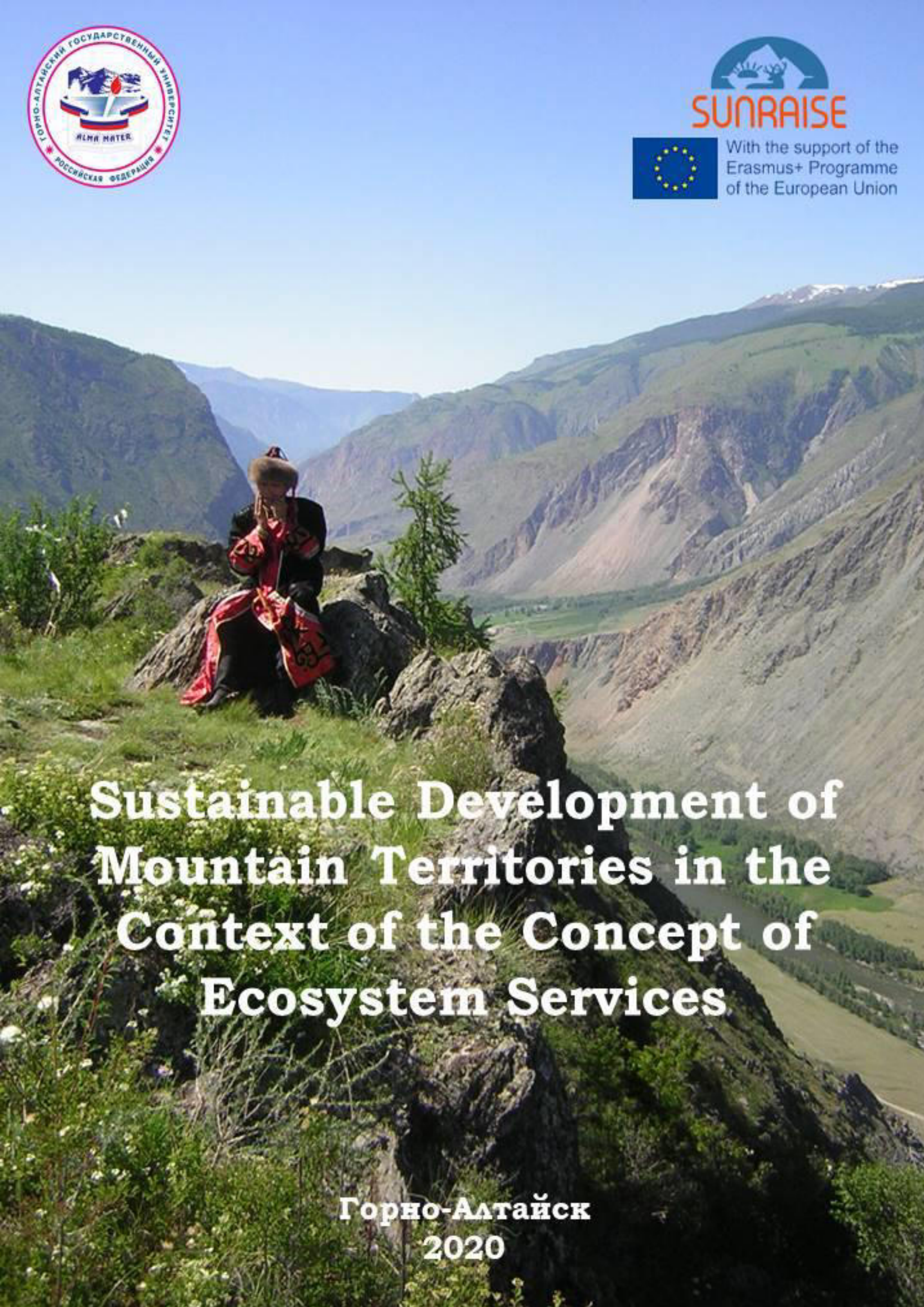

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Sustainable Development of Mountain Territories in the Context of the Concept of Ecosystem Services

Горно-Алтайск
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SUSTAINABLE DEVELOPMENT OF MOUNTAIN TERRITORIES IN THE CONTEXT OF THE CONCEPT OF ECOSYSTEM SERVICES

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Пособие разработано на основе массового открытого онлайн курса “Sustainable Development of Mountain Territories in the Context of the Concept of Ecosystem Services”(http://sunraise.gasu.ru/), который является его неотъемлемой частью, и подготовлено в рамках проекта ЕС 586335-EPP-1-2017-1DE-EPPKA2-CBHE-JP «SUNRAISE: Sustainable Natural Resource Use in Arctic and High Mountainous Areas» Программы Erasmus +.

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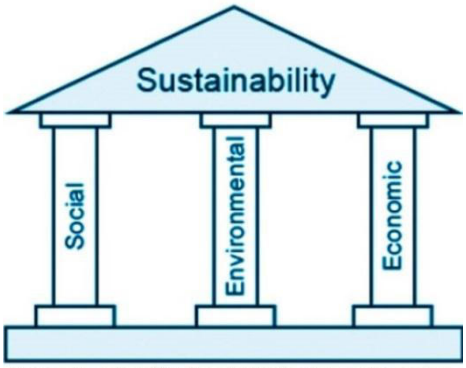
INTRODUCTION

1. Answer the following questions. Then, watch the Video and check if your answers are correct:



Source: Sustainability & Social Justice Popular Education

1. What is Sustainable Development?
2. When did the concept of sustainable development appear for the first time?
3. What is the aim of the Brundtland Report? Under what name is it also known?
4. What are the three essential pillars of sustainable development?

2. Read the text and answer the questions:

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. They were born at the United Nations Conference on Sustainable Development in Rio de Janeiro in 2012. The objective was to produce a set of universal goals that meet the urgent environmental, political and economic challenges facing our world.

The SDGs replace the Millennium Development Goals (MDGs), which started a global effort in 2000 to tackle the indignity of poverty. The MDGs established measurable, universally-agreed objectives for tackling extreme poverty and hunger, preventing deadly diseases, and expanding primary education to all children, among other development priorities.

For 15 years, the MDGs drove progress in several important areas: reducing income poverty, providing much needed access to water and sanitation, driving down child mortality and drastically improving maternal health. They also kick-started a global movement for free primary education, inspiring countries to invest in their future generations. Most significantly, the MDGs made huge strides in combatting HIV/AIDS and other treatable diseases such as malaria and tuberculosis.

All 17 Goals interconnect, meaning success in one affects success for others. Dealing with the threat of climate change impacts how we manage our fragile natural resources, achieving gender equality or better health helps eradicate poverty, and fostering peace and inclusive societies will reduce inequalities and help economies prosper. In short, this is the greatest chance we have to improve life for future generations.

The SDGs are unique in that they cover issues that affect us all. They reaffirm our international commitment to end poverty, permanently, everywhere. They are ambitious in making sure no one is left behind. More importantly, they involve us all to build a more sustainable, safer, more prosperous planet for all humanity (UNDP).

Check yourself

a. What does SDG stand for? How many SDGs are there today?
b. When were SDGs born? When were they adopted by all UN Member States?
c. What is their objective? When should they be achieved?
d. What do SDGs replace?
e. How do all SDGs interconnect?
f. Why are SDGs unique?

3. Individual assignment. Prepare a PowerPoint presentation on one of the SDGs and present it in class.

THEME 1

General Characteristics of Mountain Territories

1. Watch the Video 1 and confirm or disprove the following statements:

1. Mountains are a home to nearly 15% of the world population.
2. Mountains are vital headwaters to many rivers.
3. Mountains do not affect the lives of people living in the valleys.
4. Mountains occupy 1/3 of the land surface.
5. Free standing mountains are the most common types of mountain areas.
6. The following types of mountains are identified by their origin: rippled mountains, block and rippled-block mountains, and volcanic mountains.
7. Volcanic mountains are formed in the places where magma (molten rock) comes out on the surface.
8. A mountain may become a hill if it is worn down by erosion.
9. The Great Dividing Range is located in the north-west of Africa.
10. Mount Erebus is the highest volcano in the Arctic.
11. At high altitude, the radiation balance decreases rapidly and the air temperature drops.
12. Upwind slopes can get much more moisture than downwind ones.
13. The first (lower) altitudinal belt always corresponds to the natural zone in which the mountain range is situated.
14. Human activities do not influence the occurrence of mudflows.

2. Read the text and answer the questions:

Mountains are parts of the Earth 's crust, which as a result of the movement of tectonic plates, volcanic eruptions or other processes occurring inside the earth, have risen prominently above their surroundings by tens, hundreds, and sometimes thousands of meters.

Mountains vary in height, age, structure, and formation process. Individual mountains connect into long mountain chains. Some chains can include hundreds and even thousands of mountains. Mountain tops can have a form of a sharp peak covered with glaciers and snow patches, or on the contrary be even, flat, and swampy. On land free standing mountains are relatively uncommon. As a rule, they have volcanic origin or are the remnants of ancient destroyed mountains. More often such formations can be found at the bottom of the ocean. Some mountains are not very high, about three hundred meters, while others rise more than eight thousand meters above sea level. Mountain landscapes can vary depending on the height, slope exposure, and position of the mountain system on the continent.

A mountain ridge is a geological feature consisting of a chain of mountains or hills that form a continuous elevated crest for some distance.

The line along the crest formed by the highest points, with the terrain dropped down on either side is called the ridge line and serves as a watershed. Ridges, having the same origin and arranged in a certain order (linearly or radially), make up the mountain ranges. Gradual increases in elevation at the base of a mountain range are called foothills.

The shape, length and height of a mountain range depend on the time of its formation, history of its development, and geological composition. Mountains created by ancient mountain-formation processes and have not experienced repeated tectonic uplifts can look like hummocky terrain. Rocks having weak jointing are less susceptible to denudation (destruction) processes. Large ridges often have outskirts, which are side branches in the form of smaller ridges. Mountain ridges are the most common type of mountain areas.

Check yourself

a. Define the following terms: mountain, mountain ridge, mountain range, crest, and foothill.

b. How do mountains differ?

c. What do mountain landscapes depend on?

d. What do the shape, length, and height of a mountain range depend on?

Mountains are located on all continents and many major islands: Greenland, Madagascar, Taiwan, New Zealand, British Isles, etc. Even Antarctica covered with ice shell also has mountains, which have been created by volcanic processes, for example, Mount Erebus, Queen Maud Land, Marie Byrd Land, etc.

Mountain ranges form *Mountain Belts* of Earth (the number of belts and their names can vary in different classifications).

Background map: World map (2004, CIA World Factbook)

The *Mediterranean-Himalayan belt* includes mountains of Europe, such as the Alps, the Caucasus, and the Pamir, the entire Himalayan complex, the north west of Africa, and others. The formation of the belt began about one billion years ago and is still going on, although the most important processes occurred 20 million years ago. There are many high mountains with sharp peaks in this belt, which separate deep intermountain depressions. In the eastern part of the belt the height of mountains increases - the summit of Mont Blanc is 4,807 m, Jomolungma is 8,848 m. Within the belt there are also flat high-mountain plains with height from 4,000 m and higher, such as the Tibetan Plateau.

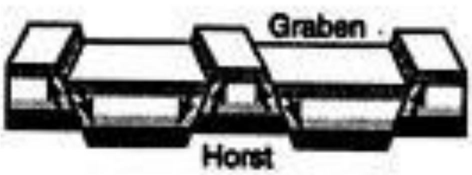
The *North Pacific belt* includes the mountains of the Pacific coast of Asia and the giant Cordillera. Most of the belt ridges are not very high. Their average height is 1,500 - 2,000 m, but there are separate peaks, which rise as much as 4,000 m and more, for example, Klyuchevskaya Sopka - 4,750 m or Pico de Orizaba - about 5,700 m. A distinctive feature of the relief of this belt is the presence of ridges having sharp crests alternating with deep intermountain depressions.

The *East Pacific Belt* includes only one mountain range, the Andes or South American Cordillera. It is one of the longest mountain ranges in the world with long clean-cut ridges located along the coast. Its western slopes go down to the Pacific Ocean and its eastern slopes to vast lowlands, which lie almost at sea level. Its highest peak, Mount Aconcagua, rises to an elevation of about 6,961 m above sea level. Currently, it is the belt that is subject to maximal seismicity and volcanic activity on the Earth.

Check yourself
a. Where are mountains located?
b. What mountains (mountain ranges) does each mountain belt include?

Mountains differ not only in height, but also in their origin and structure. The following types of mountains are identified by their origin:

Type I – Fold (folded) Mountains. They are formed due to the Earth's crust compression when two lithospheric plates collide. Heated in the process of movement rock deformed, lost its strength and as a piece of plastic bent into huge folds. Examples of fold mountains include: the Alps, the Appalachian, and Himalayan Mountains.



Type II - Block and fault-block Mountains. Over time, folded mountains destroyed. They became lower and flatter, and then as a result of new tectonic movements, rigid crystal rocks of old mountains broke into separate chunks or blocks, which moved up to different heights as separate sections. As a result of such differential movement fault-block mountains often have a steep front side and a sloping back side. Examples of fault-block mountains include: the Sierra Nevada Mountains in California, and the Harz Mountains in Germany.

Type III - Volcanic Mountains. These mountains are formed in the places where magma (molten rock) comes out on the surface. It can break through one of the cracks in the earth's crust and accumulate around it. In some areas of the globe one can see entire mountain ridges created by the spilled magma as a result of eruptions of several closely located volcanoes.

The Himalayas

Sierra Nevada Mountains

Volcano in Ecuador

Source: www.oddizzi.com

Volcanic mountains can be of different types. *Volcanic cones* are formed by accumulation of lava and rock debris or by volcanic ash or scoria, a dark-colored igneous rock with abundant round bubble-like cavities known as vesicles. Such volcanoes are located near Lassen Peak in California and in Northeast New Mexico. Volcanoes formed as result of repeated spills of lava are called *shield volcanoes*. There are many of them on the Hawaiian and Aleutian Islands.

Check yourself

a. How are fold (folded) mountains formed?
b. How are block and fault-block mountains formed?
c. How are volcanic mountains formed?
d. How are shield volcanoes formed?

The height of mountains determined the differences in the processes affecting their appearances; some of them were formed as a result of glacial activity, while others by the denudation processes. Mountains located above the snowline, which have experienced ancient and/or modern glaciations, have numerous forms of glacial relief (trough valleys, cirques, corries, moraine ridges, and horn peaks). The slopes of such mountains are steep, rocky, and covered with numerous screes; their tops have the shape of a pyramid. Such relief is called Alpine or High Mountains.

In the mountains located below the snowline (medium-high and low mountains) water flows and denudation processes are doing most of the work on the transformation of the relief. The relief created due to these processes is called erosion-denudation.

The rate of erosion-denudation relief formation depends on its geological structure, tectonic regime, and physiographic conditions of mountains. Such relief is developed in all climate zones, except the Arctic and Antarctic. Depending on the amount of precipitation, its type, mode, and time patterns, such reliefs can differ in their shape and size. Geological rocks that form mountains have different resistances to exogenous factors, that is why the destruction of mountains and the formation of erosion and denudation forms of relief occur with different intensity. Climate has both direct and indirect impact on the nature of erosional processes. Considerable moistening of the territory contributes to the strengthening of erosional processes and the development of rich vegetation. Well-developed plant's root system accelerates the process of rock destruction.

The main forms of mountain erosion-denudation relief are represented by river valleys, terraces, gorges, ravines, washouts, and other both large and small forms of relief.

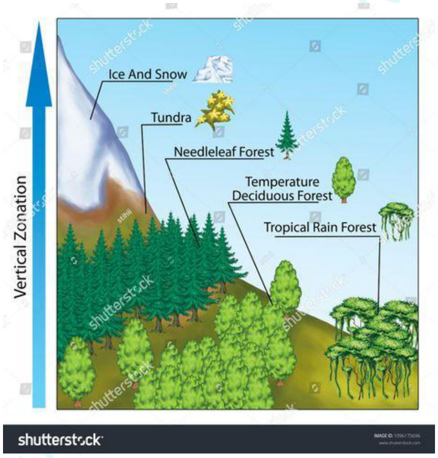
Gradually mountains disintegrate and turn into hills, which is connected first and foremost with external factors. Temperature fluctuations cause rock cracking. Plant's roots accelerate rock crushing process and rainwater flows, rivers, and wind carry rocks into valleys. Ground waters also destroy mountains. They dissolve limestone rocks forming sinkholes and caves.

Check yourself

a. What is the difference between the relief of high, medium-high, and low mountains?
b. What is denudation? What processes does it include?
c. What external factors cause the disintegration of mountains?

The height of mountains and their position on the Earth's surface form differences in climate from their foot to the top. For example, a height change of every 1,000 meters is equivalent to increase of solar radiation of about 10%. This is due to the decrease in atmospheric density and concentration of water vapor and dust in the air, which reduce radiation losses connected with absorption and reflection. As a result, the radiation balance decreases rapidly and the air temperature drops.

Mountains form the direction of air mass fluxes and their upward movement, enhance condensation of moisture, and increase the amount of precipitation at higher altitudes. Upwind slopes can get much more moisture than downwind ones. In addition, some ridges can play the role of a shield protecting neighboring ridges. As a result, widely varying climatic conditions are created inside a mountain system.



The climatic variability in the mountains causes a characteristic change of natural zones from the foot to top. The first (lower) altitudinal belt always corresponds to the natural zone, in which the mountain range is situated. If the mountain range is located in the steppe zone, it means that its lower belt is represented by steppe landscapes, which are gradually replaced by forest, meadow, tundra, nival or glacial landscapes with altitude.

Climatic factors provoke various processes in the mountains, such as avalanches, mudflows, and landslides. The falling of accumulated snow masses down the slope is usually caused by a sharp change in weather (including changes in atmospheric pressure and air humidity), rains, heavy snowfalls, as well as mechanical effects on the snow mass, including the impact of stones, earthquakes, etc. Among the factors influencing the occurrence of mudflows there can be very heavy and long-lasting rainfalls, rapid melting of glaciers or seasonal snow.

Human activities also influence these processes. Logging in mountain areas leads to instability of soil horizon, because the root system of plants helps keep the soil in place preventing it from sliding. Mountain landscapes are extremely vulnerable to external factors. They are exposed to accelerated soil erosion, avalanchine, scree, and landslide processes.

Check yourself

a. How do solar radiation, atmospheric density, concentration of water vapor and dust, radiation balance, and air temperature change in the mountains?

b. What altitudinal belts can be in the mountains? What does it depend on?

c. What natural hazards occur in the mountains? What are they caused by?

Mountains and highlands occupy 1/5 of the land surface and are major ecological systems of our planet. They are a habitat for unique species of flora and fauna, a home to nearly 13% of the world population.

Recognizing the uniqueness of mountain systems, in 1992 at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro mountain regions were identified as fragile ecosystems and their study become one of the thematic priorities of Agenda 21. Chapter 13 of the Agenda, entitled "Managing fragile ecosystems: sustainable mountain development," became a milestone in the development of mountain territories.

In this regard, by decision of the 57th UN General Assembly in January 2003 (resolution A/RES/57/245) the International Mountain Day was established (11 December).

The UN General Assembly called on the international community to organize events on this day at all levels in order to draw attention to the problems of development of mountain regions of the world and the need to help their population. The relevant resolution noted the special relevance of actions aimed at sustainable development of mountain regions.

> ***Check yourself***
> *a. What is Agenda 21?*
> *b. What is the goal of International Mountain Day?*

3. Watch the Presentation 1 .

4. Get ready to discuss the following issues:

1. Types of mountains and their formation.
2. Mountain relief and natural processes it depends on.
3. Mountain climatic conditions.
4. Natural hazards that occur in the mountains.
5. International recognition of the importance of mountain systems.

5. Do the Test 1.

THEME 2

Biological Diversity of Mountain Territories

1. Watch the Video 2 and confirm or disprove the following statements:

1. The term "biological diversity" was introduced by Charles Darwin.

2. Most centers of maximum biological diversity are located in mountain areas.

3. The Altai Mountains are among the centers of maximum biological diversity.

4. Mountain landscapes are distinguished by a great level of preservation and naturalness of ecosystems.

5. The emergence of species restricted to one highland or even one ridge can partially explain the high endemism of mountain areas.

6. The lower tier of mountains always starts with the landscapes of that zone in which the mountain ridge is located.

7. Organisms in nature are bound together by shared energy and nutrients.

8. Each food chain starts with a top predator that has no natural enemies.

9. Earth's biodiversity supports the balance of terrestrial ecosystems and helps to combat environmental pollution.

10. Over the past hundred years, biodiversity worldwide has increased.

11. Today, species are dying hundreds of times faster than required by the evolution.

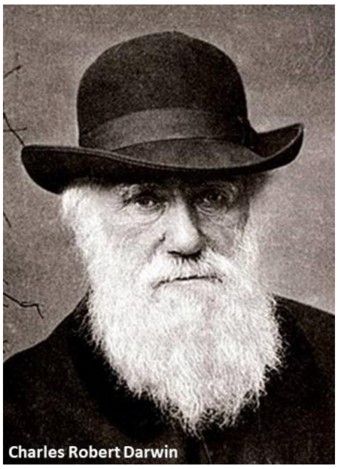
12. The destruction of natural habitats is the main cause of biodiversity loss.

13. Today, 37 areas qualify as the world biodiversity hotspots.

14. Mountain ecosystems are characterized by high resistance to anthropogenic impacts.

15. Management of mountain biodiversity has increasingly been recognized as a global responsibility.

2. Read the text and answer the questions:



The first ideas about the diversity of wildlife were introduced in the works of Aristotle in 384-322 BC. The scientific and methodological basis for the description of biodiversity was created by C. Linnaeus in his work "The System of Nature." Charles Darwin, studying the origin of species, presented a logical and convincing explanation of the reasons causing their diversity by the existence of natural selection. He was the first to truly appreciate the connection between natural selection and hereditary changes in the population that caused the emergence of new species. In 1868, M. Wagner introduced the concept of geographic speciation.

Biodiversity is derived from the combination of "biological" and "diversity." The diversity is the difference between organisms, species, communities, ecosystems, etc. Scientifically, the concept of diversity can be attributed to such fundamental concepts as genes, species, and ecosystems. The very phrase "biological diversity" was coined by Henry Walter Bates in his famous work "The Naturalist on the River Amazons."

The phenomenon of the diversity of living organisms is determined by the fundamental property of biological macromolecules, especially nucleic acids, to spontaneously change their structure, resulting in changes in genomes and hereditary variability. On this basis, diversity is created as a result of three independently acting processes: spontaneously occurring genetic variations (mutations), natural selection, and geographic and reproductive isolation. These processes, in turn, lead to further environmental differentiation at all levels of the organization of biological ecosystems: molecular, genetic, cellular, taxonomic, environmental, and others. Genetic diversity, i.e. the maintenance of the variability that is caused by adaptive necessity in natural populations, is represented by heritable diversity within and between populations of organisms.

Biological evolution is the accumulation of changes in organisms and the increase in their diversity over time. Evolutionary changes affect all aspects of the existence of living organisms: their morphology, physiology, behavior, and ecology. All these changes are based on genetic changes, i.e. changes in the hereditary substance, which interacting with the environment determines all the characteristics of living organisms (structure, growth, development, and reproduction). At the genetic level, evolution is the accumulation of changes in the genes of populations.

Evolution at the genetic level can be seen as a two-step process. On the one hand, mutations, i.e. the processes leading to the variability of organisms, arise; on the other hand, there is a change in genes and natural selection - processes through which genetic variation is passed down from generation to generation.

The term "biodiversity" is often regarded as a synonym for "species diversity" or "species richness," which is the number of species in a particular place or biotope. Total biodiversity is usually estimated as the total number of species in different groups.

The species level of diversity is usually considered as the basic or central, and the species is the basic unit of biodiversity account. Species are usually the main objects of protection.

Check yourself

a. What does the term "biodiversity" stand for? What synonyms can it be replaced by?
b. Who was the very phrase "biological diversity" coined by?
c. What are the independently acting processes of biodiversity?
d. What is biological evolution?
e. How does evolution at the genetic level occur?
f. How is total biodiversity estimated?

Earth's biodiversity performs a number of functions, including:

• maintenance of the ecosystem balance: processing and storage of nutrients, combating environmental pollution, stabilizing the climate, protecting water resources, forming and protecting soil, and maintaining the ecological compatibility of the area;

• formation of biological resources: a source for drugs and pharmaceuticals, food for humans and animals, areas where ornamental plants grow, etc.;

• social function, which is to create conditions for recreation and recovery of the world's population.

One of the reasons for biodiversity in mountain areas is the specific character of their climatic conditions. At higher elevations heat supply and humidification change, atmospheric pressure, air density, water vapor, and dust content decrease, and at the same time the intensity of direct solar radiation increases.

Thanks to the barrier effect of mountains, the amount of precipitation increases up to a certain height and then decreases. A rapid change of climatic conditions with height causes the change in soils, vegetation, surface runoff, as well as in the variety and intensity of modern exogenic processes, landforms, and the whole natural complex. This leads to the formation of diverse landscapes.

The relief of mountains is formed by surface roughness and processes that are not typical of plains - landslides, mudflows, avalanches, etc. Mountain soils are undeveloped, rubble, and shallow. Some mountain landscape zones do not have plain analogs (for example, the mountain-meadow zone with subnival, alpine, and subalpine belts).

The influence of orographic features of mountain systems (height, slope exposure, etc.) is manifested in the variety of landscapes. The landscapes of low mountains are often similar to the landscapes of plains located nearby. With height, differences increase. Living organisms inhabiting mountains are characterized by an increased rate of evolution and a higher rate of the formation of new species. Mountain ecosystems play a unique role in maintaining biodiversity in general.

Another reason for the high biodiversity in mountain areas is the endemism of flora and fauna. For example, about half of endemic birds' habitats are found in mountains, especially in tropical mountain forests. Almost the entire forest flora of the mountain regions of Hawaii and New Caledonia is endemic. Among the main reasons that cause endemism of mountain species are their evolution and ability to settle on newly formed mountains. Speciation of such species was stimulated by the presence of a large number of unoccupied ecological niches and isolation due to mountain-forming processes and climate. In the mountains of Europe, one of the reasons for a high diversity of endemic species was ancient glaciation, during which small populations were able to survive in limited areas with more favorable conditions.

The steepness of mountain slopes also determines the high biodiversity. Neighboring areas can be occupied by different communities, depending on how much the slope is exposed to wind, sun or frost. The diverse geological structure of mountains is another factor of high biodiversity. It is geological rocks that create the basis for soil formation.

Check yourself
a. What functions does the Earth's biodiversity perform?
b. What are the reasons for the high biodiversity in mountain areas?
c. What does the term "endemism" stand for? What is it caused by?
d. What is an ecological niche?

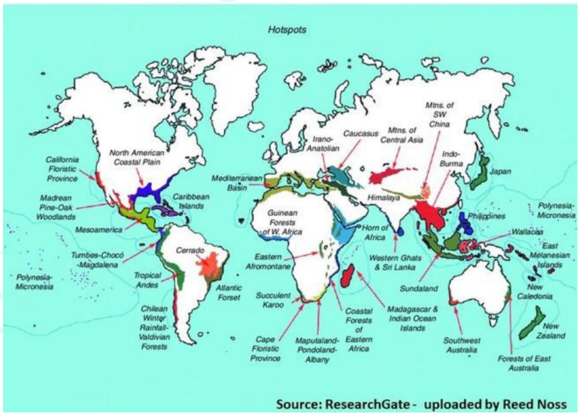
There are six major mountain centers of maximum biological diversity in the world. All of them are located in the tropics: the windward macroslope of the Eastern Andes, the Cordillera of Central America, the Atlantic forests of Brazil, the Eastern Himalayas (Yunnan region), the highlands of the Malay Archipelago (Northern Borneo), and Papua New Guinea.

In the mountains, more species can form than on the plains. For example, in Ecuador, on an area of 17,000 km², foggy tropical forests contain 3,411 species of vascular plants, which is 300 species more than in the Amazon forests located below, but on an area of 70,000 km². The total moss diversity of five tropical Andean countries is 7.5 times higher than in the entire Amazon basin. On Mount Kinabalu (4,101 m above sea level), in Malaysia alone, more than 4,000 plant species have been recorded, which is more than 1/4 of the entire US flora.

The high biodiversity of mountain areas, along with the presence of relict and endemic species, is one of the signs of rapidly formed ecosystems that are especially vulnerable to external influences.

Alpine ecosystems were among the first to experience the effects of global climate change (raising of the upper treeline) and human activities (grazing, mining), which has already led to degradation of some areas.

Currently, there are some areas on Earth notable for their biological diversity and thus require careful treatment. The British ecologist Norman Myers called such areas the hotspots of the world's biodiversity, and in 1988 he developed the concept of the "biodiversity hotspots."



To qualify as a biodiversity hotspot, a region must meet two strict criteria:

1. It must have at least 1,500 vascular plants as endemics;

2. It must have at least 70% of the natural vegetation that has been significantly threatened or extinct.

Today, 36 areas qualify as hotspots. They are distributed in different regions of the world. In West Asia and Central Asia 3 such spots have been identified, and all of them are located in mountains:

- Caucasus;
- Irano-Anatolian; and
- Mountains of Central Asia (Southern Siberia).

In East Asia, South Asia, Southeast Asia and Asia-Pacific region 5 out of 14 hotspots are mountain areas:

- Eastern Himalaya;
- Indo-Burma, India and Myanmar;
- Mountains of Southwest China;
- Eastern Australian temperate forests; and
- New Zealand.

In Europe there is only one biodiversity hotspot – the Mediterranean Basin. It is a vast territory characterized by a diverse terrain, most of which is occupied by high mountains.

Out of 8 African hotspots the Eastern Afromontane is a mountain one.

In North and Central America the Madrean pine-oak woodlands in Mexico is qualified as a mountain hotspot.

In South America 3 out of 5 biodiversity hotspots are mountain regions:

- Atlantic Forest of Brazil;
- Tumbes-Chocó-Magdalena in Costa Rica; and
- Tropical Andes.

Check yourself

a. How many major mountain centers of maximum biological diversity are there in the world? Where are they located?

b. What species can be called relict?

c. What strict criteria must a region meet to qualify as a biodiversity hotspot?

d. How many recognized biodiversity hotspots are there in the world?

"Mountains are an important source of water, energy and biological diversity. Furthermore, they are a source of such key resources as minerals, forest products and agricultural products and of recreation. As a major ecosystem representing the complex and interrelated ecology of our planet, mountain environments are essential to the survival of the global ecosystem" (Agenda 21).

Since the 1990s, mountains have gained the attention of the international community. At the United Nations Conference on Environment and Development (UNCED), also known as the Rio de Janeiro Earth Summit (1992), the Chapter 13: "Managing fragile ecosystems: sustainable mountain development," in which mountain ecosystems are identified as one of the most important ecosystems of our planet, was included in the Agenda 21. The increasing attention to the importance of mountains and mountain biodiversity led the United Nations General Assembly to declare 2002 the UN International Year of Mountains.

The global significance of mountains can be generalized in the following positions:

• Mountains occupy almost a quarter of Earth's land surface;

• They are home to one-tenth of the world's population;

• These are areas of high cultural and biological diversity; and

• They are reserves of natural resources.

Mountain biodiversity is an absolute priority for conservation.

Mountain ecosystems are a repository of a huge part of biological diversity and a place of its active formation. The vegetation cover of mountains helps stabilize water levels in the uplands, so that no flooding occurs and a constant year-round flow is ensured. Retention of the soil layer and the maintenance of slope stability are closely connected with the presence of vegetation on it. The species diversity of mountain ecosystems may increase their ability to recover. In case of extreme situations, such as rock falls and avalanches, vegetation growing on the slopes serves as an effective natural barrier. Biodiversity can also help reduce damage in low mountains.

Mountain ecosystems are characterized by increased vulnerability and sensitivity to anthropogenic impacts due to the high rate of top-down transport of substances. It is the biotic component of mountain landscapes that serves as the most important stabilizing factor, reduces the risk of natural disasters, and enables the sustainable development of these regions.

Check yourself

a. Why are mountains globally significant?

b. What are mountain ecosystems characterized by?

3. Watch the Presentation 2 .

4. Get ready to discuss the following issues:

1. The phenomenon of the diversity of living organisms.
2. Reasons for high biodiversity in mountain areas.
3. World's biodiversity hotspots.

5. Do the Test 2.

THEME 3

Global Significance of Mountain Territories

1. Watch the Video 3 and confirm or disprove the following statements:

1. Mountains provide up to 90 percent of the world's freshwater.

2. Mountains can be considered as promising areas for the development of alternative energy.

3. Mountain valleys have no potential for the development of wind power.

4. Mountain areas are rich in mineral resources.

5. Mountain tourism accounts for 20 percent of the global travel industry.

6. Mountains maintain the hydrological regime and purify water from natural and man-made pollution.

7. Mountains are not susceptible to the disruption of the ecological balance.

8. Mountains are a major indicator of global climate change.

2. Read the text and answer the questions:

Mountains are not only material objects, like ores and technical raw materials, but also consist of various natural phenomena, such as sunlight, wind, etc. They are global freshwater reserves. As biodiversity hotspots, they serve as a source of numerous valuable resources, including forests, medicinal plants, nuts, berries, forage grasses, and game animals. Mountains are centers of cultural and ethnic diversity. The regions of the world with the greatest diversity of language and religion (e.g., the Caucasus, the eastern Himalaya, and Papua) are said to be mainly located in mountain regions. Scientists have adopted three main different points of view in analyzing this diversity. A first group has focused on the sacred significance of mountains (Bernbaum1997), promoting the idea that specific landscapes and senses of place induce specific religious beliefs and experiences. A second group has correlated this cultural diversity with the degree of biodiversity. This ecological approach has been also applied to sacredness itself by those who have focused on understanding relationships between religion and ecosystems (e.g., Verschuuren et al. 2010). A third group has promoted a more political explanation: mountain areas have often been refuges for people who tried to keep their cultural specificity when facing the homogenizing forces of centralized States (e.g., Scott 2009). This cultural diversity of mountain regions has been highly popularized through the media and has become one of the main motivations for a global and mass form of tourism (Mountain Regions: A Global Common Good?).

The earth's crust consists of a variety of minerals and rocks. A mineral is a naturally occurring inorganic solid that has a definite chemical composition and physical properties, and is formed as a result of physicochemical processes in the earth's crust. Examples of minerals are gypsum, quartz, pyrite, etc. Most of them are solid crystalline chemical compounds.

Naturally occurring and coherent aggregates of one or more minerals that form independent geological bodies are called rocks (sandstone, quartzite, granite, marble, etc.). Minerals and rocks used by people are called natural mineral resources.

Each mineral resource can be classified according to its state of matter – solid, liquid or gas. Thus, minerals and rocks are solid natural resources: for example coal, non-ferrous and ferrous metal ores, precious stones, salts, and building rocks (dolomites, sands, clays, quartzites, granites, etc.). Liquid mineral resources are oil, water, and salt brines. Gas mineral resources include methane, ethane, propane, etc. Differences in mineral resources are related to the conditions under which they were formed in previous geological eras. Ancient mountains, in most cases, are richer in minerals than younger ones.

Mineral resources are the basis of scientific and technological progress. Without them, it is impossible to imagine the existence of most industries: chemical, construction, food, light, as well as ferrous and non-ferrous metallurgy. Mechanical engineering with its numerous branches is also based on the use of mineral raw materials. The use of mineral resources is constantly increasing; almost 200 types of mineral raw materials are currently being used.

Changes in the geography of extraction and consumption of raw materials and price dynamics in the world market have a significant impact on the socio-economic situation in individual countries. Stocks of raw materials are quite dynamic; their amount changes in the process of scientific and technical development.

Worldwide there is a depletion of the mineral resource base, and projections indicate that the demand for mineral and natural raw materials will increase by 2-3 times in the future. Therefore, the rational extraction and use of mineral resources are among urgent issues today. Rocks contain a wide variety of mineral resources, which is why they are of great importance in the modern world.

Check yourself

a. Why are mountain regions the most ethnically and culturally diverse areas?
b. What is the difference between minerals and rocks?
c. How can mineral resources be classified according to their state of matter? Think of the examples.
d. Why are the rational extraction and use of mineral resources among urgent issues today?

Water is one of the most common substances on Earth. Almost 70.8% of the earth's surface is covered by water. The water content in the seas, oceans, and surface water bodies (including the world's ice reserves) is approximately 1.4 billion km^3. The water volume in the rocks contained in the Earth's lithosphere (the so-called groundwater) is about 0.73-0.84 billion km^3, which is only half as much as the water on the surface. Thus, a huge amount of water is stored underground in the earth's crust.

Water is accumulated in various voids in the rocks (cracks, pores, channels, etc.). In nature, there are no rocks without any voids. As a rule, these voids are occupied by water thanks to its high mobility or fluidity, as well as by other mobile components, such as gases. It has been established that below the groundwater level, to depths of about 4-5 km and more, practically all rock voids, with the exception of hydrocarbon deposits, are filled with water.

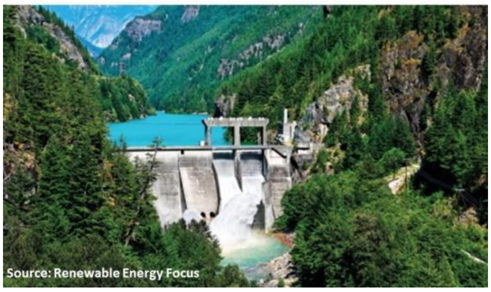
Above the snow line, high up in the mountains, there lie glaciers and snowfields. They contain 60-80% of all freshwater in the world. That is why mountain regions are called the "water towers of the world." They provide fresh water to more than half of humanity. Mountain lakes play an important role in regulating river flows, smoothing intra-annual fluctuations in glacial flow, and contributing to maintaining biodiversity and bioproductivity of mountain valleys.

The role of mountain water resources was identified at the WMO High Mountain Summit in 2019 as one of the most prioritized. The summit declaration voices concern that "*water security is becoming one of the greatest challenges of the world's population, and that the uncertainties on the availability of freshwater from mountain rivers is a significant factor of risk for local and downstream ecosystems, agriculture, forestry, food production, fisheries, hydropower production, transportation, tourism, recreation, infrastructure, domestic water supply, and human health.*"

Check yourself
a. Why are mountain regions called the "water towers of the world"?
b. What does the term "bioproductivity" stand for?
c. What was the goal of the WMO High Mountain Summit?

Mountains are promising areas for the development of renewable energy, including hydro, solar, and wind power and biogas. Hydropower already provides about one fifth of all electricity in the world, and in some countries energy is produced almost exclusively from sources located in the mountains.

The placement of hydroelectric power stations on mountain rivers is convenient because it does not require the flooding of large territories. Environmental organizations consider the construction of small hydropower plants in the



mountains as environmentally friendly technologies and support the development of small hydropower. The process of generating electricity at hydroelectric power plants, unlike thermal and nuclear power stations, does not harm the environment, as there are no polluting emissions into the environment.


Solar power station in the Altai Republic
Source: altai-republic.ru

Alpine regions have a high intensity of direct solar radiation throughout the year. Moreover, in the mountains the magnitude of direct solar radiation on a perpendicular surface on clear days is 15-20% higher than in the foothills and plains. The highest intensity of direct solar radiation occurs in the winter and spring months characterized by low atmospheric turbidity. Placing solar panels high in the mountains, where there are more clear days, will help to increase their efficiency and reduce the share of nuclear power plants in the world.


Source: Petrol Group

With height, wind speed increases significantly, making mountain valleys good platforms for the development of wind energy. The advantages of this type of energy are:

- it is not accompanied by emissions of CO² and any other gases;
- it is an inexhaustible resource; and
- it is characterized by easy maintenance, quick installation, and low maintenance and operation costs.

Thanks to the development of renewable energy, inexhaustible resources can now be considered high-quality sources of energy production.

Check yourself

a. What types of energy can be developed in the mountains?
b. Why is the placement of hydroelectric power stations on mountain rivers convenient?
c. What are the advantages for the development of solar energy in the mountains?
d. What are the advantages for the development of wind energy in the mountains?

Mountain areas are home to six of the twenty plant species that provide most of the world's food: corn, potatoes, barley, tomatoes, apples, and sorghum. They are characterized by unique biological diversity, which far exceeds the diversity of lowland territories, since mountain ecosystems are notable for more preserved natural landscapes.

The use of many flora and fauna species is closely connected with the development of forestry, hunting, and agriculture. On the southern slopes of the Himalayas in Nepal and Bhutan, potatoes and wheat ripen at heights of up to 4,100 m and barley is cultivated at the altitude of 4,900 m. The upper border of agriculture in the mountains of Bolivia reaches 4,650 m. On the Altiplano or Andean Plateau barley is grown at the height of 4,200 m and potatoes of up to 4,400 m. Llamas and alpacas, which in Peru and Bolivia are the basis of subsistence farming, can graze at the height of 5,200 m. Local people breed them for meat, milk, and wool or use as pack animals.

Mountain tourism accounts for 15-20 percent of the global tourism industry. Mountains attract tourists thanks to a wide range of possible leisure activities they provide, including skiing, mountain climbing, hiking, and sightseeing trips. Recreation and tourism in the mountains are becoming alternative ways of natural resource consumption. It is becoming more and more popular and prestigious among the residents of large cities to spend their free time in the mountains, admire mountain scenery, breathe the mountain air, and be treated with mountain mineral waters. The Alps have become the first region where mountain climbers, conquerors of high mountain peaks, and mountain tourists, lovers of travel through mountain landscapes, appeared. In the 20th century, the development of technical equipment for mountaineering, as one of the extreme forms of tourism, caused an unprecedented increase in the number of people wishing to climb the highest peaks of the world.

Currently, rivers and mountain lakes are gaining special popularity among tourists too. The abundance of white water rapids of various classes allows the use of mountain rivers both for tourism and sports competitions. Thanks to the massive development of recreation and tourism, mountain lakes are also included in the list of sites regularly visited and actively used for sports, educational, and recreational purposes.

Mountain territories are relatively sparsely populated. Difficult climatic conditions, steepness of slopes, and the reduction of areas suitable for economic purposes with altitude limit the living conditions and agricultural activities in most mountain regions of the world. The height of the relief and large slopes of the surface contribute to the development of pastoralism, hunting, and gathering. This is why the majority of the mountain population leads a nomadic or semi-nomadic lifestyle. However, urbanization processes have spread even here. According to experts, by the beginning of the 21st century there were 266 cities in the world with a population of more than 1 million people. Of those, 26 were located above 1.000 m above sea level, which made up almost 10% of all major cities in the world.

Indigenous peoples inhabiting highlands from generation to generation have acquired physiological characteristics that allow them to live under conditions of hypoxia. Their lung volume has increased that helps keep hemoglobin levels in their blood constantly high. The residents of the Eastern Pamirs, Tibet, and the Peruvian and Bolivian Andes do not experience significant difficulties from physical labor in absolute altitudes of more than 3,500-4,000 m. The Sherpas in the Nepalese Himalayas and India easily overcome the ascent to heights of more than 6,000 m with heavy load without suffering from hypoxia.

The cultures of different peoples have converged in the mountains. Here, the beauty and grandeur of their landscapes have created a special philosophy of life, which is based on contemplation and respect for the environment. At the same time, an extraordinary degree of geographical isolation of, for example, the peoples of Tibet have led to the emergence of a unique Lamaist culture, which combines local shamanism and mantric Buddhism that came from India. From shamanism, it has borrowed the manifestation of human power through initiation and the demonstration of man's courage, from Buddhism - the philosophical basis for the understanding of ideas.

Mountains are areas where history has been preserved. Traces of human sites of the Paleolithic, Mesolithic, and Neolithic, and historical periods are found on the shores of many mountain lakes. According to archaeological materials, there were numerous ancient sites and prehistoric settlements on the shores of the lakes located in the Alps, the Caucasus, the Tien Shan, the Pamirs, the Ethiopian Highlands, and others. For example, on Lake Titicaca, which is situated at the height of 3,812 m, there are the remains of one of the oldest Andean cultures, the state of Tiwanaku that was conquered by the Incas.

Check yourself
a. What types of economic activities can be developed in the mountains?
b. Why are mountain territories relatively sparsely populated?
c. What physiological characteristics allow indigenous peoples to live in high mountains?

In the 21st century, humanity faces enormous challenges, such as climate change, the retreat of glaciers, and the extinction of many plant and animal species. Air, soil, and water pollution is ongoing. Along with this, the world's population is growing and the use of natural resources is increasing. Considering both natural and spiritual resources of mountains, it could be argued that mountains play a vital role in the well-being of more than half of humanity.

The European community has long recognized the full significance of mountain regions that perform important economic, sociocultural, and environmental functions. In countries such as Italy, France, Switzerland, and Austria special “mountain” laws have been adopted and are in force to regulate sustainable mountain development. Moreover, the Alpine Convention signed in Salzburg in 1991 can serve as an example of coordinated actions of several mountain countries. Today, worldwide cooperation on the sustainable development of mountain areas has been actively developing within the framework of the Mountain Forum, the Mountain Partnership and other international organizations.

As a major ecosystem representing the complex and interrelated ecology of our planet, mountain environments are essential to the survival of the global ecosystem. Hence, the proper management of mountains' resources and the socio-economic development of their population deserve immediate action (Chapter 13 of Agenda 21).

> ***Check yourself***
> *a. What challenges does humanity face today?*
> *b. What is the Alpine Convention?*
> *c. What international organizations foster sustainable development of mountain territories?*

3. Watch the Presentation 3 .

4. Get ready to discuss the following issues:

1. Natural and cultural resources of mountain territories.
2. Development of alternative energy in mountain areas.
3. Mountain economic activities.
4. Role of special laws and organizations in the sustainable development of mountain territories.

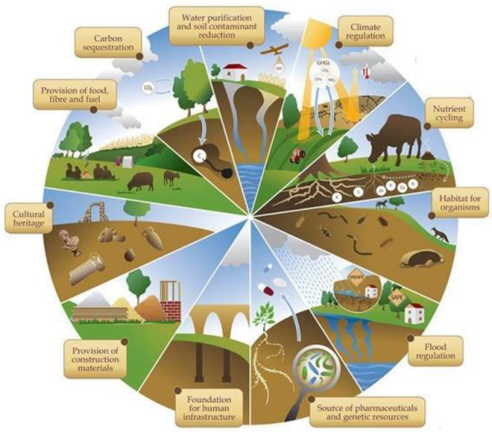
5. Do the Test 3.

THEME 4

Ecosystem Services: Essence and History of Development

1. Watch the Video 4 and confirm or disprove the following statements:

1. Ecosystems provide people with only tangible benefits.
2. The more human society develops, the less is its impact on the environment.
3. Ecosystem services have their own cost that must be taken into account while planning economic activities.



Source: www. fao.org

4. There are three different types of ecosystem

services: provisioning, regulating, and supporting.
5. Provisioning services are necessary for the production of all other ecosystem services.
6. Ecosystems can influence climate at both local and global levels.
7. Ecosystem diversity is among the factors affecting cultural diversity.
8. Photosynthesis and soil formation are the examples of regulating services.

2. Read the text and answer the questions:

The concept of ecosystem services was formed in the late 1990s with the aim of finding an economic solution to traditional problems of environmental protection, ecological safety, and ecological functions of natural and man-made ecosystems, and to provide economic and financial leverages to address them in a market economy. Services are not free. They have their own cost that must be taken into account while planning economic activities in order to ensure the sustainable development of modern society.

This realization has led to the development of an independent direction – The Economics of Ecosystems and Biodiversity (TEEB) under the framework of the United Nations Environment Programme (Konyushkov D.E., 2015).

Today, a wide range of issues related to ecosystem services, including their assessment, identification of their potential sellers, buyers and compensation mechanisms, as well as the establishment of markets for such services are being actively developed in the world. In international relations and economics these services are increasingly linked to such new terms as "payments for ecosystem services" (PES), "environmental donors," "compensation mechanism," and "debt-for-nature swaps" (Bobylev S. N., Zakharov V. M., 2009). There has been fundamental international research on the economics of ecosystem services, such as the Millennium Ecosystem Assessment, collectively prepared by a team of more than 1,000 scientists from different countries under the auspices of UNEP, The Economics of Ecosystems and Biodiversity, 2008, and reports of the Environment Department of

The World Bank and International Union for Conservation of Nature, etc.

> ***Check yourself***
> *a. When was the concept of ecosystem services formed? What is its aim?*
> *b. What independent direction was formed under the framework of the United Nations Environment Programme in regard to ecosystems and biodiversity?*
> *c. What new terms are ecosystem services increasingly linked to in international relations and economics?*
> *d. What is Millennium Ecosystem Assessment? What is its aim?*

Individual ecosystems and the biosphere as a whole provide a vast variety of goods and services. The very existence and well-being of mankind depend on ecosystem services. It is impossible to list all the valuable products that we get from ecosystems. The most highly appreciated aspects of natural ecosystems are aesthetic or cultural ones, e.g. beautiful views creating good opportunities for recreational activities. Much less consideration is given to the fact of how strongly the existence of mankind and its economic activities depend on natural ecosystems in terms of different biological and physical-chemical processes. The following examples of ecosystem services are given in the publication "Nature's Services: Societal Dependence On Natural Ecosystems" edited by a famous American economist and ecologist G.C. Daily (Daily, 1997): purification of air and water, mitigation of floods and droughts, detoxification and decomposition of wastes, generation and renewal of soil and soil fertility, control of the vast majority of potential agricultural pests, maintenance of biodiversity, from which humanity has derived key elements of its agricultural, medicinal, and industrial enterprise, protection from the sun's harmful ultraviolet rays, partial stabilization of climate and others.

Broadly speaking, ***ecosystem services are understood as the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems.*** The concept of "ecosystem services" originated in the works of ecologists in the second half of the 20th century, but the research on this issue has been particularly intensely developed in the past 10 years.

Ecosystem functions or intermediate ecosystem services are generalized ecosystem functions that can be useful for humans and can be considered as potential ecosystem services.

The differentiation of ecosystem functions and services is rather ambiguous. On the one hand, one ecosystem function can affect several services, for example, biomass production affects food ecosystem services and carbon sequestration. On the other hand, one ecosystem service, for example, recreational appeal, may depend on a number of ecosystem functions such as natural water purification, beauty of a landscape, availability of fish for amateur fishing. Moreover, in different cases the same function can be considered both as a service (final service) and as a function (intermediate service). For example, water quality is the final service in terms of providing drinking water to population and the intermediate service when assessing recreational services.

Despite a significant amount of research in the field of ecosystem services, their uniform classification has not been developed yet.

Today, there are three international classifications of ecosystem services:

- The classification given in the Millennium Ecosystem Assessment (MEA 2005) that is used for global and sub-global assessments of ecosystem services;

- The classification of the international project "The Economics of Ecosystems and Biodiversity - TEEB," which is used by the countries participating in the project for assessment of ecosystem services at the national level; and

- The Common International Classification of Ecosystem Services (CICES) developed from the work on environmental accounting undertaken by the European Environment Agency (EEA). It is based on the two above-stated classifications, but to a greater extent aimed at economic assessment and accounting of ecosystems at the national, regional, and local levels.

Check yourself

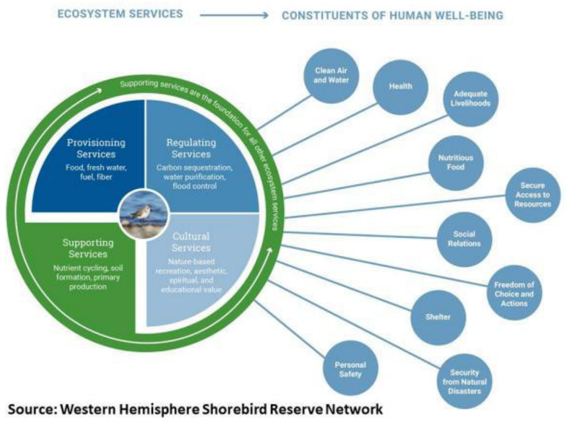
a. What is an ecosystem?

b. What are the most highly appreciated aspects of natural ecosystems?

c. What are ecosystem services?

d. How do ecosystem functions and services relate?

e. What international classifications of ecosystem services are used today?



Source: Western Hemisphere Shorebird Reserve Network

These international classifications are substantially similar and include the following categories: ***provisioning services*** are the products obtained from ecosystems, including, for example, genetic resources, food, fresh water, energy, medicinal resources, including pharmaceuticals and chemical models, raw materials, etc.; ***regulating services*** are the benefits obtained from the regulation of ecosystem processes, including, for example, carbon sequestration and climate regulation, purification of water and air, pest and disease control, etc.; ***cultural services*** are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience, including, e.g., knowledge systems, social relations, and aesthetic values. The fourth category includes ***supporting services*** that are necessary for the production of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat. In accordance with TEEB (2010) this category of services should not be assessed directly; it is considered as a prerequisite for the production of all other services. Special attention is paid to biodiversity as a characteristic of ecosystems that affects almost all ecosystem services (Wall, 2012; Ninan, 2009).

It should be noted that work on the development of a globally agreed list of ecosystem services is ongoing (TEEB, 2010; Haines-Young, Potschin, 2012, 2014).

Let's take a closer look at the categories of ecosystem services.

Provisioning Services include:

Food. This includes the vast range of food products derived from plants, animals, and microbes.

Fiber. Materials included here are wood, jute, cotton, hemp, silk, and wool.

Fuel. Wood, dung, and other biological materials serve as sources of energy.

Genetic resources. This includes the genes and genetic information used for animal and plant breeding and biotechnology.

Biochemicals, natural medicines, and pharmaceuticals. Many medicines, biocides, food additives such as alginates, and biological materials are derived from ecosystems.

Ornamental resources. Animal and plant products, such as skins, shells, and flowers, are used as ornaments, and whole plants are used for landscaping and ornaments.

Fresh water. People obtain fresh water from ecosystems and thus the supply of fresh water can be considered a provisioning service. Fresh water in rivers is also a source of energy. Because water is required for other life to exist, however, it could also be considered a supporting service.

Regulating Services include:

Air quality regulation. Ecosystems both contribute chemicals to and extract chemicals from the atmosphere, influencing many aspects of air quality.

Climate regulation. Ecosystems influence climate both locally and globally. At a local scale, for example, changes in land cover can affect both temperature and precipitation. At the global scale, ecosystems play an important role in climate by either sequestering or emitting greenhouse gases.

Water regulation. The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.

Erosion regulation. Vegetative cover plays an important role in soil retention and the prevention of landslides.

Water purification and waste treatment. Ecosystems can be a source of impurities (for instance, in fresh water) but also can help filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems and can assimilate and detoxify compounds through soil and subsoil processes.

Disease regulation. Changes in ecosystems can directly change the abundance of human pathogens, such as cholera, and can alter the abundance of disease vectors, such as mosquitoes.

Pest regulation. Ecosystem changes affect the prevalence of crop and livestock pests and diseases.

Pollination. Ecosystem changes affect the distribution, abundance, and effectiveness of pollinators.

Natural hazard regulation. The presence of coastal ecosystems such as mangroves and coral reefs can reduce the damage caused by hurricanes or large waves.

Cultural Services include:

Cultural diversity. The diversity of ecosystems is one factor influencing the diversity of cultures.

Spiritual and religious values. Many religions attach spiritual and religious values to ecosystems or their components.

Knowledge systems (traditional and formal). Ecosystems influence the types of knowledge systems developed by different cultures.

Educational values. Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.

Inspiration. Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising.

Aesthetic values. Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, scenic drives, and the selection of housing locations.

Social relations. Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies.

Sense of place. Many people value the "sense of place" that is associated with recognized features of their environment, including aspects of the ecosystem.

Cultural heritage values. Many societies place high value on the maintenance of either historically important landscapes ("cultural landscapes") or culturally significant species.

Recreation and ecotourism. People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area.

As has already been noted, ***Supporting Services*** differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. These services include:

Soil Formation. Because many provisioning services depend on soil fertility, the rate of soil formation influences human well-being in many ways.

Photosynthesis. Photosynthesis produces oxygen necessary for most living organisms.

Primary production. The assimilation or accumulation of energy and nutrients by organisms.

Nutrient cycling. Approximately 20 nutrients essential for life, including nitrogen and phosphorus, cycle through ecosystems and are maintained at different concentrations in different parts of ecosystems.

Water cycling. Water cycles through ecosystems and is essential for living organisms.

Some services, like erosion regulation, can be categorized as both a supporting and a regulating service, depending on the time scale and immediacy of their impact on people (MEA, 2005).

Check yourself
a. Define each group of ecosystem services and give examples.
b. What does the term "cultural landscape" embrace?
c. In what way do supporting services differ from other types of ecosystem services?

Special attention should be paid to the role of mountain territories, as they not only provide ecosystem goods and services but, critically, also regulate factors which underpin their provision. The regulating and supporting services provided by mountain systems can be divided between the physical and biological elements. The physical regulating services are deemed most critical. These include the regulation of climate, air quality, water flow, and erosion and natural hazards. In comparison, relatively less is known on the biological importance of mountain systems in regulating or supporting ES such as pollination, seed dispersal, and the regulation of pests and diseases.

Water is perhaps the most critical ES provided by mountains, particularly in terms of its supply to more densely populated adjacent lowlands. The great importance of mountains as sources of freshwater has justified their label as the 'water towers' of the world (Vanham and Rauch 2009; Viviroli et al.2007), as it is estimated that at least half of the world's population depends on water originating from mountain headwaters.

Mountains have also long been recognized as globally- and regionally-important centres of biodiversity (Mittermeier et al. 2011), many of which are directly used by people.

A remarkably high proportion of the world's cultural and ethno-linguistic diversity is found in mountain areas (Stepp et al. 2005), representing the legacy of human habitation in these challenging environments, typically over many centuries, if not millennia. The immense significance of mountain areas in terms of intangible services such as cultural heritage, aesthetic, and spiritual values is widely acknowledged and celebrated. The general remoteness and inaccessibility of mountains has, in many parts of the world, especially in least developed countries, allowed for the preservation of unique indigenous mountain cultures and associated traditional knowledge and production systems. Despite the intangibility of mountain cultures, they may contribute to economically relevant activities, not only through the maintenance of traditional practices for the management of land, plants, animals and other resources, but also by contributing to other resources, such as high-quality foods and attractive cultural landscapes, that attract tourists into these otherwise remote areas.

Ecosystem services thus have both a direct and indirect impact on human well-being through impacts on security, the basic materials for a good life, health, social and cultural relations and freedom of choice and action. Together these elements are influenced by and have an influence on the freedoms and choices available to people (MEA).

Check yourself
a. How can regulating and supporting services provided by mountain systems be divided?
b. What is the most critical ecosystem service provided by mountains?
c. How can mountain cultures contribute to economically relevant activities?

3. Watch the Presentation 4 .

4. Get ready to discuss the following issues:

1. The concept of ecosystem services and history of its development.
2. Ecosystem services and their categories.

5. Do the Test 4.

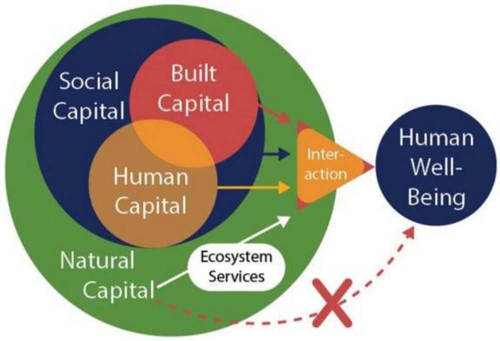
THEME 5
Economic Valuation of Ecosystem Services

1. Watch the Video 5 and confirm or disprove the following statements:

1. The long-standing perception that ecosystem services are free has had a positive impact on their condition.
2. The Millennium Ecosystem Assessment program was launched at the initiative of

the United Nations.

3. Today, the protection of natural wealth should be considered as a key challenge facing humanity.



Source: Costanza et al. (2014) Changes in the global value of ecosystem services. Global Environmental Change 26: 152-158.

4. Natural ecosystems are outside the economy.

5. People do not measure the value of ecosystem services and ignore them.

6. The value of ecosystem services is invisible in today's economy.

7. To date, there are four types of valuation of ecosystem services: ecological, monetary, social, and individual.

8. The non-use value includes those services that are consumed directly by humans.

9. The bequest value includes how valuable it is for current generation to maintain the biodiversity and functioning of ecosystem services for future generations.

10. The avoided cost method examines the costs people are willing to bear in order to access an ecosystem service.

2. Read the text and answer the questions:

Mountain systems are widely distributed across all continents, from tropical to arctic latitudes, and thus support vastly differing biota, livelihoods, and human population densities. Despite such inherent differences, it is possible to derive global generalizations of the importance of mountains as sources of ecosystem services (ES). The conceptual framework of ES was mainstreamed in the first product of the Millennium Ecosystem Assessment (MEA) in 2003 (Alcamo & Bennett 2003), in which 24 such services were defined and classified under the categories of provisioning, regulating, and cultural services (as well as supporting services which underpin each of these). On a global basis, while mountains provide very high levels of ES, the potential for deriving benefits from these largely remains underutilized. Mountain areas ranked very high in a study which examined the capacity of ecosystems to supply 15 selected ES, mostly provisioning and regulating (Grêt-Regamey et al. 2012). The vast majority of geographic areas identified as providing the highest levels of all 15 of these ES are in mountainous regions, as defined by Kapos et al. (2000).

These findings are supported by a qualitative assessment of European terrestrial and freshwater ecosystems (Harrison et al. 2010), which found that, of all habitat types evaluated, mountains provided the most diverse and numerous sources of ES. In most instances, mountains provided key contributions to ES and, of the 24 services assessed, there were none to which mountains did not contribute. However, not all mountain ES were sufficiently known to allow more than preliminary assessment. Although qualitative in nature, the assessment allows for relative comparisons amongst habitat types, which has both revealed the importance of mountains and highlighted ES categories which are poorly known and in need of greater elucidation in future studies. (Mountain Ecosystem Services and Climate Change. A Global Overview of Potential Threats and Strategies for Adaptation).

Over the past 50 years, as a result of increasing human impacts, the basis for many ecosystem services has been threatened. Among the main reasons are the imperfection of traditional market model and the inefficiency of government policies. The root cause is the lack of cost or minimum valuation of the vast majority of ecosystem services (Bobylev S.N., Zakharov V.M., 2012; Tikhonova, 2019).

Such situation has led to a continuing degradation of ecosystems, and this problem needs to be addressed. The approaches to the solution of this problem offered by various experts differ considerably and sometimes might be contradicting. There are two diametrically opposing viewpoints. The first is that economic valuations of all the elements of natural capital are recognized as the main tool to address this problem. It is necessary to determine the value of natural resources and ecosystem services with the help of continuously evolving evaluation methodology and to develop mechanisms for incorporation of these valuations into decision-making processes. Such concept underlies the works of Pearce and Turner (Pearce

D.W, Turner R.K, 1990) and a large group of the World Bank economists (Dixon J.A., Sherman P.B. 1990; Magnani E., 2000; Expanding the Measures of Wealth, 1997, etc.).

The second viewpoint, on the contrary, denies the value of economic assessment of ecosystem services at all. It is argued that since the true value of these services and ecosystems is equal to infinity, so any private assessments of their separate elements are inadequate. The constant undervaluation of ecosystem services will lead (and already is leading) to wrong decisions detrimental to environment (Rees W.E., 1999; Wackernagel M., 1999).

As a rule, most specialists take an intermediate position. They conduct economic valuations and carefully offer them for solving specific problems. It is important to understand that these valuations may have irreparable defects, but nevertheless developed countries are aware of the importance of such approach and have been actively implementing payments for ecosystem services in recent years.

An attempt to estimate the value of ecosystem services for the entire world was made by Robert Costanza and his coauthors (Costanza R. et al., 1997). The authors underline that the true economic value of these services is infinite, because neither the economy nor humanity can exist without them. However, it can be instructive to estimate the 'marginal' value of ecosystem services, i.e. the estimated rate of change of value compared with changes in ecosystem services from their current levels.

Within the conceptual framework of the infinite value of the world's natural capital the aim is to estimate monetary value of the consequences of quantitative and qualitative changes in natural capital for the well-being of mankind (Glazyrina I.P., 2001).

Check yourself

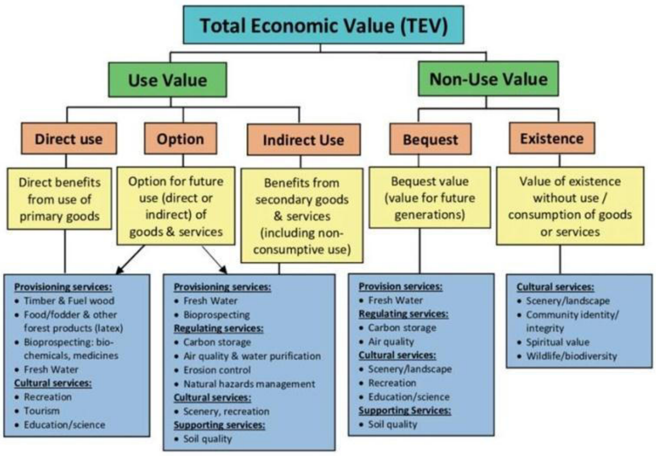
a. How many ecosystem services were defined in the first product of the Millennium Ecosystem Assessment? How many of them can be supplied by mountain areas?

b. What are the main reasons that threaten ecosystem services?

c. What are the two diametrically opposing viewpoints on the solution of the problem of a continuing degradation of ecosystems and ecosystem services?

d. What is the true economic value of ecosystem services according to Robert Costanza?

To date, there are three types of valuation of ecosystem services: *ecological*, which is based on ecosystem indicators and determines their health, i.e. ability to perform their functions; *economic or monetary*, which can be easily integrated into decision-making mechanisms and familiar to the market, but has some serious shortcomings as it reflects the current state of the economy that is far from sustainable one, which is the main goal to achieve; and *social*, which is aimed not so much at ecosystem services as such, but at their social perception to eliminate possible conflicts and ensure agreed solutions.



Source: ResearchGate - uploaded by Lin Roberts

The purpose of monetary valuation is to find the ***total economic value*** of ecosystems, which includes both *use value* and *non-use value* of services.

Use value includes direct use, indirect use and option value:

- *Direct use value*: where individuals make actual or planned use of an ecosystem service. This can be in the form of consumptive use which refers to the use of resources extracted from the ecosystem (e.g. food, timber) and non-consumptive use, which is the use of the services without extracting any elements from the ecosystem (e.g. recreation, landscape amenity).

- *Indirect use value*: where individuals benefit from ecosystem services supported by a resource rather than directly using it. These ecosystem services are often not noticed by people until they are damaged or lost, yet they are very important. These services include key global life-support functions, such as the regulation of the chemical composition of the atmosphere and oceans, and climate regulation; water regulation; pollution filtering; soil retention and provision; nutrient cycling; waste decomposition; and pollination. Measuring indirect use values is often significantly more challenging than measuring direct use values. Changes in the quality or quantity of a service being provided are often difficult to measure or are poorly understood.

- *Option value*: the value that people place on having the option to use a resource in the future even if they are not current users. These future uses may be either direct or indirect. An example would be a national park where people who have no specific intention to visit it may still be willing to pay something in order to keep that option open in the future. In the context of ecosystems and their services, option value describes the value placed on maintaining ecosystems and their component species and habitats for possible future uses, some of which may not yet be known. Option value can also be thought of as a form of insurance, e.g. a wide species mix in a particular habitat can provide an insurance function: as conditions change, different species

Non-use value (also known as passive use) is derived simply from the knowledge that the natural environment is maintained. There are three main components:

- *Bequest value*: where individuals attach value from the fact that the ecosystem resource will be passed on to future generations.
- *Altruistic value*: where individuals attach values to the availability of the ecosystem resource to others in the current generation.
- *Existence value*: derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it. For example, people are willing to pay for the preservation of whales, through donations, even if they know that they may never actually see a whale.

Non-use value is relatively challenging to capture since individuals find it difficult to 'put a price' on such values as they are rarely asked to do so. However, in some circumstances, nonuse value may be more important than use value. For example, a study on the value of Natura 2000 sites in Scotland found that 99% of the overall value of such sites was non-use (An introductory guide to valuing ecosystem services).

Check yourself

a. What are the three types of valuation of ecosystem services? Describe them.
b. What is the purpose of monetary valuation of ecosystem services?
c. What other values does use value include? Speak on them.
d. What other values does non-use value include? Speak on them.
e. Why is non-use value relatively challenging to capture?

For each type of value there are different methods of monetary valuation. The easiest methods are *market price methods* used for valuation of alienable provisioning services (food, water, raw materials). It should be taken into accounts that markets can be monopolized and not all necessary costs are included into the market value (e.g. costs associated with the need to prevent environmental pollution). For objective valuation it is possible to adjust market values (Konyushkov D.E., 2015).

Non-market valuation methods (primarily for regulating and cultural services) are based on a number of assumptions and usually require serious statistical work. It is important to clearly understand the limitations of these methods while using them (Swinton et al., 2007; Costanza et al., 2006).

The *avoided cost method* calculates the economic value of benefits that an ecosystem provides that would not exist without the ecosystem in place, and therefore, would represent an added cost to society if this environmental service no longer existed. For example, a wetland that supplies flood protection provides the "avoided cost" of having to invest in additional flood protection measures such as additional levees.

The *replacement cost method* is similar in meaning; it calculates the costs of potential replacement of ecosystem services with services produced by humans (e.g. pollution purification).

The *factor income method* estimates additional income (profit) through indirect use of nature services, for example, natural water purification increases incomes of fisheries.

The *travel cost method* examines the costs people are willing to bear in order to enjoy natural resources and to access the services (not only the ticket price, but the total cost, including time, should be taken into account). It is often used for recreational services valuation. The travel cost method requires data and analysis linking the number of trips to a site to its quality, size, or location.

The *hedonic pricing (valuation) method* assesses the value of an environmental feature (clean air, clean water, serenity, view) by examining actual markets where the feature contributes to the price of a marketed good. For example, using the hedonic pricing method one can estimate the monetary contribution of ocean views to home prices. Similarly, farm values are related to the availability of groundwater, precipitation, and soil quality. This method is particularly useful for valuing aesthetic (cultural) ecosystem services.

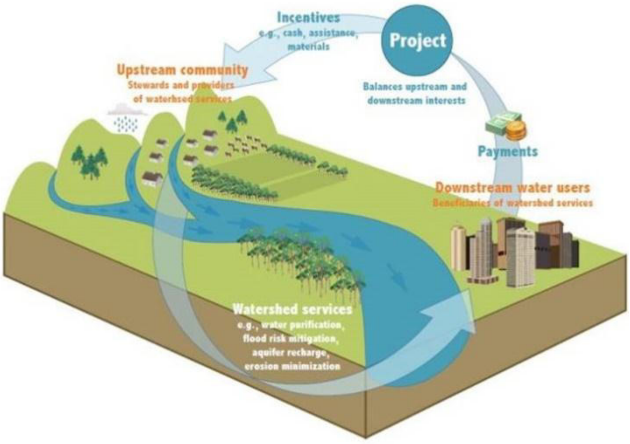
The *contingent valuation method* is a questionnaire based technique that seeks to discover individual preferences for an environmental change. The basic premise of this method is that individuals are sensitive to a given environmental change and that their preferences could be measured in terms of their willingness to pay to undergo (or their willingness to accept a compensation to avoid) this change.

A similar *group valuation method* is based on agreed group valuations rather than those of individual users.

Common to many methods is the *willingness to pay* approach. Special questionnaires are being developed to measure it. Once such primary survey studies (or studies of prices in the market) have been carried out, a *value transfer* approach, that is, extrapolation of the estimates to new but similar locations and resource contexts, is used to determine the price of ecosystem services. In the end, such a scheme is used to value ecosystem services in different regions, countries and the world (Konyushkov D.E., 2015).

Check yourself

a. What are the easiest methods of monetary valuation? What are they used for?
b. What are non-market valuation methods based on?
c. What non-market valuation methods are used to value ecosystem services? Describe them.
d. What is common to many non-market valuation methods?



Source: Oppla - Payment for Ecosystem Services (PES)

While it is acknowledged that payment for ecosystem services (PES) can serve as a valuable instrument that can underpin ecosystem-based adaptation, good examples of PES-type schemes that operate successfully at the local level are still few. Nevertheless, the concept of payments for watershed services is seen as an important innovation, as part of the wider goal of integrated watershed management. In the context of climate change, better management of water resources (including infrastructure development) in upper mountain catchment areas of the Hindu Kush Himalaya will be vital in order to enhance water security and the adaptive capacity of downstream users. Practical projects from Nepal – such as the Dhulikhel water supply project (implemented by the local municipality) and the Kanchanpur irrigation project (facilitated by the District Forest Office) – have highlighted the importance of strong local governance and institutional leadership in such processes. A collaborative approach to project development, in which both local and upstream mountain communities are embedded, has been a common thread pivotal to successful implementation. This success has been evidenced in provision of a reliable and high quality water source to the town of Dhulikhel, 20 km east of Kathmandu; whereas in Kachanpur, downstream irrigation users pay a nominal fee to upstream Community Forest User Groups (CFUGs) – and, in return for deriving this much-needed economic benefit, the CFUGs ensure adequate conservation and maintenance works on the Haldekhal River. The development of specific local-level policy and governance practices can help foster wider adoption of such 'community-to-community' models, which have the power to improve watershed services in linking communities through PES or other incentive-based mechanisms. Supporting actions by local government and institutions should anticipate the likely need of communities for legal and contractual flexibility in PES schemes, as well as their potential high vulnerability to a market-based approach – particularly where there is extensive private-sector involvement (Mountain ecosystem services and climate change: a global overview of potential threats and strategies for adaptation).

Another good example of implementing ecosystem payments is the PSA program (Pago por Servicios Ambientales) in Costa Rica. Under the program, a state contract that obligates to reduce greenhouse gas emissions, maintain aquatic ecosystems, conserve biodiversity, or simply maintain the beauty of the landscape can be made with any land owner. Funds for these contracts come from the fuel combustion tax, GEF and the World Bank funds, and end-users of ecosystem services.

An example of private self-organizing transactions is the agreement between the French mineral water producer Perrier Vittel and the land owners, according to which the producer pays them for introducing agricultural technologies that cause less damage to the environment and for planting forests in filtration zones in order to protect the clean water sources.

These examples show that valuation of ecosystem services can help environmental conservation. Payments for various types of ecosystem services are among the most innovative approaches to ecosystem resource management.

Check yourself

a. How does the instrument of payment for ecosystem services work in Nepal? What is it based on?
b. Speak on the example of implementing ecosystem payments in Costa Rica.
c. What does Perrier Vittel pay local land owners for?

3. Watch the Presentation 5 .

4. Get ready to discuss the following issues:

1. Total economic value of ecosystem services and its subcategories.
2. Ecosystem services valuation methods.

5. Do the Test 5.

THEME 6

Threats to Mountain Ecosystem Services and Their Restoration

1. Watch the Video 6 and confirm or disprove the following statements:

1. Over the past 50 years, the ecosystems have been changed due to lack of demand for food, fresh water, timber, and other resources.

2. The primary task for global change research in mountain areas is to better understand their root causes.

3. Environmental pollution is the most significant factor directly affecting the ecosystem services of mountain regions.

4. Both in the geological past and today, global climate changes were primarily caused by natural factors.

5. Most scientists believe that mean and extreme temperatures will increase, as will the frequency of extreme events.

6. It is expected that lowland regions will undergo the greatest changes.

7. Glacier retreat is perhaps the most apparent sign of climatic warming.

8. The increase in the intensity of forest fires and the areas affected by them is one of the dangerous consequences of climate change.

9. Fires also stimulate mechanisms of climate change, increasing the intensity of atmospheric carbon sequestration and decreasing emissions of carbon dioxide and other greenhouse gasses.

10. There are more than 40 thousand environmental pollutants known today.

11. The main threat to biodiversity and, consequently, to the variety of ecosystem services is the disturbance and destruction of the natural habitats of plants and animals.

12. Overexploitation of natural resources can be explained by the ever-growing demand of humanity for biological resources.

13. The spread of invasive alien species helps protecting native species and developing ecosystem services.
14. Today, the interacting drivers of global change include globalisation, land-use change, economic policy, and population pressures.

2. Read the text and answer the questions:

Human economic activities have always been connected with the necessity to satisfy his needs. As populations grow and natural resources are involved into economic turnover, anthropogenic load on natural complexes increases and the problem of environmental protection gets worse. Strengthening of this trend calls into question the well-being of future generations (Vasilenko N.V., 2019).

Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth.

The changes that have been made to ecosystems have contributed to substantial net gains in human wee-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people. These problems, unless addressed, will substantially diminish the benefits that future generations obtain from ecosystems.

The degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals. The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the MA has considered, but these involve significant changes in policies, institutions, and practices that are not currently under way. Many options exist to conserve or enhance specific ecosystem services in ways that reduce negative trade-offs or that provide positive synergies with other ecosystem services (Millennium Ecosystem

Assessment).

The most important direct drivers of change in ecosystem services are: climate change, environmental pollution, reduction of natural habitats (land use change and physical modification of rivers or water withdrawal from rivers), overexploitation, and invasive alien species.

Source: IUCN

The Earth's climate is subject to considerable fluctuations and changes in time, which scale changes in the range from one year to millions of years (Alexandrov, 1997; Power H. C. and Mills D. M. Solar, 2005; Trenberth K. E. et al., 2001). In the geological past global climate changes were caused by natural (terrestrial and space) factors, but today by anthropogenic factors as well (Intergovernmental Panel on Climate Change, 2001; Keeling C. D. and Whorf T. P., 2005). Global climate changes influence some economic sectors in one way or another, but natural ecosystems are most vulnerable and sensitive to these changes.

Mountains are among the most sensitive regions to climate change, provide some of the clearest indicators of global warming and, in the 20th century experienced above-average warming, in comparison to the global mean (IPCC 2007; Nogués-Bravoet al. 2007; Kohler et al. 2014). While predicting and anticipating the effects of climate change on the capacity of mountain systems to supply vital ES is essential, an understanding of the wider context of global change as a whole is also important. Already, many of the interacting drivers of global change are influencing mountain environments globally: in addition to climate change, these drivers include globalization, land-use change, economic policy, and population pressures. Large knowledge gaps on the effects of global change on ES still remain for mountain and other terrestrial habitats, due mostly to the high uncertainty in combining predictions of these various drivers, each of which is complex and not very well understood.

Check yourself

a. What have human economic activities always been connected with?

b. How can the challenge of reversing the degradation of ecosystems while meeting increasing demands for their services be partially met?

c. What are the most important direct drivers of change in ecosystem services?

d. What are invasive alien species?

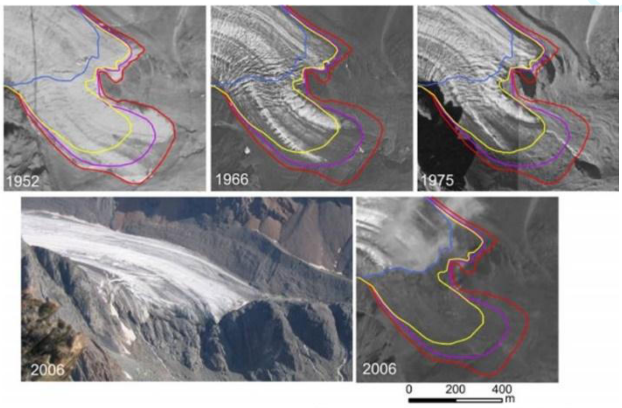
e. What drivers of global change are influencing mountain environments globally in addition to climate change?

f. What is globalization?

The primary need for global change research in mountain areas is to understand them, their drivers, and their interactions (Björnsen Gurung et al. 2012). With regard to climate change in particular, mountain areas in the northern hemisphere will generally be much more substantially affected by severe climate change than other regions. It is estimated that, for the European Alps, even an increase in warming by 2 °C (the current objective of international efforts to mitigate climate change) will not be enough to avoid significant alteration to at least several mountain ecosystem services (Elkinet al. 2013).

Although considerable regional (and even local) variations in response are expected for mountain regions, there is a consensus that mean and extreme temperatures will increase, as will the frequency of extreme events. Changes in precipitation will vary regionally; however, dry areas are likely to become drier, and wet areas wetter, and increasing temperatures will mean that the proportion of precipitation falling as snow will decrease. Mountain regions at high and medium latitudes are expected to see the greatest changes. The unique biophysical conditions that characterize mountain systems - mountain specificities, such as inaccessibility, fragility, marginality, heterogeneity - will be increasingly affected under growing climatic variability. Glacier retreat is perhaps the most apparent sign of climatic warming, with the vast majority of glaciers worldwide shrinking and thinning, a trend which has been either continuing, or accelerating over the last century (Vaughan et al. 2013).

The regulating function provided by glaciers in the form of water storage may thus be drastically altered in river basins where glacier melt provides a significant proportion of runoff. It has been estimated that 140 million people live in river basins where at least 25% of the annual flows come from glacier melts; this rises to 370 million people for a threshold of 10%. Most of these people live in High Asia (Schaner et al. 2012). When coupled to predicted intensification of the hydrological cycle, changes to drainage systems and water transfer will ultimately impact on the provision of freshwater and related ES, in the form of excesses during wet seasons, droughts of varying intensity during dry seasons, or both. Mountain livelihoods and infrastructure will be at increased risk from natural hazards and extreme events, which are set to increase in both magnitude and frequency (Oppenheimer et al. 2014).



Source: IOPscience - Surazakov et.al (2007) Glacier changes in the Siberian Altai Mountains, Ob river basin, (1952–2006) estimated with high resolution imagery

Rivers with flows formed within a zone whose water regime is most exposed to climate change are characterized by increased frequency of extreme water content values, which in turn have an adverse impact on the human population.

Rivers which flow across altitudinal zones, including glacial areas, are most exposed to frequent floods during the snow melt but are less vulnerable to drought during the summer. When the glacial water supply is reduced, in particular after glaciers retreat from their watershed area, the hydrological regime of these rivers changes significantly.

In the vegetation simulations obtained under the above warming scenarios for the end of the 21st century, plant species characterized by narrow ecological amplitudes limited to highland vegetation belts, such as highland tundra, alpine, and subalpine belts, are the most highly-endangered. Plant species whose ecological requirements allow them to grow in highlands and in the upper part of the forest belt, will be eliminated from the highlands due to climate warming, but are likely to remain in the mountain forest belt (Assessment Report: Climate change and its impact on ecosystems, population and economy of the Russian portion of the Altai-Sayan Ecoregion, 2011).

> ***Check yourself***
> *a. What is the primary need for global change research in mountain areas?*
> *b. What areas will generally be much more substantially affected by severe climate change?*
> *c. What changes in precipitation and temperature are expected?*
> *d. What is perhaps the most apparent sign of climatic warming?*
> *e. What consequences can predicted intensification of the hydrological cycle, changes to drainage systems and water transfer have for mountain livelihoods and infrastructure?*
> *f. What is ecological amplitude? How can it influence the ability of plant species to survive under the warming scenarios for the end of the 21st century?*

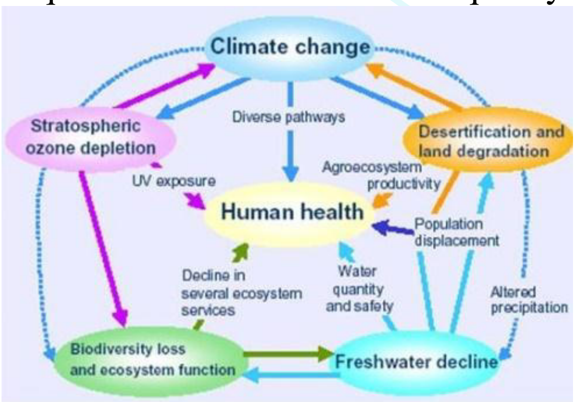
One of the hazards of climate change in a context of continually increasing aridity is a potential increase in the intensity of forest fires and the areas affected by them. Aside from the economic and ecological damage caused, fires also further stimulate mechanisms of climate change reducing intensity of atmospheric carbon sequestration, as well as increasing emissions of carbon dioxide and other greenhouse gasses (Biodiversity Conservation in the Russian Portion of the Altai-Sayan Ecoregion Under Climate Change. Adaptation. Strategy. – Krasnoyarsk, 2012).

Provisioning ES, and especially food production systems in mountains, may be adversely affected due to increased climatic variability and extreme events, as well as potential increases in pest outbreaks and epidemics of disease-causing organisms. One example that can be periodically observed is the sporadic development of the Siberian silk moth and gypsy moth, which are among the most hazardous forest pests. Outbreaks of these species occur after dry growing seasons, and especially after subsequent winters with low snowfall and severe frosts as well as spring and autumn fires, when the number of insectivores is significantly reduced as a result of freezing and burning (Assessment Report: Climate change and its impact on ecosystems, population and economy of the Russian portion of the Altai-Sayan Ecoregion, 2011).

At the same time a growing number of studies have highlighted the importance of insect pollinators in mountain agriculture (Verma 1992; Partap et al. 2012; Sharmah et al. 2015). This topic is also highly relevant from a food security perspective, given the high vulnerability of subsistence farming systems prevalent throughout most mountain regions of the developing world.

While climate change will potentially lead to dramatic negative alterations of the capacity of mountain ecosystems to maintain current ecosystem services, not all ecosystem services will be degraded under climate change, and anticipating ecosystem services which might possibly be enhanced will be key to developing adaptation strategies to increase the resilience of mountain livelihoods. For example, warming climates may lead to the potential to grow food crops (if soil and water are suitable), and to extend livestock grazing - but also to the potential for increasing conflicts between domestic and wild animals - at higher altitudes. Equally, increases in the elevation of tree line may enhance the provision of timber and non-timber forest products, and increase potentials for carbon sequestration, hazard mitigation, and recreation. Nevertheless, this may pose particular challenges when areas into which people might move have been designated as protected areas. Likewise, where water discharge is anticipated to increase (due to increases in glacial melt or precipitation levels), the potential for micro-hydropower may be enhanced, at least in the short term (Mountain ecosystem services and climate change: a global overview of potential threats and strategies for adaptation).

The second considerable threat to ecosystem services of mountain territories, as it has already been noted, is the environmental pollution, which is reflected in the introduction or appearance of new, usually uncharacteristic of this environment, chemical, physical, and biological agents having harmful effect on ecosystems. Increased concentration of certain natural substances or energy above background or maximum-permissible norms can also have negative influence on the quality of ecosystem services. There are more than 30 thousand environmental pollutants (air pollutants in the form of gases and aerosols; water pollutants; introduction and reproduction of invasive alien species; increase in the level of ionizing radiation, noise, vibrations etc.). Due to interaction of landscape components the pollution of one of them (for example, air) causes the pollution of other components (soil, vegetation and etc.) that results in negative consequences and influences the quality of ecosystem services (Barishpolets V.A., 2011; Brodskiy A.K., Safronova D.V., 2017).



Source: World Health Organization

Humans have already doubled the flow of reactive nitrogen on continents, and some projections suggest that this may increase by roughly a further two thirds by 2050. It is projected that the global flux of nitrogen to coastal ecosystems will increase by a further 10-20 % by 2030, with almost all of this increase occurring in developing countries. Excessive flows of nitrogen contribute to eutrophication of freshwater and coastal marine ecosystems and acidification of freshwater and terrestrial ecosystems. To some degree, nitrogen also plays a role in creation of ground-level ozone (which leads to loss of agricultural and forest productivity), destruction of ozone in the stratosphere (which leads to depletion of the ozone layer and increased UV-B radiation on Earth, causing increased incidence of skin cancer), and climate change. The resulting health effects include the consequences of ozone pollution on asthma and respiratory functions, increased allergies and asthma due to increased pollen production, the risk of blue-baby syndrome, increased risk of cancer and other chronic diseases from nitrates in drinking water, and increased risk of a variety of pulmonary and cardiac diseases from the production of fine particles in the atmosphere (Millennium Ecosystem Assessment).

Check yourself

a. What are the negative effects produced by forest fires and other extreme events?

b. Will all ecosystem services be degraded under climate change? Speak on ecosystem services which might possibly be enhanced.

c. What is another considerable threat to ecosystem services of mountain territories besides forest fires? How does it influence the quality of ecosystem services?

d. What is eutrophication?

e. What are the consequences of ozone pollution?

The main threat to biodiversity and, consequently, to variety of ecosystem services is the disturbance and destruction of natural habitats of plants and animals. Habitat loss involves both their direct destruction and damages caused by pollution and fragmentation. In many parts of the world, especially old cultivated and highly populated areas, the majority of primary habitats have already been destroyed. Many valuable wild species have lost the most part of their primary range, and only few of the remained habitats are under protection.

Biodiversity loss usually begins with destruction of natural habitats. Degradation of the environment as a result of human activities and development of new technologies occurs at a rate considerably exceeding the abilities of species to adapt to new conditions. The exception is made by few animal and plant species, which we call alien species and with which we do not wish to share the future of our planet. It is likely that such species possess a range of genetic variation that allow them to adapt to fast environmental changes occurring due to its disturbance, but the majority of larger plants and animals are incapable of it.

Overexploitation of natural resources in most cases is resulting in their depletion, particularly in the case of renewable resources: wood, fish, and game animals. Such excessive use can partially be explained by a very high population density of some areas of the Earth and also by ever-growing demand of humanity for biological resources. Thus, as a result of overexploitation, the biomass of fish targeted in fisheries (including that of both the target species and those caught incidentally) has been reduced by 90% relative to levels prior to the onset of industrial fishing, and the fish being harvested are increasingly coming from the less valuable lower trophic levels as populations of higher trophic level species are depleted. Industrial logging for the needs of wood-processing and cellulose and paper industry, as well as for production of sawn timber annually destroys millions hectares of forests along with unique species inhabiting them. Illegal hunting and trade involving endangered animal species are direct threats to their existence. Expansion of livestock production around the world has often led to overgrazing and dryland degradation, rangeland fragmentation, loss of wildlife habitat, dust formation, bush encroachment, deforestation, nutrient overload through disposal of manure, and greenhouse gas emissions.

For some drivers, such as the overharvest of particular species, lag times are rather short, and the impact of the driver can be minimized or halted within short time frames. For others, such as nutrient loading and, especially, climate change, lag times are much longer, and the impact of the driver cannot be lessened for years or decades.

The spread of invasive alien species and disease organisms continues to increase because of both deliberate translocations and accidental introductions related to growing trade and travel, with significant harmful consequences to native species and many ecosystem services (Millennium Ecosystem Assessment).

Check yourself

a. What is the main threat to biodiversity and, consequently, to variety of ecosystem services?

b. What is environmental degradation caused by?

c. Why are invasive alien species so survivable? How do they spread?

e. What are the examples of overexploitation of natural resources?

f. What is a time-lag?

3. Watch the Presentation 6 .

4. Group assignment. Prepare PowerPoint presentations on the following topics and present them in class:

1. Major threats to ecosystem services (in general and in your region)
2. Ways to protect and restore ecosystem services (in general and in your region)

5. Do the Test 6 .

Содержание

Учебное электронное издание

SUSTAINABLE DEVELOPMENT OF MOUNTAIN TERRITORIES IN THE CONTEXT OF THE CONCEPT OF ECOSYSTEM SERVICES

Учебное пособие

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