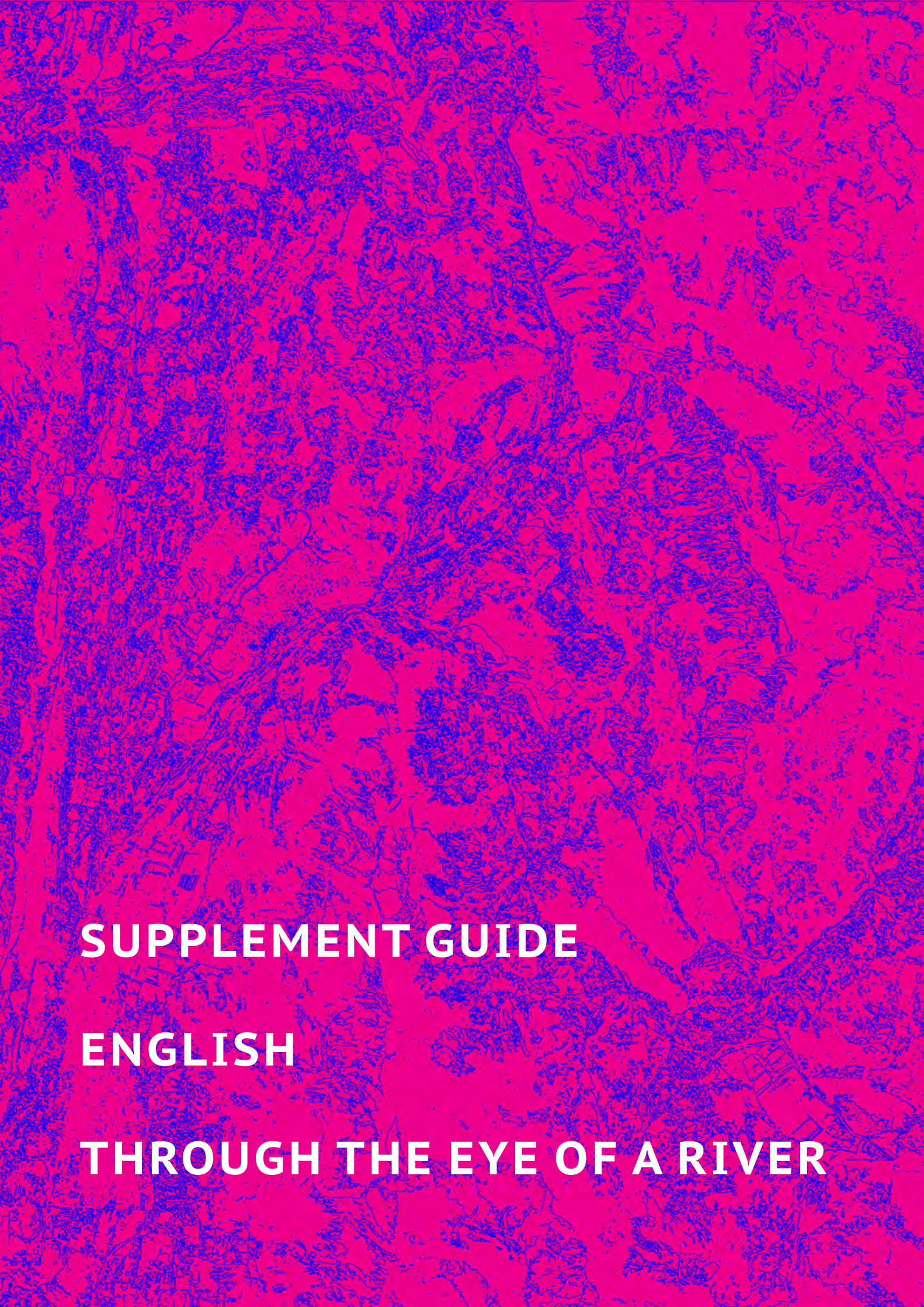

SUPPLEMENT GUIDE

ENGLISH

THROUGH THE EYE OF A RIVER

CONTENT

Rivers in the plain

Preface

The last free-flowing rivers on earth are under threat. Human lifestyles have resulted in the global loss of biodiversity from river ecosystems, and in the current climate and biodiversity crisis, the river plays an important role as a natural habitat for humans, animals, and plants. This book is of particular relevance in today's world because it offers an experiential approach to five of the world's rivers, which otherwise would not be accessible to many of the public. The conservation-related topics are illustrated for various different rivers around world.

This educational guide is designed to assist teaching staff or workshop leaders using the illustrated book "Through the Eye of a River" to educate students in the area of nature conservation.

The purely illustrative book aims to give children from the age of nine and upwards a gateway to experience free-flowing and natural rivers. Readers are taken on the adventurous journey of a kingfisher as it searches for its home. As part of its' search for a home the kingfisher travels to five rivers on three different continents.

The book conveys the biodiversity of rivers and the human impact on them through creative means, allowing the reader to almost experience the habitats. Included is the human impact on the rivers given from different perspectives.

Myriam Hombach, Andrina Janicke and Chiara Hirsch hope you enjoy reading this guide.

Learning objectives, content and the structure of the guide

The aim of this guide is to provide teachers and workshop leaders with expert knowledge on the topics covered in the book. The book is designed to be used in environmental education with children and pupils from the last few years of primary school onwards. It uses different rivers from around the world as examples to illustrate the topics of river ecosystems, their biodiversity and their role in the biodiversity and climate crisis, in addition to the human impact on these ecosystems. The book primarily deals with biological topics, in particular that of river ecosystems. The book could also be used in English, geography, ethics, social studies and politics/economics teaching.

Children and pupils should be able to use the book to discover topics about rivers and streams and gain further insight into them.

The teaching guide is divided into an introduction, rivers in a mountainous region and those in a lowland region and concludes with a questionnaire.

The teaching guide is primarily designed to provide teaching staff with specialist knowledge on the various river specific topics. Although it is designed to be used across a range of ages, the teacher must pick out the relevant topics for the ability of their class.

The content covers a wide variety of topics that can fill multiple lessons. It is designed so that the teacher can choose their topics for her/his workshop or lesson/class. In order to implement the knowledge in class, questions on all topics to easily get into a discussion are offered. The tasks and questions are highlighted in blue and can be addressed directly to the students.

Human interaction with rivers and solutions for sustainable water use can

be discussed on the basis of the five examples, because each river points to certain environmental problems. The individual rivers each show local habitat and encourage a discourse on water use and environmental protection. The five rivers together show a cross-regional picture of the diversity of fluvial ecosystems and the global relevance of natural river systems. Together they point out the differences and similarities of river ecosystems and the impact of humans on them around the world.

This teaching guide shows a wide range of knowledge about river ecosystems and offers a lot of background material that can be used for discussions about biodiversity, hydropower or climate change.

Which river looks most like your home? What is special about it?

Kuko, the kingfisher, takes us through his river stories, why is he looking for a home?

INTRODUCTION

The book explores the global topics surrounding river ecosystems predominantly focusing on the water cycle and the king fishers' habitat. The kingfisher plays an important role as it guides the reader through the book. There are several varieties of kingfisher living on the banks of rivers all over the world and they need natural rivers as their habitat. Which is why, the topic of kingfishers is a good introduction to biodiversity and the river ecosystem as a habitat.

THE WATER-CYCLE

Despite approximately 1.46 billion km³ of water on earth, the majority of it consists of salt water (approx. 97%), which can be found in the seas and oceans. Fresh water that can be utilised by humans only accounts for just under 3% of the total quantity, and most fresh water (approx. 2.2% of the total water quantity) is trapped in the form of ice at the poles, glaciers or in permafrost soils and is thus not accessible for utilisation. Groundwater accounts for a further share of approx. 0.6%. The amount of freshwater available in lakes, rivers and streams is only a tiny 0.02%. The available 0.02% of freshwater would be depleted in the foreseeable future if it were not continuously renewed by the Earth's water cycle.

The cycle is powered by the sun. Its rays cause water to evaporate in large quantities from the oceans, as well as rivers, lakes, forests and other surfaces on the mainland. Since water vapour

What opportunities do you have to spend time in and around the river?

is lighter than air, it rises and condenses in the cooler upper layers of the atmosphere to form clouds, i.e. small water droplets that are transported by the wind. If the clouds meet an obstacle on land, they continue to rise into the even cooler upper layers of the atmosphere. The water vapour then condenses into droplets, and if they are heavy enough, it falls as precipitation (rain, snow, hail).

Depending on where the precipitation falls, the water can take different paths though the water cycle. If it hits the sea, lakes or rivers, part of it can either evaporate or flow back into the sea. If it hits vegetation, for example tree tops, it could evaporate quickly. If it reaches the ground, either plants could absorb the water or it continues to seep away until it joins with the groundwater.

The role of rivers in the water cycle

The waterways between the rivers and the sea are used by many organisms for their journey. Some organisms as well as plants and plankton, are carried along by the current and eventually washed into the sea. Animals, such as fish, can migrate through the waterways in all directions thanks to their fins. For migratory fish, which use both salt and fresh water as their habitat, the connection between the sea and the river is the basis of life. River engineering, water pollution and overexploitation of water bodies pose an enormous threat to these species.

But who and what travels with the water?

Biological diversity

The waterways between the rivers and the sea are used by many organisms for their journey. Some organisms as well as plants and plankton, are carried along by the current and eventually washed into the sea. Animals, such as fish, can migrate through the waterways in all directions thanks to their fins. For migratory fish, which use both salt and fresh water as their habitat, the connection between the sea and the river is the basis of life. River engineering, water pollution and overexploitation of water bodies pose an enormous threat to these species.

Sediment and suspended matter

The water develops enormous forces on its way to the sea and takes sediment and suspended matter with it. Sediment consists of boulders, finer rocks and sand. The force of the water is not the same everywhere. Rivers carry sediment away from areas with higher flows and transport it further downstream until it is deposited again at a place where the rivers current is slower forming islands, fanning out the course of the river or making it meander. This is how rivers shape our landscape. In the estuary, the currents continue to decrease and sediment accumulates.

Nutrients

Nutrients from the surrounding landscape or other water sources collect in rivers and are transported with the current to the sea. That is why the seawater is richer in nutrients in coastal areas, and the concentration decreases in the open sea. Nutrients are often not the only things transported by the rivers, but also fertilisers or pesticides as well as waste, that not only harm the river life but also the ocean and marine life.

Literature

Ökosystem Erde

https://www.oekosystem-erde.de/html/wasser.html

Wanderfisch

https://www.wanderfisch.info/wasserkreislauf

WWF

https://www.wwf.at/immer-weniger-wanderfische/

https://www.youtube.com/watch?v=YYstU5yxoIo

THE KING-FISHER

Diversity

In the book, the kingfisher takes us from one river to the next.

Why is he looking for his home? How do kingfishers in Patagonia differ from those in Tyrol?

Kingfishers comprise of about 90 different species, with the greatest diversity found in tropical and subtropical regions. Kingfishers are small to medium-sized, stocky, usually colourful birds. The most defining characteristics are the bill, which is usually large and strong and tapering towards the front, and the feet, which are very short. Most kingfishers live in wooded areas, often near bodies of water. Only one species is native to Europe, the Kingfisher (Alcedo atthis).

Geography and habitat

The kingfisher is widespread throughout Europe and Asia. It is found on the shores of lakes, ponds, streams and in wetlands with abundant small fish and perching areas.

Appearance

The kingfisher is known for its iridescent blue plumage. The entire upper part of the bird, wings, back and head, are blue. The underbelly and a small patch below the eyes are rusty red. The throat and part of the neck are bright white, and they also have small red feet. Their beaks are long, pointed and strong to catch and hold prey. They have a body length of about 18cm and weigh about 35g.

Food

The kingfisher finds its food exclusively on and in bodies of water. It hunts its prey from a perch above the water. It preys mainly on small freshwater fish with its large dagger-like beak, by piercing the water surface upside down like an arrow, so clear waters are essential for its survival.

Nest building and reproduction

The mating season begins in April and sometimes does not end until October. In northern regions, nest-building begins around mid-March. The male and female work together to dig a hole in a bank close to a water source. For this they need steep river banks of clay, rocks or sandy soil.

Threats

Cold winter temperatures are among some of the natural threats to the kingfisher populations. The construction, expansion and canalisation of watercourses and and water pollution are having a greater effect on its decline. The natural dynamics of rivers are disrupted by bank stabilisation, canalization and riverbed constructions, which is why flora and fauna are declining. The fish find less food and fewer refuges for fish larvae. The kingfisher lacks food and perching sites on the food and perches on the banks to hunt successfully. If the banks are fortified, the breeding walls. In fact, the supply of breeding opportunities is now the limiting factor for the development of the population.

Conservation proposals

What is remaining of the natural waterways should be preserved at all costs. The restoration of watercourses can also create nesting opportunities with artificial steep banks and perching areas. Attention should be paid to improving water quality and thus preserving the diversity of fish.

Literature

Animal Diversity Web

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https://www.nabu.de/tiere-und-pflanzen/aktionen-und-projekte/vogel-des-jahres/2009-eisvogel/10125.html

RIVERS IN MOUNTAINOUS REGIONS

Many rivers have their origin in the mountains and their characteristics and ecology are very much shaped by this environment. Tyrol, as an example, is located in an Alpine region and as a result many of the rivers there originate high in the mountains and have specific characteristics owing to the glaciers. In this part of the teaching guide, the Ötz, the Río Azul and the Melamchi are used to introduce a variety of alpine rivers, their ecosystems, and the different ways in which people have an impact on them. It looks at the sustainable use of rivers by humans (Rio Azul), the use of hydropower (Ötz) and the conflicts of use that arise due to different interests/needs (Melamchi). Climate change is particularly evident in the case of glacial rivers due to the loss of ice in high mountain regions. The effects of climate change are explained in the following text.

ÖTZ

The illustrations of the Ötz shows a typical depiction of Tyrolean alpine rivers. The Ötztaler Ache is Tyrol's second largest tributary to the Inn (after the Ziller). Water from the Ötztal Alps and partly from the Stubai Alps flows through it into the Inn. The catchment area of the river has an average altitude of 2500m a.s.l. and 30% of the total catchment is glacial.

Seasonal discharge

The strong annual seasonality in the discharge of the Ache is typical for glacier rivers high in the mountains. The discharge increases rapidly in spring and reaches its maximum in midsummer. In winter, the Ötztaler Ache carries comparatively little water. When water levels are high in summer, the river delivers a lot of debris and fine sediment into the Inn.

Tyrol's largest free-flowing glacial river

The Ötztaler Ache is the largest free-flowing glacial river in Tyrol. Since the dismantling of the Brunauer Weir in 2021, there are no more weirs or dams completely across the river.

The longitudinal connectivity of a river describes the connectivity, meaning the transportability in the rivers flow from source to sea. It describes the ability for organisms, sediment, nutrients and organic substances to travel up- and downstream.

The Ötztaler Ache is one of the last free-flowing glacial rivers in Tyrol and is therefore still able to transport nutrients, sediment or organisms along with its current. The brown trout, for example, can still travel downstream or upstream along this river to its spawning ground.

The sources

What makes a glacier river?

The confluence of the two tributaries (rivers) the Gurgler Ache and the Venter Ache form the Ötztaler Ache, which in turn flows into the river Inn in Haiming. There are several other tributaries that flow into the Ötztaler Ache, many of which originate from glaciers, thus the amount of water increases as it flows down through the valley. The glaciers in the high Tyrolean Mountain regions form a valuable freshwater resource. When the glacial ice melts, a glacial stream emerges at the glacier gate.

Springs also emerge from bedrock and soil.

Take a look at the gauge of the Ötztaler Ache on Hydro Online, a service of the Tyrol (https://wiski.tirol.gv.at/hydro/#/Wasserstand?station=201434) and compare the annual flow with the gauge at the Sill near Innsbruck and/or the Ruetz/Krössbach in the Stubaital.

What could be the reason for the difference in the flow rate?

What makes the Ötz in Tyrol so special? Dou you find many free-flowing glacial rivers close to you home?

The Glacial Milk

The fine sediment carried from the glacier by the glacial river gives the water in the river a milky colour.

THE RIVER INN

The Inn is one of the most water-rich rivers in Europe, and one of the most important rivers in the Eastern Alps with its upper course high up in the mountains. Further downstream in Haiming the character of the river changes it has a bigger volume, is flatter, and wider. Later on the water of the Ötztaler Ache flows from the Inn into the Danube and on into the Black Sea.

Where does the water in the river come from?

Find out how springs form in solid rock and soil.

Normally there would be floodplain landscapes in (along) the Inn valley, but these floodplain landscapes have been greatly reduced by construction. Many species that would find their habitat on the Inn are threatened today.

Fluvial Erosion

The Ötztaler Ache is an example of how rivers shape an Alpine landscape. In the course of their glacial advance and retreat, the glaciers have carved out the valleys into so-called U-valleys. The rivers, on the other hand, leave behind a V-shaped valley. In the upper reaches of the rivers, the water has a high velocity due to the steep gradient and erodes deeply into the bedrock. The course of the river in its upper reaches is characterised by waterfalls, gorges or V-shaped valleys. The steeper the rock slopes, the greater the deep erosion of this river in comparison to the weathering of the lateral slopes. One can say that the river cuts into the bedrock.

The turbid water of a glacial river is also called glacial milk, why is that?

Where does the water of the Ötztaler Ache flow in to after the Inn?

We already know from the two examples, the Ötztaler Ache and the Inn, that rivers can look very different. The course of the Ötztaler Ache can be described as a stretched channel. When the solid rock is quite competent against the erosion of the river, narrow valleys and gorges form, which naturally stretch along the river and allows it to spread little to the left and right.

In high mountain regions such as the Tyrolean Alps, the steep gradient causes severe river erosion and the formation of narrow river beds. Due to the heavy erosion of the stream bed and the steep sides of the river, the Ötztaler Ache carries a fairly large sediment load. Mudslides and landslides are not uncommon in the steep terrain, and the Ache transports the sediment into the Inn, or further into the Danube and even as far as the Black Sea.

How about your home river, into which ocean does is flow?

Do you know the Völser Au (protected area) and Kranebitter Innau (special protected area) near Innsbruck? Or do you know a floodplain on your home river? Which species and animals can be found in the natural floodplains (Inn or your home river)? May they still find shelter in the floodplains today?

About 8000 years ago a landslide occurred in the Öztatl near Köfels. Lake Piburg in the Ötztal was also dammed by a landslide after the last ice age, and at the valley exit a massive landslide occurred about 3000 years ago. This material forms the entrance to the Ötztal today.

The Ötztaler Ache has different appearances, once it winds through the remains of the landslide, further upstream it cuts through solid rock. It forms gorges, such as the Heiligkreuz Gorge of the Venter Ache, and wide branches, further downstream before it flows into the Inn. The Ötztaler Ache thus changes its flow rate not only through water flow, but also through the variability of the morphology of the river bed.

What shape does the Inn Valley have and what shape doe the Ötztal or Stubai Valley have? Dou you know different valley types? Which of them are formed by rivers? Is there such a river-formed valley close to your home?

Topic 1: Climate change

The Alpine landscape is characterised by recurrent changes between cold and warm periods, which were accompanied by glaciations during the colder periods.

What are the glaciologists doing and what does the diagram show?

During the last glacial peak about 20,000 years ago, the Alpine valleys, such as the Inn valley, were covered by a 1km thick layer of ice.

Today we are confronted with climate change; according to the IPCC Special Report 2021, human activity, such as the emissions of greenhouse gases, has warmed the earth by 1 °C compared to pre-industrial levels. High alpine areas are particularly affected by climate change; here the snow cover, permafrost and glaciers are receding and this affects the water balance of the glacier fed rivers in Tyrol. Glacier-dominated rivers will carry less water in the course of glacier melt and the water flow will be more influenced by precipitation events and dry phases.

The glaciers in our mountains are melting, and fast. Glacier researchers, so-called glaciologists, study the glaciers. They balance mass loss in summer and mass increase in winter. The so-called mass balance determines how much ice melts on a glacier each year.

What effects does climate change have on the rivers of the Alps?

Ice cores can be used to reconstruct the temperature course of the past and the composition of the atmosphere.

The catchment area of the Ötztaler Ache contains about one third of Tyrol's glaciers, including the Hintereisferner and Kesselwandferner. The glaciers have a considerable influence on the hydrology and the natural environment of the Ötztaler Ache. This mountain-adapted habitat consists mainly of algae, insects and fish.

Topic 2: Hydropower

The figure shows the status in January 2019 with 960 hydropower plants in Tyrol; the planned hydropower plant projects, e.g. in the Ötztal, are not even shown here. The figure clearly shows that most rivers in Tyrol are blocked by transverse structures such as dams or weirs.

Tyrol has had an overproduction of electricity generated by hydropower since 2008. The provincial target of covering electricity production by renewable energy in 2030 has already been met.

According to the Tyrolean Environmental Ombudsman's Office, there are only a few major water bodies left in Tyrol that are not significantly negatively influenced by energy use. This leaves the upper reaches of the Ötztaler Ache and the Lech, the Isel, a large part of the catchment area of the Brandenberger Ache, the Großache and the Tyrolean parts of the Leutascher Ache and the Isar.

Do you know a river that is protected by a nature park in your country or elsewhere in the world? Can you think of projects that demand the protection of natural watercourses (Vjosa National Park Now)?

In Tyrol it is the Tyrolean Lech Nature Park.

The ecological status assessment of Tyrolean flowing waters based on the Water Act of 1959 came to the following results in 2015. Approx. 60% of the flowing waters are in good and very good condition and about 40% are in moderate to poor condition.

EU Water Framework Directive

The Water Framework Directive is an EU-wide set of regulations that calls for further protection of water bodies. Water protection in Austria has been determined by the EU Water Framework Directive since 2000. The Water Framework Directive stipulates that "deterioration in the status of all surface water bodies shall be prevented" (Article 4(1)(a)(i) WFD). It also requires Member States to bring all natural surface waters to "good ecological status" by 2027 at the latest.

It can be concluded from this that just under 40% of Tyrolean water bodies need to be brought into a better ecological condition through renaturation measures. Furthermore, the last free-flowing rivers should also remain untouched.

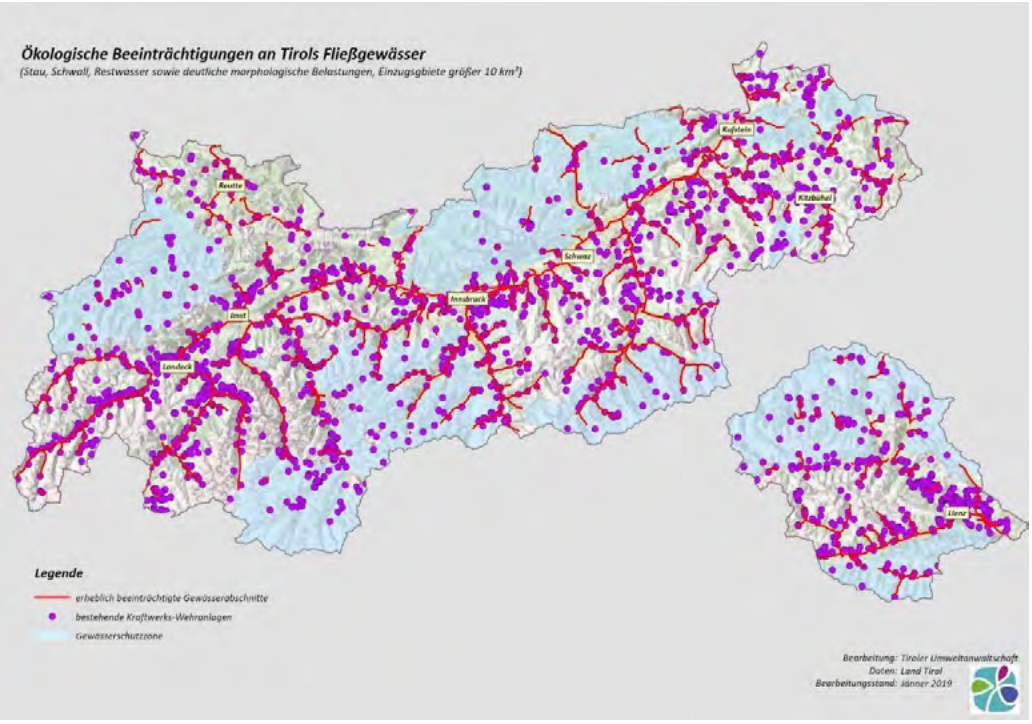

Figure 1: The map shows the existing power plant weirs (dots) and the significantly impaired watercourse sections (red) in Tyrol (as of 2019)

https://www.tiroler-umweltanwaltschaft.gv.at/fileadmin/userdaten/bilder/Naturschutz/positionen-der-umweltanwaltschaft/Ausbau_der_Wasserkraft_in_Tirol/Daten2019/Gewaesserbelastungen.pdf

Functional principle of hydropower plants

The kinetic and potential energy of the water is converted into mechanical energy, rotational energy, by means of a turbine. The rotation of the turbine shaft drives a generator, which produces electrical energy - electricity. The flow and the head of the water are crucial for the generation of electricity. Storing water in a reservoir is important for regulating the water level throughout the year. By means of reservoirs, the desired water flow necessary for planned electricity generation can be guaranteed even during periods of low precipitation and naturally occurring seasonal fluctuations, such as lower water levels in winter.

Which international regulatory framework should protect flowing waters in the future?

Reservoirs

Due to the decreasing flow velocity in the reservoir, for example, gravelly habitats in the riverbed are covered with fine sediments. The structural diversity that arises in a natural watercourse from different flow velocities and water depths is then lost. A dammed river leads to hydrological degradation and the monotonous habitat to a decline in biodiversity.

How does hydropower work?

It is true that hydropower has lower CO2 emissions than fossil fuels. However, reservoirs also have a lower albedo than other terrestrial surfaces, which again leads to climate warming.

Albedo is the reflectivity of solar radiation, i.e. the proportion of solar radiation that is reflected by a surface. A white surface, such as snow, reflects up to 90% of the incident rays. A water surface reflects approx. 10%, reflects much less sunlight.

Directly after the construction of a reservoir the albedo effect, the warming of the water, occurs. The smaller the energy yield compared to the surface area of the water The smaller the energy yield compared to the surface area of the lake, the greater the albedo effect.

Storage power plants

In a storage power plant, the water of a flowing stream is dammed up to form a reservoir. In times of increased energy demand, the dammed water can flow out through pipes and generate electricity in the hydropower plant.

Pumped storage power plant

A pumped storage power plant pumps water from the lower deep basin into the upper storage basin via electric pumps. This allows the water to be stored so that it can be used again to generate electricity when needed. When there is an oversupply of electrical energy, the electricity can be used to pump up the water. During peak loads, the water is passed through the turbines so that the electrical energy is fed back into the power grid.

Run-of-river power plants

In a run-of-river power plant, flowing water is used continuously to generate electricity and there is no significant amount of water stored. The water is dammed with the help of weirs to increase the potential energy of the water and to keep the water level constant in the backwater area. Water turbines are also used in this type of power plant to generate electricity. The output of this power plant is mainly achieved through the flow rate.

Diversion power plant

In a diversion power plant, the water of a flowing watercourse is diverted and led in a watercourse separate from the flowing watercourse to the powerhouse, where electricity is generated via turbines. After diversion, only the unused residual water remains in the riverbed until the used water is returned again to the stream.

Ecological problems

The energetic use of watercourses leads to the following ecological problems:

What are the different types of hydropower plants?

- ¬ - The discharge and bedload regime is altered by retaining bedload and releasing it only sporadically.
- ¬ - Degradation of habitat and structural diversity, e.g. in the reservoir due to siltation or downstream in the floodplain, which is no longer flooded and lacks nutrient input.
- ¬ - Stream continuum and longitudinal connectivity:
- ¬ Cross-blocking is one of the most serious interventions in stream ecology. Fish can no longer migrate upstream and die in the turbines.
- ¬ - Deepening in the downstream water:
- ¬ Downstream of a hydropower plant, the river deepens and the water table sinks. There is a lack of gravel and bedload in the streambed and the water level is lower.
- ¬ - Problems with diversion and residual water:
- ¬ In diversion power plants, the water is diverted via weirs or water catchments. Due to the seasonal fluctuations of the residual water, the river bed in the diversion section can eventually dry out in the worst case.
- ¬ - Problems with surge operation:
- ¬ The problem of threshold operation concerns storage power plants. Here, the water is dammed up in order to release it during peak demand in the form of surge operation. During intermittent water release, flood-like pre-floods occur, followed by abrupt drawdowns when the power plant is shut down. Surge and subsidence processes counteract a natural discharge regime. In autumn and winter, when water levels are normally relatively low, surging water is particularly damaging. Young fish cannot find shelter in the high waters.
- ¬ - Problems of reservoir flushing:
- ¬ Bedload and fine sediments are a problem in reservoirs and run-of-river impoundments. They fill the reservoir and thus reduce the usable storage volume and can lead to siltation. The problem is solved by flushing, in which the water flushes the bedload and fine sediment out of the reservoir. This abruptly removes the solids that have accumulated over long periods of time, which leads to unnaturally high turbidity concentrations.

Look at page 4 of the Ötz illustrations. Which types of power plants do you recognise? Do you know a place near your home where one of the power plants is built?

What ecological burdens and problems can you think of in connection with hydroelectric power plants? Take a look at pages 4 and 5 of the Ötz illustrations.

The most important anthropogenic forms of intervention in flowing waters worldwide are wastewater pollution, flood protection measures, diversion and discharge of water, and hydropower plants. In terms of connectivity, large-scale regulations such as flood control measures in particular lead to a monotonous habitat and significantly reduced diversity. Hydropower plants intervene in the river ecology in a very complex way. They lead to major changes in morphological and hydrological conditions. Beyond the location of a power plant, there are negative consequential effects of connectivity conditions, such as disturbed sediment transport in the river.

Due to strong anthropogenic interventions and different forms of use, running waters are among the most threatened ecosystems worldwide today.

Hydropower in the climate and biodiversity crisis

The Austrian federal government is responding to the man-made climate crisis with climate and energy targets. In the course of the energy transition, Austria's entire electricity demand is to be switched to renewable energies by 2030. This is intended to protect the climate.

The climate crisis has negative effects on biodiversity. Suitable habitats are shifting and extreme weather conditions lead to a decrease in the availability of food and water. But hydropower is also affected by climate change: Increased evaporation, droughts and heavy precipitation events are expected to lead to declining yields. Glaciers are melting and with them the water reserves in the form of continental ice. The construction of new hydropower plants must be viewed critically because of the considerable interference with nature and the landscape. Instead of ecologically problematic new constructions, an increase in electricity production from hydropower can also be achieved by modernising existing plants.

Globally, we are not only affected by the climate crisis, but also by a biodiversity crisis. Therefore, in addition to achieving climate goals, the preservation of species-rich habitats such as rivers should also be strived for. However, the construction of hydropower plants is accompanied by a loss of biodiversity in flowing waters. The expansion of hydropower in Tyrol thus destroys unique river ecosystems. Our goal, on the other hand, should be to combine climate protection and nature conservation. Last but not least, glacier rivers even act as climate buffers and absorb CO2. Glacial rivers remove CO2 from the atmosphere through chemical weathering. Near their source, glacial rivers contain many dissolved minerals and little organic material. Chemical weathering of the rock turns CO2 into carbonic acid and the river can absorb CO2 again.

Advantages and disadvantages of hydropower: Discuss how ecological the generation of energy with hydropower is.

Discuss how "green" hydropower is. Is the expansion of hydropower a desirable climate goal? Which interests are in conflict here?

1. Assign yourself to the different stakeholders (energy companies, environmental representatives from politics, NGOs, local communities, fishermen or water sportsmen). What actions can you imagine to improve the ecological condition of Tyrolean rivers and to protect the last free-flowing rivers at your home?

2. Who gets the most say in your discussion? What results have you come to?

Topic 3: Relationships between humans and the river

Kayak and rafting tourism

In autumn, the Wellerbrücke (river section of the Ötz) is a training and playground for kayakers. During this time the Ötz has the right water level in many of its sections to have fun with kayaks in the steep and blocky course of the river. Since 2021, the international extreme kayaking championship OETZ TROPHY has also been held at the Wellerbrücke.

In summer, several rafting tours are offered daily by different companies on the lower Ötz. They start in Ötz village and end on the Inn river after the Imst Gorge in Haiming.

Wood fishing

Wood fishing is an old tradition to collect alluvial wood from the river. To fish for wood, wooden or metal stakes are fixed in the banks of the river. During floods, branches and tree trunks gather between the poles, and as soon as the water level drops again, the wood can be "fished". With the regulation of the rivers, wood fishing became less important.

The last remains of wood fishing can be seen in Oetzbruck. Even today, there is a warning sign for boat traffic in the Inn near Oetzbruck, indicating that there are metal poles on the bank between which the wood of the wood fishermen is supposed to get caught.

Find the place in Tyrol where wood is still fished today. Is there also such a tradition at home?

The left thought bubble shows the fisherman in his younger years. What did he do in the past and what does he do today? Why does he throw fish into the water today?

Fish stocks and water regulation

Many Tyrolean rivers, but also worldwide, have been obstructed by hydraulic engineering measures and their ecology has been profoundly disturbed. For example, many tributaries of the Inn are no longer passable for fish today and the bedload barriers of the mountain streams have the consequence that gravel is not transported further downstream and thus the structural diversity of the water courses decreases.

In a natural watercourse like the Ötztaler Ache, many habitats can be found in a small area due to different flow velocities, water depths and substrate distribution. This structural diversity is vital for fish, especially in the early developmental stage, i.e. for egg and yolk sac larvae. In addition, there are cross-bank obstacles, such as dams, which hinder fish migration and prevent gene exchange between populations.

The naturally occurring brown trout and grayling in the Inn are so disturbed by a lack of migration opportunities, spawning habitats and hydropeaking that they no longer find suitable living conditions. The fish stock of the Inn is artificially replenished so that it does not die out. According to a study on the fish ecology of the Tyrolean Inn, an average of 75%, in many sections of the Inn even 100% of the stock can be attributed to stocking measures.

Do you know whether water sports are also practised on your home river? Have you ever been kayaking or rafting on a river? If so, which one was it? Or have you ever been fishing, hiking, paddling, swimming or walking on a river?

The two black and white thought bubbles on page 3 of the Ötz illustrations are flashbacks to the past. What is the woman doing in the right-hand part?

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RÍO AZUL

The illustrations of the Río Azul show a short, natural mountain river that rises in the Andes in Argentina. It flows from the Hielo Azul glacier into Lago Pueblo, a lake formed by former glaciers and rivers. From there, the water flows via Chile into the Pacific Ocean. Argentines, including indigenous Mapuche, live along the Río Azul riverbed.

The river valley is shaped by the mountain building of the Andes, the glaciological history and the active fluvial erosion of the river itself. On its short stretch, several gorges have formed in the upper part, which are accessible to tourists mainly through hikes of up to several days. In the section shortly before it flows into Lago Pueblo, its character resembles a branching river system. Here the river spreads out laterally and forms gravel banks between the channels.

Which river close to your home has a branched river system?

What is life like for people living along the Río Azul?

Look at the second to fifth page of the illustrations about the Río Azul. Do you notice differences and similarities with your home river and the interaction between people and the river?

Can you imagine a life like on the Río Azul?

Topic 1: Gentle relationship between human and river

The Río Azul valley is located close to the small town of El Bolsón in Argentina's southern Patagonia. The river and the town are separated by a low mountain ridge called Cabeza del Indio. The place is well-known among hiking tourists from all over the world. The river with its clear blue water is the destination for hiking tourism. Along the tributaries and the course of the Río Azul are hiking trails and huts for overnight stays. Its gorges are the main attraction. There are campsites in the lower part of the river, where rafting tourism is also practised and a local group of kayakers meet to surf a wave in a kayak. The Mapuche also live along the Río Azul and usually only cross the river on horseback. Tourists, on the other hand, usually take the path across the installed suspension bridges.

Compare tourism on the Río Azul with river tourism in your home country?

Which types of river tourism do you know and which of them hardly affect the ecosystem of the river?

Flora along the watercourse

The vegetation along the Río Azul is called Valdivian rainforest. It is a temperate rainforest that extends from the Patagonian Pacific coast in Chile to the edge of the Andes in Argentina. The vegetation is associated with the former large continent of Gondwana. About 200 million years ago, this continent united Patagonia, Antarctica, New Zealand and Australia, among others. This special vegetation is home to numerous endemics, i.e. plants and animals that only occur in this environment.

Different beech species and also the Patagonian cypress (los Alerces) are native here. This species-protected cypress grows slowly and can become very old. It thrives along the riverbed together with other trees (mostly false beech species like the Coihue) and forms forest communities.

Pan del Indio is a fungal parasite that is eatable and collected by humans. The fungal parasite mainly attacks the copper beech (Nothofagus).

What do you see on page 4?

The Kingfisher on the Río Azul

The kingfisher is known as Martin Pescador on the Río Azul. It is site-faithful and finds its habitat with feeding and breeding sites here.

Compare the appearance of the kingfisher with that of the kingfisher native to Tyrol, what is different (see introduction)? Which kingfisher is native to your home?

Figure 2: The photo shows a kingfisher on the Río Azul (The photo was taken and provided by a friend).

MELAMCHI

The illustrations show the Melamchi Khola River (Khola (nep.): river) in Nepal. The Melamchi has its source in the Jugal Himal part of the Himalayas at an altitude of about 5875 metres. The Jugal Himal is a mountain range in the central Himalayas, about 70km northeast of Kathmandu. The Melamchi is a tributary of the Indrawati that flows into the Sunkoshi. From there, the water enters the Bay of Bengal, i.e. the Indian Ocean, via the Koshi, the Ganges and the Meghna.

The Melamchi is fed by glaciers. Its average discharge is 9.7m3/s and the maximum discharge is 289m3/s.

¿Cuál crees que es la línea de puntos en la tercera página del introducción?

¿Por qué razón se canaliza el agua en la ciudad? Mira las ilustraciones del Melamchi para esto.

In 2021, the Melamchi Water Supply Project (MWSP) was completed. Since then, 170 million litres of water per day are diverted from the Melamchi River through a 26km tunnel and made available to the people of Kathmandu as drinking water.

Compare the length and discharge of the Melamchi with the values of a mountain river near your home.

Research the natural hazards on the Melamchi. What happened in June 2021? Compare what happened with similar events in the Tyrolean Alps or a mountain region near you.

Topic 1: River people

Like many other rivers in Nepal, the Melamchi Khola rises in the high mountains. The clear blue water of the Melamchi forms the livelihood for many locals who live on and from the river. In the villages that lie directly on the river, rice is the main crop.

But everyday life also takes place at the river: people bathe, wash their laundry in the river, have picnics and children play in the river. In addition, the Melamchi is a well-known destination for fishermen. The Melamchi still harbours many different species of fish. Students and schoolchildren from the city Kathmandu come to the river on weekends to fish. This way they can support their families financially and finance their education.

Further downstream, there are countless sediment diggers of all genders, ranging in age from 15 to well over 60. Sediment mining is how the villagers further downstream earn their living. The river provides work for the younger generation so that they do not have to leave their homes.

The river people have protested against the MWSP project because the diversion will deprive them of their livelihood. Without enough water in the riverbed, they will no longer be able to grow rice; without fish and without sediment loads, the locals will lose their jobs and their financial basis. Moreover, they will be deprived of the quality of life in their homeland.

Figure 3: The photo shows the valley of the Melamchi Khola, with the rice fields of the villages along the river. (Photo taken by Anup Gurung during his kayak tour on the Melamchi).

Figure 4: Photo of people working in sediment mining. People from young to old working together on the river (photo taken by Anup Gurung during his kayak tour in Melmachi).

2. Topic 2: City People

Drinking water problem in Nepal

Nepal currently has a population of almost 29 million people, of which about 3 million live in the Kathmandu Valley. Nepal is one of the poorest countries in the world: 42% of the population live below the poverty line and only 27% have improved access to sanitation. Some of the biggest challenges Nepal faces are related to water pollution and water scarcity.

Water is one of the basic human needs, but a large part of Nepal's population does not have access to safe and sufficient drinking water. According to one estimate, about 80% of the population has access to drinking water, but it is often contaminated. The reason for this is that the quality of surface and ground water is constantly deteriorating due to the lack of sewage systems in the Kathmandu Valley. In addition, industrial and household waste ends up in rivers and lakes. In the capital Kathmandu, an estimated 150 tonnes of waste is generated daily, almost half of which is discharged into rivers, mainly the Bagmati River, which flows south of the city centre, and its tributaries. Moreover, due to population growth, surface water sources are no longer sufficient to supply all the inhabitants of the Kathmandu Valley.

Melamchi Water Supply Project (MWSP)

The MWSP foresees to channel fresh water from Sindhupalchok district to Kathmandu valley. The first part of the project was completed in 2021. Since then, water has been taken from the river in the Melamchi catchment area and piped through a 26km tunnel to Sundarijal, where it is further treated in plants and then made available to the population through large-scale distribution systems in the Kathmandu Valley. The project supplies 170 million litres of water per day, which corresponds to a flow rate of 6m^3 per second. However, these 170 million litres do not even cover the current demand, which continues to increase due to population growth. Therefore, the Yangri and Larke rivers, which lie upstream near the Melamchi, are currently being studied as further future sources of supply. Another 170 million litres of water per day and river are to be taken from them. A total of 510 million litres of water per day would then be diverted from this district. Policy makers, engineers and others consider the MWSP to be the best

long-term solution to the drinking water problem in the Kathmandu Valley. Locals only partially agree.

Topic 3: River diversion

Conflict: Drinking water in Kathmandu vs. livelihood of the river people

Research the Melamchi Drinking Water Project (Melamchi Water Supply Project):

What are the reasons for implementing the project?

Outline the advantages and disadvantages of the project (environmental and social impacts).

Can you think of alternative solutions to the drinking water problem in Kathmandu?

Do you know of other interventions in the river that affect local residents?

Ecological impacts of diversions

On the Melamchi, a large part of the water is diverted for the drinking water supply in Kathmandu. Such diversions also exist on many other rivers. Large amounts of water are taken from the river over a certain distance, e.g. for hydropower plants or in the past for the operation of mills. However, it also happens, as in Nepal, that entire rivers or large parts of the water are diverted completely for hydropower and are not later returned to the river. In the Ötztal in Tyrol, for example, several hydropower plants are currently being planned for which several tributaries of the Ötz are to be completely diverted. Complete diversions of rivers logically lead to a complete loss of river habitat downstream or, in the case of the Ötztal, to a reduction of water flow downstream, which reduces habitat. Even partial and only sectional diversions, as already described in the case of the Melamchi, have e.g. impacts on the people living on and from the river. But the ecological consequences can also be significant.

What are the reasons for river diversions? Discuss to what extent they justify the ecological consequences for the river ecosystem.

River diversions lead to a reduction in natural dynamics, as the lower water flow takes away some of the river's power. This can result in the riverbed moving little or not at all. The river's lack of power means that it can transport less sediment. This leads, for example, to less erosion of areas and aggradation of new gravel areas. This reduces vegetation-free areas that could be habitats for pioneer vegetation or spawning sites for fish. In the long term, this would lead to vegetation consisting mainly of forest and scrub. This means that habitat diversity in the water course and in the floodplain is lost and species adapted to it are endangered. In addition, during low water there is a risk that the amount of water remaining in the original riverbed is too small, so that the organisms in the water are endangered. This affects not only the adult fish, but also the spawning habitats, which are often located in shallow water zones. This can lead to fish eggs drying out, for example (see Ötz story,

last picture). Overall, therefore, there is a decline in floodplains and a decrease in habitat and species diversity when large amounts of water are diverted from the river, up to the complete loss of the ecosystem when the water is completely diverted.

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Compare the plans in the Ötztal and Stubaital to divert rivers for hydropower with the project at the Melamchi. Find out about how Tyrolean weirs work.

Are there already diversions in your region?

RIVERS IN THE PLAIN

When the rivers move from the mountainous area to the plain, they change their appearance due to the changed conditions. This ecosystem of rivers in the plain is described here, mainly using the example of the Rhine (thematic block lateral connectivity) and the Amazon (thematic block sediment and nutrient transport). Furthermore, references and comparisons are drawn to rivers in the mountains, especially in Tyrol. An important topic here is the biodiversity crisis and biodiversity on the natural river system. The example of the Rhine with its past and present appearance illustrates this strongly. Another topic that is dealt here is the deforestation in the Amazon. This is ideal to get back to the introductory topic of the water cycle, as deforestation has an important influence on the water cycle.

RHINE

The illustrations of the Rhine on the first three pages show the river as it might have looked 300-400 years ago, for example, before it was straightened. In the 19th century, the Rhine was straightened by the Baden engineer Tulla, and then in the 20th century it was further obstructed with barrages from Karlsruhe to Basel in order to make the Rhine navigable for large transport ships in this area as well. This area, as it looks approximately today, represent the 4th and 5th page of the Rhine illustrations.

The aim of the Rhine illustrations is to show the biodiversity (variety of species, variety of habitats) of the original Rhine and to show the influence of man through straightening and damming.

Welche Tier- und Pflanzenarten findet ihr am ursprünglichen Rhein und welche am heutigen? Which animal and plant species can you find on the original Rhine and which on the present one?

Topic 1: Lateral connectivity

Relationship between human and river

For thousands of years, humans have settled all over the world, preferring rivers and streams. This is because they are a source of drinking and useful water, provide shelter, and have often been the only means of transportation. In addition, there are particularly fertile soils (due to sediment input from the rivers) and a mild climate. The water can also be used, for example, to drive mill wheels or to harness energy.

What caused the differences between the two illustrations of the Rhine? Do you have any ideas?

Name towns whose names have something to do with rivers (e.g. Innsbruck or Ludwigshafen).

Is your home located on a river? How is it used?

What does your river look like at home? Which image of the Rhine do they most closely resemble?

What are the benefits of living by a river?

Do you have any idea why rivers have been developed and straightened?

Straightened and obstructed rivers

Fertile soils in the floodplain are regularly flooded and side channels take up a lot of space:

- Straightening allows more space for settlements and agriculture
- Dikes along rivers prevent flooding of settlements and agriculture
- When all water flows in one main bed, larger ships can be used for transportation
- Fewer wetlands mean fewer disease-carrying mosquitoes

The original Rhine

Do you know areas along rivers that resemble the first picture of the Rhine?

What is a floodplain?

The floodplain is the lowland along a stream or river, which is characterized by alternating high and low water. -> Rhine near Karlsruhe: floodplain originally approx. 10 km wide

In the alpine regions of Tyrol with steep gradients, this floodplain is often only a few meters wide. As soon as the gradient decreases, river valleys with wide floodplains are formed, which are often characterized by a river with many side arms and very many gravel islands and gravel banks (see e.g. Tyrolean Lech). In the further course with a low gradient, meandering rivers form, as can be seen, for example, in the first illustration of the Rhine.

What is special about a floodplain?

A floodplain is formed by the lateral connectivity of the river with its surrounding land. This means that for the development of the floodplain it is essential that the river can spread out over its banks during floods -> without floods no floodplains!

The river creates its floodplain habitat by itself and shapes it again and again.

During floods, flow velocities are highest in parts of the floodplain close to the river and decrease with distance from the river. Sediment enters the floodplain with the water. The lower the flow velocity, the smaller the grain size of the sediments. When the floodwater recedes, these sediments are deposited. Thus, new gravel islands are continually formed near the river and nutrient-rich silt is deposited far from the river.

During floods, the river also erodes previously deposited gravel islands. Furthermore, these erosion and

sedimentation processes create side arms of the river or cut them off again. Thus, a new course of the river and a new landscape are constantly created around it.

Durante las crecidas, el río también erosiona, por ejemplo, las islas de grava previamente depositadas. Además, estos procesos de erosión y sedimentación crean brazos laterales del río o los cortan de nuevo. De este modo, se crea constantemente un nuevo curso de agua y un nuevo paisaje a su alrededor.

For example, a natural river with floodplain has:

- Main channel
- Side arms
- Unilaterally connected side arms: still connected to the main channel on one side only.
- Dead arms: disconnected river loops that still carry water (e.g., flooded during high water and/or fed by groundwater)
- Gravel islands, sandbars.
- Point bars and cut banks (cut banks are important habitat for kingfishers, for example)
- Regions with fast and slow flow velocities, with shallow and deep water areas
- Vegetation-free areas over herbaceous vegetation, willow scrub to forest.

Functions of the floodplain

Imagine there is a flood. In which of the illustrations of the Rhine does the flood cause a problem?

- Floodwater retention: when the floodplain is flooded, the flow velocity slows down and the water is thus retained longer
- Groundwater recharge: by retaining water during floods and allowing it to remain in depressions and swales after floodwaters recede, it can slowly percolate and thus reach groundwater instead of being transported directly away from the river
- Water purification (groundwater and surface water): the slow flow velocities in floodplains, for example, cause sediments to be deposited and thus retain phosphorus and nitrogen, among other pollutants.
- Biotope/species/biodiversity: see topic block Biodiversity and Species Diversity.
- Carbon storage: through sedimentation and a very high productivity (of vegetation) storage of carbon in soils and vegetation.
- Recreation: recreational function for humans.
- Climate improvement: e.g., by retaining water, some of which then evaporates, leading to cooling

Effects of river development

- Species-rich floodplain landscapes are lost and thus also retention space for floods
- River course shortens (Rhine became 81 km shorter) -> floods faster and stronger in downstream areas (e.g. in Cologne)
- River digs into the bed and deepens -> this also lowers the groundwater level
- No new nutrient input to the original floodplains -> fertile soils lose this property in the long run.

Floodplains create a variety of habitats by structuring the water. There is a wide variety of habitats ranging from vegetation-free gravel and sand banks to areas with reeds, willow scrub, and silver willow forests to oak-ash-elm forests (habitat type species exemplary for Central Europe). In addition, there are areas with fast and slow flowing water up to depressions where still water remains and thus represents an ideal habitat for e.g. amphibians.

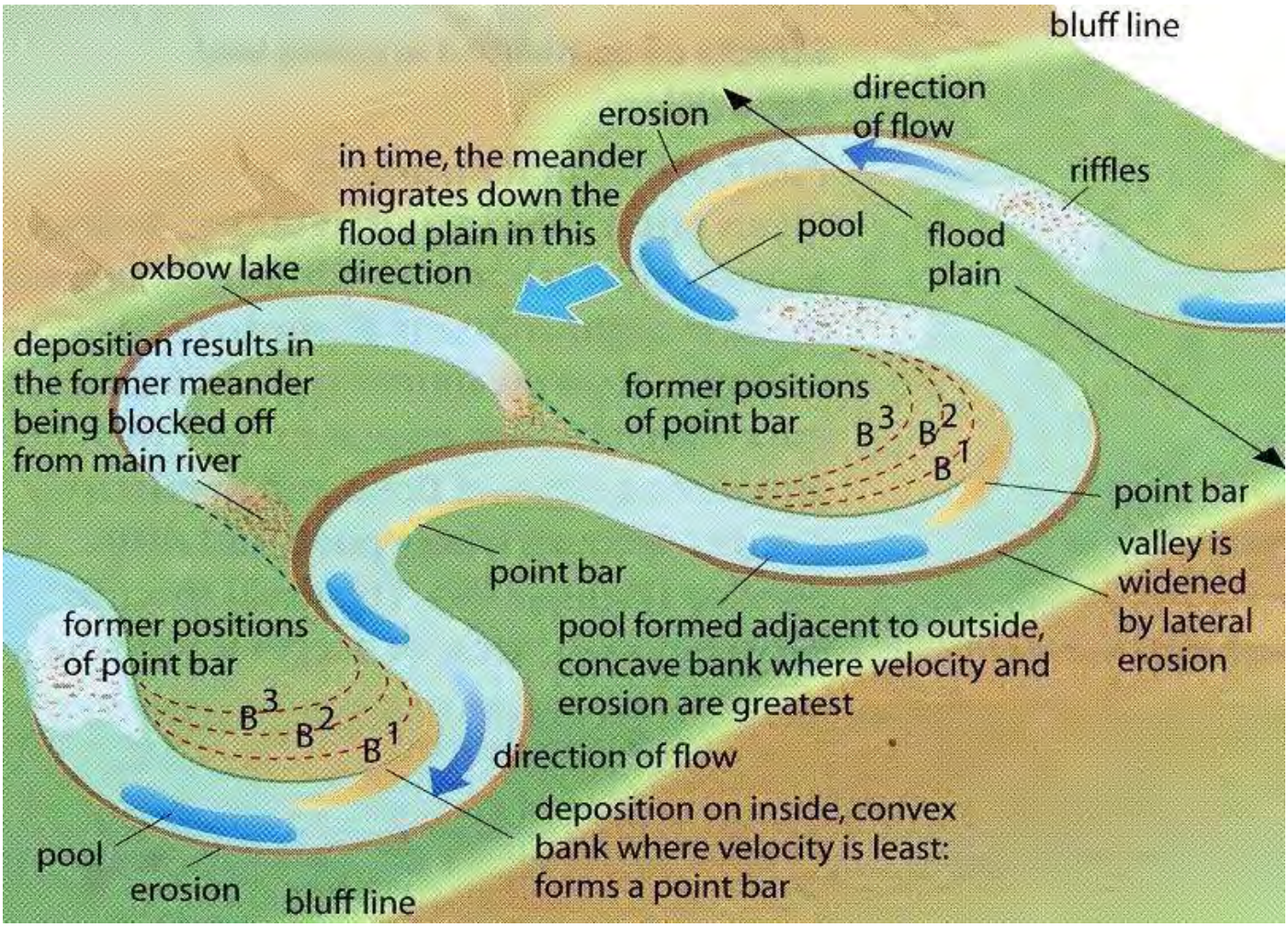
Furthermore, the individual areas of a floodplain are flooded with different frequency and for different lengths of time. Different sediments are deposited at different heights. For plants, flooding, sedimentation, and flow velocities are stresses to which they have adapted differently. Therefore, there are many different plant species in the floodplains and within the rivers.

Natural floodplains are the most species-rich areas in Central Europe. What is the reason for this?

Which fish species do you know? Have you ever seen one of these fish species in your home river?

Through its force, the river repeatedly destroys these habitats, for example by washing away a gravel island. But in another place a new gravel island is created. Thus, the river landscape is always in flux, with all these different habitats occurring in a natural river landscape.

Figure 6: Rhine correction near Plittersdorf, https://naturfreunde-rastatt.de/rhe-inauen/rhein/rheinkorrektion/index.php



Effects of river engineering

The river is deprived of the space and characteristic to form floodplain forests. Diversity also decreases in the river itself, because in a straight, uniform riverbed, flow velocities, water depth, and bed sediment are also uniformly expressed. As a result, many habitats are lost in and around the river, and thus the habitat for many plants and animals.

On the Rhine, only about 10% of the floodplain forests exist today and of these, the majority are not in good condition. On the Inn River even only 5% of the floodplain forests are left compared to 1855. In former times more than 30 different fish species were recorded in the Tyrolean Inn River. Today, only a few native species occur in larger self-sustaining populations, largely due to river degradation.

Individual examples of species on rivers, their adaptations and the effect of river engineering on them

Look again at the two illustrations of the Rhine. In each case, what might be the reasons why individual species or habitats have disappeared or become smaller?

Example: Silver willow (Salix alba)

Silver willows have adaptations such as aerial roots that allow them to survive prolonged flooding. In addition, their branches are flexible and thus more resistant when exposed to higher flow velocities during floods. However, if a branch breaks, it can re-grow where it washes up on the bank, and a new tree emerges. Silver willows, however, can only germinate and grow in sunny locations. They cannot thrive in the shade of large trees. Therefore, they always need new vegetation-free areas created by the river, such as gravel islands, to reproduce. Due to river engineering, however, there are hardly any gravel islands/benches left. Therefore, there are mainly old silver willow stands on the Rhine, which, however, are displaced by other species in the long run.

Example: Salmon

Salmon migrate up rivers from the sea to spawn. To do so, they need coarse gravel. They find this, for example, in the original floodplains of the Rhine. Many other fish species also depend on floodplains with their calm zones and alternating shallow and deep water as spawning habitats and habitats for young fish.

200 years ago, the Rhine was a free-flowing river with islands, floodplains and a rich salmon population. The Rhine was once Europe's largest salmon river - by 1950 this fish had completely

Compare the situation of salmon in the Rhine with that of salmon in the Inn.

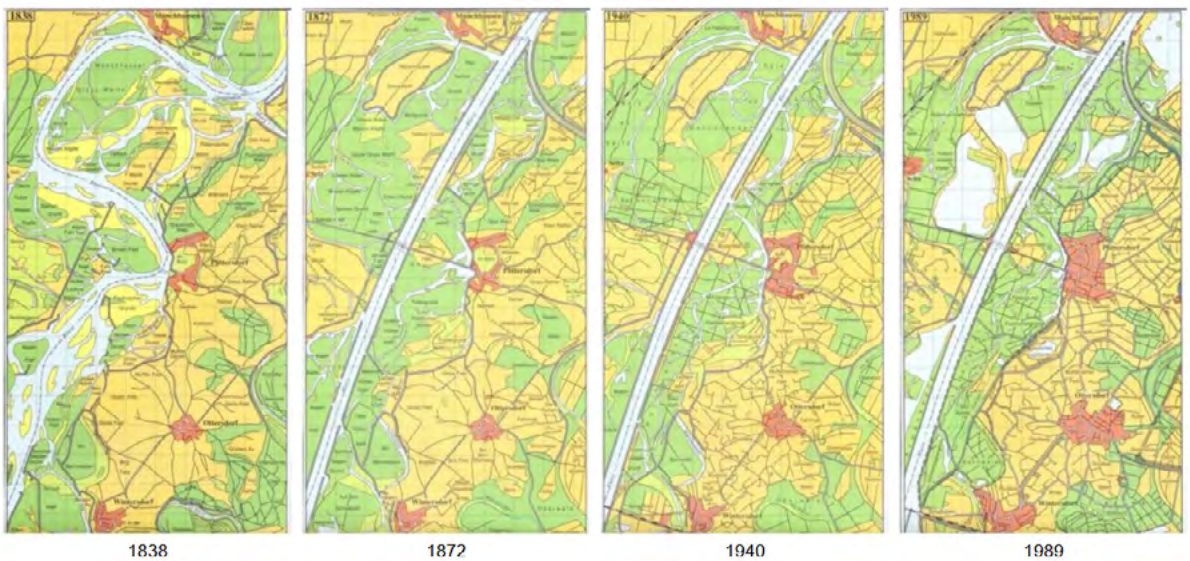


Figure 6: Rhine correction near Plittersdorf, https://naturfreunde-rastatt.de/rheinauen/rhein/rheinkorrektion/index.php

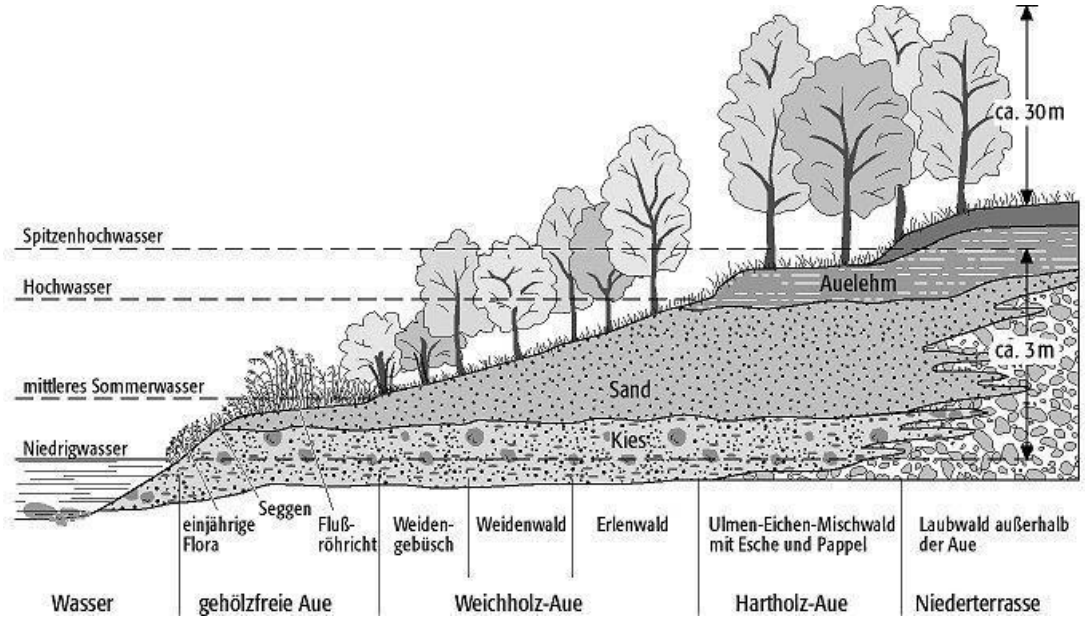


Figure 7: Cross section through a floodplain with its vegetation zones depending on substrate and water levels, https://www.spektrum.de/lexikon/geowissenschaften/aue/1098

disappeared as hardly any floodplains existed and dams blocked the salmon's way. But in recent years, many measures have been taken to reintroduce salmon to the Rhine. These include fish ladders at dams and renaturation measures to restore spawning areas. Since 2000, several hundred salmon have been migrating upstream again each year to reproduce!

Example: Kingsfisher

The kingfisher breeds in burrows on steep slopes along rivers. These steep slopes usually occur on so-called cut banks, which in turn occur on the outer banks of river meanders. Straightened rivers have little to no baffle slopes anymore, which has also caused the kingfisher's occurrence on our rivers to decline significantly.

Look for other animal and plant species on the illustration and research what adaptations they have to life on the river, what living conditions they need and to what extent they are affected by human changes to the river.

Renaturation to restore rivers to a more natural state

Due to the decline in biodiversity and for flood protection, renaturation projects are being carried out. There are funding projects from the EU and individual countries for this purpose. These projects try to restore the passability for fish at the watercourses by fish ladders or bypass channels at dams and weirs. However, bank reinforcements are also removed from rivers and dams are moved back, or in-river measures are taken to re-establish a diversity of flow velocities, water depths and sediments, at least in the river.

Example: Inn

Various renaturation projects are planned for the Inn and its tributaries. This is because structures, straightening or artificial reservoirs have forced the former natural jewel into a concrete corset. At the Hattinger Bach and the Giessenbach, migration obstacles for endangered fish species such as the Innäsche are being removed so that the animals can once again migrate into the streams from the main flow of the Inn. They will find calm water zones in the new estuaries where they can spawn and the young fish can develop. In the course of the reconnections and improvements,

flood protection will also be increased (https://www.bluehendesoesterreich.at/naturerfolge/renaturierung-zufluesse-inn-tirol).

Research the renaturation projects on the Inn, Tyrolean Lech or your home river. What are the reasons for renaturation? What measures are/were implemented? Are there already successes of the measures?

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AMAZONAS

Después de ver la historia del libro, ¿cómo te imaginas la vida en el Amazonas?

¿Por qué los afluentes del Amazonas tienen diferentes colores (página 1, abajo)? (Sedimentos y nutrientes)

¿Cuál es la fluctuación del nivel del agua en el Amazonas por año (página 2)?

¿Qué tamaño tiene la cuenca del Amazonas? ¿Tan grande como el Tirol, España o Australia?

Topic 1: Relationship between human and river on the Amazonas

The Amazon is the world’s most water-rich river and the largest river system in the world with its tributaries. It crosses the Amazon basin with its numerous tributaries from the Andes to the Atlantic Ocean and is sometimes several kilometres wide (e.g. 10-20km even in the dry season, comparison with Lake Constance at its widest point: 14km). When it floods, it inundates the floodplains in a width of up to 60km. The water level can fluctuate up to 15 meters per year.

Research the average water level, the water level of a 50-year flood and the water level of a 100-year flood at your home river and compare these water levels with the water level fluctuations at the Amazon.

What would life at your home river look like if there were similar water level fluctuations in the rivers there as there are in the Amazon?

Isolation

The constant presence of water bodies and the Amazon rainforest is also the cause of a striking characteristic of most riverfront communities: geographic isolation. In these regions, land-based infrastructure is precarious or non-existent. Living along the rivers also means using them as a means of transportation with rowboats or more modern boats. People here have been using rivers as their main routes and transportation routes for centuries. In addition, rivers are also important sources of food due to the large abundance of fish and fertile soils along the rivers. Therefore, people have always preferred to settle along the water here as well. To live with the high water level fluctuations, they build their houses on stilts, for example.

Acai

Local people earn their living by fishing, farming, tourism and collecting Brazil nuts and acai. Acai is a berry from the Amazon (see page three of the Amazon story). The berry grows on a palm tree that requires very large amounts of water and therefore thrives in the floodplains of the Amazon. This berry is an important part of the local diet and local people earn money from its cultivation. Today it is known as a so-called "superfood" and is increasingly exported globally. As a result, local people can now earn money from agroforestry. However, the cultivation of acai in plantations is already leading to a decline in biodiversity in the floodplains.

Compare the economic benefits of rivers using the example of acai in the Amazon and the use of hydropower e.g. in Tyrol (Austria). Discuss the different ecological effects of the two forms of use.

Ribeirinhos

he so-called ribeirinhos live along the edges of rivers, streams, and lakes in the Amazon and embrace the seasonal fluctuations of the waters as a fundamental feature in shaping their living and working routines. The water levels of the rivers regulate the dynamics of food, work, and interaction among members of different groups. The differentiated relationship with nature provides the inhabitants of the riverbanks with a great knowledge of aspects of the fauna and flora of the forest, the use of medicinal plants, the rhythm and path of water, the sounds of the forest, and the times of the earth. So the local people live with the water. Therefore, people also have a spirituality connected to water.

What could life at your home place look like if we lived with the rivers there again, too, instead of adapting them to our ideas?

Imagine it is the festival of the rivers and you are the shaman of your village/town. How would your river ritual run/look like to honour this river?

Topic 2: Sediment and nutrient transport

Rivers are transporters of sediments and nutrients. Depending on the origin and surrounding area of the river, they transport different sediments and nutrients. Depending on the sediment and nutrient content, the water takes on a different coloration. In the Amazon river system, therefore, three types of rivers are distinguished: the white-water, the clear-water and the black-water rivers.

White water rivers

These rivers originate in the geologically young Andes and carry large amounts of sediment and nutrients, which is why their water is milky turbid.

Clear and black water rivers

They originate in the geologically ancient crystalline highlands. Blackwater tributaries have higher levels of humic acids (responsible for their dark color) and

originate from nutrient-poor, often sandy uplands, so they contain little or no silt or dissolved solids. The humic acids come from the decomposition of organic material such as broadleaf leaves. Clear water tributaries have higher mineral content and lower humic acid content. Some rivers flow as clear water in the rainy season and as black water in the dry season.

What color has the water of your home river and which have the glacier rivers in Tyrol (Austria -> See story Ötz)? What could be the reason for this? To which of the Amazon river types could they be most closely associated?

During floods, the nutrients and sediments of the rivers reach floodplains. A large part of the sediment is gradually transported from the source to the sea, where it forms a delta. This sediment transport to the sea is important for coastal regions to compensate for erosion by the sea.

Depending on the coastal region and sediment transport, coastal growth also occurs. At the delta of the Mississippi River, for example, the ground from the land to the sea additionally only slopes shallowly and large amounts of sediment come from the Mississippi River to the coast, causing the delta there to grow further and further into the sea.

Today, however, many coastal regions have problems with increased erosion because, due to the construction of dams for hydroelectric power, sediment is held back and reaches the sea in much smaller quantities only.

Discuss: Does the construction of hydroelectric power plants at your home river (or in Tyrol, Austria, see story Ötz) have an impact on their delta regions?

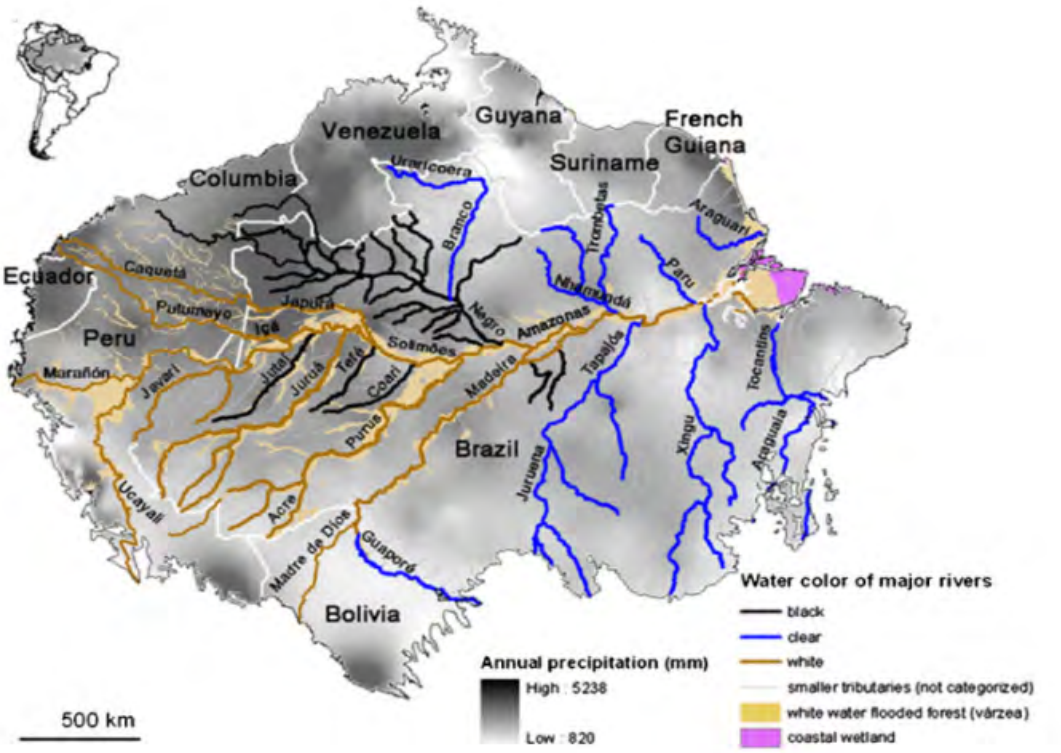

Figure 8: the different river types in the Amazon basin, Junk et al. (2011)

Topic 3: Forest fire and deforestation

In recent years, forest fires and deforestation are on the rise again in the Amazon. The forest fires are often set to deforest large areas. These are subsequently used primarily for agriculture. However, forests and trees play an important role in the hydrological cycle and are an important factor in the local climate. They influence local precipitation as well as soil properties in an area.

When it rains, some of the rain does not reach the ground but remains trapped in the treetops. In addition, trees store large amounts of water with their roots. In the Amazon, around 50% of the water required by the local ecosystem is available in this way. Through the process known as transpiration, the trees return the water (from the soil and treetops) to the atmosphere. The wind carries this water further and so precipitation reaches downwind regions.

Research how much rainforest was cut down in the Amazon last year. How large is this area compared to the area of your home country? Discuss the effects on climate change.

As a result of deforestation, less water returns to the atmosphere, causing downwind regions to have less precipitation. In addition, runoff increases in the deforested region and rivers cause stronger flooding both there and downstream. In addition, soils erode more quickly without the protection of trees. Therefore, the loss of a forested area can have profound effects on how the hydrologic cycle transfers water between the soil and the atmosphere on a regional or even global scale. In the Amazon, for example, it could significantly reduce the transport of moist air masses from the Atlantic to the Andes in the long run.

Educational video on the topic (English): https://www.youtube.com/watch?v=LBe4LTLOLvU

Discuss the importance of forests in your home country (or Tyrol, Austria) also with regard to floods and the drought in some past summers (this is the case for e.g. Austria, so discuss the importance of forest with regard to climate changes in your home country). Should there be more forests in your home country (or Tyrol, Austria) again?e

Abbildung 9: Mississippi-Delta: sehr gut sieht man hier die Sedimente die vom Fluss ins Meer gelangen und das Delta aufbauen, https://pixels.com/featured/mississippi-delta-in-louisiana-seen-from-space-lavit.html

Literature

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Final questionnaire

The final questionnaire is designed to provide instructors with additional sample questions across topics. They can use these, for example, at the end of the lesson/workshop, as presentation topics, or in group discussions. In part, the questions are intended to link the knowledge taught on the various topics and to encourage reflection on our treatment of the river ecosystem.

- ¬ Which path does the water of your home river take before it flows into the sea?
- ¬ What role do the mountains of the Alps (or mountains at your home country/region/continent) play for rivers and vice versa?
- ¬ What are the functions and value of rivers locally at your home region (and globally)?
- ¬ Why is biodiversity being lost in e.g. your home country rivers? What can we do about it?
- ¬ What role do rivers play today in the age of globalization, climate change and the biodiversity crisis?
- ¬ What does nature conservation mean with regard to our rivers?
- ¬ What restrictions would affect your life if you lived by a free-flowing river at your home?
- ¬ What associations are there in your area that you could get involved with to protect free flowing rivers? (e.g. River Collective, Free Rivers Fund, WWF, Save the Blue Heart of Europe, Balkan River Defence, River Watch…)