Flood frequency analysis using systematic and non-systematic information', in Benito, G. and Thorndycraft, V. R. (eds) Systematic, palaeoflood and historical data for the improvement of flood risk estimation: Methodological guidelines. Madrid: CSIC, pp. 54–70.
- Golian, S. et al. (2011) 'Probabilistic rainfall thresholds for flood forecasting: evaluating different methodologies for modelling rainfall spatial correlation (or dependence)', Hydrological Processes, 25(13), pp. 2046–2055.
- Gottesfeld, A. S. (1996) 'British Columbia flood scars: maximum flood-stage indicators', Geomorphology, 14, pp. 319–325.
- Horritt, M. S. and Bates, P. D. (2002) 'Evaluation of 1D and 2D numerical models for predicting river flood inundation', Journal of Hydrology, 268(1–4), pp. 87–99.
- Kochel, R. C. and Baker, V. R. (1988) 'Paleoflood analysis using slackwater deposits', Flood geomorphology, pp. 357–376.
- Kron, W. (2012) Floods: From risk to opportunity. Springer.
- Kundzewicz, Z. W. and Kundzewicz, W. J. (2005) 'Mortality in flood disasters', in Kirch, W., Menne, B., and Bertollini, R. (eds) Extreme Weather Events and Public Health Responses. Berlin, Heidelberg: Springer, pp. 197–206.
- Lastra, J. et al. (2008) 'Flood hazard delineation combining geomorphological and hydrological methods: an example in the Northern Iberian Peninsula', Natural Hazards, 45(2), pp. 277–293. doi: 10.1007/s11069-007-9164-8.
- Marquínez, J. et al. (2008) 'Aspectos geomorfológicos en la modificación del Reglamento del Dominio Público Hidráulico y el Sistema Nacional de Cartografía de Zonas Inundables', in Benavente, J. and Gracia, F. J. (eds) Trabajos de Geomorfología en España 2006-2008. Cádiz: Universidad de Cádiz, pp. 377–380.
- Marquínez, J., Fernández, E. and Lastra, J. (2006a) 'Estudio de inundabilidad en la ciudad de Sarria (Lugo)', Tecnoambiente, pp. 76–79.
- Marquínez, J., Fernández, E. and Lastra, J. (2006b) Metodología utilizada para cartografiar la peligrosidad de inundaciones. INUNMAP.
- Martini, F. and Loat, R. (2007) Handbook on good practices for flood mapping in Europe. Paris, Bern: EXCIMAP.
- Ortega, J. A. and Garzón, G. (2006) 'Interpretación de los depósitos de avenida como clave para establecer la dinámica de la llanura de

inundación', in Pérez Alberti, A. and López Bedoya, J. (eds) Geomorfología y territorio. Actas de la IX Reunión Nacional de Geomorfología . Santiago de Compostela: Universidade de Santiago de Compostela, pp. 629–644.
- Sigafoos, R. S. (1964) 'Botanical evidence of floods and floodplain deposition', Geological Survey Professional Paper, 45-A, p. 35.
- Smith, K. and Ward, R. (1998) Floods: Physical Processes and Human Impacts. London, U.K.: John Wiley & Sons Ltd.
- Stoffel, M. et al. (2010) Tree rings and natural hazards. A state-of-the-art. Springer.
- Stoffel, M. and Bollschweiller, M. (2008) 'Tree ring analysis in natural hazards research – an overview', Natural Hazards and Earth System Sciences, 8, pp. 187–202.
- van Alphen, J. et al. (2009) 'Flood risk mapping in Europe, experiences and best practices', Journal of Flood Risk Management, 2(4), pp. 285–292.
- Ward, R. C. and Robinson, M. (2000) Principles of Hydrology. 4th edn. London: McGraw-Hill.

W9.10 The recommended reading for VET students

- Bedient, P. B., Huber, W. C. and Vieux, B. E. (2013) Hydrology and floodplain analysis. Pearson.
- Evelpidou, N. et al. (2023) 'GIS-Based Assessment of Fire Effects on Flash Flood Hazard: The Case of the Summer 2021 Forest Fires in Greece', GeoHazards, pp. 1–22. doi: 10.3390/geohazards4010001.
- Johnson, L. E. and Lam, K. C. (2011) Flood hazard mapping: Uncertainty and its value in the decision-making process. Springer.
- Karkani, A. et al. (2021) 'Flash Flood Susceptibility Evaluation in Human-Affected Areas Using Geomorphological Methods—The Case of 9 August 2020, Euboea, Greece. A GIS-Based Approach', GeoHazards 2021, Vol. 2, Pages 366-382. Multidisciplinary Digital Publishing Institute, 2(4), pp. 366–382. doi: 10.3390/GEOHAZARDS2040020.
- Kron, W. (2012) Floods: From risk to opportunity. Springer.
- Pal, M. and Srivastava, P. K. (2015) GIS and Remote Sensing Applications in Flood Management. Springer International Publishing.
- Schüttrumpf, H. (2016) Flood Risk Assessment and Management. John Wiley & Sons.

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W9.11 Recommended assessment of student knowledge and skills

1. **How can AR technology be used in flood mapping and management?**

Answer: AR technology can provide a more immersive and interactive experience of the flood environment, allowing users to visualize and assess the impacts of flooding on buildings, infrastructure, and communities. AR can also assist in emergency response and evacuation planning by providing real-time flood data and visualizations to decision-makers.

2. **What are the benefits of using GIS software to analyze terrain data for flood modeling and mapping?**

Answer: GIS software can process large amounts of terrain data and create 3D models of the landscape to identify flood-prone areas. GIS can also integrate different data sources such as rainfall data, streamflow data, and land use data to improve flood predictions and risk assessments.

3. **How do hydraulic models, hydrologic models, and statistical models differ in their approach to flood modeling?**

Answer: Hydraulic models simulate the flow of water through a river or channel system, while hydrologic models focus on the water balance and precipitation-runoff relationships. Statistical models use historical data to predict future floods based on probability and regression analysis.

4. **In flood modeling, a ____________ model simulates the flow of water through a river or channel system.**

Answer: hydraulic

5. **The main types of floods are flash floods, river floods, coastal floods, and urban floods. True or false?**

Answer: True

6. **GIS software can integrate different data sources such as rainfall data, streamflow data, and land use data to improve flood predictions and risk assessments. True or false?**

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Answer: True

7. **What is the objective of a flood hazard map, and how can it be used to better manage flood hazards?**

Answer: A flood map is a visual representation of the areas that are at risk of flooding, typically based on elevation, topography, and hydrology data. Flood maps can be used to identify areas that require flood protection measures, such as levees or floodwalls, or to plan evacuation routes for at-risk communities.

W9.12 Workshop feedback

Please take a few minutes to provide feedback on the workshop. We value your comments and will use it to enhance future sessions.

1. How well was the workshop organized?
    a. Very well
    b. Well
    c. Poorly
    d. Very poorly
2. What motivated you to attend this workshop?
    a. Interest in the topic.
    b. Professional development requirement.
    c. Recommendation from a friend.
    d. Other
3. Were the workshop goals and objectives clearly communicated?
    a. Yes
    b. No
4. How would you rate the overall organization and structure of the workshop?
    a. Excellent
    b. Good
    c. Average
    d. Poor
5. Did the workshop meet your expectations?
    a. Yes
    b. No

6. Was the workshop content appropriate for your level of knowledge and experience?
   a. Yes
   b. No
7. Did you feel comfortable asking questions and participating in group discussions?
   a. Yes
   b. No
8. Do you have any feedback or suggestions for improving the workshop content or delivery?

____

____

____

W9.13 Summary of the Workshop

The Flood Prediction Workshop is a 90-minute program for teachers. The workshop's goal is to provide instructors an introduction of flood prediction modeling, measuring, and mapping, as well as to expose them to STEAM methodology and the use of Augmented Reality in the classroom.

The workshop covers the fundamentals of flood prediction, such as flood models, measuring instruments and mapping approaches. It also looks at how STEAM technique may be used in the classroom, including hands-on activities and augmented reality to engage students and improve their learning experience.

To participate in the workshop, you must have a basic understanding of STEAM technique, be acquainted with augmented reality, and have access to a computer or mobile device with internet connection. Instructors must also download the necessary software for the session.

Teachers participate in group discussions, individual exercises and self-assessment questions throughout the interactive session. Teachers will have a greater knowledge of flood prediction modeling, measurement and mapping, as well as the application of STEAM methodology and augmented reality in the classroom, by the conclusion of the session. They will also have created unique

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teaching tactics and activities to engage and enrich their students' learning experiences.

Overall, the Flood Prediction Workshop provides educators with a wonderful chance to acquire new skills and ways to teaching while also contributing to the development of students' scientific knowledge and critical thinking abilities. Teachers may create a more immersive and engaging learning environment by using STEAM technique and augmented reality, allowing students to better grasp and appreciate the complexity of flood prediction and its effect on our communities.

W9.14 Glossary

Adaptation: the process of adjusting to the impacts of a flood or other hazard.

Channel: the bed of a river or other body of water where the water flows.

Coastal flood: a flood that occurs when ocean water overflows onto land, often due to storm surges or high tides.

Drainage basin/catchment: topographical – hydrological unit in the Earth's surface, bearing a specific drainage system, and channelling the rainfall water into its individual streams, rivers etc. and, consequently, the final recipient, which is primarily the sea or a lake.

Flash flood: a sudden and intense flood that typically occurs in a short period of time, often due to heavy rainfall or a rapid snowmelt.

Flood frequency: the probability of a flood of a particular size happening in a specific region over a given time period.

Flood mapping: the process of developing a map that depicts the extent and severity of floods in a certain region.

Flood modeling: the process of developing a mathematical or computer-based model to replicate the behavior of a river or other body of water during a flood event.

Flood warning: a notification that warns individuals in a specified region that flooding is possible.

Flood: An overflow of water that submerges normally dry areas.

Floodplain: A low-lying area of land near a river that is made mostly of river sediments and is prone to floods.

GIS (Geographic Information System): a computer system for collecting, storing, analysing and displaying geographic data.

Hydraulic model: a type of flood model that simulates the flow of water through a river or channel system.

Hydrology: the study of water in the Earth's system, including its movement, distribution, and quality.

Mitigation: the process of reducing or preventing the impacts of a flood or other hazard.

Remote sensing: the collection of information about the Earth's surface using satellite or airborne sensors.

Resilience: the ability of a community or system to adapt and recover from a disruptive event, such as a flood.

Risk assessment: the process of evaluating the likelihood and potential consequences of a flood or other hazard.

Riverine flood: a flood that occurs when a river overflows its banks, often due to heavy rainfall or snowmelt.

Urban flood: a flood that occurs in a city or other urban area, often due to inadequate drainage or land use practices.

Watershed: an imaginary line connecting the areas of the highest altitude around the basin.

W9.15 The presentations

Power Point presentation is available as an annex.

[The series of 12 Workshops]

Workshop 10 Flood risk management

W10.1 Instructor(s) name(s) and contact information

Prof. **Martina Zeleňáková**, Department of Environmental Engineering, Faculty of Civil Engineering, Technical University of Košice, Slovakia, martina.zelenakova@tuke.sk

W10.2 Workshop Description

This Workshop provides knowledge for flood protection measures and flood risk assessment and management obligations to reduce the adverse effects of floods on human health, the environment, cultural heritage and economic activity. It discusses the planning, organization and management of flood protection and activities before - during and after flood. The workshop will include power point presentation and some videos related to the topic. Participants will do some activities during the workshop related to flood management and flood protection measures.

W10.3 Workshop goals and objectives

This workshop for flood risk management and activities before - during and after flood will provide students with basic information about flood: flood risk assessment and flood risk management through power point presentation, some videos related to the topic and activities done by participants.

Learning goals

Some examples:

- identify methods/steps for flood risk management
- understand the difference among secure and rescue works
- explain activities before, during and after flood
- synthesize possible flood management activities

Learning objectives

- analyze the reasons of flood occurrence
- discuss flood risk management activities

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- create a list of flood protection measures
- evaluate the approach of flood risk management

The participating teachers are also concerned with these learning goals objectives. Participating teachers will learn more about the above subjects and their experience will increase. Additionally, they will learn how to use various STEAM tools and AR in the classroom which could help students in understanding such topics.

W10.4 Pre-requisites

The student should be aware of the following pre-requests before attending this workshop:

- Basic knowledge of hydrology cycle
- Familiarity with the water management
- Completion of a workshop on Hydrological risk (floods - droughts); Floods types (river - urban - flash); Flood risk assessment (damages - losses); Flood prediction (modelling - measurement - mapping)

Resources required for the workshop – computer, basic software skills, advantage is knowledge of HEC RAS, MIKE, AutoCAD, GIS.

W10.5 Workshop methodology

STEAM methodology will be applied in this workshop through the use of stream table that will be used for simulating flood risks and management in urban and rural areas. In addition to other activities that depend on thinking, share data and discussions. Flood management will be presented by different methods of presentation, explanation, discussions and videos.

The main activity in this workshop will focus on using stream table for simulating different flood management activities before, during and after flood. Students will be able to select the proper activity for flood protection before – structural / nonstructural measures, during security and rescue works and after flood renovation of the environment and evaluation of flood.

Participants in this workshop will do simulation of flood management activities themselves and apply different scenarios before, during and after flood. They will discuss the possible activities mainly of security and rescue works. Applying STEAM approach and AR will help participants in understanding and analysis of flood management.

W10.6 Workshop Participation

The students will participate in the workshop in present in classroom and interactive laboratory. First, they will get presentation for flood management. During the presentation they will participate in discussions and some activities. Then they will do an experiment for simulating flood management activities using stream table. They will apply different cases for flood management before, during and after flood with the aim to protect human and environment from flood damages. They will observe the possible flood protection activities and discuss the results which will help in understanding the flood management including flood mitigation.

W10.7 Time outline

Activity	Time
Presentation to flood risk management	20
Discussion of activities before, during and after flood with attention to security and rescue works	30
Propose a list of flood protection measures	30
Summarize of obtained knowledge and experiences	10
Total	**90 minutes**

W10.8 Theoretical background

Flood protection measures

(1) Flood protection measures shall be carried out preventively, at the time of flood hazard, during the flood and after the flood.

(2) **Preventive flood protection measures** are:

(a) Measures which slow the flow of water from the catchment into watercourses, increase the water retention capacity of the catchment or promote the natural accumulation of water in locations suitable for that purpose, and which protect the area from inundation by surface runoff, which is the component of the total runoff flowing from the catchment over the ground surface into watercourses or other bodies of water, such as forestry treatments, agricultural land treatments and urbanised land treatments,

(b) measures that reduce the maximum flood flow, such as the construction, maintenance, repair and reconstruction of water structures and polders; a polder is a water structure for flood protection that includes an area intended to be inundated with water for the purpose of flattening the flood wave,

(c) measures which protect the territory from inundation by water from a watercourse, such as the modification of watercourses, the construction, maintenance, repair and reconstruction of protection dykes or flood protection lines along watercourses,

(d) measures to protect the territory from inundation by internal waters, such as the construction, maintenance, repair and reconstruction of facilities for the pumping of internal waters,

(e) measures which ensure the flow capacity of the watercourse channel, such as the removal of sediment from the watercourse channel and of vegetation on the bank of the watercourse; the bank is the lateral restriction of the watercourse channel from its bed to the bank line,

(f) the preparation, review and updating of flood risk management plans, including preliminary flood risk assessments and the production of flood hazard maps and flood risk maps,

(g) drawing up and updating flood plans,

(h) carrying out a flood forecasting service,

(i) carrying out flood inspections,

(j) other preventive measures to reduce flood risk.

(3) **Measures during a flood situation** are:

(a) the performance of the tasks of the flood forecasting service,

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(b) carrying out the flood warning service and warning the population,

(c) setting up and carrying out a flood watch,

(d) carrying out flood protection works,

(e) carrying out flood rescue work,

(f) carrying out tasks and measures during an emergency situation7) in a flood-prone or affected area,

(g) drawing up interim reports on the flood situation,

(h) ensuring hydrological measurements, hydrological observations, collection and processing of hydrological data, record-keeping and documentation work recording the progress of the flood,

(i) other measures to reduce the adverse effects of flooding on human health, the environment, cultural heritage and economic activity.

(4) **Post-flood measures** shall be:

(a) restoration of basic conditions for human life, for economic activity in the flooded area and measures to prevent diseases according to a special regulation,

(b) the provision of documentary work recording the consequences of the flood,

(c) the detection, evaluation, verification and repair of flood damage,

(d) analysing the causes and progress of the flood,

(e) drawing up summary reports on the course of the floods, their consequences and the measures taken,

(f) analysing the effectiveness of preventive measures and measures implemented during the flood situation and proposals for increasing their effectiveness in the future,

(g) other measures to eliminate the adverse effects of the flood and to learn from its course.

Preliminary flood risk assessment

(1) The preliminary flood risk assessment determines the geographical areas in which there is a potentially significant flood risk or in which it can be assumed that its occurrence is likely.

(2) Implementation, reassessment, and, if necessary, updating of the preliminary flood risk assessment in sub-basins is usually every six years.

(3) The municipality and the higher territorial unit provide the manager of the watercourses important for water management with information from the spatial planning documentation.

(4) The preliminary flood risk assessment is carried out in such a way as to provide an assessment of the potential risk. A preliminary flood risk assessment is developed on the basis of information that is available or that can be easily obtained based on reports on the course and consequences of floods, reports on the causes and course of floods, records and studies of long-term development, especially information on the impact of climate change on the occurrence of floods.

(5) The preliminary flood risk assessment mainly includes:

a) maps of the administrative territory of the basin in an appropriate scale, on which the borders of the basins and sub-basins are shown, indicating the topography and use of the territory,

b) a description of floods that have occurred in the past and had significant adverse effects on human health, the environment, cultural heritage and economic activity and which are still likely to occur in the future, including their extent and routes of progress and assessment of adverse effects, which caused

c) a description of significant floods that occurred in the past, if significant adverse consequences of similar events in the future can be assumed,

d) an assessment of the potential adverse consequences of future floods on human health, the environment, cultural heritage and economic activity, taking into account aspects such as topography, the location of watercourses and their general hydrological characteristics and geomorphological characteristics,

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including floodplains as areas of natural retention water, the effectiveness of the existing flood protection infrastructure, the location of inhabited areas, areas of economic activity and long-term development, including the impact of climate change on the occurrence of floods.

Flood hazard map

(1) The flood hazard map shall be drawn up at the most appropriate scale for each geographical area in which there is a potentially significant flood risk or in which it can be assumed that the occurrence of a significant flood risk is likely.

(2) The flood hazard map shows the possibility of flooding the territory

a) a flood with a low probability of occurrence, which is 1. a flood that may recur on average once every 1,000 years or less frequently, or 2. a flood with an exceptionally dangerous course,

b) a flood with a medium probability of occurrence, which may recur on average once every 100 years,

c) floods with a high probability of occurrence, which may recur on average once every 10 years.

(3) The map shows the flood threat as a guide

a) the extent of the flood represented by the flood line, which is the intersection of the flood water level with the terrain,

b) water depth or water level,

(c) the flow rate of the water stream or the corresponding water flow, if necessary.

Flood risk map

(1) The flood risk map contains data on the potentially adverse consequences of floods caused by floods, which are shown on flood risk maps. The flood risk map is prepared on the same scale as the flood risk map and contains

a) flood line, which delimits areas potentially threatened by floods, which coincides with the flood line shown on the flood risk map,

b) information on the estimated number of inhabitants potentially at risk of a flood,

c) types of economic activities in potentially flood-prone territory,

d) locations with industrial activities that can cause accidental water pollution in case of flooding,

e) location of potentially threatened areas for water abstraction for human consumption and recreational activities,

f) locations with waters suitable for swimming, g) information on other important sources of potential water pollution after their inundation during a flood,

h) territories that form the national system of protected areas and the European system of proposed and declared protected areas (NATURA 2000), if they are located in the geographical area shown on the flood risk map.

Flood risk management plan

(1) The objectives of the flood risk management plan are aimed at reducing the potential adverse consequences of floods on human health, the environment, cultural heritage and economic activity in geographical areas, and, if appropriate, also at non-technical initiatives to reduce the probability of flooding caused by floods.

(2) The flood risk management plan determines specific measures to achieve the goals. The flood risk management plan contains

a) conclusions of the preliminary flood risk assessment in the form of a summary map of the sub-basin with marked geographical areas that are subject to the flood risk management plan,

b) flood threat maps, flood risk maps and conclusions about flood risks resulting from them,

c) a description of appropriate flood risk management goals,

d) a summary of measures and determination of their priorities for achieving the goals of flood risk management and measures related to floods adopted according to special regulations,

e) a description of the used methodology for cost-benefit analysis developed with neighboring states, which was used to evaluate measures with transnational effects in common sub-basins, if available,

f) a description of the implementation of the flood risk management plan, namely 1. a description of the determination of priorities and the way in which progress will be monitored in the implementation of the first flood risk management plan, 2. a summary of measures taken and steps taken to inform the public and consult the public, 3. list of entities competent to solve flood risk management issues, 4. coordination procedures with other states in the administrative territory of the basin, 5. coordination procedures for implementing the flood risk management plan with the basin management plan.

Flood security works

(1) Flood security works prevent the occurrence of flood damage. Flood protection works are carried out on watercourses, buildings, objects or equipment that are located on watercourses or in inundation areas and in flood-prone areas with the aim of ensuring the smooth outflow of water, protecting buildings, objects and equipment from damage by floods and ensuring the function of protective dams and anti-flood lines. For the purposes, flood protection works carried out on construction sites are considered public works and the expenses incurred for their implementation are paid from public funds.

(2) Flood security works are:

a) performing patrol duty,

b) removing obstacles limiting the smooth flow of water,

c) protection of the water course bed against damage by water currents, objects carried by water or ice,

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d) removing ice floes, breaking and chopping ice, breaking ice barriers and ice jams,

e) protection of dams against waves, seepage, effects of erosion, springs and protection against overflowing of the crown of the dam and construction of temporary access roads for these purposes,

f) extraordinary handling on water structures,

g) closing dam breaks or anti-flood lines,

h) drainage of water from flooded territory and from flooded structures, buildings and equipment,

i) draining or pumping out internal waters,

j) building secondary protection lines,

k) temporary reversal of clogged watercourse beds,

l) establishment of temporary fences on water structures and on objects located on dams,

m) measures against backflow of water at the outlets of sewers into the water course and at culverts under roads and railway lines,

n) measures to prevent the pollution of the water course by dangerous substances when the territory is flooded,

o) activity of flood protection authorities, flood commissions, flood dispatching and technical staffs,

p) activities of the flood forecasting service and the flood notification service,

q) extraordinary measurements to assess the safety and stability of water structures,

r) marking and measuring the water level on watercourses, protective dams and anti-flood lines during a flood, including records of the time of measurement,

s) measurement of water flow in water courses and on water structures,

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t) ground measurements, aerial measurements and surveys in connection with monitoring the development of the flood and obtaining information for decisions on the implementation of measures, which include evacuation of the population, deliberate and controlled flooding of the protected area and artificial breaches of protective dams or anti-flood lines,

u) creation of artificial ruptures,

v) other work carried out on the order of the flood protection authority and other work to prevent the occurrence of flood damage.

Flood rescue work

(1) Flood rescue work is carried out to save lives, health, property, cultural heritage and the environment at the time of flood danger, during a flood and after a flood in flood-prone areas and flood-inundated areas.

(2) Flood rescue works, in addition to the following, are:

a) protection and rescue of property, including possible early harvesting of crops threatened by floods,

b) removal of dangerous substances from the predicted range of flooding of the territory by a flood,

c) temporary traffic opening of the area that was cut off by the flood, including the construction of temporary bridge structures or footbridges,

d) protection of water sources and distribution of drinking water, electricity, gas and telecommunications networks from damage by floods,

e) evacuation,

f) measures to prevent diseases,

g) disinfection of wells, cesspools, living spaces and removal and disposal of dead animals and other waste,

h) ensuring public order in the area affected by floods,

i) removal of alluvium from houses and other buildings, public spaces and roads,

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j) securing damaged structures against collapse or their rehabilitation,

k) other work to save lives, health, property, cultural heritage and the environment.

W10.9 Bibliography or/and additional reading list for teachers

This is a list of references of sources that could help to increase the knowledge about the workshop topic [hydrological risks (flood – drought)].

- Zevenbergen, C. et al. (2010) Urban flood management. Boca Raton, Florida, U.S.A.: CRC Press.
- Schüttrumpf, H. (2016) Flood Risk Assessment and Management. John Wiley & Sons.
- Zeleňáková, M, Gaňová, L., Diaconu, D.C. Flood Damage Assessment and Management, Cham: Springer Nature Switzerland, 2020. 131 p.
- Meyer, V., Haase, D., Scheuer, S. 2007. GIS-based multicriteria analysis as decision support in flood risk management. UFZ - Discussion papers, Department of Economics, 6, 57 p.
- Apel, H., Aronica, G.T., Kreibich, H., Theiken, A.H. 2009. Flood risk analyses–how detailed do we need to be? Natural Hazards, 49(1), p. 79–98.
- Alphen Van J., Martini, F., Loat, R., Slomp, R., Passchier, R. 2009. Flood risk mapping in Europe, experiences and best practices. Journal of flood risk management, 2(4), p. 285–292.
- Coppenolle, R. V., Temmerman, S. 2019. A global exploration of tidal wetland creation for nature-based flood risk mitigatin on coastal cities. In: Estuarine, Coastal and Shelf Science, 226, 106262.
- Da Silva, L.B.L., Alencar, M.H., De Almeida, A. T. 2020. Multidimensional flood risk management under climate changes: Bibliometric analysis, trends and strategic guidelines for decision-making in urban dynamics. In: International Journal of Disaster Risk Reduction, 50, 101865.
- Hankin, B., Page, T., Mcshane, G., Chappell, N., Spray, C., Black, A., Comins, L. 2021. How can we plan resilient systems of nature-based mitigation measures in larger catchments for flood risk reduction now and in the future? In: Water Security, 13, 100091.

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- Mishra, S., Ghosh, A., Rai, K., Jaiswal, B., Yadav, D. S., Agrawal, M., Agrawal, S.B. 2021. Dimensions of climate change and its consequences on ecosystem functioning. In: Global Climate Change, pp. 109-149.
- Scheuer, S., Haase, D., Meyer, V. 2011. Exploring multicriteria flood vulnerability by integrating economic, social and ecological dimensions of flood risk and coping capacity: from a starting point view towards an end point view of vulnerability. Natural Hazards, 58(2), p. 731–751.
- Solin, L., Skubincan, P. 2013. Flood risk assessment and management: review of concepts, definitions and methods. Geographical Journal, 66(1), p. 23–44.
- Yalcin, G., Akyurek, Z. 2004. Analysing flood vulnerable areas with multicriteria evaluation. Geo-Imagery Bridging Continents, XXth ISPRS Congress, p. 359–364.
- Vrijling, J.K., Van Hengel, W, Houben, R.J. 1998. Acceptable risk as a basis for design. Reliability Engineering & System Safety, 59(1), p. 141–150.
- IPCC 2021. Masson-Delmotte, V.; Zhai, P.; Pirani, A.; Connors, S. L.; et al. (eds.). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
- Zeleňáková M., Abd-Elhamid H. F., Krajníková K., Smetanková J., Alkhalaf I. 2022. Spatial and temporal variability of rainfall trends in response to climate change, A case study: Syria Water, 14 (10), 1670,
- Hlinková M., Zeleňáková M. and Abd-Elhamid H. 2022. Comparison between flood damages evaluation methods and selection of the appropriate method for application in Slovakia, CEC, TUKE
- Šoltész A., Zeleňáková M., Čubanová L., Šugareková M. and Abd-Elhamid H. F. 2021. Environmental Impact Assessment and Hydraulic Modelling of Different Flood Protection Measures, Water, MDPI, 13(6): 786.
- Fathy I., Zeleňáková M. and Abd-Elhamid H. F. 2020. "Highways protection from flood hazards, a case study: New Tama road, KSA", Natural Hazards, Springer, 103:479-496.
- Zeleňáková M., Repel A., Vranayová Z., Kaposztasová D., Abd-Elhamid H. F. 2020. Impact of land use changes on surface runoff in urban areas-Case study of Myslavsky Creek Basin in Slovakia, Acta Montanistica Slovaca, EBSCO, 24 (2), 129-139
- Abd-Elhamid H. F., Fathy I. and Zeleňáková M. 2018. Flood prediction and mitigation in Hurghada, Egypt, Natural Hazards 93 (2), 559-576.

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[The series of 12 Workshops]

W10.10 The recommended reading for VET students

This is a list of references of sources that could help to increase the knowledge about the workshop topic [hydrological risks (flood – drought)].

- Larry W Mays, 2011. Water Resources Engineering, 2nd edition, John Wiley & Sons.
- Chow, V.T. 1964. Handbook of Hydrology. McGraw-Hill, New York.
- Mead, D.W. 1950. Hydrology. 1st ed., McGraw-Hill, New York, 2d ed., rev.by H.W. Mead.
- Subramanya, K. 2008. Engineering Hydrology, 3rd edition, McGraw-Hill.
- Johnston, DON, and Cross, W.P. 1949. Elements of Appliedc Hydrology, Ronald, New York.
- Eagleson, P. 1970. Dynamic Hydrology, McGraw-Hill, New York.
- Zevenbergen, C. et al. 2010. Urban flood management. Boca Raton, Florida, U.S.A.: CRC Press.
- Kazmann, R.G. 1972. Modern Hydrology, 2d ed., Harper & Row, New York,.
- Linsley, R.K, Kohler, M.A. and Paulhus, J.L.H. 1949. Applied Hydrology, McGraw-Hill, New York,
- Smith, K. and Ward, R. 1998. Floods: Physical Processes and Human Impacts. London, U.K.: John Wiley & Sons Ltd.
- Ward, R. C. and Robinson, M. 2000. Principles of Hydrology. 4th edn. London: McGraw-Hill.
- Bedient, P. B., Huber, W. C. and Vieux, B. E. 2013. Hydrology and floodplain analysis. Pearson.
- Kron, W. 2012. Floods: From risk to opportunity. Springer.
- Schüttrumpf, H. 2016. Flood Risk Assessment and Management. John Wiley & Sons.
- Zeleňáková, M, Gaňová, L., Diaconu, D.C. 2020. Flood Damage Assessment and Management", Cham: Springer Nature Switzerland, 131 p.
- Viessman, J.R., Knapp, J.W., Lewis, G.L, Harbaugh, T.E. 1977. Introduction to hydrology. New York (Harper).
- Malczewski, J. 1999. GIS and Multicriteria Decision Analysis, John Wiley & Sons, New York.
- UN/ISDR (United Nations International Strategy For Disaster Reduction). 2004. Living with Risk, A Global Review of Disaster Reduction Initiatives, 430 p.

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- EXCIMAP. 2007. Handbook on food practices for flood mapping in Europe. November, 2007, 57 p. [online]. Dostupné na internete: <http://ec.europa.eu/environment/water/flood_risk/flood_atlas/pdf/handbook_goodpractice.pdf>.
- IPCC 2021. Masson-Delmotte, V.; Zhai, P.; Pirani, A.; Connors, S. L.; et al. (eds.). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.
- Douville, Hervé; Raghavan, Krishnan; Renwick, James A.; Allan, Richard P.; et al. 2021. "Chapter 8: Water cycle changes". IPCC AR6 WG1 2021.

W10.11 Recommended assessment of student knowledge and skills

Assessment will be done using different methods including, discussions during the workshop, evaluation to activities done by participants and short assessment will be submitted by participants (attachement-1).

W10.12 Workshop feedback

A form for feedback on the workshop will be distributed to all participants to assess the workshop (attachement-2).

W10.13 Summary of the Workshop

The workshop Flood risk management (activities before, during and after) was prepared to VET students and teachers to be familiar with the flood risks. The workshop focuses on flood assessment, management and flood protection aimed to provide participants with basic knowledge of definitions, procedures of flood impacts mitigation and flood protection measures. Flood protection activities aimed at reducing flood risk in a flood-prone area, preventing flooding caused by floods and mitigating the adverse effects of floods on human health, the environment, cultural heritage and economic activity. The workshop includes power point presentation, some videos, and some activities done by participants. STEAM approach is applied in the workshop through using stream table to simulate flood event including different scenarios of flood management

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and flood protection measures such as water retention by technical or natural approaches. The participants can propose some protection measures to protect flooded areas from flood risks. Finally, the activities and discussions during the workshop could help participants to increase their knowledge or the workshop topic.

W10.14 Glossary

(1) **Flood** is a natural phenomenon in which water temporarily inundates an area not normally covered by water. A flood occurs as a result of

(a) an increase in the flow of water in a watercourse,

(b) the formation of an obstruction or obstruction in a watercourse, on the bank of a watercourse or on a building, structure or installation crossing a watercourse, which has caused the water to rise and spill over onto adjacent land,

(c) prolonged or heavy rainfall, snowmelt or the simultaneous occurrence of these phenomena,

(d) the inflow of water from rainfall or the inflow of water from snowmelt over the surface from the adjacent area,

(e) the rise of the water table above the surface as a result of a prolonged high water level in an adjacent watercourse or as a result of prolonged precipitation.

(2) **Flood hazard** is a situation characterized by

(a) The possibility of extreme precipitation, sudden snowmelt, or rapid rise in watercourse levels,

(b) prolonged heavy atmospheric precipitation and consequent increased runoff,

(c) increased runoff from snowmelt,

(d) a rapid rise in water level or flow in a watercourse which is expected to reach flood stages,

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(e) the formation of an obstruction that restricts the smooth flow of water in a watercourse channel, bridge, culvert or floodplain,

(f) hazardous ice conditions with the potential for ice jamming, ice jamming or

(g) a failure or accident at a water structure or hydroelectric power plant on a watercourse.

(3) **Flood situation** is a condition where a flood hazard is imminent or has already occurred.

(4) **Flood risk** is the combination of the probability of a flood occurring and its potential adverse effects on human health, the environment, cultural heritage and economic activity.

(5) **Area at risk of flooding** is generally

(a) an area adjacent to a watercourse on a reach where a significant rise in water level is expected or has already occurred as a result of

1. intensive surface runoff from the catchment and the creation of a flood wave in the watercourse,

2. the formation of obstructions which restrict the smooth flow of water,

3. dangerous ice flow, ice jams and ice jams,

4. failure or accident of a water or hydropower structure,

(b) an area in which natural runoff from rainfall or snowmelt into a receiving watercourse is temporarily prevented and, as a result, inundation by internal waters is expected or is already occurring,

(c) an area that is flooded due to extreme rainfall or increased runoff from snowmelt.

(6) **Flood damage** is damage caused by a flood

(a) to the State,

(b) a higher territorial unit,

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(c) a municipality and

(d) a person.

W10.15 The presentations

Power Point presentation was prepared (attachement-3).

Workshop 11 Flash flood

W11.1 Instructor(s) name(s) and contact information

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W11.2 Workshop Description

The workshop's topic is flash floods. The participants will become familiar with the main geographical entities that compose a drainage basin (e.g., catchment, watershed, hydrographic network, mouth of the basin etc.). Additionally, they will become familiar with the term "flash flood" and the natural parameters that cause it, as well as affect its properties (e.g., intensity, damages etc.). The workshop on flash floods is a laboratory and its primary tool will be the stream table, which can be used to simulate the superficial movement of water and the consequent phenomena (e.g., landform formation, relief evolution, floods, erosion, landslides) (see section 5). During the workshop, several parameters will be altered by the instructors, so that students can view the different impacts of these parameters on the relief and the flooding. Additionally, during the workshop's different phases, different locations will be defined where human activities will take place (e.g., human constructions, roads, bridges, settlements etc.), so that students can view which areas are more prone to flooding within a catchment. The defining of all these parameters and their combinations will be made by the instructors, but upon discussion with the students, who will

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propose several different combinations. After the simulation for each combination, the instructors will discuss with the students about the results they observe.

W11.3 Workshop goals and objectives

Learning goals

The learning goals of this workshop include the following:

- Students will learn the basic physiographical/geomorphological terms regarding a drainage basin (catchment, watershed, hydrographic network, basin mouth etc.) and how they are connected to each other.
- Students will become familiar with the hydrological cycle and its components (precipitation, surface runoff, evapotranspiration and infiltration of the water).
- Students will learn what natural factors cause flooding and what parameters affect their properties (e.g., duration, intensity, water velocities etc.).
- Students will learn which areas of a drainage basin are more prone to flood events, what the possible impacts could be on infrastructure and human activities etc.
- Students will learn how each different combination of parameters such as rainfall duration, rainfall intensity, catchment relief and distribution of the human activities has different results regarding flooding (distribution of the phenomenon, intensity, impacts on infrastructure etc.).
- Students will develop their critical thinking, being able to judge any information they get about actual flash flood events, as discussions will be made with them after each phase of the workshop.
- Students will be able to recall the information they will obtain during the workshop, due to its interactive and entertaining character, whereas they will be able to apply that knowledge to a practical level and in any necessary case.

These learning goals will be also extended to the participating teachers, who will also become familiar with the aforementioned, in case they are unaware, or enrich their pre-existing knowledge regarding the various aspects of the physiography of catchments and flash floods.

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Learning objectives

The learning objectives of this workshop include:

- Students will comprehend in which cases and under which circumstances they should expect a potential flash flood in their own residence, school etc.
- Students will comprehend what they need to do or what they must not do in case of a flash flood, so that they can be as safe as possible, if they happen to be at home, at school or outdoors.
- Students will comprehend what they need to be always prepared for, even if they have never experienced a flash flood phenomenon.
- Students will realise whether their own residence is prone to flood phenomena and to what extent.
- Students will learn to respect nature and, in this case, the superficial water, that is neither be afraid of it nor defy it, as they will comprehend its power and might, its potential for destruction, but also its importance for all natural processes that take place at the Earth's surface.

These learning objectives also concern the participating teachers. They will obtain knowledge regarding the aforementioned, or enrich their pre-existing knowledge. What is more, they will be trained in using various STEAM tools in education. During this workshop, they will be trained in using the stream table, but they will become familiar with the usage of STEAM in general, which will aid them in utilising any other tool among the ones included in the guide for teachers.

W11.4 Pre-requisites

The pre-requisites for the participating students include:

- Familiarity with the morphology of a typical drainage basin (not necessarily the terminology)
- Familiarity with the primary effects of running water on the relief (e.g., soil removal/erosion, flooding) (not necessarily the terminology)

For the implementation of this workshop, a stream table will be needed (see section 5).

Although this is not necessary, students can use the following links before attending the workshop.

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- https://geovirtualfieldtrips.com/wp-content/uploads/2021/11/Screenshot-2021-11-08-at-5.35.18-PM.png
- https://storymaps.arcgis.com/stories/b0a91ce973484a99859d9b8a45a06048

These are two story maps created by the team of EKPA and available for free in Greek. The first link includes a collection of interactive maps that familiarise pupils with the basic physiographical terminology of drainage basins and the second one refers to the recent (2020) flash floods in Euboea island, Greece.

W11.5 Workshop methodology

For the workshop "Flash Flood", a stream table will be used. It is a tub that can be used to simulate water-provoked phenomena (floods, erosion, landslides etc.). For its usage, several steps are followed.

Initially, the tub is filled with sediments. Sediments include clay, sand and cobbles. The type of sediments, as well as the proportion of each of the types, are defined by the users based on what it is they want to simulate. For example, regarding flash floods, cobbles allow for more water to infiltrate and less to flow superficially, contrary to clay or mixed cobble-clay, where infiltration is lower.

Subsequently, the relief of the simulated basin is determined, again by the users according to what they want to show. For example, they can create a mountainous catchment, a floodplain or both. Regarding the drainage network, they can make it sparce, with few streams, or intense. Regarding the main river, they can make it large or small in length, deep, broad, narrow etc.

Afterwards, other characteristics of the drainage basin are determined, mainly regarding vegetation and human interventions. For example, users can use small items to simulate a settlement, bridges, roads etc. in different locations of the basin.

Consequently, water is poured in the upstream part of the simulated basin. This simulates the rainfall. Users can define the amount of water (i.e. amount of rainfall), the duration for which they will pour it (rainfall duration) and its power (rainfall intensity).

After these steps, the water follows its natural course downstream. In this way, flooding is simulated. Different properties regarding all the above factors will result in different response to flooding.

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The workshop “Flash flood” is an experiential laboratory, combining Science and Engineering, basic components of the STEAM approach, but also includes the active participation of the involved persons. The participants will not solely observe the flash flood simulations, but they will take part in the basin’s configuration (the type of sediments, creation of the relief, human interventions etc.). What is more, they will take part in the discussion that will follow each experiment with the tutors. Therefore, the workshop will be an entertaining and efficient way for the participants to obtain valuable knowledge regarding the physiography of flash floods, as well as their relationship with the human interventions.

W11.6 Workshop Participation

The workshop “Flash Flood” is an interactive laboratory. The active participation of the students is essential for its implementation. Initially, students will participate in the creation of the experiments’ workspace; by discussing with the tutor(s), they will create the relief of the simulated drainage basin for each experiment. Moreover, they will determine, again by discussing with the tutor(s), the characteristics of the rainfall, as well as the types and locations of potential human activities. After each experiment, students will discuss with their tutor(s) about what they observed, for example what factors affected the flood’s properties and how its impacts are related (affect and/or are affected by) the human interventions. In this way, students will comprehend the physiography of flash floods, their causes, as well as what types of human interventions affect them.

W11.7 Time outline

Activity	Time
Preparation of the experiment (creation of the desired relief using sand and pebbles).	5 minutes
Discussion on the physiography of catchments and the natural causes flash floods	10 minutes
First experiment on flash floods (without human interventions) with limited runoff (and observations – discussion).	12 minutes
Second experiment on flash floods (without human interventions) with increased runoff (and observations – discussion).	12 minutes

Third experiment on flash floods (without human interventions) the presence of a large plain rather than steep relief (and observations – discussion).	12 minutes
Fourth experiment on flash floods, with human constructions and relatively steep relief (and observations – discussion).	12 minutes
Fifth experiment on flash floods, with human constructions and the presence of a large plain rather than steep relief (and observations – discussion).	12 minutes
Overall discussion	15 minutes
Total	**90 minutes**

W11.8 Theoretical background

The Earth's relief is highly dynamic and is constantly changing. There are two primary process types that affect the landscape: The endogenous and the exogenous ones (Charlton, 2007).

The endogenous or endogenic processes are processes that take place in the Earth's interior. The most common endogenous processes include tectonism-seismicity, volcanism and isostasy. Tectonism refers to the processes that control the structure and properties of the Earth's crust and its evolution through time. There exist many types of tectonic movements. The most common categories include vertical and horizontal movements, but there are other subtypes as well. However, it is only rarely that such movements occur discretely and independently from the others. In most cases, at least two types of tectonic movements occur simultaneously and interacting with each other. There are also areas where tectonic movements have been absent for thousands or even millions of years, but were active in the past (Park, 2013).

Seismicity is one of the results of tectonism. Its most typical form are earthquakes. Seismicity occurs in areas that are dominated by active faults. It is worth mentioning that not all faults are active and therefore, not all areas where faults are present undergo seismicity or active tectonics (Stein and Wysession, 2003).

Tectonism and seismicity generally provoke the generation of new relief or, tantamountly, cause the existing relief to become more intense and the altitudes to rise. For example, the creation of the Earth's most prominent mountain ranges, i.e. the Himalayas, the Alps, the Andes, the Caucasian

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mountains, the Pyrenees, the Atlas mountains, the Ural mountains, the Scandinavian mountains, the Rocky mountains, the Appalachian mountains, the Apennines etc., is a result of active and very intense tectonic movements that occurred millions of years ago (Zhang et al., 2012; Zi et al., 2013). Tectonism and seismicity also lead to the creation of new relief at a regional or local scale, for example in the creation of lesser mountain ranges.

However, there are also cases where tectonism and seismicity cause the lowering of the relief. For example, the creation of several basins has been initiated because of tectonics, even though in this case, exogenous processes play a vital role. At a global scale, the most typical basins that have been created due to tectonic processes include the Atlantic Ocean, which separates three once united continents (Europe-Africa and America) and the Red Sea, which separates the once united Arab peninsula and Africa (Park, 2013).

Volcanism is the process through which, material from the Earth's interior is exposed at the surface. This material could be magma (known as "lava" when exposed at the surface), gasses, ash and/or stone fragments. The most typical landforms associated with volcanism are the volcanoes. Volcanism only causes relief generation, as the lava, ash and other materials are deposited atop pre-existing formations and structures, thus increasing the area's altitude and causes relief accretion (Schmincke, 2003).

Finally, isostacy is the process through which, an area where glaciers had accumulated during glacial periods has been lowered due to the weight of the glaciers and after their melting, it is uplifted and tends to be restored at its previous position. During the accumulation of ice, the relief is lowered and upon its melting, the lowered areas are uplifted (Kukkonen et al., 2006; Hickin et al., 2015).

The other process category includes the exogenous or exogenic processes. These are processes that tend to shape the Earth's relief in a way that every area will have a plain relief and a low altitude. The exogenous processes generally tend to lower the relief and destroy pre-existing structures, but in some cases, for example in the case of a basin adjacent to a prominent mountain, the exogenous relief will tend to lower the mountain by eroding it and fill the basin with the produced sediments (that is, contributing to the accretion of its relief), so that the whole area obtains a plain morphology (Huggett, 2011).

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The exogenous processes cause erosion of the Earth's material (soil, rocks etc.) and the deposition of the eroded material at a lower altitude. Some of the main exogenous factors include the gravity, the glaciers and the wind.

However, the most important factor for shaping the Earth's relief is the flowing water. The action of runoff has played the most important role in the configuration of the landscape we observe. The flowing water acts in two ways: either through unconcentrated flow, that is randomly on a slope, or through concentrated flow, that is through streams, rivers, torrents and creeks. All the latter compose the area's drainage or hydrographic network.

A drainage basin or catchment is a topographical – hydrological unit in the Earth's surface, bearing a specific drainage system, and channelling the rainfall water into its individual streams, rivers etc. and, consequently, the final recipient, which is primarily the sea or a lake. A drainage basin is delimited by the watershed, which is an imaginary line connecting the areas of the highest altitude around the basin. A watershed segregates two adjacent drainage basins. A common definition used for its comprehension is that it is the line where a raindrop falling on this line is separated, and if it does not infiltrate the soil or evaporated, it partly flows within one of the two segregated catchments and partly within the other.

Within a drainage basin, the hydrological cycle plays a very important role. It is based on the Principle of Conservation of Energy. Extending this principle to a drainage basin, the hydrological cycle is as follows (Davie, 2019):

The total amount of water falling on a drainage basin through precipitation (e.g., rainfall, snow, hail, drizzle, sleet etc.) follows three directions. A part of is infiltrates the soil or rock formations or remains stagnant. Another part of the water is evaporated, or absorbed by the plants and subsequently transpired by them. In any case, it returns back to the atmosphere. These two processes, evaporation and transpiration, are often very hard to separate and therefore, they are commonly referred to as evapotranspiration.

The amount of the falling water that does not follow one of these two courses flows superficially as surface runoff. Runoff refers both to concentrated and non-concentrated flow. As an equation, the hydrological cycle is expressed by the following relationship:

$$P = R + E + I$$

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where P is the total amount of precipitation within a drainage basin, R the total amount of runoff water, E the total amount of water subject to evapotranspiration and I the total amount of water infiltrating the soil and rocks.

It is clear that, for a given amount of precipitation over a drainage basin and in a specific time period, the amount of runoff water is strictly associated with the amount of water subject to evapotranspiration and infiltration. If one of these two parameters decreases, the amount of runoff will increase.

Flooding is the overflow of a river's banks and the inundation of areas that would normally be dry. There are many types of floods, such as riverine and coastal ones. Regarding riverine floods, a special category includes the flash floods. These are floods that occur within a very short time period, but often have many negative impacts on the human society, such as infrastructure damages, injuries, fatalities, environmental impacts etc. (Jonkman, 2005; Ahmadalipour and Moradkhani, 2019; Flack et al., 2019).

Flash floods generally occur in small, mountainous drainage basins. On the contrary, large river floods are not rapid in most cases compared to floods of mountainous torrents. Flash floods are provoked by short, but intense rainfall or storm events.

Based on all the above, we can understand that an area's lithological structure plays a vital role regarding its response to flash flood events. For example, a reach that is covered by rocks that contain many pores will have increased infiltration compared to a reach that consists of impermeable rocks, because in the first case, water will have several holes through which it will infiltrate. Therefore, runoff will be decreased in the first case. Subsequently, the flood risk itself will also be reduced (Bateman and Medina, 2010).

Another important factor affecting an area's susceptibility to flash floods is the morphological inclination (James and Roulet, 2009). Water tends to accumulate in flat areas. Therefore, low slopes render an area more prone to flash floods. In other words, the plain of a river, the so-called floodplain, is the most vulnerable reach of any drainage basin regarding flash floods. The floodplain itself, as stated by its name, has been formed through multiple successive flood events of different intensities. And within the plain itself, the highest hazard is found near the riverbed rather than in the plain's margins.

In an area covered by soil, its properties highly affect the area's vulnerability to flash floods (Anni, Sagy and Sarah, 2020). Initially, it is worth mentioning that soil facilitates the infiltration of the rain water. However, its moisture plays a very important role. In each soil type and each area covered by soil, a specific amount of surface water can infiltrate. Therefore, if water has already been stored in the soil through previous rainfalls, the amount of water that can infiltrate in the next rain will be decreased and, thus, surface runoff will be increased. This is the exact reason why most in Europe flash floods occur during autumn and winter; because soil has become saturated in water during the first rainfalls of autumn and in the next events, it cannot receive an adequate amount of water.

Another factor affecting flash floods is the presence or absence of vegetation (Fiener, Auerswald and Van Oost, 2011). Plants prevent flooding in three different ways. Initially, a significant amount of the rain water falls on their crown (leaves) instead of falling directly to the ground. It is restrained at the leaves until it is evaporated in the atmosphere. Therefore, this amount of water does not infiltrate the soil or flow superficially as surface runoff.

Furthermore, through their roots, they create holes in the soil and thus increase its porosity, meaning that more water can infiltrate it. Finally, they absorb water from the ground for their biological activities and reduce the water that has infiltrated the soil in previous rainfall events, thus increasing infiltration even further. In all these ways, surface runoff and, consequently the flash flood hazard, is reduced.

Finally, human interventions highly affect an area's susceptibility to flash floods (Suriya and Mudgal, 2012; Mahato et al., 2022). While several flood protection measures are taken in many regions and in most cases, they do offer protection against floods, most human activities enhance the possibility for a flood to occur, as well as its potential impacts.

For example, in most cases, the most common, as well as the deadliest flash flood events occur in large cities (the so-called urban floods) (Evelpidou, Mamassis and Koutsoyiannis, 2009; Ramachandra and Mujumdar, 2009; Zevenbergen et al., 2010; Thanvisitthpon, Shrestha and Pal, 2018; Diakakis et al., 2019). This is because the human constructions (road network, buildings, facilities etc.) prevent the flowing water from infiltrating. Therefore, the total amount of water that would normally infiltrate flows superficially. This, in combination with the fact that most large cities are built on plains and generally flat areas, renders them particularly prone to flash floods. Another human intervention is the artificial embankment of several torrents. The artificial

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removal of the protective vegetation (e.g., deforestations) and wildfires also increase the susceptibility to flash floods.

Floods represent a 32% of the total number of natural disasters occurring globally. The total number of fatalities caused globally by floods are 9 % of the total fatalities owed to natural disasters (Hoyois et al., 2007). Regarding the flood regime in Europe, it is worth mentioning that approximately 33% of the natural disasters that strike the continent are floods and they are responsible for 34% of the total financial losses caused by natural disasters (Hoyois et al., 2007). The European floods have increased during the last decades due to the increased human activities and urbanisation. Between 1870 and 2016, Europe has been struck by more than 1,500 floods, more than half of which (56%) were flash floods. Another 40% of them were owed to large river overflows (Kundzewicz, Pińskwar and Brakenridge, 2013; Kundzewicz, Pin'skwar and Brakenridge, 2018; Tasoulas, 2020).

Many surveys have shown that flash floods have increased during the last decades (Kundzewicz, Pin'skwar and Brakenridge, 2018; Paprotny, Morales-Nápoles and Jonkman, 2018; Santangelo, 2019). One of the main reasons for this is the fact that more and more areas prone to flooding (e.g. floodplains or areas near large rivers) are urbanised, thus increasing the susceptibility to the phenomenon. Additionally, many human interventions take place near rivers or torrents, including construction of buildings, bridges, roads etc.

Flash floods have been increased for another reason as well. During the last two centuries, the so-called climate crisis has been observed. Through various activities, such as the combustion of fossil fuels and hydrocarbons, several greenhouse gases are emitted, leading to various types of climate alterations within short time periods. One of the most typical consequences of the climate crisis is the increase in the intensity and frequency of extreme weather phenomena such as rainfalls, storms, cyclones etc. As mentioned above, flash floods are mostly owed to intense and short rainfalls. Therefore, the climate crisis has caused a significant increase in the number of flash flood, as well as their impacts on the communities they strike (Prein et al., 2017; Paprotny, Morales-Nápoles and Jonkman, 2018; Tasoulas, 2020).

Various flood management methods are used to reduce or prevent the detrimental effects of floods (Kundzewicz, 2002; Kryžanowski et al., 2014). The most common measures follow. Initially, the diversion of the channels is one good solution to mitigate flash floods to a specific extent. By making a channel wider, more space is given to the water to flow, thus reducing the possibility for it to overflow its banks. Clearing the channel beds from any material that could cause water to overflow (e.g. waste, wood, boulders etc.) is a similar method. River defenses have also been used to mitigate riverine floods. They include levees, bunds, reservoirs and weirs and they can partly prevent the overflowing water from reaching the nearby areas (e.g. the cities).

Additionally, flood hazard assessment and prediction are a very important tool for flood management (Shah, Rahman and Chowdhury, 2018). Through them, flood managers and the local authorities, as well as the citizens themselves, will be aware of which areas are more prone to floods and, more importantly, what measures need to be taken so that they are efficiently protected. Finally, it is always important to ensure that buildings are constructed in a way that they are resilient to floods to the maximum extent possible, thus having the least possible damage.

W11.9 Bibliography or/and additional reading list for teachers

- Ahmadalipour, A. and Moradkhani, H. (2019) 'A data-driven analysis of flash flood hazard, fatalities, and damages over the CONUS during 1996–2017', Journal of Hydrology, 578(August), p. 124106. Available at: https://doi.org/10.1016/j.jhydrol.2019.124106.
- Anni, A.H., Sagy, C. and Sarah, P. (2020) 'Sensitivity of urban flood simulations to stormwater infrastructure and soil infiltration', Journal of Hydrology, 588, p. 125028. Available at: https://doi.org/10.1016/j.jhydrol.2020.125028.
- Bateman, A. and Medina, V. (2010) 'Soil infiltration effect in flat areas floods simulation', in J. Carrera (ed.) 18th International Conference on Water Resources. Barcelona, Spain: CIMNE.
- Charlton, R. (2007) Fundamentals of fluvial geomorphology, Fundamentals of Fluvial Geomorphology. New York, U.S.A. & Abingdon, England: Routledge. Available at: https://doi.org/10.4324/9780203371084.
- Davie, T. (2019) Fundamentals of Hydrology, Second Edition. 3rd edn. Abingdon, U.K. andNew York, U.S.A.: Routledge. Available at: http://books.google.com/books?hl=en&lr=&id=x0HfA6HJvogC&oi=fnd&pg=PP1&dq=Fundamentals+of+Hydrology&ots=fi3rcmkBRZ&sig=xXLEc2AGr243RS1Iqr6q66rbyFM.

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- Diakakis, M. et al. (2019) ‘An integrated approach of ground and aerial observations in flash flood disaster investigations. The case of the 2017 Mandra flash flood in Greece’, International Journal of Disaster Risk Reduction, 33(September 2018), pp. 290–309. Available at: https://doi.org/10.1016/j.ijdrr.2018.10.015.
- Evelpidou, N., Mamassis, N. and Koutsoyiannis, D. (2009) ‘Flooding in Athens: The Kephisos River flood event of 21-22 / 10 / 1994’, in International conference on Urban Flood Management. Paris, France, pp. 1–14.
- Fiener, P., Auerswald, K. and Van Oost, K. (2011) ‘Spatio-temporal patterns in land use and management affecting surface runoff response of agricultural catchments-A review’, Earth-Science Reviews, 106(1–2), pp. 92–104. Available at: https://doi.org/10.1016/j.earscirev.2011.01.004.
- Flack, D.L.A. et al. (2019) ‘Recommendations for improving integration in national end-to-end flood forecasting systems: An overview of the FFIR (Flooding From Intense Rainfall) programme’, Water (Switzerland), 11(4). Available at: https://doi.org/10.3390/w11040725.
- Hickin, A.S. et al. (2015) ‘Pattern and chronology of glacial Lake Peace shorelines and implications for isostacy and ice-sheet configuration in northeastern British Columbia, Canada’, Boreas, 44, pp. 288–304. Available at: https://doi.org/10.1111/bor.12110.
- Hoyois, P. et al. (2007) Annual Disaster Statistical Review: Numbers and Trends 2006. Brussels, Belgium.
- Huggett, R.J. (2011) Fundamentals of Geomorphology. 3rd edn, Fundamentals of Geomorphology. 3rd edn. London, UK and New York, U.S.A.: Routledge. Available at: https://doi.org/10.4324/9780203860083.
- James, A.L. and Roulet, N.T. (2009) ‘Antecedent moisture conditions and catchment morphology as controls on spatial patterns of runoff generation in small forest catchments’, Journal of Hydrology, 377(3–4), pp. 351–366. Available at: https://doi.org/10.1016/j.jhydrol.2009.08.039.
- Jonkman, S.N. (2005) ‘Global perspectives on loss of human life caused by floods’, Natural Hazards, 34(2), pp. 151–175. Available at: https://doi.org/10.1007/s11069-004-8891-3.
- Kryžanowski, A. et al. (2014) ‘Review Article: Structural flood-protection measures referring to several European case studies’, Natural Hazards and Earth System Sciences, 14, pp. 135–142. Available at: https://doi.org/10.5194/nhess-14-135-2014.

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- Kukkonen, I.T. et al. (2006) LITOSPHERE 2006: Fourth Symposium on the Structure, Composition and Evolution of the Lithosphere in Finland. Helsinki, Finland.
- Kundzewicz, Z.W. (2002) 'Non-structural Flood Protection and Sustainability', in Water International, pp. 3–13. Available at: https://doi.org/10.1080/02508060208686972.
- Kundzewicz, Z.W., Pin'skwar, I. and Brakenridge, G.R. (2018) 'Changes in river flood hazard in Europe: A review', Hydrology Research, 49(2), pp. 294–302. Available at: https://doi.org/10.2166/nh.2017.016.
- Kundzewicz, Z.W., Pińskwar, I. and Brakenridge, G.R. (2013) 'Grandes crues en Europe, 1985-2009', Hydrological Sciences Journal, 58(1), pp. 1–7. Available at: https://doi.org/10.1080/02626667.2012.745082.
- Mahato, P.K. et al. (2022) 'Assessing the impacts of human interventions and climate change on fluvial flooding using CMIP6 data and GIS-based hydrologic and hydraulic models', Geocarto International, 37(26), pp. 11483–11508. Available at: https://doi.org/10.1080/10106049.2022.2060311.
- Paprotny, D., Morales-Nápoles, O. and Jonkman, S.N. (2018) 'HANZE: A pan-European database of exposure to natural hazards and damaging historical floods since 1870', Earth System Science Data, 10(1), pp. 565–581. Available at: https://doi.org/10.5194/essd-10-565-2018.
- Park, R.G. (2013) Foundations of Structural Geology. London, U.K.: Routledge.
- Prein, A.F. et al. (2017) 'The future intensification of hourly precipitation extremes', Nature Climate Change, 7, pp. 48–52. Available at: https://doi.org/10.1038/nclimate3168.
- Ramachandra, T. and Mujumdar, P.P. (2009) 'Urban Floods: Case Study of Bangalore', Journal of Disaster and Development, 3(2), pp. 1–97. Available at: http://eprints.iisc.ernet.in/43235/1/DandD_Special_Issue_3-2_2009.pdf.
- Santangelo, N. (2019) 'Geomorphological Contribution to Flash Floods Hazard Evaluation: Examples from Campania (Southern Italy)', Journal of Environmental Science and Allied Research, 2(1), pp. 1–7. Available at: https://doi.org/10.29199/2637-7063/esar-201018.
- Schmincke, H.-U. (2003) Volcanism. New York, U.S.A.: Springer.
- Shah, M.A.R., Rahman, A. and Chowdhury, S.H. (2018) 'Challenges for achieving sustainable flood risk management', Journal of Flood Risk

Management, 11, pp. 352–358. Available at: https://doi.org/10.1111/jfr3.12211.
- Stein, S. and Wysession, M. (2003) An introduction to Seismology, Earthquakes, and Earth Structure. Oxford, U.K.: Blackwell.
- Suriya, S. and Mudgal, B. V. (2012) 'Impact of urbanization on flooding: The Thirusoolam sub watershed - A case study', Journal of Hydrology, 412–413, pp. 210–219. Available at: https://doi.org/10.1016/j.jhydrol.2011.05.008.
- Tasoulas, G. (2020) Natural and Man-Made Disasters: The Case of Floods. University of Thessaly, Volos, Greece (In Greek).
- Thanvisitthpon, N., Shrestha, S. and Pal, I. (2018) 'Urban Flooding and Climate Change: A Case Study of Bangkok, Thailand', Environment and Urbanization ASIA, 9(1), pp. 86–100. Available at: https://doi.org/10.1177/0975425317748532.
- Zevenbergen, C. et al. (2010) Urban flood management. Boca Raton, Florida, U.S.A.: CRC Press.
- Zhang, J. et al. (2012) 'Tectonics of the northern Himalaya since the India-Asia collision', Gondwana Research, 21, pp. 939–960. Available at: https://doi.org/10.1016/j.gr.2011.11.004.
- Zi, J.W. et al. (2013) 'Late permian-triassic magmatic evolution in the Jinshajiang orogenic belt, SW China and implications for orogenic processes following closure of the paleo-tethys', American Journal of Science, 313, pp. 81–112. Available at: https://doi.org/10.2475/02.2013.02.

W11.10 The recommended reading for VET students

- Andjelkovic, I. (2001) *Guidelines on non-structural measures in urban flood management*. International Hydrological Programme (IHP), United Nations E-ducational, Scientific and Cultural Organization (U.N.E.S.C.O.). Available at: http://unesdoc.unesco.org/images/0012/001240/124004e.pdf.
- Lewis, E.B. *et al.* (2011) 'Elementary teachers' comprehension of flooding through inquiry-based professional development and use of self-regulation strategies', *International Journal of Science Education*, 33(11), pp. 1473–1512. Available at: https://doi.org/10.1080/09500693.2010.506523.
- Mereli, A. *et al.* (2021) 'Investigation Of The Beliefs And Assessment Of The Security Feeling In Primary Education In Greece In Relationship To Rapid Onset Natural Disasters.', *International Journal of Educational Research Review*, pp. 56–70. Available at: https://doi.org/10.24331/ijere.1028563.
- Oulahen, G. and Doberstein, B. (2012) 'Citizen Participation in Post-disaster

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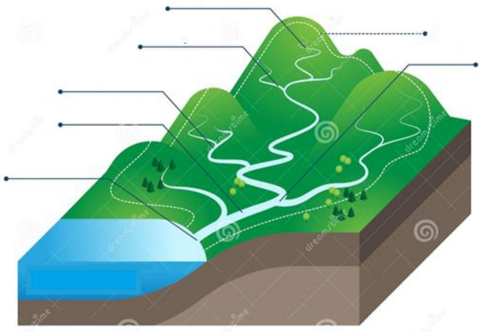
Flood Hazard Mitigation Planning in Peterborough, Ontario, Canada', *Risk, Hazards & Crisis in Public Policy*, 3(1), pp. 1–26. Available at: https://doi.org/10.1515/1944-4079.1098.

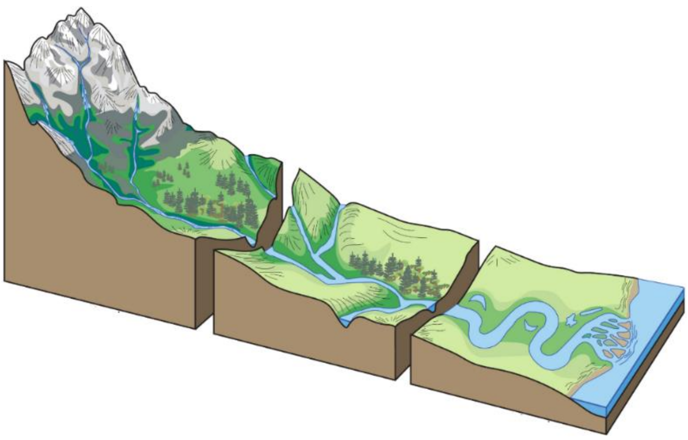
- Wurstner, S. *et al.* (2005) 'Teacher/scientist partnership develops a simulated natural disaster scenario to enhance student learning', *Journal of Geoscience Education*, 53(5), pp. 522–530. Available at: https://doi.org/10.5408/1089-9995-53.5.522.
- Zevenbergen, C. *et al.* (2010) *Urban flood management*. Boca Raton, Florida, U.S.A.: CRC Press.

W11.11 Recommended assessment of student knowledge and skills

1. In the following scheme, name the different parts of a drainage basin.



2. The following drainage basin has been divided into three zones.
   - Which of these zones is more prone to flooding and how is it named?
   - Can you depict on this scheme the components of the hydrological cycle? Describe how they are related to flooding.



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3. Between two otherwise similar drainage basins, choose the one that is more likely to face a flash flood.
   (a) One that is uniformly inclined.
   (b) One that abruptly changes from mountainous to flat.
4. Between two otherwise similar drainage basins, choose the one that is more likely to face a flash flood.
   (a) One that is made of rocks with many holes, where water can infiltrate.
   (b) One that is made of rocks without any holes, where water cannot infiltrate.
5. Between two otherwise similar drainage basins, choose the one that is more likely to face a flash flood.
   (a) One that is fully covered by vegetation.
   (b) One where vegetation is scarce.
6. Between two otherwise similar drainage basins, choose the one that is more likely to face a flash flood.
   (a) One that is densely populated.
   (b) One that is inhabited.
7. Between two otherwise similar cities, choose the one that is more likely to be damaged by a flash flood.
   (a) One that is built on a catchment's plain.
   (b) One that is built on a catchment's mountainous part.
8. Between two otherwise similar cities, choose the one that is more likely to be damaged by a flash flood.
   (a) One that has properly constructed flood protection measures.
   (b) One that has poorly constructed flood protection measures.
9. Between two otherwise similar cities on a river's plain, choose the one that is more likely to be damaged by a flash flood.
   (a) One that is built very close to the river.
   (b) One that is built very far from the river.
10. Suppose that you are walking to your school and you come across an Irish passage. Would you pass it? If not, why? If so, under what circumstances would you avoid it?
11. To what extent would you consider your own town/city safe or prone to flash floods and why? What do you think can be done to further secure your town?

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W11.12 Workshop feedback

The following questions will be filled in by the participants to assess the workshop. The answers (except for the final one, which asks the students to freely comment on the overall workshop) concern the rate of satisfaction (1 to 5 with 5 the highest).

1. Was the workshop interesting?
2. Was the workshop entertaining?
3. Was the workshop experiential and/or interactive?
4. Would you like to participate again in this workshop with different scenarios?
5. Do you think the discussion with the tutor(s) was fruitful?
6. Have you understood what a catchment's morphology is composed of?
7. Have you understood what a flash flood is and why it occurs?
8. Have you understood which areas of a catchment are more prone to flooding?
9. Have you understood how our activities affect the flood hazard?
10. Would you like to have another similar workshop for another course?

Please make any comments you would like to make about the workshop.

W11.13 Summary of the Workshop

The workshop "Flash flood" concerns schools, as well as VET teachers and its aim is to train them on the physiography of flash floods, their causes, their impacts and their relationship with the human interventions. A stream table will be used, simulating a drainage basin. Several experiments will be conducted, each one referring to a different combination of natural factors (e.g. catchment morphology, catchment lithology, drainage network development, rainfall type, intensity and duration etc.) and human interventions (flood protection measures, as well as roads, bridges, buildings, cities etc.). After each experiment, students will discuss with the tutor(s), so that they can interpret what they saw in the experiment.

W11.14 Glossary

Bed: a channel's ditch, through which, water flows downstream.

Channel: a natural chute through which the water flows superficially downstream due to gravity.

Drainage basin/catchment: topographical – hydrological unit in the Earth's surface, bearing a specific drainage system, and channelling the rainfall water into its individual streams, rivers etc. and, consequently, the final recipient, which is primarily the sea or a lake.

Drainage/hydrographic network: the total of rivers, streams, torrents etc. that drain an area.

Endogenous processes: the processes shaping the Earth's relief and taking place within the Earth's interior.

Endogenous processes: the processes shaping the Earth's relief and taking place on the Earth's surface/atmosphere.

Evaporation: the process through which the water changes its state from liquid to gas (vapor).

Evapotranspiration: the water that returns to the atmosphere through the processes of evaporation and transpiration (combined).

Flash flood: a flood that occurs rapidly, mainly in small, mountainous drainage basins, due to short, but intense rainfall or storm events.

Flood: the overflow of a river's banks and the inundation of areas that would normally be dry.

Floodplain: a plain created by successive floods of a river.

Hydrological cycle: the cycle of water within a drainage basin.

Impermeable rock: a rock whose surface is characterised by the absence of pores, thus preventing the water from infiltrating it.

Infiltration: the flow of water from the surface to the underground.

Permeable rock: a rock whose surface is characterised by the presence of pores, thus allowing the water to infiltrate it.

Plain: a broad area of relatively flat land; fluvial plains are referred to as floodplains.

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Precipitation: the liquid or frozen water that forms in the atmosphere and falls back to the Earth.

Relief: the differences in height from place to place on the land's surface.

River: a channel with a wide drainage basin, low inclinations and a perennial flow of water.

Runoff: the superficial flow of the water.

Slope/inclination: the angle formed by a slope.

Tectonism: the processes that control the structure and properties of the Earth's crust.

Torrent: a channel with ephemeral or seasonal water flow and usually a medium or small drainage basin.

Transpiration: the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers.

Unconcentrated flow: the flow of water directly on a slope rather than a channel.

Unconcentrated flow: the flow of water within a channel.

Urban floods: floods occurring in large urban centers.

Valley: a concave area between two mountains that leans downstreams; a valley is not always flat (plain).

Volcanism: the process through which, material from the Earth's interior is exposed at the surface.

Watershed: an imaginary line connecting the areas of the highest altitude around the basin.

W11.15 The presentations

Power Point presentation is available as an annex.

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[The series of 12 Workshops]

Workshop 12: Flood protection measures

W12.1 Instructor(s) name(s) and contact information

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W12.2 Workshop Description

Flash floods are sudden and rapid floods that occur within a short period of time, often within a few hours or even minutes. They can be extremely dangerous, causing significant damage to infrastructure, property, and posing a serious threat to human lives. To minimize the impact of flash floods, various protection measures can be implemented. While studying, participants' get to know the common measures. Through a presentation, practical exercise using QGIS, a discussion, students will be able to understand combination of structural, non-structural, and community-based measures.

W12.3 Workshop goals and objectives

Learning goal

To enhance participants' understanding of different types of flood protection measures.

Learning objectives

The learning objectives of a module on "Flood protection measures (structural and nonstructural" cover:

- Understanding the basics of floods: Students should learn about the causes and types of floods, including riverine floods, coastal floods, and flash floods. They should understand the factors that contribute to flooding, such as heavy rainfall, topography, and human activities.
- Identifying flood-prone areas: Students should learn how to identify flood-prone areas by studying flood maps, assessing topography, and understanding hydrological patterns. They should be able to recognize areas at risk and understand the importance of early warning systems.

- Exploring flood protection measures: Students should be introduced to various flood protection measures, both structural and non-structural. This may include studying concepts such as floodplain zoning, levees, flood walls, flood forecasting, flood insurance, and emergency preparedness.
- Understanding the role of land use planning: Students should learn how land use planning can contribute to flood protection. They should understand the importance of proper urban planning, including zoning regulations and building codes, in minimizing flood risk and preventing damage to infrastructure.
- Analyzing the effectiveness and limitations of flood protection measures: Students should critically evaluate the effectiveness of different flood protection measures in mitigating flood impacts. They should consider factors such as cost, feasibility, environmental impacts, and long-term sustainability.

W12.4 Pre-requisites

The pre-requisites for the participating students include installing QGIS.

Group work must have mobile phones, access to the internet.

W12.5 Workshop methodology

In the workshop on flood types the STEAM methodology will be incorporated by the use of GIS technology to enhance the workshop's effectiveness and engagement.

Science: The science component of the workshop will focus on understanding the scientific principles behind different types of floods protection measures (structural and nonstructural). Participants will learn about the mitigation measures through interactive discussions, hydrological and data analysis.

Technology: GIS technology will play a crucial role in the workshop. Using QGIS, participants will be able to visualize and simulate flood scenarios in a realistic and immersive manner. They can observe water flow patterns, and understand how different factors contribute to flooding.

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Mathematics: Mathematics will come into play during data analysis and problem-solving exercises. Participants will analyze flood-related data, mapping practice to identify trends and make predictions.

By integrating GIS technology, participants will be able to visualize complex concepts and immerse themselves in interactive learning experiences. GIS can provide real-time feedback, enabling participants to make informed decisions and understand the consequences of their actions in simulated flood scenarios. This combination of STEAM creates an engaging and comprehensive learning environment that fosters critical thinking, collaboration, and a deeper understanding of flood types and their implications.

W12.6 Workshop Participation

Participants in the Flood protection measures (structural, nonstructural) Workshop will be expected to actively engage with the material and participate in all aspects of the workshop. During the workshop, participants will work in small groups to apply their knowledge and skills. Participants should be prepared to collaborate, share ideas, learn from each other and to participate in the discussion. Participants should also come prepared with the necessary resources. This may include mobile phone, access to the internet.

W12.7 Time outline

Activity	Time
Introduction Introduce the workshop topic and goals Review of the workshop prerequisites and required resources	5 minutes
Presentation Theoretical background of flood types	15 minutes
Group work (with AR app)	45 minutes
Overall discussion	25 minutes
Total	**90 minutes**

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W12.8 Theoretical background

Flash floods are sudden and rapid floods that occur within a short period of time, often within a few hours or even minutes. They can be extremely dangerous, causing significant damage to infrastructure, property, and posing a serious threat to human lives. To minimize the impact of flash floods, various protection measures can be implemented. Here are some common measures:

1. Early Warning Systems: Installing reliable and efficient early warning systems is crucial. These systems monitor weather conditions, rainfall patterns, and water levels in rivers and streams. When there is a potential for flash floods, warnings can be issued promptly, giving people time to evacuate and take necessary precautions.

2. Floodplain Mapping: Accurate mapping of flood-prone areas is essential. Identifying and delineating floodplains helps in land-use planning and prevents construction in high-risk areas. This reduces the exposure of vulnerable communities and infrastructure to flash flood hazards.

3. Structural Measures: a. Retention and Detention Basins: Constructing retention and detention basins can help regulate water flow during heavy rainfall. These basins store excess water and release it slowly, reducing the peak flow downstream and minimizing the risk of flash floods. b. Channel Improvements: Modifying or widening channels and waterways can increase their capacity to handle high volumes of water, preventing overflow and reducing flood risks. c. Flood Control Dams: Constructing flood control dams on rivers and streams can effectively store excess water during heavy rainfall, gradually releasing it downstream. This helps to regulate the flow and reduce the risk of flash floods.

4. Green Infrastructure: Implementing nature-based solutions can help absorb and manage excess water during heavy rainfall. This includes creating green spaces, parks, and urban wetlands, as well as preserving natural floodplains and restoring natural drainage systems. These measures increase water infiltration, reduce runoff, and mitigate flash flood risks.

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5. Land Use Planning: Implementing appropriate land use planning strategies can minimize the exposure of vulnerable areas to flash flood hazards. Restricting construction in flood-prone zones, promoting the use of permeable surfaces, and maintaining natural buffers can help reduce the impact of flash floods.

Public Awareness and Education: Raising public awareness about flash floods and disseminating information on preparedness measures is crucial. Educating communities about evacuation procedures, emergency kits, and safe behavior during floods can help save lives and reduce injuries.

W12.9 Bibliography or/and additional reading list for teachers

1. Ahmed, K. N., & Rahman, M. M. (2016). Flood Control and Drainage Engineering. Springer.

2. Australian Government Bureau of Meteorology. (2017). Flood Warning Centre Operations Manual. Retrieved from https://www.bom.gov.au/water/about/publications/flood-warning-centre-operations-manual.shtml

3. Federal Emergency Management Agency (FEMA). (2009). Introduction to Flood Proofing: A Guidebook for Property Owners. Retrieved from https://www.fema.gov/media-library/assets/documents/2551

4. International Federation of Red Cross and Red Crescent Societies (IFRC). (2013). Community-Based Disaster Risk Reduction: A Guidance Note for Red Cross Red Crescent Volunteers and Staff. Retrieved from https://www.ifrc.org/PageFiles/95619/1319100-GN-CBDRR_EN_LR.pdf

5. Kays, W. M., & Collins, T. W. (Eds.). (2019). Design and Construction of Urban Stormwater Management Systems. American Society of Civil Engineers (ASCE).

6. Rees, H. G., Collins, D. N., & Jenkins, A. (2016). An Introduction to Human-Environment Geography: Local Dynamics and Global Processes. Routledge.

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7. Ritter, D. F., Kochel, R. C., & Miller, J. R. (2012). Process Geomorphology (5th ed.). Waveland Press.

8. Tingsanchali, T. (2015). Flood Hazard and Risk Assessment: New Insights from Research and Practice. Springer.

9. United Nations Office for Disaster Risk Reduction (UNDRR). (2019). Words into Action Guidelines: National Disaster Risk Assessment. Retrieved from https://www.undrr.org/publication/words-action-guidelines-national-disaster-risk-assessment

10. Water Services Association of Australia (WSAA). (2018). Floodplain Management Guidelines. Retrieved from https://www.wsaa.asn.au/sites/default/files/publication/WSAA-Floodplain-Management-Guidelines.pdf

W12.10 The recommended reading for VET students

Structural Measures:

1. U.S. Army Corps of Engineers. (2014). Engineering and Design: Flood Risk Management Measures for Levees, Embankments, and Floodwalls. Retrieved from https://planning.erdc.dren.mil/toolbox/library/ERs/ER_1100_2_8162.pdf

2. Federal Emergency Management Agency (FEMA). (2014). Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas. Retrieved from https://www.fema.gov/media-library-data/1409003449394-8e853b107e241b8ee5c50498aaf2923d/FEMA55-1.pdf

Non-Structural Measures:

1. United Nations Office for Disaster Risk Reduction (UNDRR). (2017). Making Cities Resilient 2030: My City is Getting Ready! A Global Strategy for Local Level Implementation of the Sendai Framework for Disaster Risk Reduction

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2015-2030. Retrieved from https://www.undrr.org/publication/making-cities-resilient-2030-my-city-getting-ready

2. World Bank. (2012). Mainstreaming Climate Change Adaptation into Development: A Guidebook for Practitioners. Retrieved from https://openknowledge.worldbank.org/handle/10986/4395

Structural and Non-Structural Measures:

1. Australian Government Department of the Environment and Energy. (2016). Australian Disaster Resilience Handbook Collection: Guidelines for Reducing Flood Losses. Retrieved from https://knowledge.aidr.org.au/resources/handbook_collection/

2. United Nations International Strategy for Disaster Reduction (UNISDR). (2015). Making Development Sustainable: The Future of Disaster Risk Management. Global Assessment Report on Disaster Risk Reduction 2015. Retrieved from https://www.undrr.org/publication/gar2015

W12.11 Recommended assessment of student knowledge and skills

These questions will help the student review and evaluate their knowledge of flood types and their impacts. They will also encourage further research and exploration of the topic:

1. Name one example of a structural flood protection measure.
2. Give an example of a non-structural flood protection measure.
3. What are the key advantages of using structural flood protection measures?
4. How do non-structural flood protection measures contribute to community resilience?
5. Briefly explain the difference between structural and non-structural flood protection measures.

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W12.12 Workshop feedback

The following questions will be filled in by the participants to assess the workshop. The answers (except for the final one, which asks the students to freely comment on the overall workshop) concern the rate of satisfaction (1 to 5 with 5 the highest).

1. Was the workshop interesting?
2. Was the workshop entertaining?
3. Was the workshop experiential and/or interactive?
4. Would you like to participate again in this workshop with different scenarios?
5. Do you think the discussion with the tutor(s) was fruitful?
6. Have you understood what GIS is?
7. Have you understood why it is important to create digital maps of flood risks and hazards?
8. Have you understood what spatial data we represent with a raster and what we represent with a vector?
9. Did you enjoy creating the digital map and what other objects would you like to create digital maps of?
10. Would you be willing to organise another similar workshop in the next course?

Please make any comments you would like to make about the workshop.

W12.13 Summary of the Workshop

The aim of the workshop "Flood protection measures (structural and nonstructural)", aimed at schools and vocational teachers, is to introduce them to digital flood mapping and attribute data analysis to assess and analyse past natural, catastrophic, and other major floods, to review the impact of climate change on flooding, and to assess the probability of similar events in the future. The workshop will use the open source software QGIS to create a digital map of flood severity and risk for river X in the country. After creating a digital flood extent and risk map of the river and filling in the given attribute information, the students will discuss with the teacher the possibilities of using such maps for flood risk prevention and for the design of measures to reduce flood risks.

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W12.14 Glossary

Attribute - An essential or specific characteristic or sign of a person, thing, phenomenon.

Conservation area' - means an area designated for the protection of objects and subject to specific land use conditions.

Contract marks - elements of map content.

Digital map - Models that store information about objects and phenomena that have coordinates in a reference frame associated with the surface of the Earth or other celestial body.

Digital Elevation Model (DEM) - A digital expression of the surface of an area, including roofs of houses, trees, grass or snow cover, etc.

Digital Terrain Model (DTM) - A digital representation of the terrain of an area that includes the ground surface without structures, trees, i.e. everything on the ground (artificial parts of the terrain).

Digital surface model (DSM) - A digital representation of the surface of a territory that includes not only the entire surface of the earth but also all objects on it.

Geographical Information System (GIS) - An information system for working with spatial and descriptive information. A system for the collection, storage, representation, editing, integration and analysis of digital, spatially coordinated data.

Flood risk area - an area likely to be at high risk of flooding.

Flood - flooding means the temporary inundation of land that is not normally under water, such as rivers, lakes, artificial water bodies, intermediate waters, sea coasts, as well as the inundation of areas as a result of the failure of hydraulic structures, excluding sewerage overflows.

Flood extent - the area inundated during a flood.

Flood risk' - means the likelihood of flooding and the potential adverse effects of flooding on human health, the environment, cultural heritage or economic activity.

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LiDAR - Light Detection and Ranging - is a technology based on laser beams. When a device detects a laser, it records the time needed to emit and recover its light. It is also known as an active sensor, which emits energy rather than detecting energy emitted from objects on the ground.

Map scale - The ratio of the length of a line on a map (plan) to the horizontal projection of the corresponding line in the terrain.

Open source GIS software - is an open source, free tool for working with geographic data.

Orthophoto maps - a map produced using aerial photographs and spatial surface model data.

Remote sensing - the determination of spatial data of points on the ground or other surface using spatial scanning equipment.

River - A natural channel on the surface of the Earth through which water flows without external pressure in the direction of slope. Some may also flow underground.

River basin - the area of land from which surface water drains by rivers and lakes to the sea at the mouth of a single river.

River channel - the lowest part of a valley through which a river flows.

Shape files - data file formats.

W12.15 The presentations

Power Point presentation is available as an annex

ANNEX: Instructions for practical exercise (group work)

"Digital mapping of river flood hazards and risks"

QGIS is an Open Source Geographic Information System. The project was born in May 2002 and was established as a project on SourceForge in June the same year. We have worked hard to make GIS software (which is traditionally expensive proprietary software) available to anyone with access to a personal

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computer. QGIS currently runs on most Unix platforms, Windows, and macOS. QGIS is developed using the Qt toolkit (https://www.qt.io) and C++. This means that QGIS feels snappy and has a pleasing, easy-to-use graphical user interface (GUI).

QGIS aims to be a user-friendly GIS, providing common functions and features. The initial goal of the project was to provide a GIS data viewer. QGIS has reached the point in its evolution where it is being used for daily GIS data-viewing needs, for data capture, for advanced GIS analysis, and for presentations in the form of sophisticated maps, atlases and reports. QGIS supports a wealth of raster and vector data formats, with new format support easily added using the plugin architecture.
(https://docs.qgis.org/3.28/en/docs/user_manual/preamble/foreword.html)

Installing QGIS

QGIS project provides different ways to install QGIS depending on your platform. If you need to build QGIS from source, please refer to the installation instructions. They are distributed with the QGIS source code in a file called INSTALL. You can also find them online at https://github.com/qgis/QGIS/blob/release-3_28/INSTALL.md.

Starting and stopping QGIS

QGIS can be started like any other application on your computer. This means that you can launch QGIS by:

- using the Start menu.
- double clicking the icon in your Applications folder or desktop shortcut
- double clicking an existing QGIS project file
  (with .qgz or .qgs extension). Note that this will also open the project.
- typing qgis in a command prompt (assuming that QGIS is added to your PATH or you are in its installation folder)

To stop QGIS, use:

- the menu option ***Project*** → ***Exit QGIS*** or use the shortcut `Ctrl+Q`.
- ***QGIS*** → ***Quit QGIS***, or use the shortcut `Cmd+Q`.

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- or use the red cross at the top-right corner of the main interface of the application.

Introducing QGIS projects

The state of your QGIS session is called a project. QGIS works on one project at a time.
https://docs.qgis.org/3.28/lt/docs/user_manual/introduction/project_files.html
A setting can be project-specific or an application-wide default for new projects. QGIS can save the state of your workspace into a QGIS project file using the menu options ***Project*** → ***Save or Project*** → ***Save As…***.

Note
If the project has been modified the * symbol will appear in the title bar and QGIS will, by default, ask you if you would like to save the changes. This behavior is controlled by the ***Prompt to save project and data source changes when required*** setting under ***Settings*** → ***Options*** → ***General***.

You can load existing projects into QGIS from the Browser panel or by through ***Project*** → ***Open…, Project*** → ***New from template or Project*** → ***Open Recent*** →.
At startup, a list of ***Project Templates*** and ***Recent Projects*** are displayed, including screenshots, names and file paths (for up to ten projects). The ***Recent Projects*** list is handy to access recently used projects. Double-click an entry to open the project or project template. Right-click an entry to ***Pin to List, Open Directory…*** or ***Remove from List***. You can also add a layer to create a new project automatically. The lists will then disappear, giving way to the map canvas.

If you want to clear your session and start fresh, go to ***Project*** → ***New***. This will prompt you to save the existing project if changes have been made since it was opened or last saved.

When you open a fresh project, the title bar will show Untitled Project until you save it.

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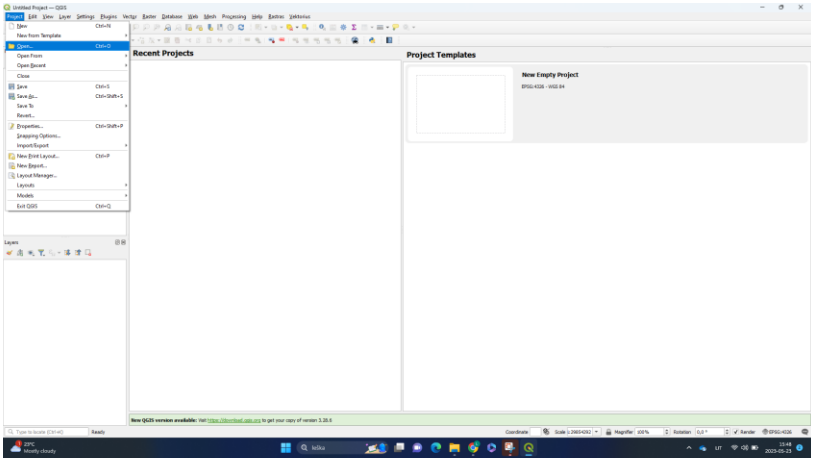

Fig. 1 *Starting a new project in QGIS*

The information saved in a project file includes:

- Layers added
- Which layers can be queried
- Layer properties, including symbolization and styles
- Layer notes
- 2D and 3D map views
- Projection for each map view
- Last viewed extent for each map
- Print layouts
- Print layout elements with settings
- Print layout atlas settings
- Digitizing settings
- Table Relations
- Project Macros
- Project default styles
- Plugins settings
- QGIS Server settings from the OWS settings tab in the Project properties
- Queries stored in the DB Manager

The project file is saved in XML format. This means that it is possible to edit the file outside of QGIS if you know what you are doing. The project file format has been updated several times. Project files from older QGIS versions may not work properly any more.

Note

By default, QGIS will warn you of version differences. This behavior is controlled in the ***General*** tab of ***Settings*** → ***Options* (☑ *Warn when opening a project file saved with an older version of QGIS).***

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Whenever you save a .qgs project file in QGIS, a backup of the file is created in the same directory as the project file, with the extension .qgs~.
The extension for QGIS projects is .qgs but when saving from QGIS, the default is to save using a compressed format with the .qgz extension. The .qgs file is embedded in the .qgz file (a zip archive), together with its associated sqlite database (.qgd) for auxiliary data. You can get to these files by unzipping the .qgz file.

Note
The ***Auxiliary Storage Properties*** mechanism makes a zipped project particularly useful, since it embeds auxiliary data.

Projects can also be saved/loaded to/from a PostgreSQL database using the following Project menu items:

Project → Open from
Project → Save to

Both menu items have a sub-menu with a list of extra project storage implementations (PostgreSQL and GeoPackage). Clicking the action will open a dialog to pick a GeoPackage connection and project or a PostgreSQL connection, schema and project.
Projects stored in Geopackage or PostgreSQL can also be loaded through the QGIS browser panel, either by double-clicking them or by dragging them to the map canvas.

Hydrological analysis

Open QGIS. You will have a new, blank map.
The ***Data Source Manager*** dialog allows you to choose the data to load depending on the data type. We'll use it to load our dataset: click the Open Data Source Manager button.
If you can't find the icon, check that the ***Data Source Manager*** toolbar is enabled in the ***View*** → ***Toolbars*** menu.
Load the ***Akmenos upė_dsm*** dataset:

1. Select the ***Akmenos upė_dsm*** file in your training directory.
2. Transfer the file to the QGIS window.

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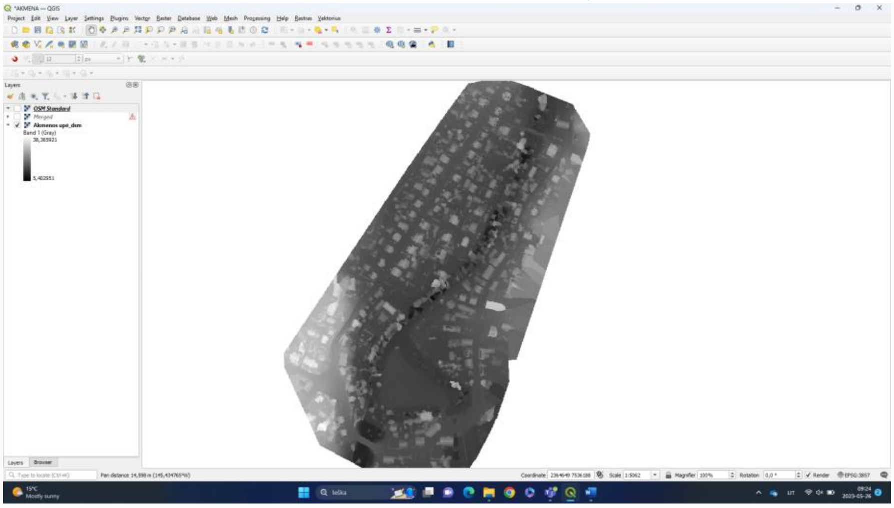

Fig. 2 Uploading vectors for ***Akmenos upė_dsm***

If you wish to replace the default data set with localised data for your course, this can easily be done with tools built into QGIS. The region you choose to use should have a good mix of urban and rural areas, containing roads of differing significance, area boundaries (such as nature reserves or farms) and surface water, such as streams and rivers.

1. Go to **Plugins** → In the **All** tab, type QuickOSM in the search box.
2. Select the OSM plugin, press **Install Plugin** and then **Close** the dialog.

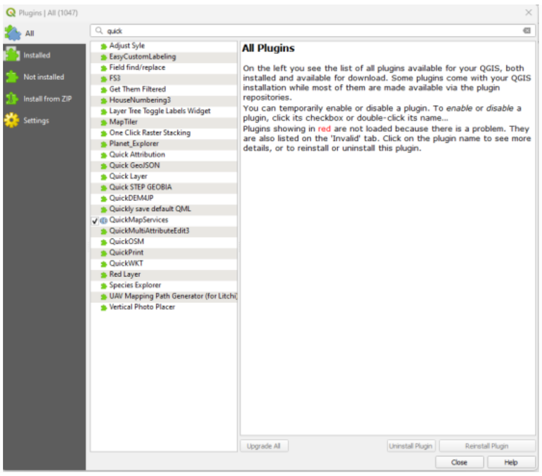

Fig. 3 *Installing QuickOSM*

Now load the Open Street Map into the QGIS window:
Map → ***QuickMapServices*** → ***OSM*** → ***OSM Standart***

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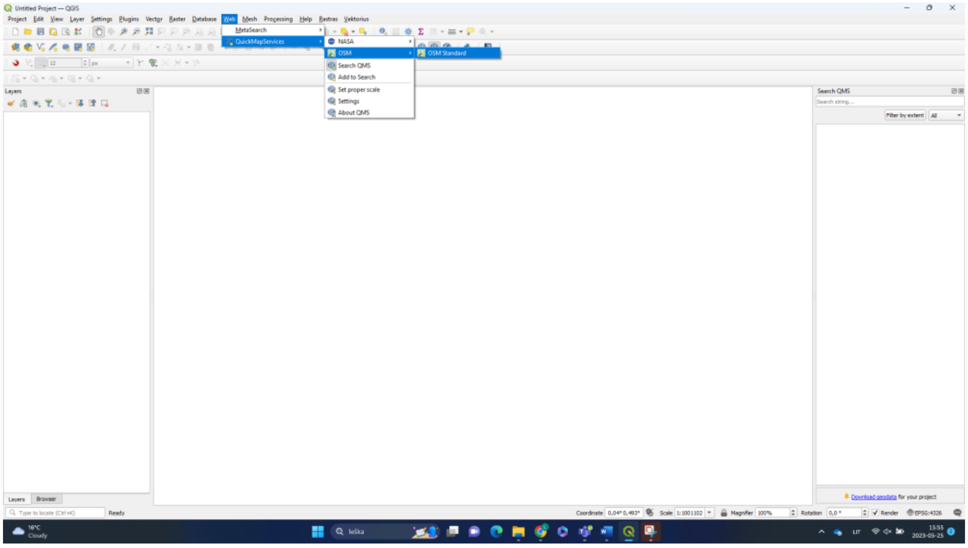

Fig. 4 *OSM Upload*

Trim the boundaries of your project:

1. Stand on the ***OSM Standard*** layer in the layer bar;

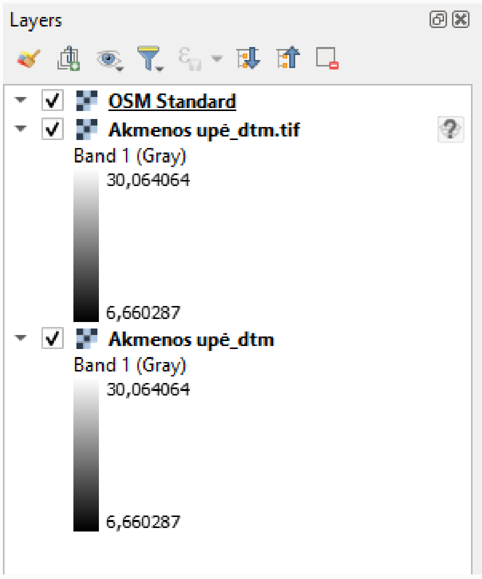

Fig. 5 *The Layers*

2. Click the right mouse button twice;
3. In the window that appears, select ***Simbology*** → In the ***Blending mode*** tab, select ***Lighten***;
4. Click ***Apply*** →***OK.***

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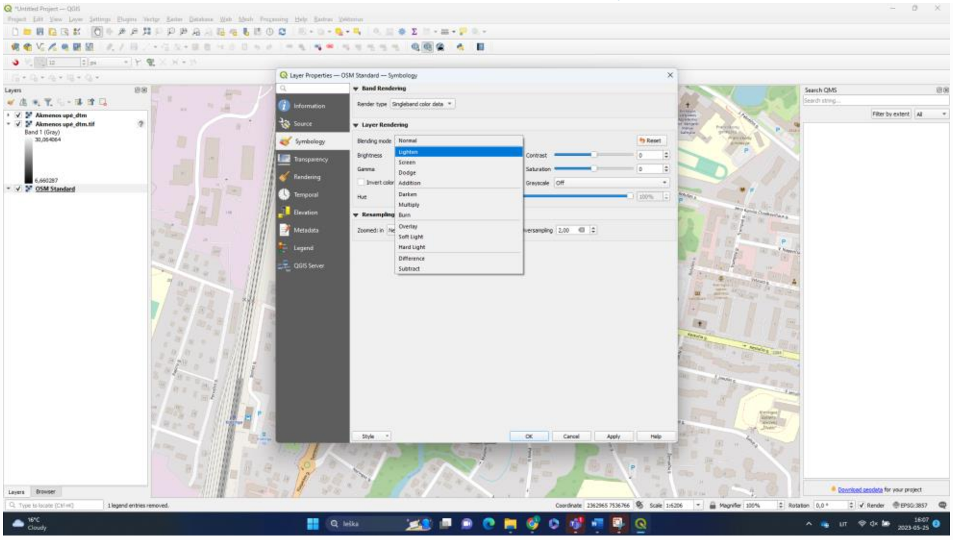

Fig. 6 The boundaries of your project

Both layers loaded in the project are raster layers, so you need to make one of the layers transparent in order to see the information it contains at the same time.

Rasters are made up of a matrix of pixels (also called cells), each containing a value that represents the conditions for the area covered by that cell.

Transperency tab helps you configure the current layer symbols overlay with other symbol layers or labels, from any layer. This is meant to improve the readability of symbols and labels whose colors are close and can be hard to decipher when overlapping; it adds a custom and transparent mask around the items to “hide” parts of the symbol layers of the current layer.

In our project, we will perform the ***Transperency*** command with the ***OSM Standard*** layer:

1. Stand on the ***OSM Standard*** layer in the layer bar;
2. Click the right mouse button twice;
3. In the window that appears, select ***Transperency***;

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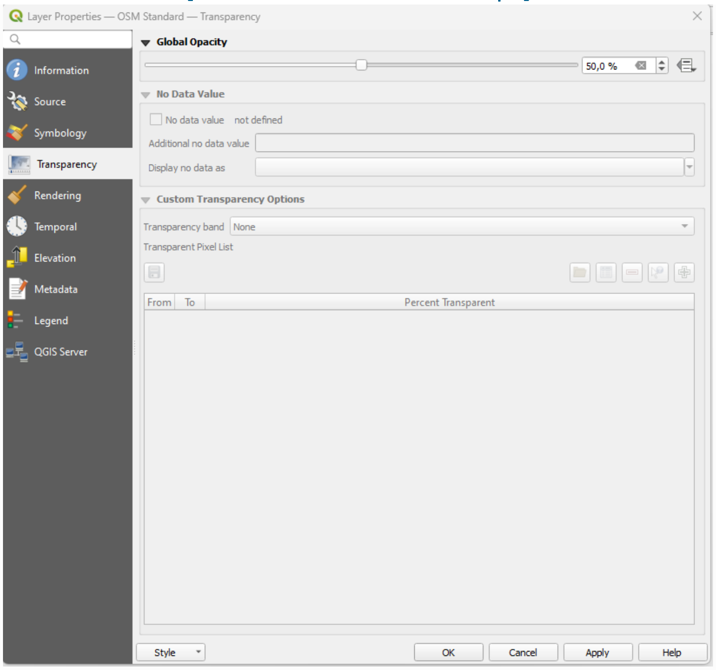

Fig. 7 The Transperency window

4. Reduce transparency by up to 50%;
5. Click ***Apply*** →***OK***.

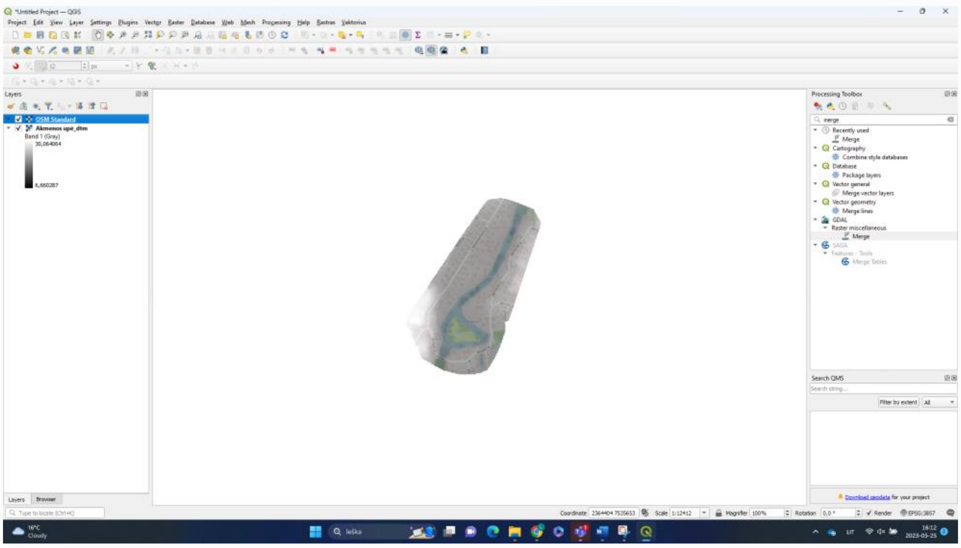

Fig. 7 The QGIS project

The next step is to load the QGIS ***Processing Toolbox*** tools. In the top toolbar, click on ***Processing*** → ***Toolbox***.

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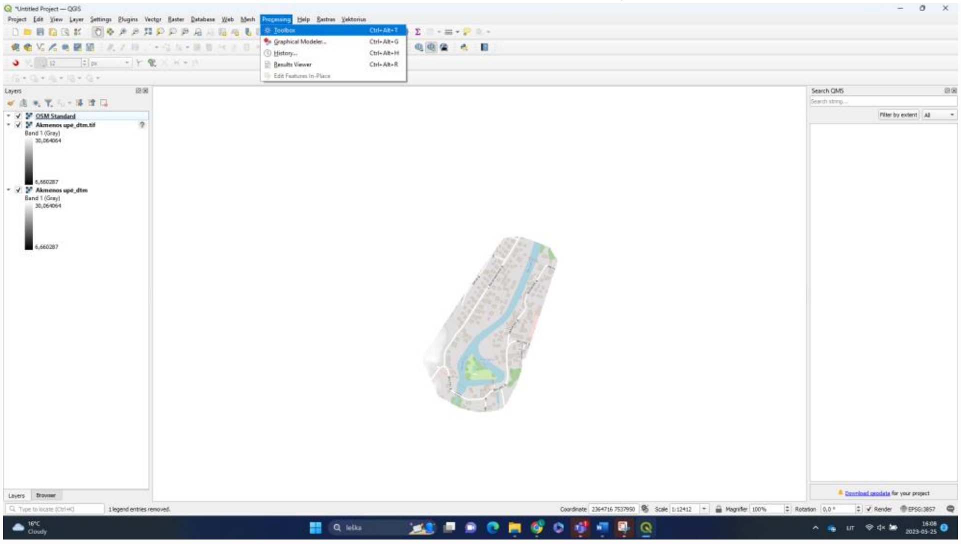

Fig. 8 The QGIS ***Processing Toolbox*** tools

In the ***Search field*** tab, type Merge in the search box.

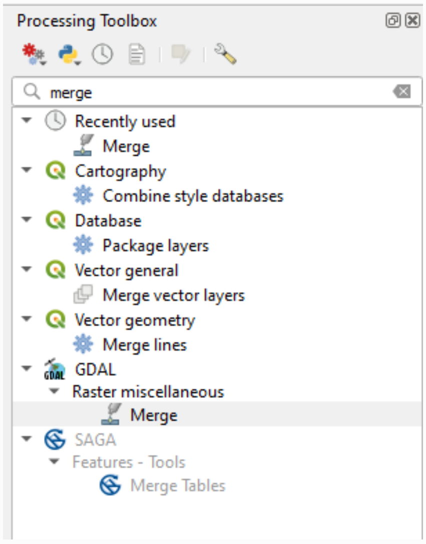

Fig. 9 The Merge command

In the ***Pocessing Toolbox*** on the right, stand on the ***Merge*** Merge command and double-click the mouse button. The ***Merge*** command window will open. Place a tick on the layer of ***Akmenos upė_dsm*** and click on ***Run***.

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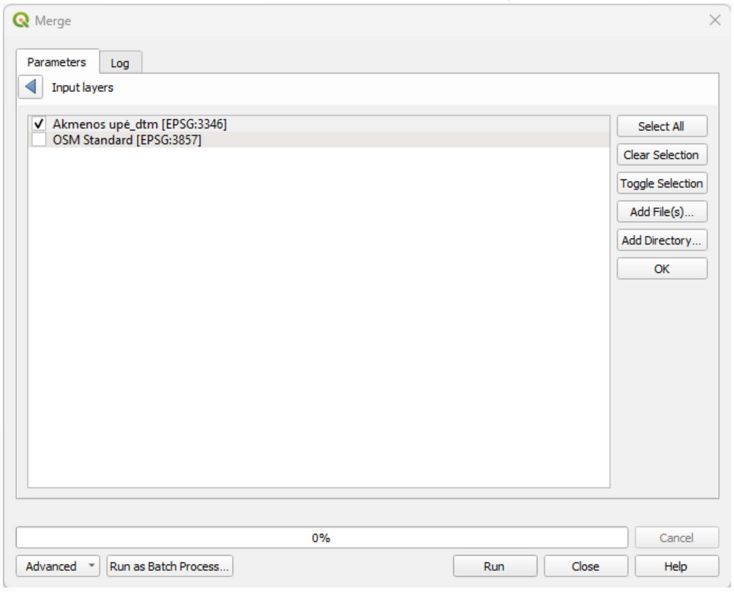

Fig. 10 The ***Merge*** command window

To assess areas that are likely to be flooded because they are at the lowest points of the land, the newly created layer ***Merged*** symbols should be changed.

Stand on the ***Merged*** layer, right-click and click ***Properties***.

In the ***Layer Properties-Merged*** window that appears, select ***Symbology***.

Set the color palette from min-0 to max-20. Click ***Apply*** →***OK***.

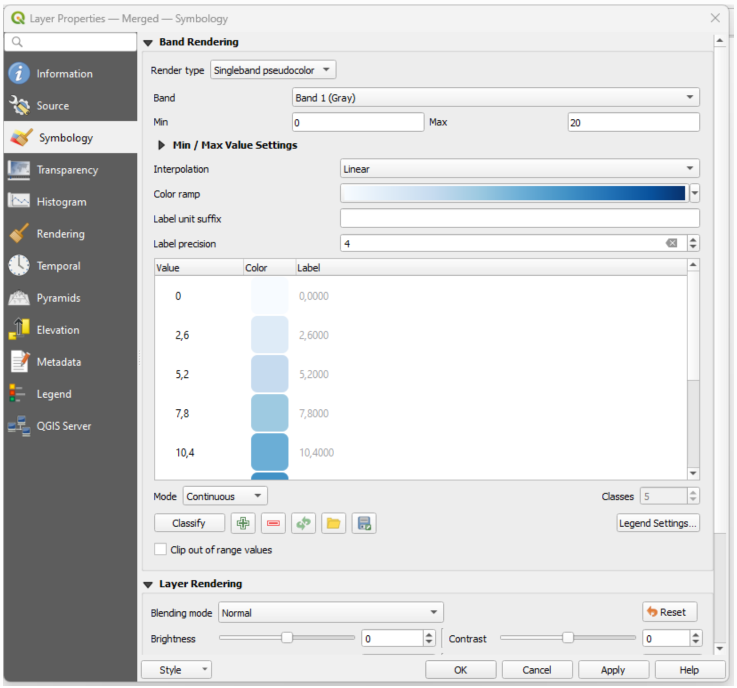

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Fig. 11 The ***Layer Properties-Merged*** window

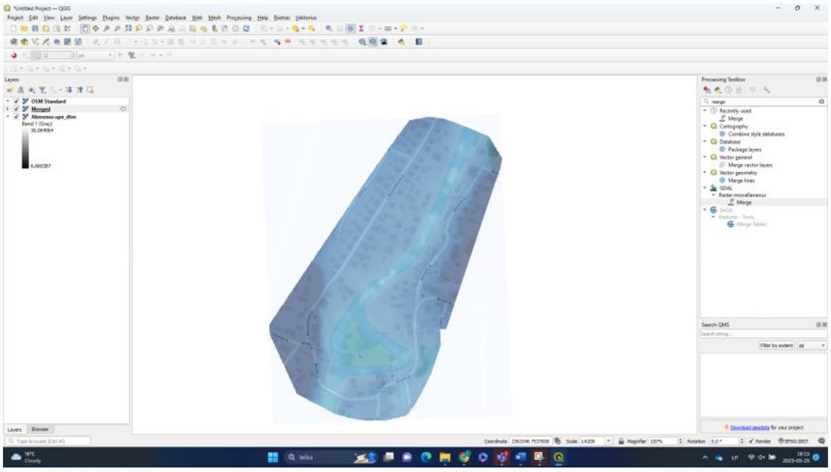

Fig. 12 The lowest points of the land by the river Akmena

In this way, GIS instruments (QGIS software) can be used to identify river and riparian areas which, due to their topography, the position of watercourses and their general hydrological and geomorphological characteristics, may be subject to flooding in the future, with the potential to cause significant adverse consequences due to the high water levels during a flood.

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