Learning module

“Ecological aspects of urbanization in mountain areas”

GIMENEZ-MARANGES Marc, CAMPBELL Laura-Bethia, KOHOUTKOVÁ Kristýna, BREUSTE Jürgen

Learning module

“Ecological aspects of urbanization in mountain areas” (S1)

GIMENEZ-MARANGES Marc, CAMPBELL Laura-Bethia, KOHOUTKOVÁ Kristýna, BREUSTE Jürgen

Module 1: Ecological aspects of urbanization in mountain areas

S1: Ecological aspects of urbanisation

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1. Urbanisation – from the diffused to the eco-city model

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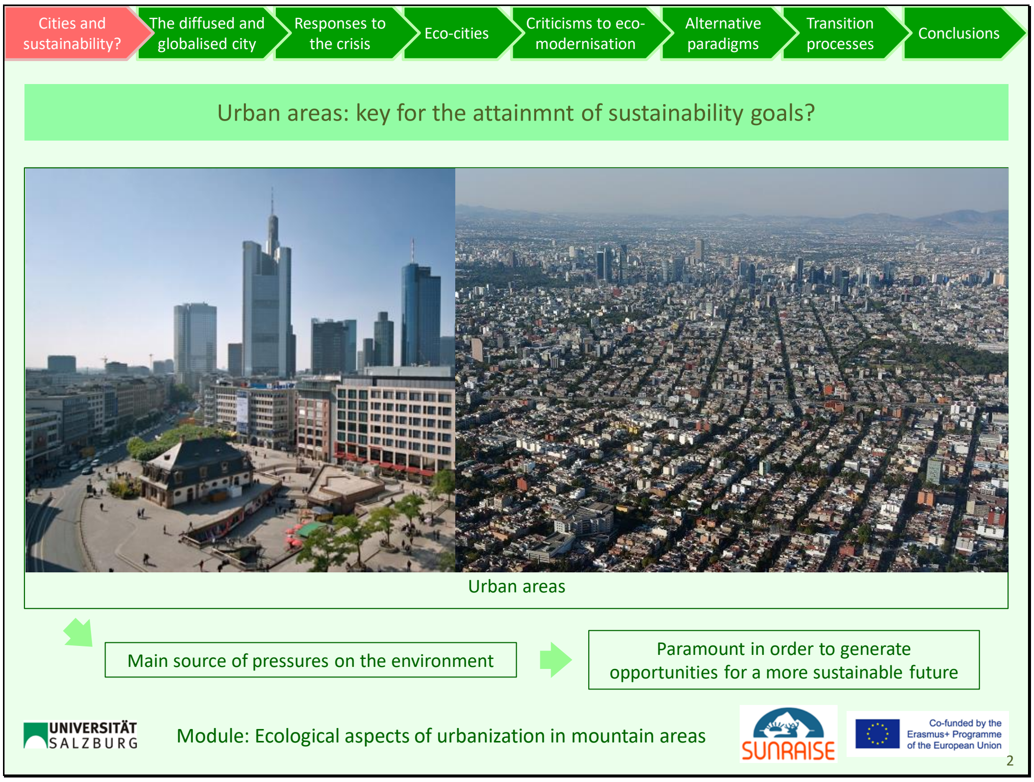

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Cities and sustainability? | The diffused and globalised city | Responses to the crisis | Eco-cities | Criticisms to eco-modernisation | Alternative paradigms | Transition processes | Conclusions

The diffused city model

Zoning of the space

Los Angeles, USA

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Cities and sustainability? | The diffused and globalised city | Responses to the crisis | Eco-cities | Criticisms to eco-modernisation | Alternative paradigms | Transition processes | Conclusions

The diffused city model

Zoning of the space

Development of the mobility network

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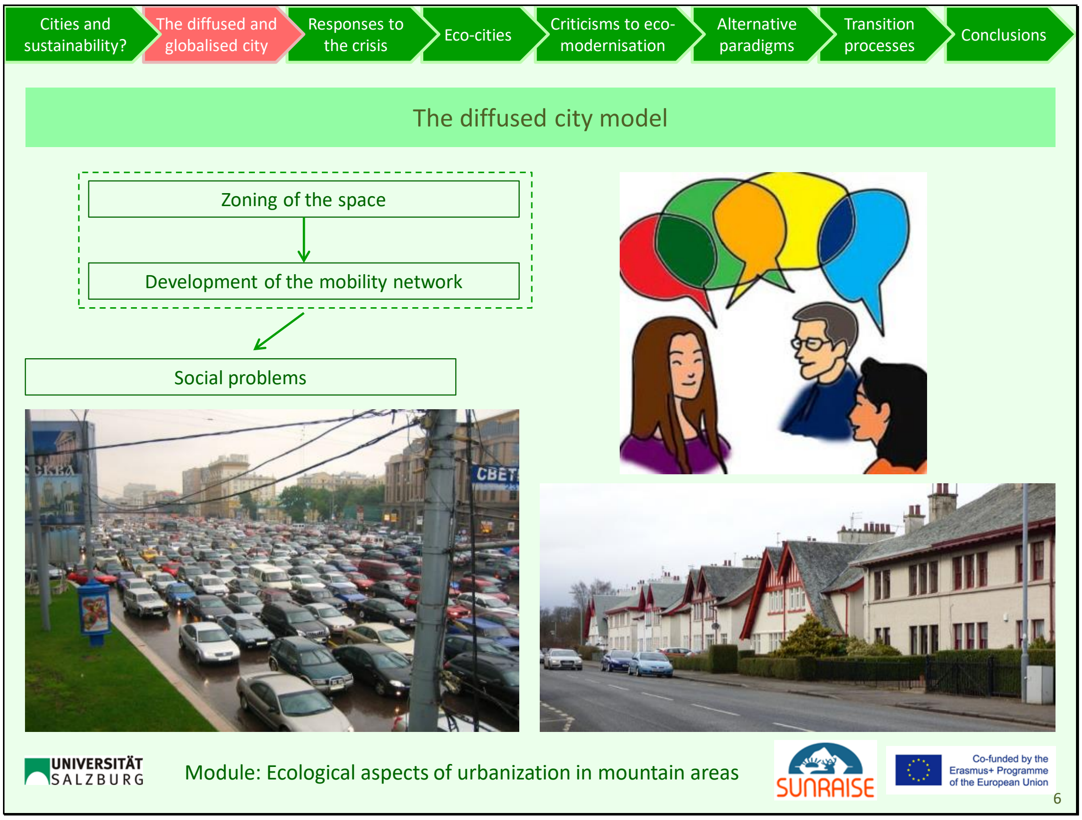

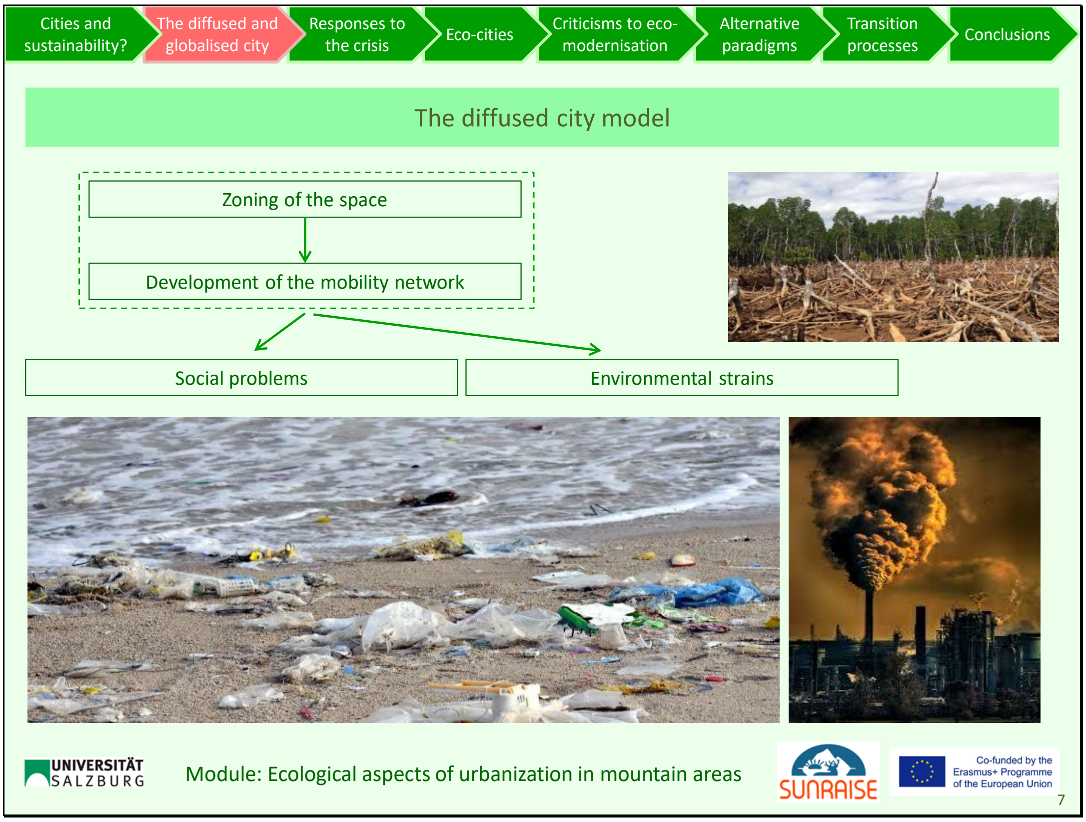

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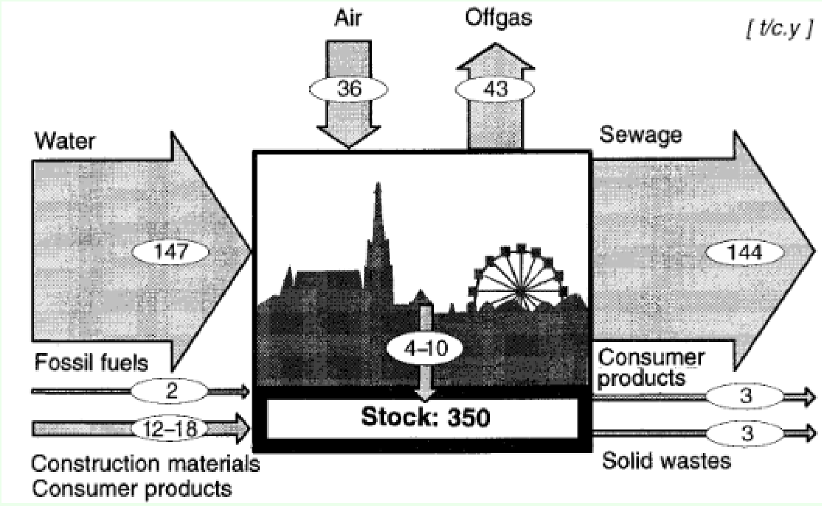
Material flows in cities - the globalised city



Flows and stocks of goods in Vienna (*Daxbeck et al., 1996*)

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Responses to the environmental crisis

2 main responses

International consensus (United Nations) | Private sector

3rd response → Calls for profound and radical changes

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Responses to the environmental crisis

2 main responses

International consensus (United Nations)

1 Earth Summit held in Rio de Janeiro in 1992 → 2 Agenda 21/ Aalborg Charter → 3 Creation of numerous demonstration urban development projects

Concept of eco-city was introduced

Sets of principles and traits of sustainable cities were proposed

BUT: Processes trapped in a cycle of challenges

Agenda 21 Local

Responses to the environmental crisis

2 main responses

International consensus (United Nations)

The compact city model

1 Articulation of mixed-use compact nodes

2 Nodes are connected to each other through effective public transport

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Responses to the environmental crisis

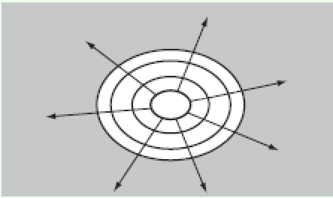
2 main responses

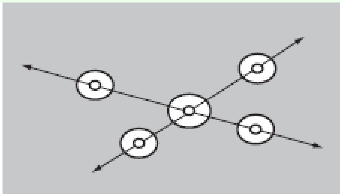
International consensus (United Nations)

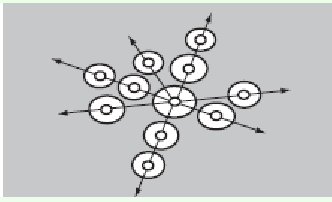
The decentralized concentration model

1 Several centres throughout the territory

2 Avoidance to concentrate all functions in a single urban unit


Only one central node


Small and multiple central nodes


Dispersed nodes

(Graham and Hunter, 1994)

Responses to the environmental crisis

The city of the 3 levels (Salvador Rueda)

Biodiversity and preservation of geographic and natural values

Urban metabolism

Subsoil

THE CITY OF THE 3 LEVELS

Surface

Height

Mobility and functionality

Urban complexity and knowledge society

Public space

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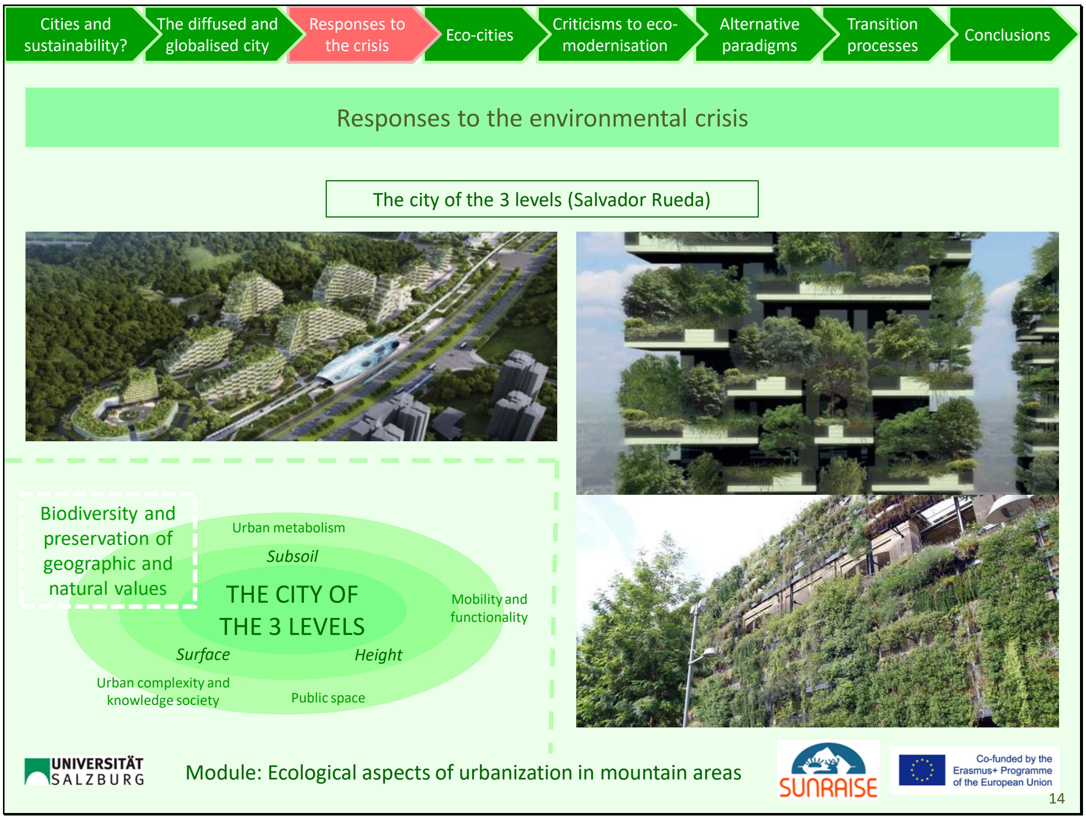

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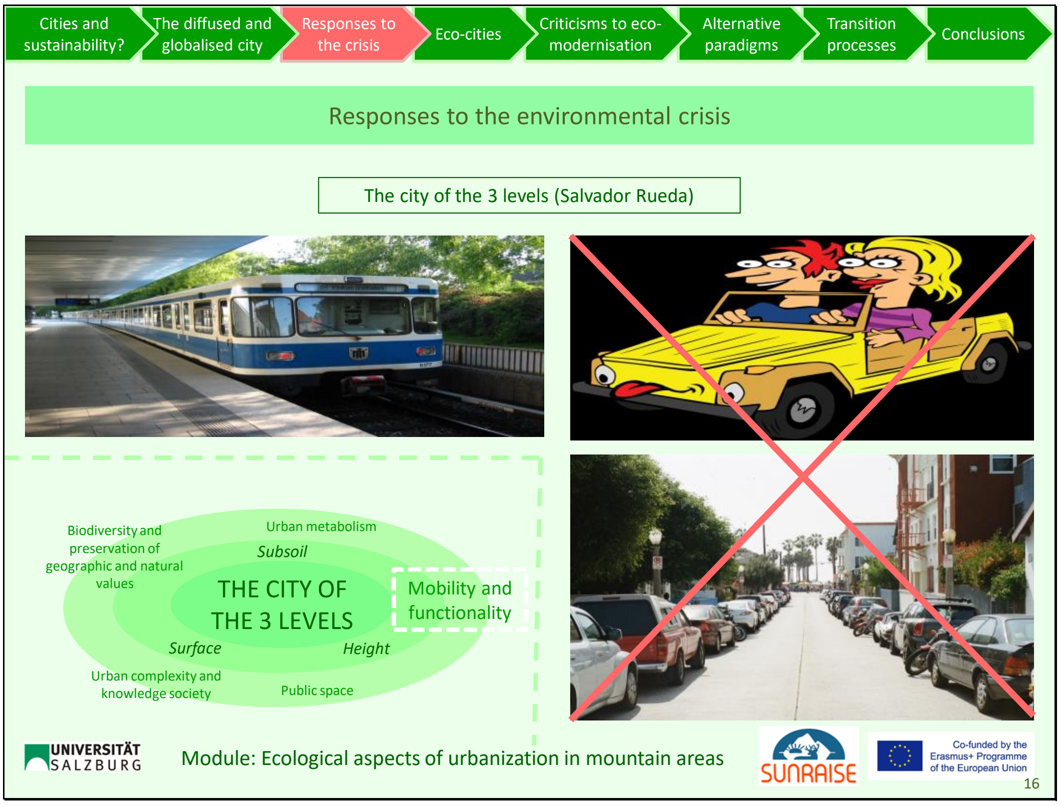

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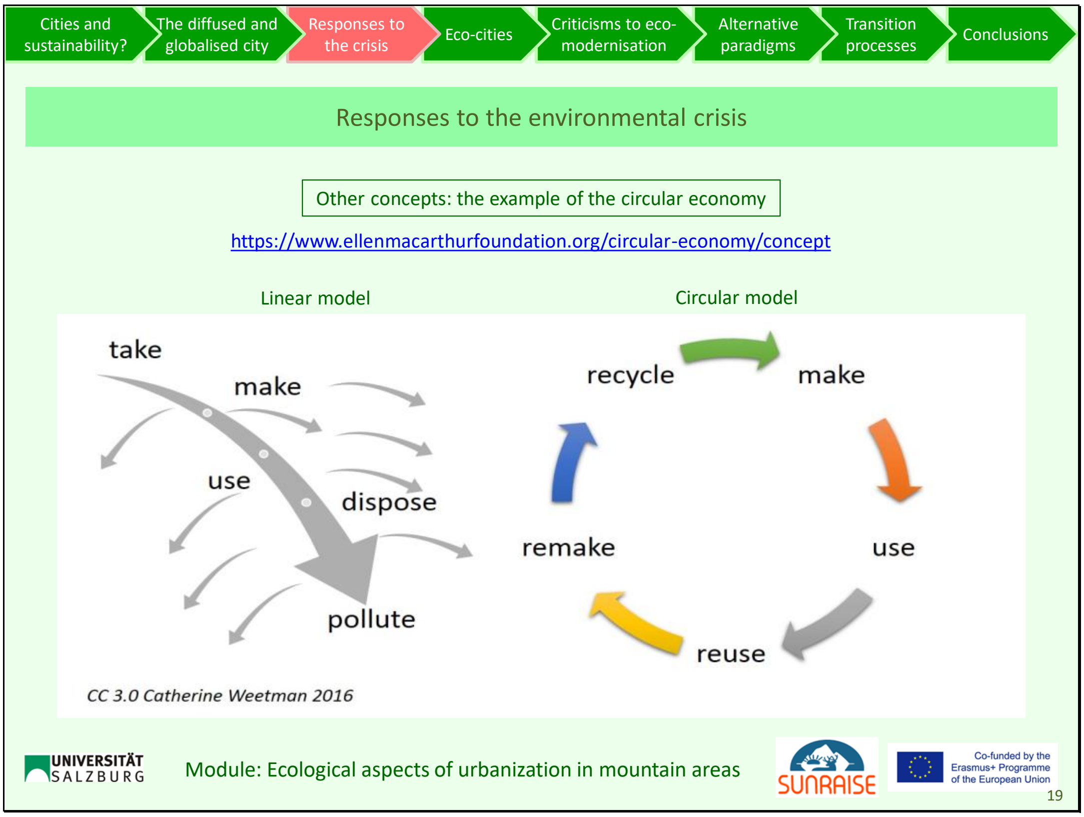

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Cities and sustainability? | The diffused and globalised city | **Responses to the crisis** | Eco-cities | Criticisms to eco-modernisation | Alternative paradigms | Transition processes | Conclusions

Responses to the environmental crisis

2 main responses

Ecological modernisation — Private sector

1. Emergence during the 1980s and 1990s → Multinational corporations wield more power than national governments
2. Market-based system of consumption and production is not incompatible with environmental reforms
3. Business language and concepts are used

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Cities and sustainability? | The diffused and globalised city | Responses to the crisis | **Eco-cities** | Criticisms to eco-modernisation | Alternative paradigms | Transition processes | Conclusions

Eco-cities

What is an eco-city?

Requirements to be met by an eco-city (Eco-city World Summit, 2008):

1. Ecological security
2. Ecological sanitation
3. Ecological industrial metabolism
4. Eco-scape
5. Ecological awareness

Eco-city of Dongtan, China

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Eco-cities

What is an eco-city?

Actions needed for the development of eco-cities (Łobejko et al., 2015):

1. Provide safe water, sanitation, etc.
2. Build cities for people
3. Identify ecological sensitive areas, etc.
4. Design cities for energy conservation, renewable energy uses and the reduction, re-use and recycling of materials
5. Build cities for safe pedestrian and non-motorized transport use

Masdar City, United Arab Emirates

Eco-cities

What is an eco-city?

Actions needed for the development of eco-cities (Łobejko et al., 2015):

6. Encourage investment in eco-city building
7. Provide education and training programs
8. Create a government agency at each level
9. Address global heating, etc. in the plans and actions of all institutions
10. Share experiences, lessons and resources

BedZED, UK

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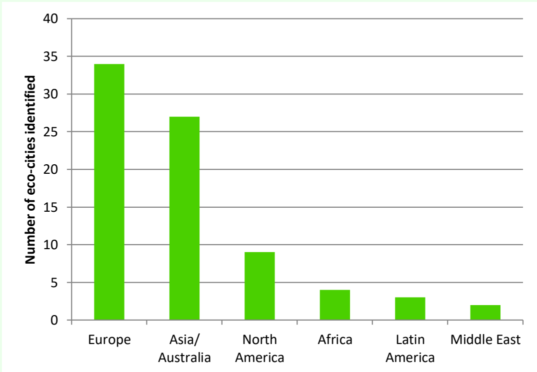
Eco-cities

Current trends

Joss (2009) identified:

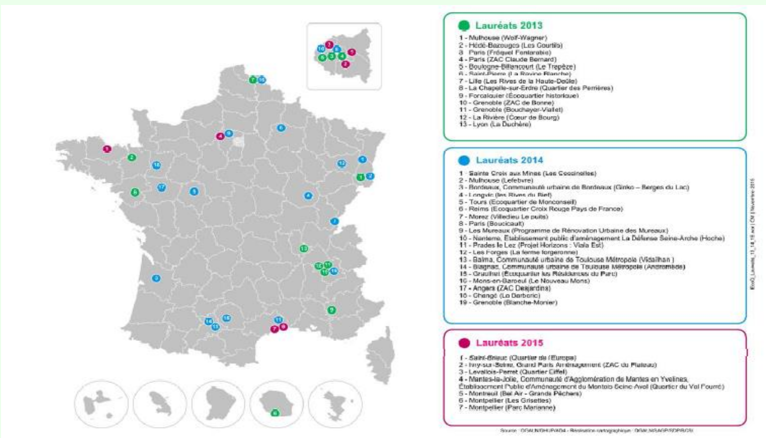
- 79 eco-city initiatives around the globe (autumn 2009)
- In Europe, most eco-cities in Scandinavian countries, the UK and Germany
- Over ¼ of the eco-city initiatives have been implemented



Number of eco-quarters identified by Joss (2009) per geographical region

Eco-cities

Current trends



Districts awarded as eco-quarters in France between 2013 and 2015 (*Ministry of Housing, Territorial Equality and Rurality of the French Republic, 2015*)

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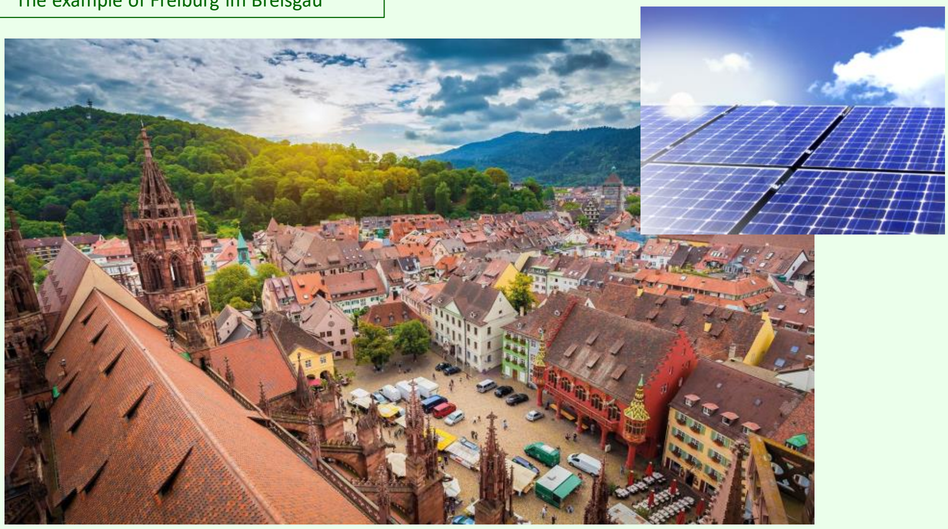
Eco-cities

The example of Freiburg im Breisgau



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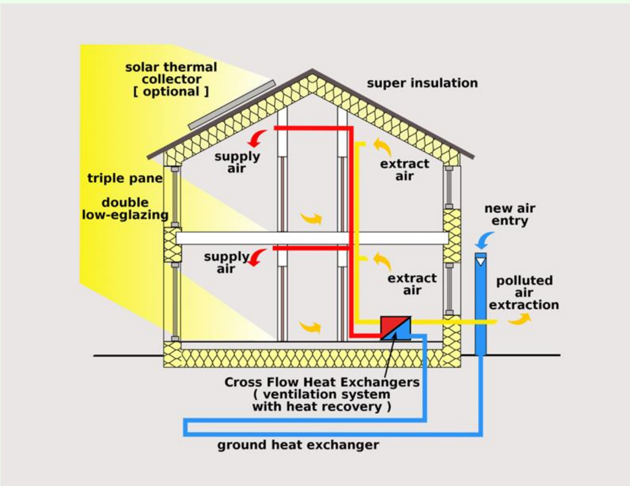
Eco-cities

The example of Freiburg im Breisgau

Energy saving



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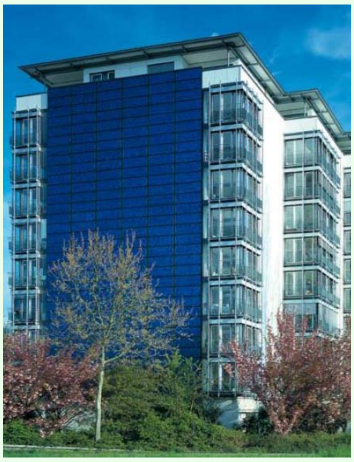
Eco-cities

The example of Freiburg im Breisgau

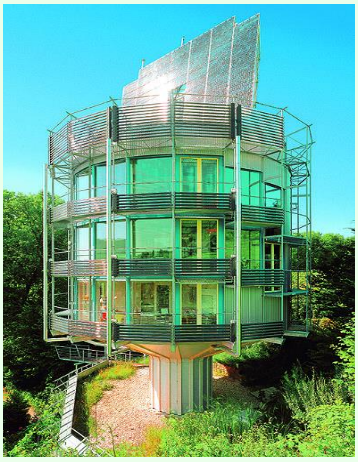
Renewable energy sources

Football stadium of Freiburg *(Management Marketing FWTM Freiburg, 2018)*

Solar city hall (*City of Freiburg, 2008*)



Solar facade of the residential complex at Wilmersdorfer Street (*City of Freiburg, 2008*)



The Heliotrope

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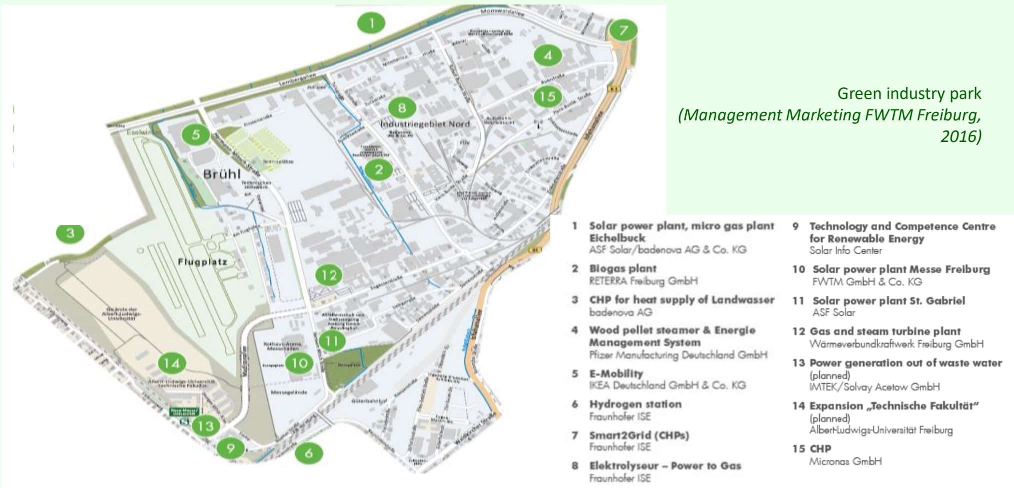
Eco-cities

The example of Freiburg im Breisgau

Renewable energy sources



Green industry park *(Management Marketing FWTM Freiburg, 2016)*

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Eco-cities

The example of Freiburg im Breisgau

Transport

Management Marketing FWTM Freiburg, 2016

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The example of Freiburg im Breisgau

Public involvement

Management Marketing FWTM Freiburg, 2016

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Eco-cities

The example of Freiburg im Breisgau

International reputation/ eco-tourism

Fraunhofer Institute for Solar Energy Systems

Eco-tourism in Freiburg *(Management Marketing FWTM Freiburg, 2016)*

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The example of Freiburg im Breisgau

Eco-district of Vauban – energy

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The example of Freiburg im Breisgau

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The example of Freiburg im Breisgau

Eco-district of Vauban – transport

Car-free areas
(https://freiburg-vauban.de/en/traffic/)

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The example of Linz

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The example of Linz

The SolarCity – energy

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The example of Linz

The SolarCity – water

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The example of Linz

The SolarCity – landscape and urban planning

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Eco-cities

Exercise 1 (SE 1)

Please gather in groups and prepare yourself for an exciting quiz on strategies for the sustainability of cities.

We will have three group, 1 hour and lots of points to deliver. And the most important thing: one winner. Who will be the winner? You decide!

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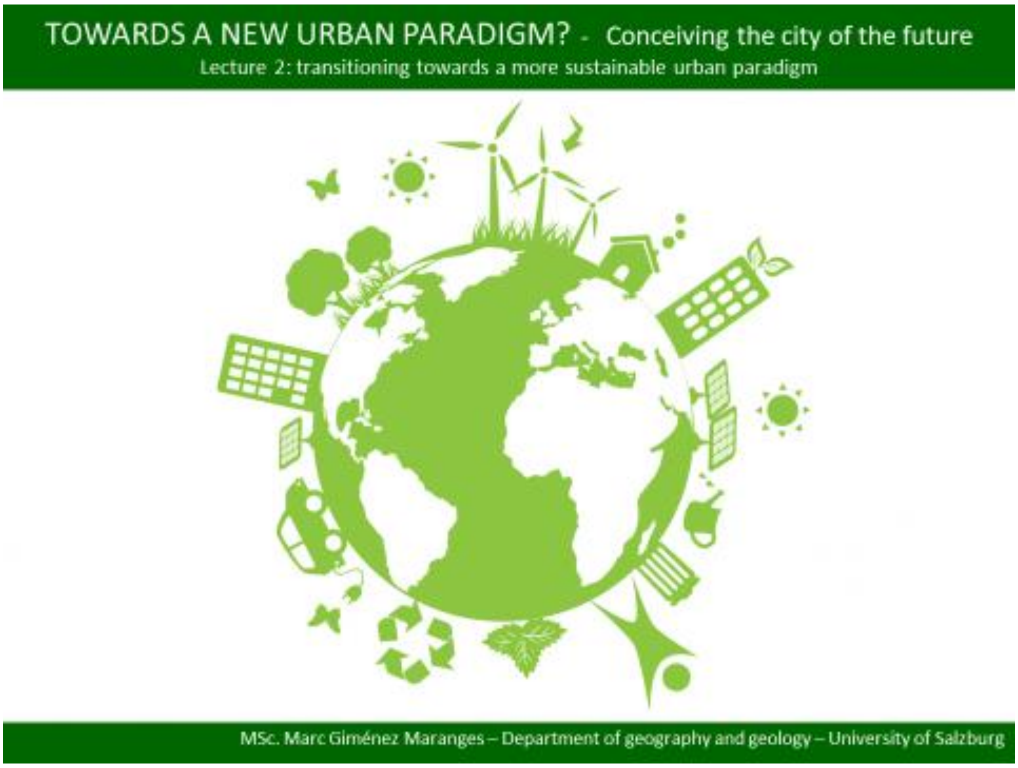
2. Transitioning towards a more sustainable urban paradigm



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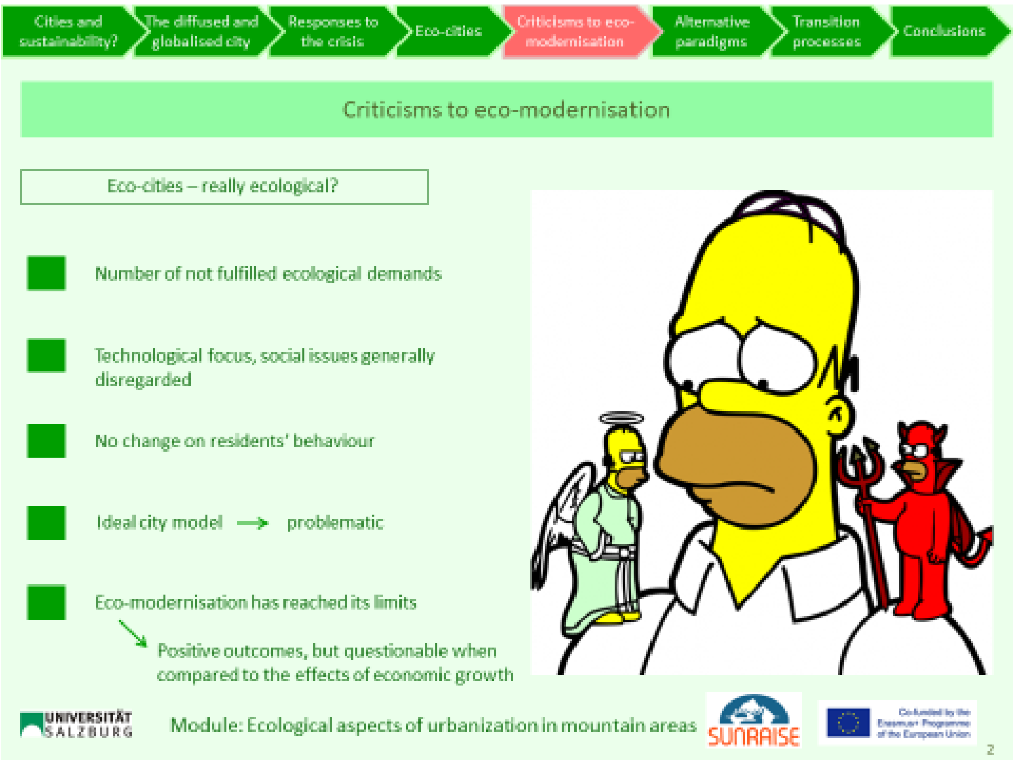

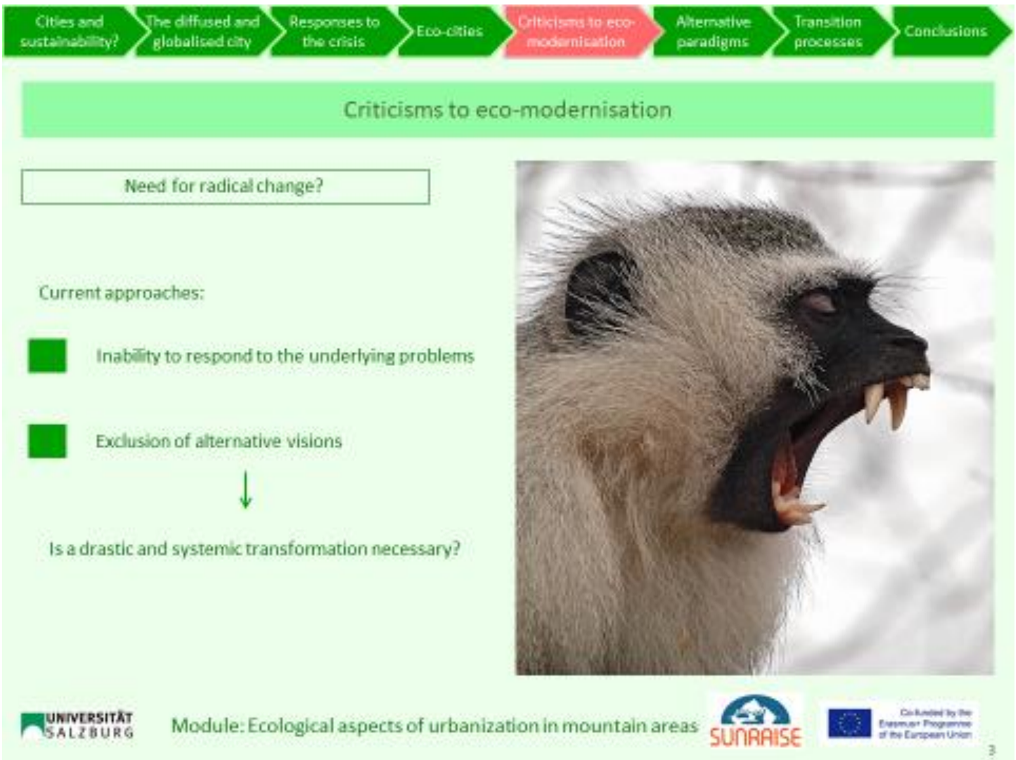

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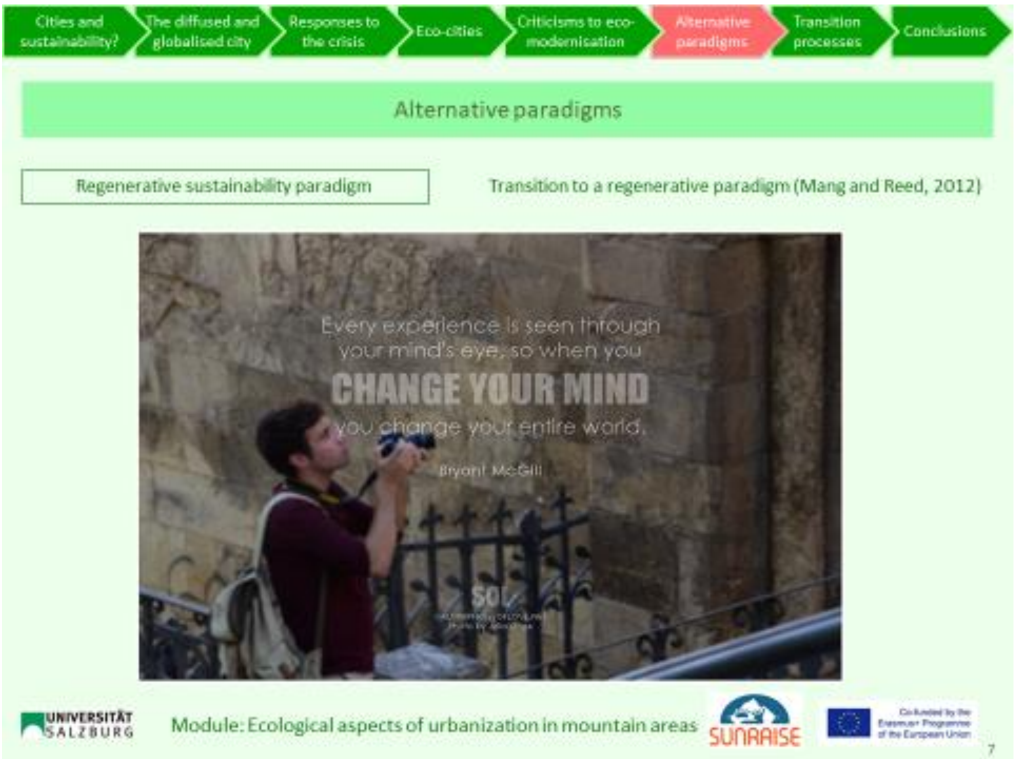

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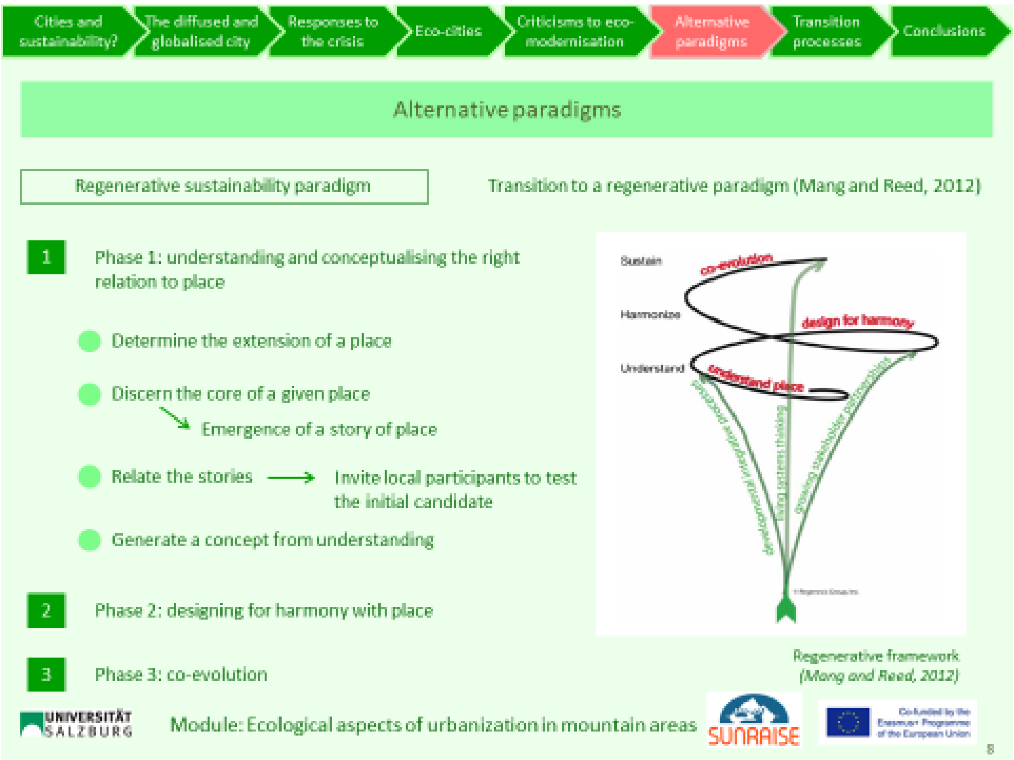

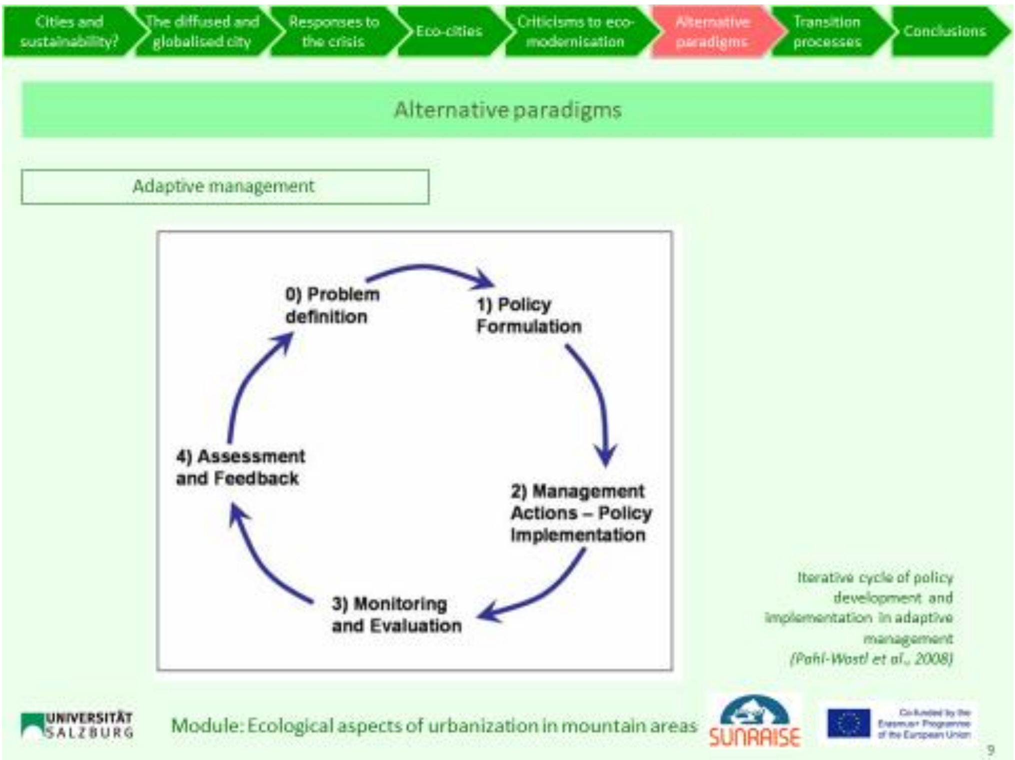

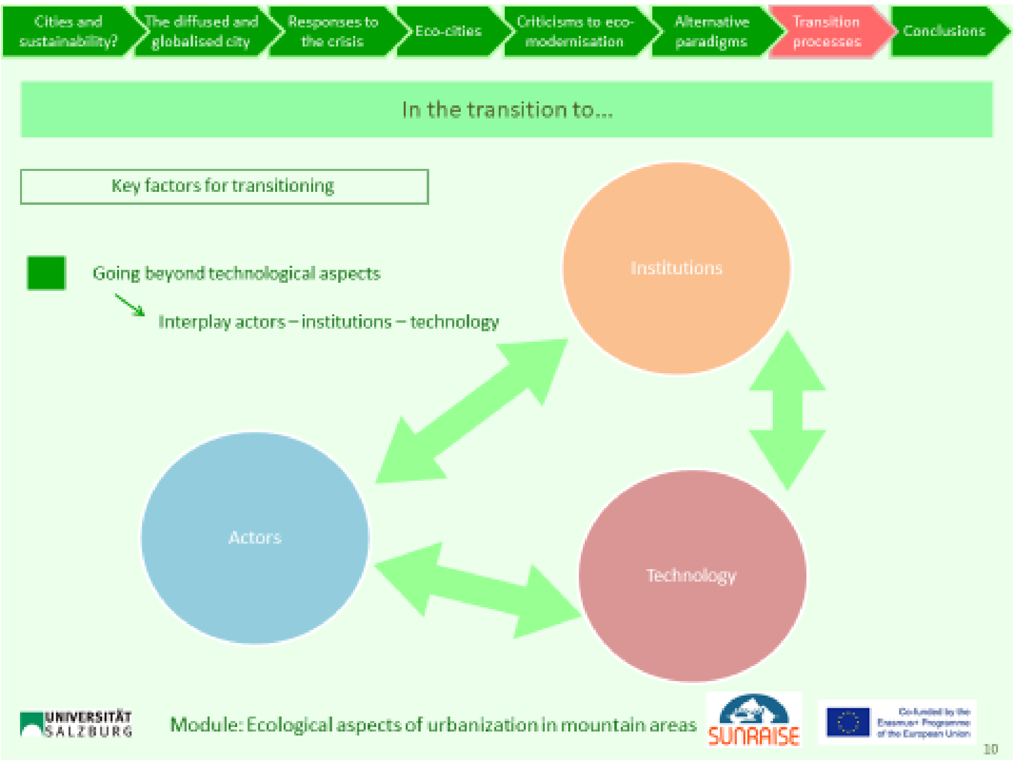
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Key factors for transitioning
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Interplay actors – institutions – technology
Institutions
Actors
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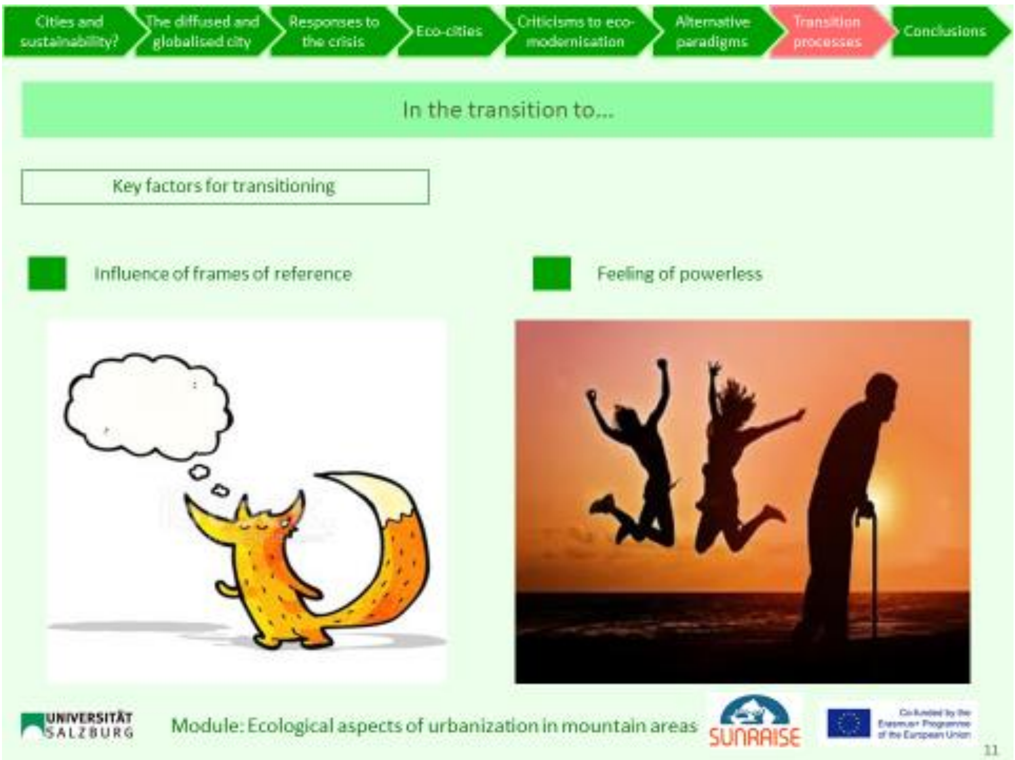
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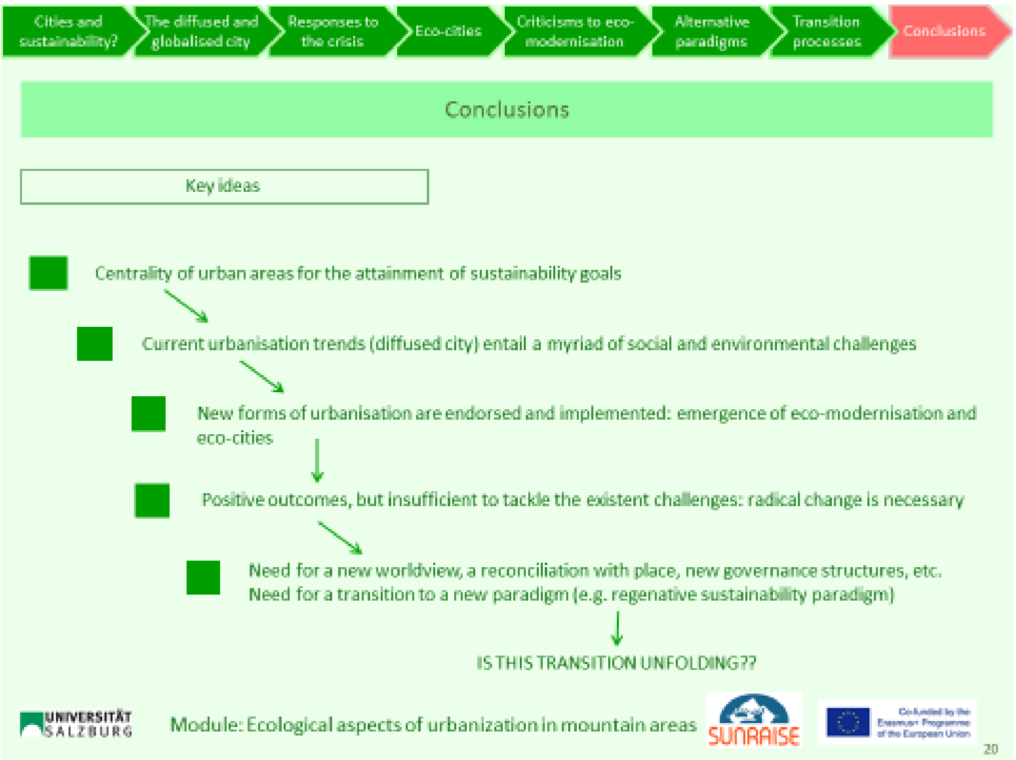


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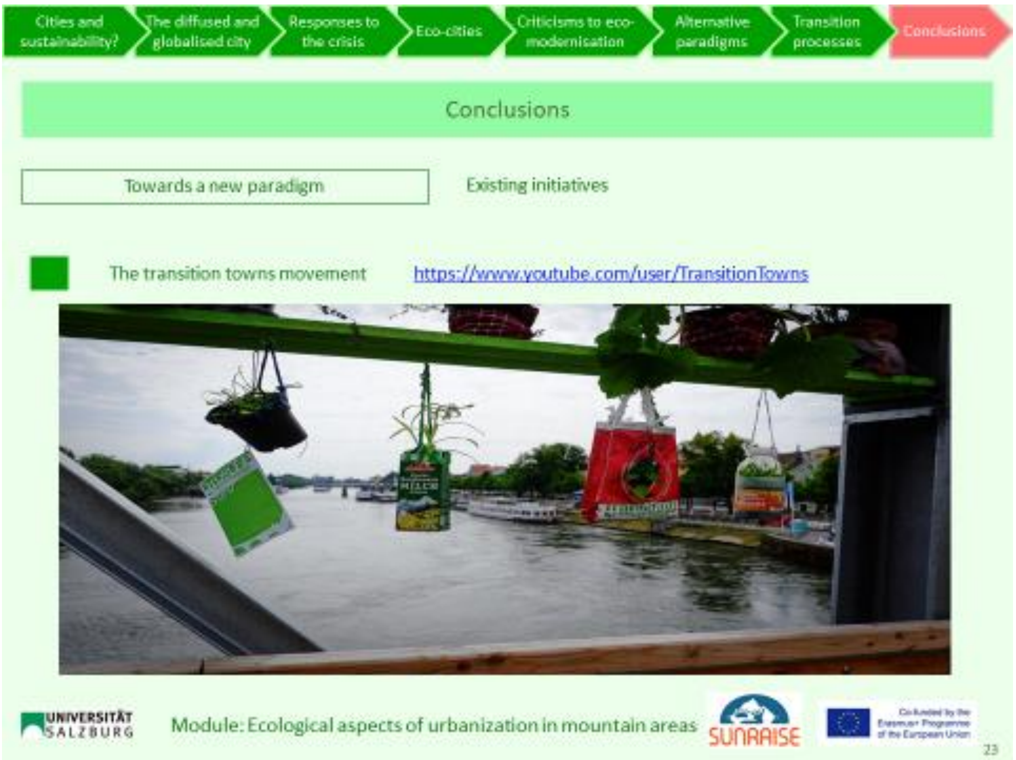
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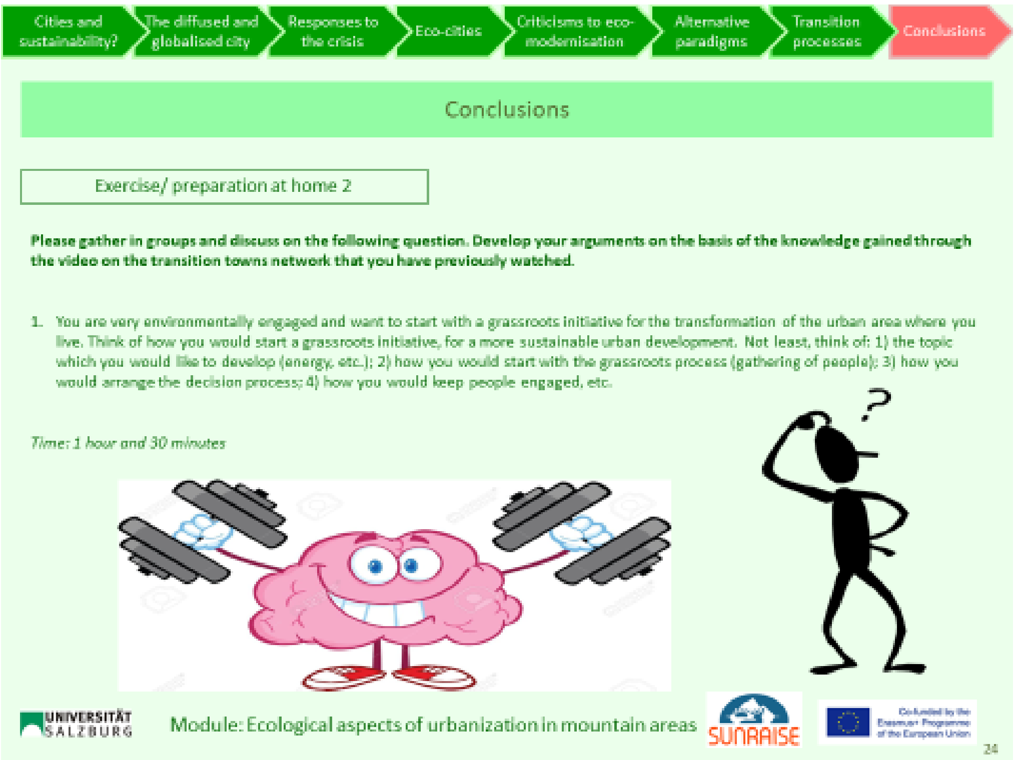

Module 1: Ecological aspects of urbanization in mountain areas

Learning module

"Ecological aspects of urbanization in mountain areas" (S2)

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Module 1: Ecological aspects of urbanization in mountain areas

S2: The case of urban nature and urban rainwater management

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Module 1: Ecological aspects of urbanization in mountain areas

1. Nature in cities

Key words

Nature, urban nature, urban green and blue infrastructure, four urban natures, urban ecosystem services, urban biodiversity

1.1. Definition: what is urban nature?

Theory

Definition - Nature

Understanding nature as the entirety of things that make up the world (all-nature) is only little expedient, since the notion of nature has meanwhile split into various separate terms and has made space for different approaches to nature (Leser 2008). If nature was defined as "natural" in the sense of "not affected by humans", nature would be hard to find (Breuste at el. 2016). "We perceive nature as given – yet it is a projection of cultural ideas and social ideals. It is thus not only an ecologic system, but also an ambiguous symbol. 'Locus amoenus' and 'locus terribilis': wilderness on the one hand, and magnificent, native, heroic and idyllic landscape on the other hand" (Kirchhoff and Trepl 2009, front text, translated from German).

Source: Breuste (2020b)

Definition - Urban nature

Whatever is defined as urban nature will be answered differently depending on the general understanding of nature (Breuste 1994, 2016; Brämer 2006, 2010; Reichholf 2007). Traditionally, nature is not to be found in cities, but in the untouched landscapes such as forests, coasts, fenlands or mountains.

Urban nature encompasses the entirety of natural elements in urban areas, including their ecosystems with their functional relationships, in relation to their use. Therefore, urban nature comprises all living beings, biocoenosis, and their habitats in cities. Almost all types of urban use host urban nature – either random ("wild") or brought in by human decisions (trees, plantations). Urban nature predominantly exists in open spaces, but it may also be found on, at and in buildings. By the existence of vegetation, areas not in use or areas explicitly intended for nature are defined as dominant urban nature. These areas are either actively used (e.g. meadows, grassland, parks,

gardens, urban forests, etc.) or are abandoned of their previous use (e.g. brownfields or certain wetlands and forests) (e.g. Naturkapital Deutschland TEEB-DE 2016, p. 15). Alongside to the scientific-analytic attempt of understanding nature (e.g. Brämer 2006, 2010; Trepl 1992), there is perceiving nature, which can be particularly found in romanticism (Kirchhoff and Trepl 2009). Understanding nature, perceiving nature and using nature has to be approached well in cities. A good approach will offer the "right" nature at the "right" place in a formative way to enrich the human habitat. Urban nature can be explained by a random spread and establishment according to the diverse habitat conditions in cities. It can further be explained by a cultural historic-utilitarian approach, which means looking at uses and their respective history. Urban nature is symbolic and embodies positive values (affection) or negative values (aversion, brownfields, dirt, threat, etc.) when left to its own resources (Breuste 1994, 1999, 2016). In the broadest sense, urban nature also encompasses all abiotic factors which influence the habitats. Among these factors are climatic parameters, hydrologic features and material parts of the soil and of the earth's surface. They are summarised as atmosphere, hydrosphere and pedosphere; these abiotic spheres are penetrated by the biotic biosphere. Together with their processes, feedbacks and interactions they make up what different scientists selectively or holistically investigate in: the "nature system" city (Breuste 2016).
Source: Breuste (2020b)

1.2. Urban blue and green infrastructure

Theory

Definition - urban green and blue infrastructure

The concept of "Urban Green Infrastructure" has its origins in planning. It was introduced to understand the urban green space network as coherent subject of planning. This understanding helps assigning the network functions that could not be assigned to single green spaces.

Urban nature consists from both green and blue infrastructure. The term "blue" can be used additionally to emphasise the existence of water bodies as part of urban nature. Building a link between "green" and "infrastructure" aims at attaching a similar value and meaning to urban nature as it is known from technical infrastructure. This link should help making urban nature more assertive, since the term infrastructure is understood as the required substructure for making it function as a whole. This necessity of a nature-based city should be expressed.

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Green infrastructure, in general also called green and blue infrastructure, describes a strategic planning network for promoting nature on different scales. Urban green infrastructure is a network of all urban natural elements – either close to nature or designed. This also includes nature in developed and sealed areas. Planning, maintaining and developing this network of various natural structures – different in size, position and ownership – is a common task for governmental, economic and civil agents.
Source: Breuste (2020b)

Target of green infrastructure

The aim is that in the sense of a socially, economically and ecologically sustainable city development, all natural components:

- Are usable for all citizens,
- Promote citizens‘ health and well-being,
- Collectively facilitate a high degree of biodiversity and experience of nature,
- Collectively contribute to an attractive cityscape and to a high quality of life,
- Generate locally intended ecosystem services for citizens.

(see Dover 2015; Naumann et al. 2011; Bundesamt für Naturschutz (BfN) 2017)

Source: Breuste (2020b)

Management of green infrastructure

Development, management and protection of urban green infrastructure is based on following principles:

- Adjusting usability and capacity of nature to the demands
- Thereto developing strategic plans
- Connecting nature
- Promoting multiple use and functional diversity
- Allowing unaffected development of nature and reducing cultivation and management

where possible An understanding of urban nature as a system, whose interacting elements are in communication with its environment, has been established by now. If this system is foresightfully planned, developed and maintained as "urban green infrastructure" it has potential to direct city development and integrate economic growth, nature protection and public health protection (Walmsley 2006; Schrijnen 2000).
Source: Breuste (2020b)

1.3. Urban nature is diverse

Theory ***Causes for urban biodiversity*** Compared to agriculturally shaped cultural landscapes and vast forests, urban nature is notably diverse and species rich. The causes for the comparably high degree of biodiversity in cities can be partially attributed to the increasing decline of biodiversity in agricultural landscapes due to intensive farming. However, it is also partially due to the particular ecological conditions provided by the urban environment itself. Due to the broad spectrum of human activity, the urban environment offers a range of habitats for different species. The main causes for urban biodiversity and species-richness are attributed to: • Structural variability within the urban landscape (variety of architectural structures including type and intensity of building usage) • Supply of nutrient-poor, dry and warm habitats. • Favourable for species tolerant of pollution and disturbances. • Support of pollution and disturbance resistant species • Supply of certain habitats and food resources • Introduction and propagation of non-native species (Breuste et al. 2016).
Source: Breuste (2020c)

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1.3.1. The four urban natures

Tools & Instruments

Introduction to the four natures approach

A simple method for presenting urban nature in a clear and concise manner was suggested by Kowarik (1992) in her "four natures approach". This categorization focuses on the particular features of urban nature (fauna, flora and vegetation) and distinguishes between four different "types of nature" based on the degree of anthropomorphic influence that the landscape has experienced. This approach allows for a better classification of further in-depth studies (Kowarik 1992, 2018; Breuste et al. 2016).

Source: Breuste (2020c)

First nature

"First nature" (Kowarik 1992) includes remnants of primeval landscapes as well as ancient forms of land-use such as forests and wetlands, which are often idealized as "pristine nature". They are the "old wilderness" to which something primeval still adheres and which is still a substantial part of spontaneous vegetation in general. Particularly forests are associated with "first nature".

Source: Breuste (2020c)

Second nature

"Second nature" (Kowarik 1992) consists of agricultural land which continues to be (commercially) used, although it has been engulfed by urban expansion and either lies at the outskirts of the city or has already been integrated into the city suburbs. This includes meadows, pastures and cropland as well as related landscape elements such as hedges, heather, drifts and grassland. "Second nature" is often heavily influenced by the city and typically characterized through intense management.

Source: Breuste (2020c)

Third nature

"Third nature" (Kowarik 1992) describes the "symbolic nature" found in gardens and parks – the type of urban nature typically perceived as "urban green" and specifically used to shape the city landscape as well as to provide economic and aesthetic value. "Third nature" ranges from kitchen gardens created out of economic necessity to decorative gardens ("city gardens" or parks) as aesthetic elements of division and design. Included are very diverse yet typical urban living spaces, such as house gardens, allotment gardens, roadside green, city parks, large recreation parks, single trees, tree avenues, etc. Their degree of anthropogenic shaping due to use and maintenance, however, varies strongly and is influenced by economic circumstances, trends and temporal fluctuations. Management, use and style are subject to trends, fashion and economic factors. Spontaneous growth is typically not tolerated and suppressed as the focus lies on aesthetic interpretation of nature.

Source: Breuste (2020c)

Fourth nature

„Fourth nature" (Kowarik 1992) is often given special attention in the research of urban ecology, as this form of nature is neither sown nor planted but instead occurs naturally in urban-industrialized areas. This type of nature emerges under anthropogenic influences as spontaneous growth and is closely linked to the degree of habitat change (soil, hydrological balance, micro-climate, etc.) following the cessation of specific land-use. In accordance with typical urban-flora, pioneer species develop, followed by spontaneous shrub-communities and urban pioneer-forests. This type of nature is frequently the subject of urban-ecological studies and has increasingly become the main area of interest in botanical research since the 1970s (e.g. Kowarik 1993, 2018, etc.).

Source: Breuste (2020c)

1.3.2. Examples of urban nature

Reference case

Urban woodlands

Urban woodlands are typical (residual) elements of cultural landscapes used for agriculture and forestry, which have expanded into the city and now exist within direct vicinity of urban development. These areas typically lie on the city's periphery but can also be fully integrated within the city itself.

There is an ongoing debate regarding the use of the terms "urban woodlands" and "urban forests" (e. g. Randrup et al. 2005). The terms are not synonymous and are used differently in e.g. English-and German-speaking countries. The English expressions "urban woods and woodlands" include "forest", "wooded land", "natural forest", "plantations", "small woods", and "orchards" irrespective of the ownership of said land (Randrup et al. 2005).

The characteristics of urban woodlands are:

- Tree population that creates a distinct forest-climate and specific habitat conditions.
- Embedded within the city or on the city's periphery (urban, peri-urban).
- Area of at least 0.3/0.5 ha.
- Publicly or privately owned and is typically accessible for the public.
- Provides a variety of ecosystem services such as recreation, health and wellbeing, climate regulation and hydrological balance, forestry, as well as biodiversity.

The area of urban woodlands is based on the minimal size enabling to create own microclimate and specific habitat characteristics. They are usually either planted or created through (vegetative) succession, and are typically commercially used. Their accessibility is an essential prerequisite for the cultural ecosystem services that they provide for the city residents (Randrup et al. 2005; Konijnendik 2008; Konijnendijk et al. 2005, 2006; Gilbert 1989; Burkhardt et al. 2008; Leser 2008).

Source: Breuste (2020c)

Reference case

Urban forest

Urban forest refers to the entirety of urban tree stock within the city, irrespective of ownership and is considered a resource and provider of ecosystem services benefitting the city residents. It includes woods and woodlands as well as all trees on both public and private land (street trees, trees in parks, private gardens, cemeteries, brown fields, orchards) (Dwyer et al. 2000; Randrup et al. 2005; Konijnendijk et al. 2006; Konijnendijk 2008; Pütz et al. 2015; Pütz and Bernasconi 2017).

Source: Breuste (2020c)

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Table 1.1

Elements of the urban forest *(see also Pütz and Bernasconi 2017)*

Element	***Description***	**Classified as Forest under the forestry law.**	**Private property**
Urban forest /urban woodland	*Forest within the city boundaries, often intensely /frequently used for leisure and recreation.*	Yes/no	Typically not
Forests in peri-urban areas	*Forests in the greater city area*	Yes	Yes/no
Woodland in residential areas	*Wooded areas with „forest character"*	No	Typically not
Parks	*Forest-parks with relatively dense tree stock, but also all other parks with woodland, patches of trees or individual trees.*	No	Typically not
City parks	*Privately owned gardens with fruit tree stock / orchards*	No	yes
Orchards, tree nurseries	*Agriculturally used land*	No	Yes
Canopy roads (tree avenues), tree patches, individual trees	*Remaining urban tree stock (excluding forests and parks) in public spaces, town squares and along streets*	No	no

Source: Breuste (2020c)

Reference case

Public parks

Parks belong to the most common and thoroughly researched forms of urban nature worldwide. This can be attributed to the fact that they are amongst the most intensely used forms of urban nature and are typically perceived by the public as the most important and often also the only useable form of urban nature. However, urban parks were eligible for broad public use at a relatively late stage.

The attractiveness of parks and the intensity of their use are based on the diversity of the park's features (natural elements and infrastructure) as well as the corresponding range of possible uses, which cater to the various interests of potential park users. For many people living in the densely populated city centre, parks are often the only possibility to experience and enjoy nature as well as to escape the daily stress of city life.

While parks were once typically located on the outskirts of the city (i.e. Hyde Park in London, Central Park in New York, English Garden in Munich), they soon became embedded into the urban environment as cities expanded during the 19th and 20th century. In the 20th century, new parks were established at the city's new periphery, often as vast landscape parks, intended to be used for leisure and recreation on weekends. The transition into the "open landscape" is often smooth– as is the transition between park, forest-park and urban woodland.

Parks are a public asset and should be equally accessible to all people. However, in practice this notion of equality seldom applies, as parks are rarely distributed evenly in cities and thus distance alone often limits their accessibility for some city residents. Further reasons for the unequal accessibility of parks can be attributed to the historical development of parks, the willingness of municipalities to provide parks as public assets, the availability and affordability of land, the morphology of the city itself, and lastly the interest-driven policies of certain population groups.

Public parks can be further divided into 4 categories based on their size, structure and functions:

- *Local Park* – up to 1.2 ha, coverage area 500 – 1000 m, usually includes a playground and landscaped green, no further infrastructure or facilities.
- *Neighbourhood Park* – up to 4 ha, coverage area 1000 – 1500 m, landscaped green with versatile infrastructure.
- *District Park* – up to 8 ha, coverage area 1500 – 2000 m, diverse landscape features / design and infrastructure, i.e. sport fields, play areas, children's play area.
- *Principal/City/Metropolitan Park* – more than 8 ha, coverage area includes the entire city, diverse landscape designs and infrastructure of particularly high quality and attractiveness (Dunnet et al. 2002).

Source: Breuste (2020c)

Reference case

Urban waters - blue infrastructure

Blue infrastructure encompasses all water bodies within a city. Both flowing and standing waters can be portrayed as urban water bodies. Use can lead to significant changes of ecologically relevant traits

in urban water bodies compared to water bodies outside of cities (Breuste et al. 2016). Examples for urban water bodies are ponds, lakes, rainwater retention basins, streams, rivers, drainage channels, canals, and harbour basins. (Faggi and Breuste 2015; Brun 2015; Grafton et al. 2015). Water bodies in cities are typically well received by city residents. Prerequisites for this acceptance include the minimizing or even better the complete prevention of the risks associated with water. The biggest risks related to water bodies are floods, danger of drowning (especially in regard to small children), health hazard due to pollution, and olfactory and visual impairment (i.e. due to sewage and waste). On the other hand, the high attractiveness of water bodies is based on several factors, such as uniqueness of water as an (inaccessible) counterpart to familiar land, their high visual aspect (reflection of light, view over water bodies, etc.), the opportunity to witness the processual character of water, as such impressive dynamic short-term changes. The possibility to observe life forms and processes near the water like birds, fish, various insects or natural vegetation development is also an important feature attracting people. To sum up, water is linked to high quality of living in cities. Hence, urban water bodies provide an opportunity of use for city residents of all ages. Together with green spaces, they constitute an attractive green- and blue infrastructure. The linear structure of flowing water bodies is a unique advantage and - together with the waterside vegetation - can create natural corridors in cities. A prerequisite, however, is that city management and planning are aware of this advantage and that these corridors are not primarily used as traffic routes. Natural and / or man-made water bodies are frequently elements of city parks and can even connect them (e.g. Summer Garden in Beijing, West Lake in Hangzhou, English Garden in Munich). The main function, namely the preservation of animal and plant life, consequently needn't be impaired, if managed properly. Cities with wetlands are not as rare as one might presume, yet residents are seldom aware of these areas, therefore they are often only infrequently visited. From the perspective of environmental protection this is not necessarily viewed as a problem, as disturbances caused by humans can interfere with habitat features, whereas their absence could be beneficial for environmental protection. Examples for important wetlands in cities include parts of Chongming Island in Shanghai (RAMSAR Site), Ljubljana marshland in Ljubljana, the Venetian Lagoon, Wetlands of the Sabana de Bogota in Bogota, marshlands in Salzburg, etc. A major problem with urban water bodies is their limited or even complete lack of accessibility. This is not only due to a general lack of attention paid to this form of urban nature, but often because of the relatively high effort required to make these areas accessible, while also minimizing risks for both visitors and the animal and plant life. Hence, their isolated location and low accessibility remain a reason for their infrequent use. Wherever these obstacles are not present and the water bodies are accessible, they are frequently used– sometimes to an extent requiring regulation of attendance.
Source: Breuste (2020c)

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Table 1.2

Change of the function of water bodies in central European inland cities based on anthropogenic use and perception *(Kaiser 2005, p. 22)*

	Before 1750	*1750-1850*	*1850-1915*	*1915- 1950*	*1950- 1980*	*From 1980*
protection	⬤	●	-	-	-	-
Food production, fishing, irrigation	⬤	⬤	●	•	-	-
Transport route	⬤	⬤	●	•	•	•
Energy source	⬤	⬤	⬤	•	•	●
Fresh water supply	⬤	⬤	●	●	●	●
Service water supply	⬤	⬤	⬤	●	●	●
Waste disposal	⬤	⬤	⬤	⬤	●	●
Leisure and recreation	-	-	-	•	•	⬤
Improvement of housing environment	-	-	-	-	-	●
Habitat for plants and animals	-	-	-	-	-	●

⬤ Great importance ● Moderate importance • Little importance - No importance

Source: Breuste (2020c)

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Reference case

Urban gardens

Gardens are the last remaining connection between city residents and rural life. Hence, both private and public gardens are remnants of nature within the city boundaries.

The cultivation of fruits and crops has always been a subsidiary use of nature in cities and primarily serves as food supply for the city residents. As this form of food provisioning fails to support the demand of a growing city population, urban gardening and agriculture is typically only a supplementary form of food provisioning. The term Urban Agriculture has been used since the 1930s in reference to the production of food (fruit and vegetables) within the city boundaries (Qinglu Shiro: Agricultural Economic Geography) (Mougeot 2006; Swintion et al. 2007; Barthel and Isendahl 2013). Private and communally managed gardens are usually no larger than several hundred square metres and located within proximity of their users, i.e. as home-gardens, allotment gardens or community gardens. In contrast to large public city gardens, they allow for shaping and design according to the desires and needs of their users. Hence, the users are those who shape and manage the gardens. These types of gardens are frequently used for recreation and horticulture (Dietrich 2014; Breuste et al. 2016).

Source: Breuste (2020c)

Reference case

Allotment gardens

Allotment gardens represent a distinctive way of urban gardening. They are usually used both for recreation and food production and are managed by individuals. Allotment gardens continue to play a significant role in the 21st century regarding ecologically oriented urban development, as well as human health and leisure activities within the urban environment - particularly in large cities (in Germany alone there are approx. 17 million hobby gardeners) (Breuste 2010; Breuste and Artmann 2015; Bell et al. 2016; Breuste et al. 2016). Today, allotment gardening is a European phenomenon with worldwide “outposts”.

Source: Breuste (2020c)

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Table 1.3

Categorization of urban gardens and urban agriculture *(Greensurge 2015; Breuste et al. 2016)*

Type of garden and agriculture	***Type of green space***	***Description***	***Use / perception***	***Management / maintenance***
Urbane Gardens	*Front yard*	Decorative gardens (5 – 20 m²) in front of dwelling units, on open street areas	Private / public	individual/ maintenance company
	House garden	Garden connected to a private domicile used for both decoration and food production. 150 – over 1000 m²	Private /private	individual
	Allotment garden	Patch of rented land used for recreation and food production 200 – 400 m²	Private / publicly visible	individual
	Green buffers	Garden area between more storied apartment building several 1000 m²	Semi-public / semi-public	maintenance company
	Community gardens	Kitchen gardens, 100 – several hundred m²	Collectively / semi-public	Collectively
Urban agriculture	*Arable land*	Wheat production	Commercial / private or public	privately / machines
	grassland	Fields and meadows / meadows and pastures	Commercial / private or public	privately / machines
	orchards	Fruit production – high stemmed trees	Commercial / private or semi-public	privately
	Plantation	Fruit production – small trees / bushes, bio fuel production	Commercial / private	privately / machines
	Horticulture	Land devoted to growing vegetables, flowers, berries, etc.	Commercial / private	Privately / Individually or with or with machines

Source: Breuste (2020c)

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Reference case

Community gardens

Another distinctive kind of urban gardening corresponds to community gardens. Community gardens are publicly accessible pieces of land that are collectively maintained and used by a group of people for the purpose of gardening. Unused land areas are frequently converted into such community gardens. The legal status of community gardens varies. The community responsible for maintaining these gardens is united by a mutual interest in gardening, particularly by the cultivation of healthy fresh food. Aside from gardening, the community is united by a common desire to participate in joint actions to achieve certain social, environmental or socio-political goals. The concept of "community gardens" was developed in the United States during the 1970s and was established in Europe during the 1990s – frequently in conjunction with goals of social integration (intercultural gardens) (Rosol 2006; Larson 2012). Community garden organisations also aim to send a political message with their activities, such as actively and concretely contributing to the "cultural- and energy revolution" by collectively using and shaping green spaces. They also serve as a field for experimentation regarding new forms of society (Reimers 2010).

Source: Breuste (2020c)

Reference case

Wildlife gardening

Wildlife gardening is a special kind of urban agriculture that aims for the reintegration of nature with the processes of gardening. This notion is becoming increasingly attractive as an individual and personal countermeasure against denaturation. As such, wildlife gardening can be seen as a lifestyle and entails certain values, which have established themselves in society. Wildlife gardens leave some of the gardening to nature and provide a habitat for certain wild plants and animals. Maintenance is reduced in favour of natural processes and natural elements are used wherever possible. This provides the gardener with a sense of contributing to nature and a healthy environment.

Aspects of near-nature gardening includes:

- Plant selection: wild and robust species are planted.
- Maintenance: reduced maintenance, no strict order /arrangement, wild meadows – infrequent mowing, reduced soil sealing (greening of pavement grooves), sand, chips (wood/stone) and gravel used for pathways, composting and permaculture.

- Habitats: for insects, bees, butterflies, birds and small mammals, “Insect-hotels”.
- Fertilizer: no artificial fertilizers, no insecticides or pesticides, use of home-made (organic) fertilizer.
- Elements: shrubs, patches, herb spirals, fruit trees, bushes, predominantly indigenous species, natural materials for fences and boundaries, water areas.
- Soil: only natural measures should be implemented to maintain and improve soil.

Source: Breuste (2020c)

Reference case

New urban wilderness

New urban wilderness are habitats that have experienced strong anthropogenic changes (i.e. industry) that suddenly came to a standstill. Therefore, these areas often experience few disturbances for several years, enabling the emergence of succession stages ranging from pioneer species to entire urban forests. Thus, they belong to the few urban habitats that are not managed and allow for scientific observation. New urban wilderness quickly became an experimentation field and object of ecological studies (Gilbert 1989; Ossola and Niemelä 2018). Urban brownfields are valuable habitats for many species – some of which cannot be found elsewhere. Moreover, they offer opportunities to observe and experience nature like nowhere else in the city. This importance of urban brownfields will increase, as the value of urban brownfields for said uses has not yet been recognized. Currently, the reappropriation of brownfields for developmental use is still prioritized.

The acceptance of Kowarik’s “fourth nature” approach and its potential uses for experiencing nature, as well as the possible integration of succession zones with traditional parks, will largely depend on whether people manage to shed their prejudices towards “unorderly” and “unsightly” natural succession, and instead become acquainted with this “fourth nature”. In order to facilitate such a change of perception, greater efforts for environmental education are necessary, especially in kindergartens and schools. Mathey et al. (2016) demonstrated in a study that the primary stages of succession through herbaceous pioneer species as well as the end stages characterized by dense woodland were viewed as the least favourable areas for personal use. The intermediary stages of succession were, however, viewed more favourably. This indicates that some “design” intervention might be necessary to manage succession stages and make them more appealing for users.

Source: Breuste (2020c)

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1.4. Urban ecosystem services

1.4.1. Definition: what are urban ecosystem services?

Theory

Definition - Urban ecosystem services

The concept of urban ecosystem services aims to measure and assess the usefulness of urban nature for city residents and provide a foundation for urban development and planning. “Urban ecosystem services” refer to benefits for city residents provided by urban nature. They are based on ecological functions that offer a direct or indirect benefit for human well-being (De Groot et al 2002; Fischer et al. 2009). Since urban nature is generally landscaped, it requires maintenance. The provision of ecosystem services is not “free” but comes at a price. An economic perspective allows for a more concrete understanding of the potential of “ecosystem services”. Nature, as a service provider, ought to be better integrated into decision-making processes. The permanent protection and promotion of “nature capital” in urban areas aims to contribute to physical and mental well-being, as well as the preservation of our natural basis of life (Naturkapital Deutschland – TEEB DE 2016, p. 7). Overall, it is about analysing the type, capability and scope of ecosystem services in regard to their contribution to human well-being and further including these aspects in decision-making processes.

The efficiency of urban ecosystem services depends on human action, management and care, and can consequently be reduced or increased (e.g. management of green spaces, street trees, etc.) (Langemeyer et al. 2018). In the urban context, ecosystem services are at the intersection of urban nature and society. Ecological functions of urban nature only become ecosystem services through their benefit for individuals, different social groups or the community. Hence, conceptual differences can arise (Naturkapital Deutschland – TEEB DE 2016). The provided benefit has a perceived and appreciated value (e.g. recreation and leisure in the city park) or is consumed without any awareness of its value (e.g. clean air). Often the value and use of ecosystem services are only noticed after they have been reduced or removed (e.g. lack of green spaces, felling trees alongside roads, etc.).

Source: Breuste (2020a)

Terminology surrounding ecosystem services

The terminology surrounding ecosystem services has not yet been standardized (Bastian et al. 2012a,b). De Groot et al. (2002) cite “ecological functions” as the basis of “ecosystem services”. Bastian et al. (2012a,b) include ecological functionality (structures, components and processes) in “ecosystem properties” and consider this to be the foundation of “ecosystem services”. Haase et al.

(2014) and Naturkapital Deutschland – TEEB DE (2016) summarize the basic properties (e.g. habitat availability, carbon- and nitrogen cycle, decomposition, primary production) as "ecosystem functions" that characterize ecosystems ("service providing units") in a particular way. Many of the "ecosystem services" listed by the Daily (1997) or the Millennium Ecosystem assessment Report (MEA) (2005) are not necessarily services for the user but are more appropriately described as "ecosystem processes or functions" (Boyd and Banzhaf 2007). Bastian et al. (2012a,b) add "ecosystem potentials" as a third category alongside "ecosystem properties" and "ecosystem services". This category evaluates the natural assets from the perspective of the user and contrasts the "service capacity" of the area with the services provided, while incorporating factors such as risks, carrying capacity, resilience and resistance towards stress.
Source: Breuste (2020a)

1.4.2. Categories of ecosystems services

Theory

Three categories of ecosystem services

The "Millennium Ecosystem Assessment" (MEA) (2005), published by the United Nations, uses three categories for ecosystem services that provide direct benefits for humans:

- Provisioning services:
    - Provisioning of food
    - Provisioning of resources
    - Provisioning of fresh water
- Regulating services:
    - Reduction of air temperature
    - Reduction of air pollution
    - Reduction of noise pollution
    - Reduction of the pollution in soil and groundwater
    - Reduction of the contribution towards climate change

• Cultural services:
  ○ Physical and mental recuperation
  ○ Emotional “nature experience”
  ○ Acquisition of knowledge about nature
  ○ Spiritual and aesthetic appreciation

Source: Breuste (2020a)

1.4.3. Disservices

Theory

Definition - Disservices

The undesired effects of urban nature on individuals, groups or the community are referred to as “disservice” (Lyytimäki and Sipiä 2009; von Döhren and Haase 2015). These include damages in building structures caused by plant growth, road hazards such as fallen trees or visual obstruction caused by vegetation alongside roads, health risks caused by animals and plants (allergies, spread of diseases). Greening can also cause some social problems, such as “green gentrification” (Wolch et al. 2014). This refers to the displacement of residents by improving the green infrastructure of an area to increase its attractiveness and consequently the residential value, real estate and rent prices.

Negative effects of natural processes, some of which come from areas outside the city (e.g. floods, landslides, mud slides, etc.), are risks immanent to nature and must always be calculated and managed, yet can never be entirely discounted.

Source: Breuste (2020a)

1.4.4. “Units of account” for ecosystem services

Tools & Instruments

“Units of account”

Boyd and Banzhal (2007) argue for “units of account” for ecosystem services, so that they can be linked to these as a public asset. The selection of such “service provider ecosystems” was already

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used as a frame of reference at the beginning of the debate on urban ecosystem services.

Source: Breuste (2020a)

Table 1.4

Correlation between ecosystem services and their service providers *(according to Niemelä et al. 2010, p. 3229-3230, edited)*

Group	*Ecosystem services*	*Service providing unit*
Supporting services	Wood production	Various tree species
	Food: venison, berries, mushrooms	Various species
	Fresh water supply	Groundwater, surface water
	Soil	Suspension and securing
Regulating services	Micro climate regulation on street and city level	Vegetation
	changes in heating costs, O_2 production, CO_2 sequestration	Vegetation (particularly forests, trees)
	Provisioning of habitats	Geobiocenosis
	Air purification	Vegetation, particularly forests, trees, biodiversity, vegetation cover, microorganisms in soil
	Noise reduction in residential areas and along transport routes	Protected green spaces, dense/natural forests, surface cover
	Rainwater collection, infiltration, absorption of heavy rainfall	Vegetation cover, soil, wetlands, ponds
	Pollination, care of plant communities, food production	Insects, birds, mammals
	Humus formation and preservation of soil nutrient content	Waste, invertebrae, micro-organisms
Cultural services	Recreation	Green and blue infrastructure
	Psycho-physical and social health benefits, knowledge creation, research and education	Biodiversity

Source: Breuste (2020a)

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1.4.5. Assessment tools

Tools & Instruments

Tools for the assessment of urban ecosystem services - an introduction

In a world of goods and assets, the value of a product is determined by supply and demand. Urban nature is such a product and can be assessed according to this scale. All things considered, the focus always lies on the "value" of urban ecosystem services and therefore the value of individual components of urban nature (e.g. the "value" of a park). In a broader sense, the value can refer to worth, meaning and importance for the individual or a community. In a narrower sense it is an expression of the equivalent of a commodity (expressed in some form of currency).

Although this field of work is still developing, there are several approaches, methods and instruments. These can be divided into the following two categories:

- Non-monetary approaches (meaning and importance, which are often difficult to quantify)
- Monetary approaches („value" of nature expressed in monetary units)

The juxtaposition of different values should be taken into consideration and value pluralism should be explicitly emphasized. Ecosystem services, however, ought to be ascertainable both in a quantifiable sense as well as in regard to their value. In this regard, it is also important to distinguish different values (value pluralism), because the " total value" of individual services provided by a single component or element of urban nature cannot be compared to that of another– even if they both have the same "summarized / total" value. The recipients, the evaluators as individuals and certain social groups, the actual beneficiaries or even the entirety of all potential users must also be taken into consideration, since the value of urban nature is largely determined by those who evaluate it.

Source: Breuste (2020a)

Objectives

The purpose of the assessment is also relevant and Naturkapital Deutschland – TEEB DE (2016, p. 30) mentions the following objectives:

- Promoting awareness for the importance of nature (awareness mechanism)
- Accounting ecosystem services (e.g. for accounting the national economy – accounting mechanism)

- Communication with interest groups and / or the public (feedback mechanism)
- Support for setting priorities in political decision (decision-making mechanisms)
- Information on the choice and design of instruments (e.g. the outline of compensation payments, or the inclusion of interest groups through the application of certain assessment processes (information mechanism)) (Naturkapital Deutschland – TEEB DE 2016; Lienhoop and Hansjürgens 2010; Gómez-Baggethun et al. 2015).

Source: Breuste (2020a)

Assessment approaches

Naturkapital Deutschland – TEEB DE (2016) comes up with several different methodological approaches for the assessment of urban ecosystem services:

- Importance of urban nature and its effects on the health and quality of life of individuals.
- Participatory of deliberate processes (processes of contribution or negotiation)
- Quantitative bio-physical and socio-ecological indicators ("ecological assessment", supply *based approach)*

The identification and assessment of ecosystem services based on individual preferences include the assessment of health costs and quality of life. The assessment of ecosystem services based on social values includes the assessment of urban nature in the communal budget management.

Currently, socio-ecological approaches for the identification and assessment of ecosystem services predominantly build on regulating ecosystem services. Other frequently used approaches for the socio-economic assessment particularly emphasise the correlation between land-use and land-use management and the provisioning of ecosystem services. Bio-physical indicators of an environment are also assessed, particularly green spaces, and compared to the user's perception of the recreation service. Unfortunately, these types of perception-based studies are often associated with high financial costs, time consumption as well as the difficulty of integrating measurement- or model-based analyses of the supply side (Haase et al. 2014).

Source: Breuste (2020a)

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1.5. Urban biodiversity

1.5.1. Definition: what is urban biodiversity?

Theory

Definition - Biodiversity

The term biodiversity or "biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems (CBD 2018). The variability of special, temporal and functional features of natural elements of different hierarchical classification is an aspect of biodiversity (Beierkuhnlein 1998).

Source: Breuste (2020a)

Definition - Urban biodiversity

Urban biodiversity comes from the particular features of urban ecosystems, of which it is comprised. This pertains to all species and habitats and consequently different levels of integration regarding biological diversity (Beierkuhnlein 1998). Urban biodiversity does not exclusively pertain to residual habitats and indigenous species within the urban environment, but also includes the diversity of cultivated and non-native plants. Therefore, urban biodiversity is not merely the result of natural processes, but also that of conscious and unconscious shaping by humans, particularly in regard to the way they use urban ecosystems. Biodiversity is not discovered, but instead is designed. This means a paradigm shift regarding the traditional ideas of nature conservation that focus on preserving pristine habitats and exclusively on indigenous species.

Source: Breuste (2020a)

1.5.2. Urban biodiversity, ecosystem services and human well-being

Theory

Cities as hot spots in biodiversity

Cities are frequently identified as regional "hot spots" of biodiversity, due to the high diversity and population density of species found within them (Werner and Zahner 2009). Kühn et al. (2004)

determined that in central Europe city areas over 100 km² and with a population of over 200,000, more than 1000 plant species and anywhere between 30-600 plant species per km² can be expected. This far surpasses the biodiversity of intensely used agricultural areas.

The high number of species in cities is linked to the habitat diversity that they provide and often to extreme and particular location conditions. The comparison of plant diversity and nature-based ecosystems, in which mostly indigenous species are found, substantiates that urban biodiversity is often characterized by non-native species (Breuste et al. 2016).

Source: Breuste (2020a)

Case study

Urban biodiversity in Frankfurt am Main (Germany)

In the Frankfurt area, for example, there are 1675 different fern- and flower species. At only 0.06 % of Germany's total surface area, this region accounts for approximately half of all species known to be found in Germany. In the Taunus mountain range, which is 11 times larger than the Frankfurt area, merely 1250 species can be found.

Source: Breuste (2020a)

Theory

People and biodiversity

The complex relationship between humans and biodiversity is referred to as the "people-biodiversity paradox" (Fuller et al. 2007; Shwartz et al. 2014; Pett et al. 2016). This refers to the incongruity of:

- Biodiversity preferences of people and the manner in which they relate to their personal subjective sense of well-being
- The limited ability of individuals to become aware of the biodiversity that surrounds them.

Haber (2013, p. 32) states that it is misleading to claim that biodiversity is a basis for human existence. Between biodiversity and the perception of said biodiversity ("subjective biodiversity") lies a significant difference. People can make use of biodiversity without needing to understand or even be aware of the complexity of biodiversity. There is a great affinity towards urban nature in its neat and maintained form, however, only little understanding of biodiversity beyond the educated elite and this despite great efforts from the media to educate the public on the environment. In both the

scientific and environmental-political debate, the assumption persists that urban biodiversity is a prerequisite for ecosystem services in cities and that its increase results in an increase of ecosystem services (e.g. Hand et al. 2016; Kabisch et al. 2016; Ziter 2016).
Source: Breuste (2020a)

Correlation between biodiversity and ecosystem services Many findings confirm that, even without biodiversity, beneficial ecosystem services can develop in cities (e.g. an intensive non-native urban tree stock will still contribute to local climate regulation). Positive correlations between biodiversity and ecosystem services have only been confirmed in a small number of studies on non-urban ecosystems (forests, grasslands, wetlands) and experiments (Schwarz et al. 2017). Currently, there are not enough empirical findings on whether the concepts “green infrastructure” (European Commission 2012) and “nature-based solutions” (European Commission 2015) really improve urban biodiversity and ecosystem services, as previously assumed (Schwarz et al. 2017).
Source: Breuste (2020a)

Trends in urban biodiversity management The preservation and development of biodiversity in cities is increasingly becoming a design goal, which is pursued with different understandings of biodiversity and different justifications that go beyond traditional notions of environmental protection and view biodiversity as an integral objective and vision for cities. The protection of biodiversity therefore cannot primarily be focused on the protection of rare indigenous species and residual habitats, even if these are actually found in cities. Instead, there should be a holistic approach that revolves around human needs and the usefulness of nature in cities for said purpose (Sukopp and Weiler 1986; Breuste 1994). „Urban biodiversity is the only biodiversity that many people directly experience. Experiencing urban biodiversity will be the key to halt the loss of global biodiversity, because people are more likely to take action for biodiversity if they have direct contact with nature” (Erfurt Declaration 2008, p. 1). Cities now state more explicitly what they require in order to promote and maintain biodiversity – a process referred to as “mainstreaming biodiversity”. Communal and regional strategies for biodiversity increasingly focus directly on urban biodiversity.
Source: Breuste (2020a)

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Case study

Berlin Strategy for biological Diversity

The “Berlin Strategy for biological Diversity”, includes 38 goals divided into the four topic areas: species and habitats, genetic diversity, urban diversity and society (SenStadt 2012). The focus is set on making city residents enthusiastic about the nature in the urban environment and to let them experience its benefits.

Source: Breuste (2020a)

1.6. What has been done so far? - The European experience

Theory

The implementation of the “urban nature” concept in Europe

The idea of urban nature has spread throughout Europe and has achieved a broad public base, notwithstanding that the national vision of urban nature is not reflected enough in politics. Prime examples for this are De Groene Stad (NL) (www.degroenestad.nl) and The Green City (UK) (www.thegreencity.co.uk).

In 1994, European cities launched an initiative of cities and communities on the way to future sustainability. In Aalborg in 2004, the European process of sustainable city development became more specific. About 2.500 local and regional administrations in 39 countries and 80 cities and communes consented to self-committing. For that purpose, 10 holistic themes were resolved (Aalborg Commitments). Urban nature is not a central, yet integrated part of it. Theme 3 “Natural common goods: We are committed to fully assuming our responsibility to protect, to preserve, and to ensure equitable access to natural common goods”, directly concerns urban nature. This subject area commits to “promote and increase biodiversity, and extend and care for designated nature areas and green spaces”.

National organisations and ELCA, the European Landscape Contractors Association, carry the idea of a city based on urban nature. Twenty European countries are already a member of ELCA, which represents 74,000 companies and 330,000 members. In 2003 the panel THE GREEN CITY (DIE GRÜNE STADT – www.die-gruene-stadt.de), was founded in Germany. Since 2009 the panel has been operating as a foundation, which offers a platform for organisations, companies and individuals. This drive stems from the fundamental belief that green and urban nature should have a higher significance in policy making, and that pooling of knowledge, exchange of experiences, creation of public and private urban green as well as awareness-raising among citizens are necessary. In a common charter, the Federal Association of Horticulture, Landscaping & Sports Facilities Construction (BGL) and THE GREEN CITY advocate for „more life quality through urban green". Eight fields of activities were identified: 1) mitigation of climate change impacts; 2) health promotion; 3) securing social functions; 4) increase in location quality; 5) protection of soil, water and air; 6) preservation of biodiversity; 7) promotion of technical research for buildings and vegetation; and 8) creation of legal and fiscal incentives.

For now, the vision of urban nature remains locally, where it well belongs to and where it can be realised exemplary. It is a European vision, which by now has received globally growing attention and support.

Source: Breuste (2020b)

Case study

German National strategy for biodiversity 2007

In the field of action "settlement and traffic", reduction of land consumption and fragmentation, reachable green areas, spaces for nature experiences and promoting an understanding of nature among children are key aspects (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) 2007, p. 79). The aims are that by 2020: 1) the greening of settlements, including green spaces close to residential environments (such as courtyard plantings, small green spaces, green roofs and facade greenery), has advanced significantly; and 2) publicly accessible green with various qualities and functions is generally accessible on foot (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) 2007, p. 42, translated from German).

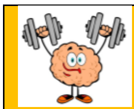
Source: Breuste (2020b)

Case study

Dresden – nature in the city with the central idea: "Compact city within the ecological network"

The guiding principle of Dresden's urban planning is: compact urban settlement structures embedded in a network of ecological functional areas. The existing complex water system is the spatial base for the ecological network. Together with the Elbe river, the 400 local streams form an almost comprehensive network, which should be gradually expanded to an ecologic network together with green spaces. In the landscape plan for Dresden of 2012, urban nature is seen as infrastructure and open spaces are the guiding structure for city development. Each sub-structure is assigned concrete functions:

• Fresh air supply and healthy urban climate; • Sufficient regeneration of groundwater; • Flood prevention, water retention and water development; • Recreational spaces for humans; • Habitats for plants and animals, migration corridors; and Beauty and uniqueness of cultural landscapes.
Source: Breuste (2020b)



Assignment 4

Urban nature and urban ecosystem services

1. Watch the video, select 3 green spaces shown in it and discuss the ecosystem services provided by these spaces: https://topdocumentaryfilms.com/nature-cities/
2. Afterwards, find at least three different types of urban green spaces in your city, mark them on satellite imagery and upload. Also upload images of those green areas. Describe green infrastructure of the city: How many green areas are there? What is their relative size compared to the city? Do you think it is sufficient?
3. Discuss on your results with the other course participants in the online-forum.

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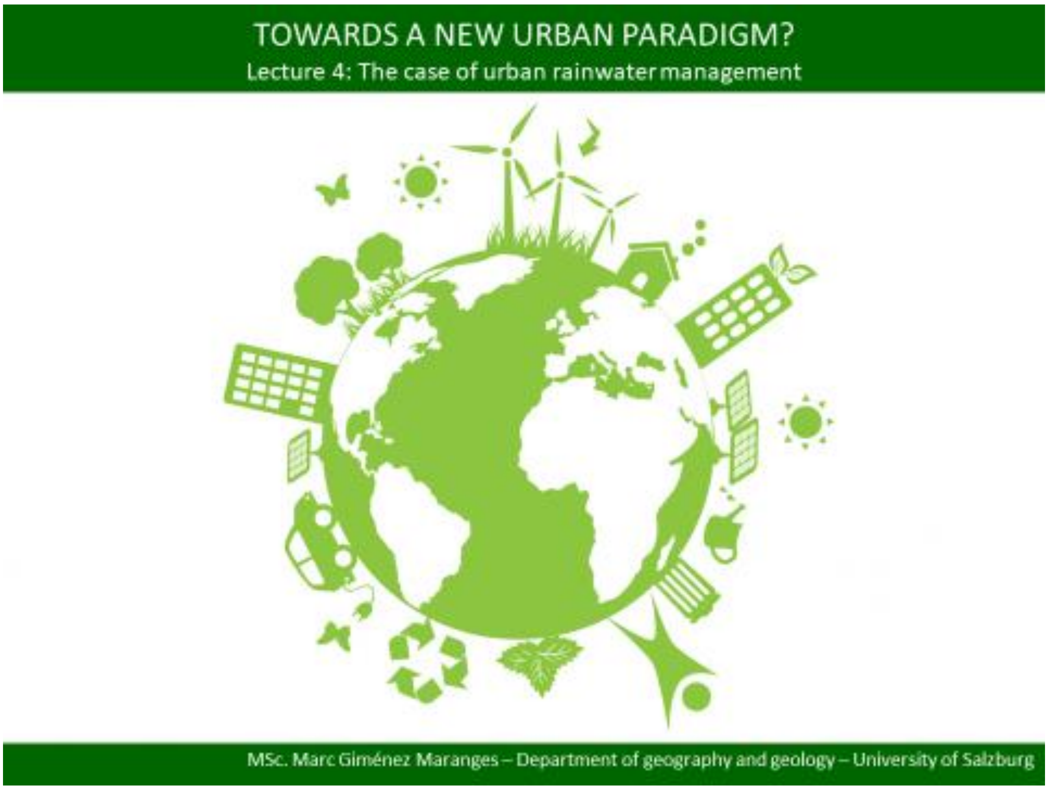
2. Urban rainwater management



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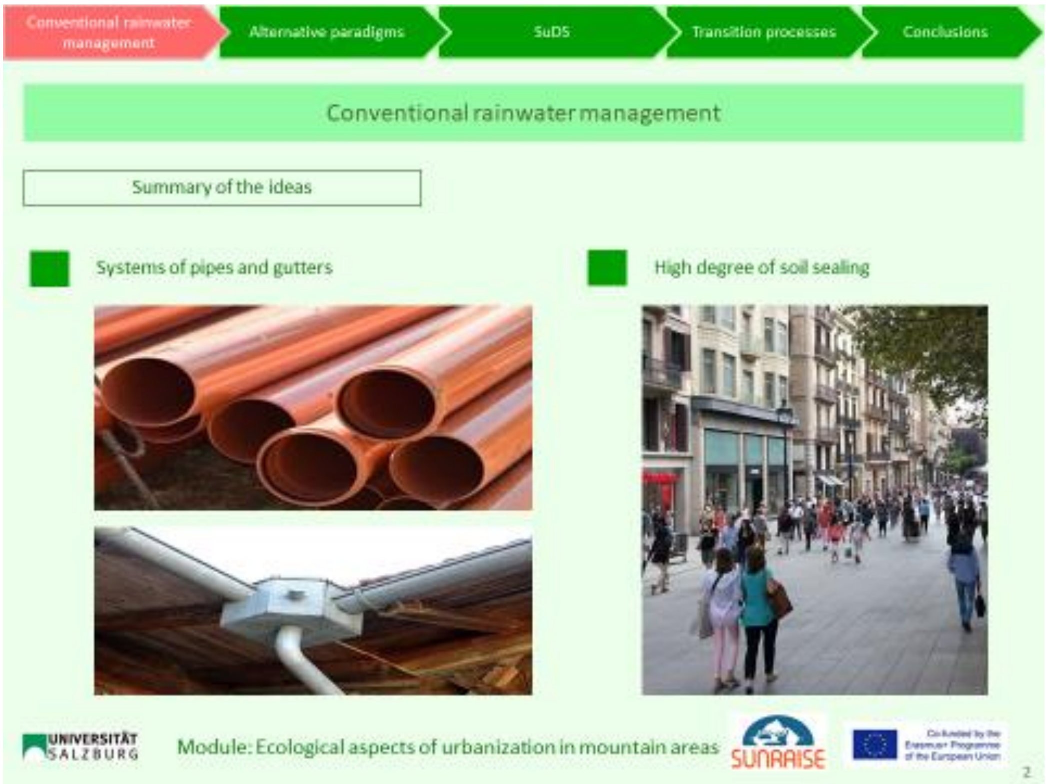

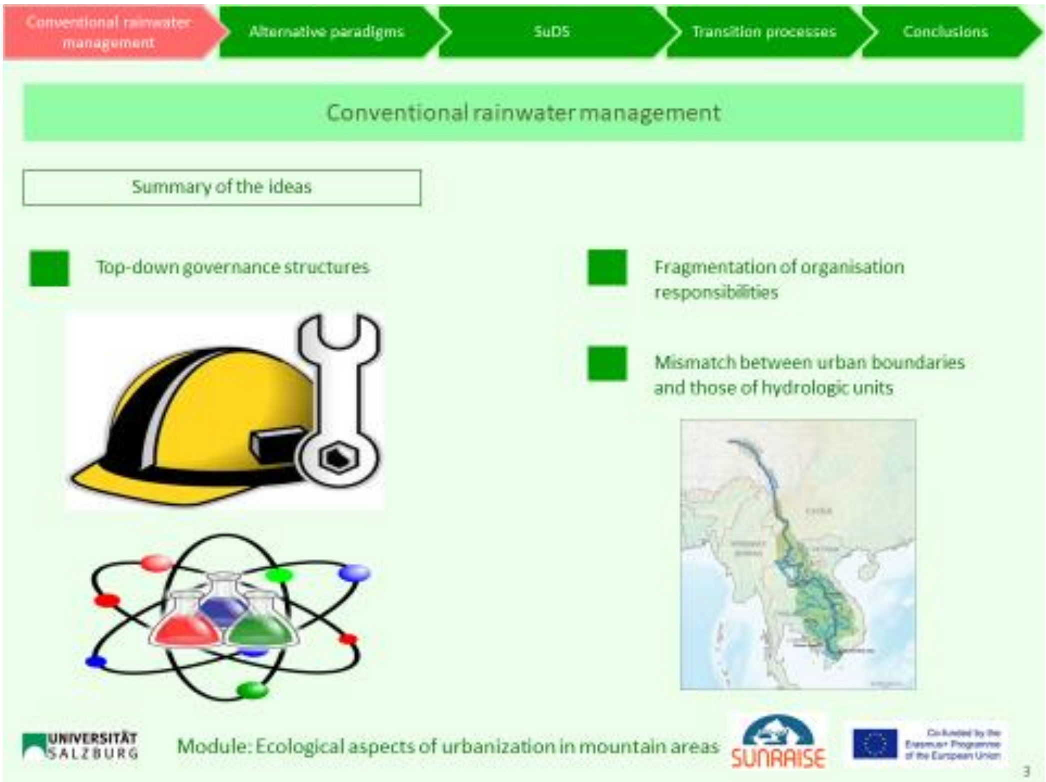

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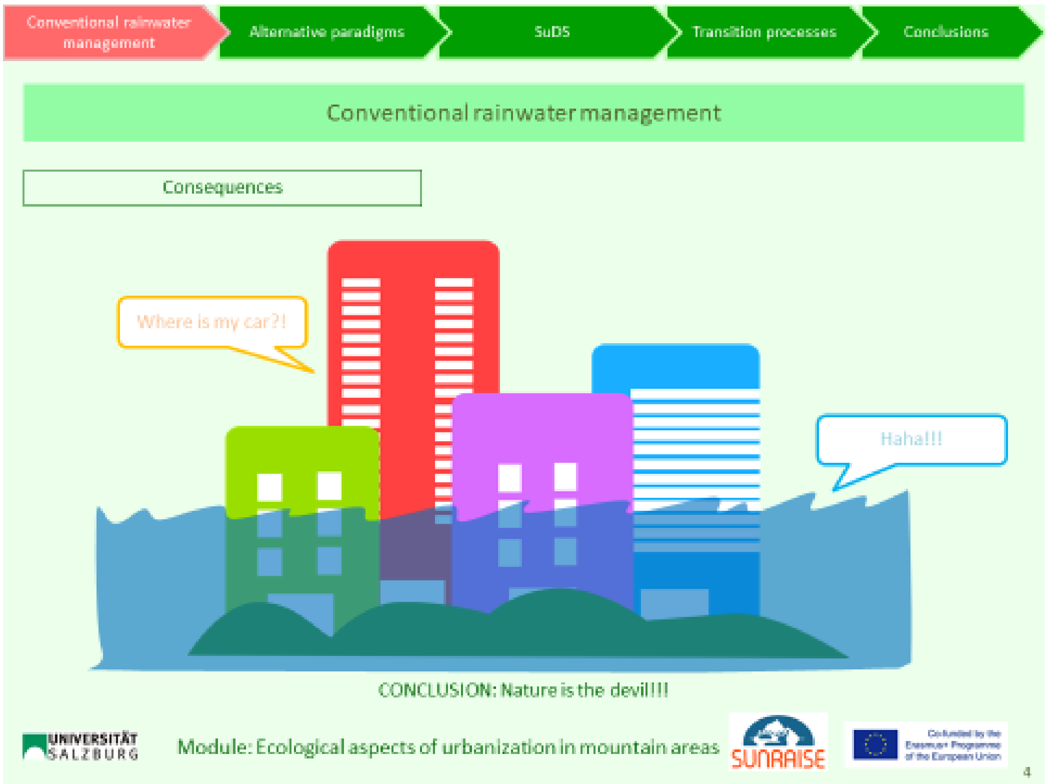

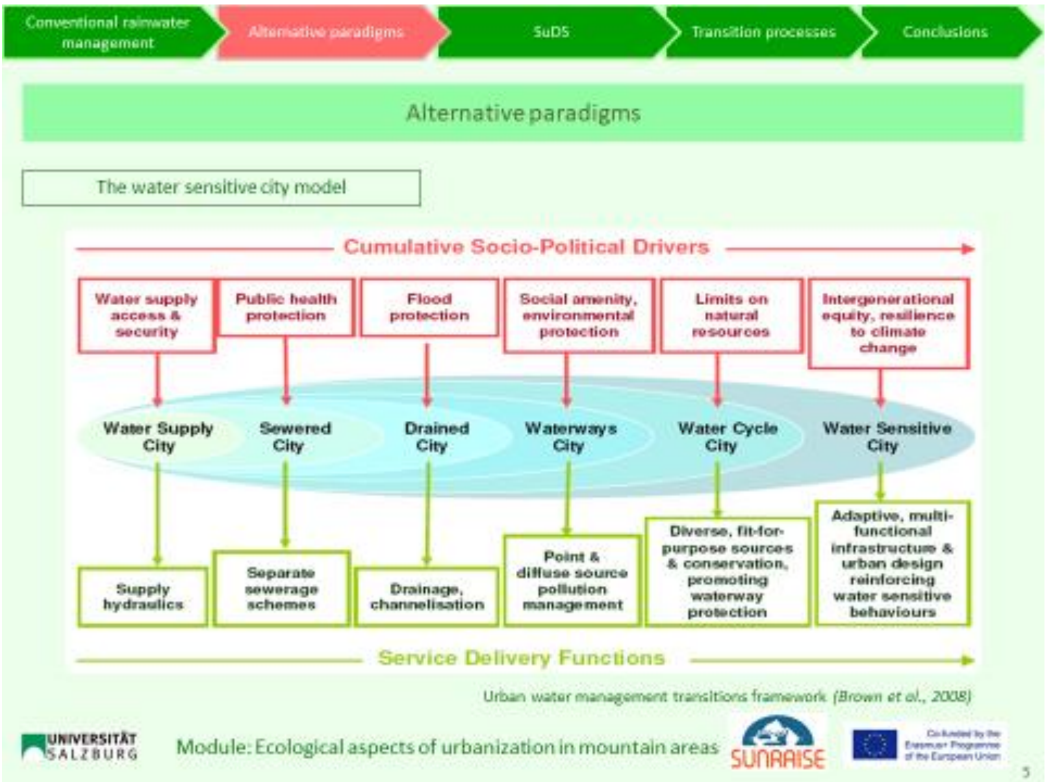


Conventional rainwater management
Alternative paradigms
SuDS
Transition processes
Conclusions
Alternative paradigms
Chief ideas
Drainage systems:
Are designed as part of the local environment with which they co-evolve
Can be easily adapted to changing requirements
Are adapted to the specifics of each location
Their collapse is understood as an opportunity to learn
Interdisciplinary networks are responsible for the decision-making
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Conventional rainwater management
Alternative paradigms
SuDS
Transition processes
Conclusions
SuDS
Definition
"Drainage systems that consist of aboveground mechanisms that mimic natural processes to deal with flooding."
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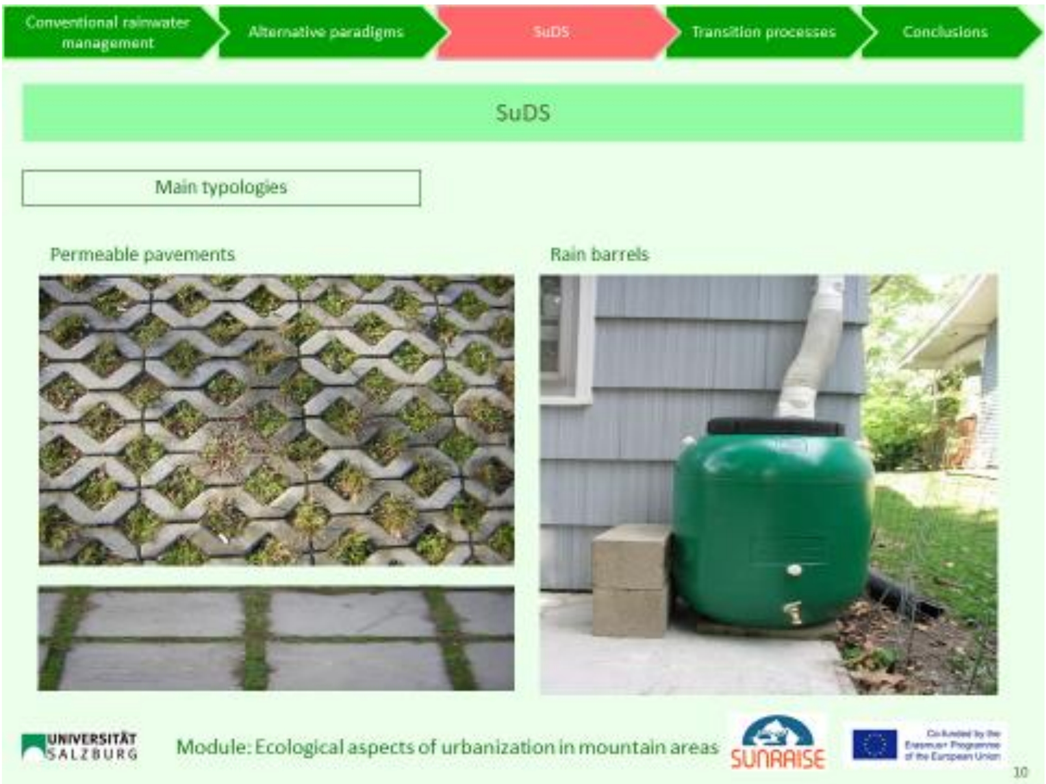
Conventional rainwater management
Alternative paradigms
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Main typologies
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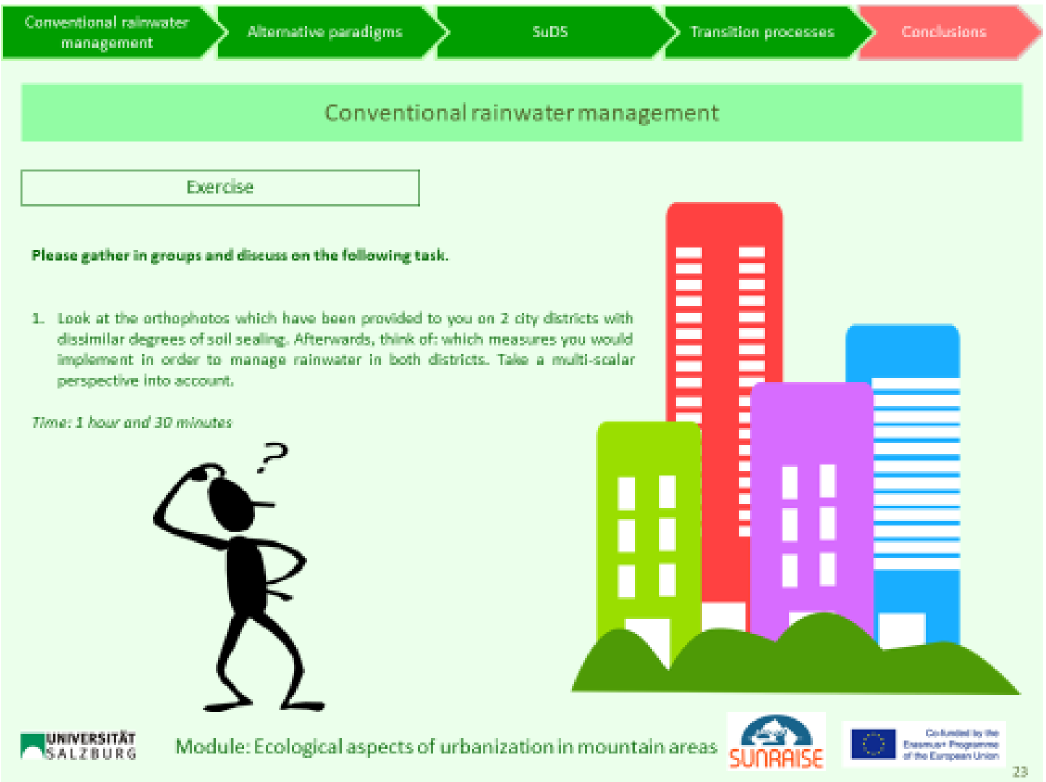


Module 1: Ecological aspects of urbanization in mountain areas

Learning module

“Ecological aspects of urbanization in mountain areas” (S3)

GIMENEZ-MARANGES Marc, CAMPBELL Laura-Bethia, KOHOUTKOVÁ Kristýna, BREUSTE Jürgen

Module 1: Ecological aspects of urbanization in mountain areas

S3: Urbanization in mountain areas

Contents

Module 1: Ecological aspects of urbanization in mountain areas

1. Mountain areas: an introduction

Key words

Mountain areas, biophysical characteristics, geomorphological traits, climate, mountainous flora & fauna

Study areas: the Alps, the Himalaya, the Caucasus & Altai, the Rocky Mountains

1.1. Definition: What are mountain areas?

Theory

Definition - Mountain areas

No single definition can be given for the term "mountain area", as it does not apply to areas above a certain altitude. It is also determined by variable social and economic aspects that characterise particular regions as "mountain areas", while other influences such as topography, exposure and inclination of slopes, or difficulty of access, can also mean that it is considered as such. (Aulitzky, 1971)

An objective basis for defining mountains is elevation. A landform must attain at least a certain altitude (e.g. 300m) to qualify. Nevertheless, while this is an important criterion, by itself it is still insufficient. For instance, the Tibetan Plateau reaches an elevation of 5,000m, but it is not classified as mountainous. In contrast, western Spitsbergen, situated only a few meters above the sea level, has the appearance of a high mountain landscape with its glaciers, frost debris, and tundra vegetation. (Price, 1981)

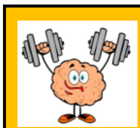
An objective definition of mountainous terrain should include local relief, steepness of slope, and the amount of land in slope, in addition to elevation. Local relief is the elevational distance between the highest and lowest point in an area. By itself, it is an incomplete definition of mountains, as is elevation. As an illustration, a plateau may display spectacular relief when incised by deep valleys (e.g. the Grand Canyon). The same occurs with the amount of steepy dissected land, as it might be rather limited in mountainous areas. In mountains such as the Alps and the Himalayas, steep and serrated landforms are dominant features. (Price, 1981)

Mountains may be delimited by geological criteria, in particular, faulted or folded strata, metamorphosed rocks, and granitic batholiths (Hunt, 1958). Most of the major mountain chains have these features, and they are also important in identifying former mountains. Implicit in this definition is the idea that mountains are features of construction, that they are built by some internal force. This is certainly true of the major ranges, but mountainous terrain may also result from destructive processes, i.e., erosion. For example, a strongly dissected plateau may take on a mountainous character, although it contains none of the geological characteristics listed above. (Price, 1981)

Another basis for defining mountains is by their climatic and vegetational characteristics. An essential difference between hills and mountains is that mountains have significantly different climates at successive levels (Thompson, 1964). This climatic variation is usually reflected in vegetation, where a vertical change in plant communities from bottom to top is apparent, which hills lack. The major advantage of this perspective is that it recognises ecology as well as topography. Clearly, one of the most distinctive characteristics of mountains, in addition to high relief and steepness of slope, is great environmental contrast within a relatively short distance. (Price, 1981)

In short, mountains are specific ecosystems, characterised by their diversity and complexity (Messerli and Ives, 1997). Steep topographic, climatic and biological gradients combined with sharp seasonal contrasts trigger extreme climatic and geomorphic events, which may in turn strongly affect ecological and human environments (Ives and Messerli, 1989; Price, 1999; Beniston, 2002; Viviroli et al., 2007; Hüggel et al., 2010; Körner, 2013). (in Fort, 2015)

Source: Aulitzky (1971), Fort (2015), Price (1981)



Assignment 1 (0.5hr)

Main characteristics of mountainous areas

1. Fill in the table about the main characteristics of mountainous areas. Think about different aspects of natural conditions, including climate, geomorphology, fauna and flora

Table

Mountainous Areas	**Lowlands**

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2. Discuss on the forum with others. Are there any differences between mountainous areas in your countries?

1.2. Biophysical characterisation of mountain areas

1.2.1. Geomorphological traits

Theory

Geomorphological traits of mountain areas

The kinds of landscapes that develop in different mountain regions depend on the rate of uplift and deformation, the nature and reaction of various rock surfaces, and the intensity and types of erosional processes. These combined circumstances result in a wide variety of conditions and outcomes depend upon whether the geologic structure is passive or active. If the area is passive or stable, with no uplift or deformation taking place, the major controls are the existing differences in bedrock, topography, and structure; but if the area is tectonically active, a much more dynamic relationship exists between form and process, because erosion is taking place simultaneously with uplift and deformation. (Price, 1981)

The nature of the rock itself has a major impact on landscape development. Massive and resistant crystalline rocks, such as granite and quartzite, have the potential for producing outliers and ridges, while landforms formed in weak and friable rocks, such as limestone or shale, often form valleys. The exact developments depend upon local circumstances, but the more resistant the rock, the more likely it is to produce salients, peaks, and ridges. (Price, 1981)

Although there are widespread regional differences, many pervasive and overriding similarities suggest that similar geomorphic processes operate under comparable environmental conditions and give rise to similar kinds of landforms. (Price, 1981)

The basic components of the mountain landscape are upland surfaces, valley bottoms, and the slopes between them. Slopes occupy the greatest area and result in a high degree of energy transfer through their effect of gravity. Geomorphic processes are intensified on steep slopes. While precipitation is often the major factor at intermediate altitudes, low temperatures become significant at higher altitudes and give rise to glacial, nivational and periglacial regimes (Davis, 1969; Price, 1972; Washburn, 1973; Embleton and King, 1975b). The glacial system is one in which ice directly shapes the land. It generally occurs on the highest part of mountains. Nivation is a combination of frost action and downslope movement of earth material by gravity (mass-wasting) resulting from the presence of snow patches. Nivation occupies the narrow transitional zone between the glacial and periglacial environments. The periglacial system, peripheral to both glacial and nivation systems, is characterised by cold climate, frost action, and mass-wasting. Of the three, the periglacial regime occupies the greatest area in high mountains. Below the timberline, erosion operates at a slower rate, due to the protective buffer forests create. (in Price, 1981)

The mountain landscape is characterised by instability and variability. Rock-strewn surfaces resulting from rapid physical weathering processes are common, and earth materials are continually being transported downslope. Large-scale events such as mudflows, landslides, and avalanches can reach catastrophic dimensions and do more geomorphic work in a matter of minutes than day-to-day processes accomplish in centuries. Such spectacular phenomena epitomise the inherent instability of the mountain system (Hewitt, 1972; Caine, 1974). The process begins, however, with the weakening and breakdown of the bedrock. (in Price, 1981)

Source: Price (1981)

1.2.2. Climate

Theory

Climate in mountain areas (an introduction)

Climate is fundamental to establishing a natural environment; it sets the stage upon which all physical, chemical and biological processes operate. Under temperate conditions, the effects of climate are often less apparent and intermingled, so that the relationship between stimulus and reaction is difficult to isolate, but under extreme conditions, the relations becomes more evident. Extremes are common in many mountain areas; for this reason, a basic knowledge of climate processes and characteristics is necessary to understand the mountain milieu. (Price, 1981)

Mountain climates are extremely diverse. Varied topography and high contrasts in energy fluxes within mountain systems create microclimates. The climate of a slope might be very different from that of a ridge or valley. Climatic patterns of mountains become highly complex when innumerous combinations are created by the orientation, spacing, and steepness of slopes, along with the presence of snow patches, vegetation, and soil. Nevertheless, predictable patterns and characteristics are found within this heterogeneous system. For example, it is usually windier in mountains, the air is thinner and clearer, and the sun's rays are more intense. (Price, 1981)

Great variations also occur within short time-spans. Areas exposed to the sun undergo much

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greater and more frequent temperature contrasts than those in shade. This is true for all environments, but the difference is much greater in the mountains because the thin alpine air does not retain heat well. (Price, 1981) Mountains also have important effects on the climate of adjacent regions. They may influence other areas for hundreds or thousands of kilometres. The exact effect of the mountains depends upon their location, size and orientation with respect to the moisture source and the direction of the prevailing winds. As an illustration, the 2,400 kilometre-long natural barrier of the Himalayas permits tropical climates to extend farther north in India and southeast Asia than they do anywhere else in the world. On the north side of the Himalayas, however, there are extensive deserts and the temperatures are abnormally low for the latitude. (Price, 1981)
Source: Price (1981)

Major climatic controls in mountain areas

Mountain climates are controlled by latitude, altitude, continentality, and regional circumstances such as ocean currents, prevailing wind direction, and the location of semi-permanent high and low-pressure cells:

- Latitude: Latitudes are determined by basic patterns of global atmospheric-pressure systems known as the equatorial low (0º-20º latitude), subtropical high (20-40º latitude), subpolar low (40-70º latitude), and polar high (70-90º latitude). The global pressure areas have a major influence on mountain climates. Mountains near the Equator - such as Mount Kilimanjaro in East Africa - are under the influence of the equatorial low and receive precipitation almost daily. By contrast, mountains located at 30º latitude may experience considerable arity - for example, the northern Himalayas and Tibetan highlands, as well as the Puna de Atacama in the Andes, the most arid high-mountain region in the world (Troll, 1968). Further poleward, the Alps, the Rockies, the southern Andes, and the Southern Alps of New Zealand also receive heavy precipitation, especially on westward slopes facing prevailing winds from the sea. (Price, 1981)
- Altitude: Fundamental to mountain climatology are the changes that occur in the atmosphere with increasing altitude, especially the decrease in temperature, air density, water vapour, carbon dioxide, and impurities. The sun is the ultimate source of energy. The earth absorbs the sun’s energy and becomes a radiating surface. This is why the highest temperatures usually occur near the earth and decrease outward. Mountains present a smaller land area at higher elevations, so they are less able to modify the temperature of the surrounding air. For this reason, mountains depend almost entirely on the sun for warmth, and not on the surrounding air. Consequently, although the temperature at

1,800m high in the atmosphere changes very little between day and night, next to the mountain peak, the sun's rays are intercepted and absorbed. The soil surface may be quite warm but the envelope of heated air is usually a few meters thick and displays a steep temperature gradient. That is the reason why the mountain's environment response is more accentuated than that of a desert, in terms of daily temperature ranges. Concerning precipitation, it is generally highest on middle slopes, where clouds initially form, while it often decreases at higher altitudes. (Price, 1981)

- Continentality: The relationship between land and water has a strong influence on the climate of a region. Generally, the more water-dominated an area is, the more moderate its climate. The effect of continentality on mountain climate is much like that on climate generally. Mountains in the interior of continents experience more sunshine, less cloudiness, greater extremes in temperatures, and less precipitation than mountains along the coasts. This would seem to add up to a more rigorous environment, but there may be extenuating circumstances. The extra sunshine in continental regions tends to compensate for the lower ambient temperatures, while the greater cloudiness and snowfall in coastal mountains tend to make the environment more rigorous. (Price, 1981)

- Barrier effects: All mountains serve as barriers to a greater or lesser extent, depending on their size, shape, orientation, and relative location. Specifically, the barrier effect of mountains can be grouped under the following subheadings:

    - Damming: It occurs when the mountains are high enough to prevent the passage of an air mass across them. When this happens, a steep pressure-gradient may develop between the windward and leeward side of the range. (Price, 1981)

    - Deflection: When an air mass is dammed by a mountain range, the winds are usually deflected by the mountains. As an illustration, in winter, polar wind coming from Canada across the central United States is channeled to the south and east by the Rocky Mountains. Consequently, the Great Plains experience more severe winter weather than does the Great Basin (Church and Stephens, 1941; Baker, 1944). (in Price, 1981)

    - Blocking: Large mountain ranges are very efficient at blocking storms, since they are often the focus of anticyclonic systems, the storms must detour around the mountains. The jet streams may also split to flow around the mountains; they rejoin to the lee of the range, where they often intensify and produce storms (Reiter, 1963). (in Price, 1981)

    - Disturbance of the upper air: In addition to the effect of blocking, mountains cause other perturbations to upper-air circulation. This occurs on a variety of scales: locally, with the wind adjacent to the mountains; on an intermediate scale, creating large waves in the air; and on a global basis, with the larger mountain ranges actually influencing the motion of planetary waves (Bolin, 1950; Gambo, 1956; Kasahara, 1967) and the transport momentum of the total circulation (White, 1949). (in Price, 1981)

- Forced ascent: When moist air blows perpendicular to a mountain range, the air is forced to rise; as it does, it is cooled. Eventually the dew point is reached, condensation occurs (clouds), and precipitation results. Some of the rainiest places in the world are mountain slopes in the path of winds blowing off relatively warm oceans. (Price, 1981)
- Forced descent: Atmospheric-pressure conditions determine whether the air, after passing over a mountain barrier, will maintain its altitude or whether it will be forced to descend. If the air is forced to descend, it will be heated by compression and will result in clear, dry conditions. This is a characteristic phenomenon in the lee of mountains. (Price, 1981)

Source: Price (1981)

1.2.3. Flora and fauna

1.2.3.1. Flora

Theory

Main traits of mountainous flora

Because they extend vertically into different environmental regimes within small horizontal distances, mountains display the most rapid and striking changes in vegetation of any region on Earth. Indeed, the primary characteristic of mountain vegetation is the presence of sequential plant communities with increasing altitude. A number of typical plant-community characteristics occur with increasing altitude. Foremost among them is the decrease in the number of species. Changes also take place in the form and structure of plants and in the assemblage of species: the general tendency is toward smaller and less elaborate plants with slower growth rates, decreased productivity, decreased plant diversity, and less interspecies competition. (Price, 1981)

Whether there exist clear and recognisable vegetation belts is, however, another question (Beals, 1969). In the tropics, such zones might be quite distinct and obvious, while in latitudes nearer the poles, zones are often difficult to identify. Nevertheless, most mountains display a sequence of forest vegetation of some sort on their upper slopes and, if they are high enough, they display a treeless zone. The lower mountain forest is generally known as the submontane or montane zone. On the other hand, the higher forest composes the subalpine zone. The treeless area above is known as the alpine zone (Daubenmire, 1943, 1946; Marr, 1961; Love, 1970). (in Price, 1981)

Source: Price (1981)

Differences in high-mountain plant populations around the globe

Plant populations display different characteristics in tropical, middle-latitude and polar mountains, even if the same climate conditions occur, due to the divergent length of the day. If an individual is taken from e.g. a tropical mountain and is planted e.g. in a middle-latitude mountain, it usually fails to survive, and even if it survives, it will not reproduce (Mooney and Billings, 1961). Moreover, the distribution of vegetation and climate on a global scale varies not only with respect to altitude and latitude, but also from the northern to the southern hemisphere. The northern hemisphere contains two-thirds of the land area of the earth, which produces a much greater degree of continentality. This, in turn, has favoured the development of the boreal forest and Arctic tundra, neither of which has any real counterpart in the southern hemisphere. Vegetation types are unequally distributed on either side of the equator, with a sharp transition between the northerly high altitudes and tropical mountains. Mid-latitude southern-hemisphere mountains are climatically and vegetatively more similar to tropical mountains, owing to the stronger ocean presence which moderates the seasonal extremes (Troll, 1960). (in Price, 1981)

Source: Price (1981)

Influence of mountains on the Earth's flora

The presence of mountains profoundly influences the biogeography of the Earth through their effects on global climate and their biological role of serving as pathways, barriers, and islands with respect to the migration and evolution of species: (Price, 1981)

- Pathways for plant migration: Mountains extend from areas of high temperature to areas of lower temperature and provide an environment more like that found nearer the poles. Plants that are adapted to cold conditions may move freely in either direction along the mountain crest, especially when mountains are oriented north-south, as they are e.g. in America. Much less interchange takes place between e.g. Europe and tropical Africa, due to the east-west orientation of European mountains with no interconnecting range, plus the presence of the Mediterranean Sea and the Saharan barrier. Although the Himalayas are also oriented east-west, they are much more massive and have interconnecting ranges, so extensive exchange of species has occurred in the high mountains of Australasia (Van Steenis, 1934, 1935, 1962, 1964; Raven, 1973). (in Price, 1981)

- Barriers to the migration of species: Species which cannot survive in high-altitude environments will not be able to cross the mountains (Janzen, 1967). The unlike conditions which typically develop on the windward and leeward sides of ranges also present an obstacle. Even if a species does manage to pass across the mountains, it may still be unable to establish itself, because of the unsuitable environment on the other side and because of competition from other species which are better adapted to these conditions. (in Price, 1981)

- Mainland islands: Migration to or from a mountain is hindered by a "Sea" of unlike environment and vegetation. The smaller the size of mountain masses at different altitudes and the further apart they are, the greater the difficulty of species interchange. Some of the best examples of mainland island are the high tropical mountains of Africa, surrounded by savannas. An important consequence of this isolation is that each species has a limited gene pool that receives little infusion from outside. Consequently, adaptation becomes adjusted primarily to the local environmental conditions, and evolution frequently results in the creation of species which are found only on that mountainous environment (endemisms). (Price, 1981)

Source: Price (1981)

1.2.3.2. Fauna

Theory

Main traits of mountainous fauna

In spite of the dynamic and multifaceted nature of animal populations, they share many characteristics and patterns with mountain vegetation. One of the most pronounced characteristics is the decrease in number of species with altitude. For example, there are 96 species of butterflies in the coniferous forests of the Swiss Alps, but only 27 in the shrub and meadow zone, while 8 species range into the high tundra (Hesse et al., 1951, p. 592). The decrease in number of species with altitude results in decreased species diversity and, potentially, less interspecies competition. The lower number of species may be counterbalanced by an increase in the number of individuals within any given species, but the total biomass and biomass productivity nevertheless decreases. Particularly above the timberline, the shortage of food and shelter entails a shift in the animal community toward smaller creatures that can find shelter and food near the ground, amid stones, and beneath the snow. (in Price, 1981)

High mountain environments are relatively undeveloped ecosystems, and the majority of inhabitants are pioneers. Being pioneers, most species are generally able to cope with a wide range of environmental conditions, rather than specialising in a narrow spectrum of circumstances. Versatility and flexibility are the qualities of the highest survival rates. For this reason, the majority of high-altitude wildlife are rodents, scavengers, and unspecialised insects, and flora consists primarily of weed species. Furthermore, most animals are summer residents that spend most of the year at lower altitudes or latitudes. (Price, 1981)

It has long been assumed that low temperature is one of the major factors influencing the low degree of development of ecosystems in high mountains. Dunbar (1968) contends that, while low temperature may be the immediate or proximate cause for the decrease in numbers of species, it is not the ultimate reason. Instead, the limiting factors are, large environmental oscillations, lack of nutrients, lack of habitat diversity, and the young age of ecosystems (Dunbar, 1968). Alpine environments have additionally two other limiting factors: the disjunct islandlike distribution of mountain areas, and reduced oxygen with altitude. (in Price, 1981)

Organisms respond to all these environmental stresses by morphological adaptations, physiological adjustments, behaviour patterns, and community relations and interaction. Animals respond primarily through behaviour (Kendeigh, 1961); they often deal with environmental extremes by escaping them through migration, hibernation, burrowing, or the use of microhabitats: (in Price, 1981)

- Migration: Migration is the “large scale shift of the population twice each year between a restricted breeding area and a restricted wintering area” (Lack, 1954, p. 243). The bi-annual movement is important in mountains, but seasonal migrations and irregular movements in response to e.g. the sporadic occurrence of severe weather, are of equal or greater importance. (in Price, 1981)
- Hibernation: Hibernation is an efficient survival mechanism for those species not mobile enough to migrate or are disinclined to remain active all winter. Organisms become inactive and withstand the harsh climatic period in a state of dormancy. Due to the unmarked seasonal changes in the tropics and the cold climate of the polar regions, hibernation is principally a phenomenon of the middle latitudes. (Price, 1981)
- Burrowing and use of microhabitats: Species unable to migrate or hibernate escape climatic extremes by burrowing or by taking advantage of microenvironments under snow, rocks or vegetation. During winter this activity is restricted to small mammals, whereas during summer (year-round in the tropics) it includes reptiles, amphibians, insects, and

those mammals that have come out of hibernation. (Price, 1981)
Source: Price (1981)

Differences in high-mountain animal populations around the globe
The exact number and composition of species varies for different mountain regions, depending on environmental conditions and size, history, and relationship to other mountain areas. Generally, the larger the mountain area, the greater the number of species. Thus, the largest number of mountain species exists in the Himalayan region. (Price, 1981) Although alpine and arctic zones have much in common, the island-like, patchy distribution of mountains and the large, nearly continuous circumpolar belt of the Arctic constitutes a fundamental difference among them. In the Arctic, there is a good degree of continuity and interchange among animal populations, with the same species occurring throughout. This is impossible in mountain areas, because of the difficulty in dispersal and colonisation. As in the case of flora, fauna becomes therefore increasingly diverse away from the polar region. Mammals become the most exclusive, in such a way that no single species in the alpine tundra in middle latitudes is found in the arctic tundra (Hoffmann, 1974, p. 475). This is true, however, for those species who live only in arctic or alpine tundra, as a number of more widely ranging species occasionally occupy both environments. Birds and insects are less exclusive, and amphibians are notably rare in both areas (Hock, 1964a,b). (in Price, 1981)
Source: Price (1981)

1.3. Study areas

1.3.1. Study area 1: THE ALPS

Reference case

THE ALPS: An introduction

The Alps are the second highest and most extensive mountain system in Europe. They comprise a total area of 240,000 km^2, extent a length of 1,000 km, and are between 130 and 250 km wide. Many summits rise above 4,000 m (the highest of which is Mont Blanc at 4,807 m), while most

mountain groups exceed 3,000 m and have snow- and ice-capped peaks. (Stone, 1992)
Source: Stone (1992)

Geomorphology

Typical of folded mountains of the Tertiary period, the Alps are composed of greatly extended parallel mountain chains. In the western part of the western Alps, between the Mediterranean and lake Geneva, these chains are curved, while in the rest of the Alps they are almost straight, running from east to west. They include very large intermontane valleys and basins. (Stone, 1992)

Alpine geology can be generally sketched in terms of the following typical features: (Stone, 1992)

- The highest, most centrally located portion of the Alps consists of extremely hard rock (crystalline rock, gneiss and granite) which weathers slowly and produces steep formations, although vertical walls are rare. (Stone, 1992)
- To the north and to the south, there are areas of relatively soft rock (sedimentary rock such as calcareous schist), which weather rather quickly and produces smooth formations. The major intermontane longitudinal valleys are located here. (Stone, 1992)
- Further out towards the exterior, we find northern and southern Alpine limestone. This limestone weathers slowly. Large vertical rock walls and extended arid high plateaus are typical of this region. (Stone, 1992)
- The entire exterior zone of the Alps is composed of soft sedimentary "flysch", which weathers quickly and produces soft formations. (Stone, 1992)

Source: Stone (1992)

Climate

Because of their size and their location in a double border area between the temperate latitudes and the Mediterranean subtropics, and between oceanic and continental Europe, the Alps exhibit a great range of climatic conditions. Virtually, every Alpine valley has a different local climate. There are no clear boundaries, only broad, gradual transitions: (Stone, 1992)

- Hypsometric change: As elevation increases, the average temperature drops, the annual growing season becomes shorter, and there is greater precipitation. Precipitation increasingly takes the form of snow at higher and higher altitudes. (Stone, 1992)

- Peripheral-central change: Whereas oceanic influences (temperate and humid) prevail in the climate of exterior Alpine zones, a distinctly continental climate (dry with great variations in temperature between summer and winter, day and night, and sunny and shaded areas) is found in the inner Alps. (Stone, 1992)
- Planetary change: The Southern Alps are subject to Mediterranean climate influences (high temperatures, dry summers and heavy precipitation in autumn and spring), while the northern Alps have a central European climate (low temperatures, precipitation throughout the year and no dry periods). (Stone, 1992)
- Change from west to east: The Alps are subject to climatic changes in Europe, ranging gradually from the moist oceanic climate in the west to the dry continental climate in the east. (Stone, 1992)

Source: Stone (1992)

Ecosystems

The ecosystems of the Alps are influenced by the interplay between: 1) the parent rock, weathering and landscape forms associated with it; and 2) the four forms of climate change mentioned above. Every valley in the Alps exhibits fundamentally different natural conditions and can be compared with neighbouring valleys only in very limited ways. (Stone, 1992)

Source: Stone (1992)

1.3.2. Study area 2: THE HIMALAYA

Reference case

THE HIMALAYA: An introduction

The Hindu-Kush Himalaya stretches 3,500 km from East to West, covering 3.4 million square kilometres over eight countries. The geographical and climatic diversity is extreme: altitude ranges from sea level to over 7,600m and climate covers subtropical to alpine zones. (ICMOD, 2001)

Source: ICIMOD (2001)

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Geomorphology

The Himalaya can be divided into four latitudinal belts on the basis of its geology: (Stone, 1992)

- **The Sub-Himalaya**: It forms the outermost and youngest part of the Himalaya. It is characterised by broad open folds. (Stone, 1992)
- **The Lesser Himalaya**: It lies North of the Sub-Himalaya and is the main habitat of the Himalayan people. (Stone, 1992)
- **The Great Himalaya**: Further north, this belt includes the crest-line with peaks frequently exceeding altitudes of 7000 m. (Stone, 1992)
- **Tethyan or Trans-Himalaya**: It is more commonly known as the Tibetan plateau and is characterised by intense folding and minor thrusting. (Stone, 1992)

Source: Stone (1992)

Climate

The Himalayan region is dominated by the Asian monsoonal system, for which the great heights of the mountain chain make a climatic barrier. Without the existence of the high ranges, the climatic pattern of Asia would have been very different. Only a small part of the summer monsoon can cross the range through the Yarlungtsangpo valley, where the river enters the plains of Assam. This entry of the monsoon is then impeded only by the ridges of the Hengduan mountains and so creates reasonably water-rich areas in parts of eastern Tibet. (Stone, 1992)

The Himalaya acts as a similar barrier in winter, when it prevents the spread of the current of cold air from Central Asia, giving the plains to the south a much warmer winter than the regions to the north. In this way, while much of eastern Himalaya and Hengduan receive almost all the annual precipitation from June to September, the Western Himalaya, the Hindu Kush and Karakoram receive most precipitation as snow during the winter months of January to March. Furthermore, the Himalayan ridge with a southern aspect receives far more precipitation than the northern flanks and the Tibetan plateau. The variation of annual precipitation and climatic conditions provide an almost unparalleled assortment of micro and regional climatic conditions. Within a horizontal distance of about 200 km, from the foothills of the Tibetan plateau, the climate changes from wet subtropical to dry desert, giving rise to conditions favourable to the existence of rich biodiversity. (Stone, 1992)

Source: Stone (1992)

Ecosystems

The wide variations in climate govern the ecosystems found. At one extreme are the cold and dry areas of the Hindu Kush, where the vegetation cover is limited by the availability of water, grasslands and shrubs dominating the landscape, and there are a low number of plant species. On the other hand, we find the rainy forests of the eastern Himalaya and the Hengduan, where the number of plant species has been estimated at 9000 or more. (Stone, 1992)

Source: Stone (1992)

1.3.3. Study area 3: THE CAUCASUS AND THE ALTAI

Reference case

THE CAUCASUS AND THE ALTAI: An introduction

Thanks to the wide coverage of latitudinal zones and the high and dissected topography of mountain countries, Russian mountains are characterised by great natural diversity and are composed of many of the world's landscapes, except for humid tropics and mountain-savannah tropical biomes (Stone, 1992). Among several mountain ranges in the country, the Urals, the Caucasus and the Altai Mountains are most prominent. In this course, the latter two will be focused on:

- **Caucasus**: They lie between the Black Sea (west) and the Caspian Sea (east), and cover a total area of 580,000 km², occupied by Armenia, Azerbaijan, Georgia, Russia, Turkey, and Iran. Trending generally from northwest to southeast, the mountains consist of two ranges: 1) the Greater Caucasus in the north; and 2) the Lesser Caucasus in the south. Mount Elbrus in the Greater Caucasus range at 5,642 m, is the highest peak. (Gvozdetsky et al., 2019)
- **Altai**: They cover 600,000 km² of Russia, Mongolia, Kazakhstan and China, reach an altitude of 4,500 m above mean sea level and include many peaks over 4,000 m. The highest peak is the twin-peaked Mt Belukha (4,506 m) in Russia. (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009)

Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Gvozdetsky et al. (2019), Stone (1992)

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Geomorphology

- **Caucasus**: The greater part of the Caucasus originated during the Alpine geosyncline, dating from the late Oligocene Epoch (about 25 million years ago). Structurally the Caucasus represents a great anticline (upfold) uplifted at the margin of the Alpine geosyncline about 25 million years ago and subsequently altered by fresh cycles of erosion and uplift. Hard, crystalline, metamorphosed rocks such as schists and gneisses, as well as granites that predate the Jurassic Period (i.e., are older than 200 million years), have been exposed at the core of the western sector of the Greater Caucasus, while softer, clayed schists and sandstones of Early and Middle Jurassic origin (about 200 to 160 million years ago) have emerged in the east. Whereas the western sector of the Lesser Caucasus is formed chiefly of deposits laid down about 50 million years ago during the downwarp episode of the geosyncline, the central and eastern sectors consist of sedimentary strata with areas of intrusive volcanic rock that is at least twice as old. (Gvozdetsky et al., 2019)

- **Altai**: The Altai Mountains were lifted in the Miocene and Pliocene (23 to 5 million years ago). Rocks vary in age from Pre-Cambrian (over 500 million years) to Quaternary (less than 1 million years) sediments. During the Pleistocene, widespread glaciation led to the current topography of wide U-shaped valleys, with hollows and mountain lakes between the peaks. Recent erosion has formed deep ravines in some of the mountains. (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009)

Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Gvozdetsky et al. (2019)

Climate

- **Caucasus**: The crest of the Greater Caucasus forms a barrier between the temperate mid-latitude and subtropical climatic zones. In summer the temperature differences between north and south are slight, and there is a more noticeable contrast between the west, with its cooler maritime climate and the more continental east. Because the Greater Caucasus stands at an angle to the westerly air currents, the heaviest precipitation, reaching an annual maximum of more than 4,000 mm, accumulates on the south and southwest-facing slopes. The northern slopes of the Lesser Caucasus facing the southern slopes of the Greater Caucasus have a climate similar to that of the latter at corresponding elevations, with rainfall concentrated in the west. Along the northern Black Sea coast, the climate is typically Mediterranean. (Gvozdetsky et al., 2019)

- **Altai**: The position of the Altai Mountains in the centre of Eurasia gives them a harsh continental climate with widespread snow and ice cover, and January temperatures as low

as -60 °C on the Ukok Plateau, contrasting with July temperatures of up to 40 °C on the lower slopes. Summers are short, and cool at higher altitudes. Mean annual precipitation reaches up to 1,500 mm or more in the western Altai, mostly as snow at altitudes of over 2,000 m. This decreases in the eastern Altai to around 300 – 400 mm at 3,000m and to around 100 mm or less at lower altitudes. (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009)
Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Gvozdetsky et al. (2019)

Ecosystems

- **Caucasus**: In the western and central Caucasus, steppe vegetation once prevailed on the region's rich black soils, but these areas now have been converted largely to agricultural land. Forest-steppe vegetation, with oaks and beeches dominating the overstory (forest canopy), is found on the higher ground of the northern foothills of the Greater Caucasus. The eastern Caucasus are semidesert, with grasses and sagebrush (*Artemisia*) on the richer chestnut soils, and saltworts where the soil is saline. The fauna of the Greater and Lesser Caucasus includes certain endemic species (the West Caucasian and the Dagestanian mountain goat; the Caucasian black grouse; and the Caucasian mountain turkey) and even some endemic genera, such as the long-clawed mole vole (*Prometheomys schaposchnikowi*). (Gvozdetsky et al., 2019)

- **Altai**: The Altai Mountains are home to over 75 species of mammals, and 2000 species of wild plants inhabiting a wide range of habitat types extending from the alpine zone down through scattered high mountain forest and mountain steppe, to lowland desert steppe and sparse riparian forests in the valleys. As a result of the varied ecological conditions, the isolation of the mountains, and their position at the meeting point of the Central Asian Desert, the Mongolian Steppe and the Siberian forests, the flora of the Altai is generally rich in species and contains a lot of endemic and relict species. (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009)

Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Gvozdetsky et al. (2019)

Module 1: Ecological aspects of urbanization in mountain areas

1.3.4. Study area 4: THE ROCKY MOUNTAINS

Reference case

THE ROCKY MOUNTAINS: An introduction

Introduction

The Rocky Mountains (typically known as 'The Rockies') form the cordilleran backbone that dominates the upland systems of North America. The ranges stretch approximately 4,800 km from northern Alberta and British Columbia all the way to Southern Mexico. The Rocky Mountains are bordered on the east by the Basin and Range Province, the Columbia Plateau and the Coastal Mountains of Canada. The Great Plains lie to the west of the Rockies. They consist of at least 100 different mountain ranges which can generally be categorized into four groups: the Canadian/Northern Rockies (Montana & Idaho), the Middle Rockies (Wyoming & Utah), the Southern Rockies (mostly Colorado & New Mexico), and the Colorado Plateau (Four Corners region of Utah, Colorado, Arizona & New Mexico). These four regions differ in terms of geology, yet they all exceed elevations of 4,000 meters and they share similar traits in soil structures, mineral abundance, volcanic activity and climatic features. (Marston 2019)

Source: Marston (2019)

Geomorphology

- **The Northern Rockies:** The Canadian Rockies include the Mackenzie and Selwyn mountains as well as ranges in western Alberta and eastern British Columbia. These ranges have been formed on a 27 km thick terrain of carbonate sedimentation, dating back to the Precambrian and Mesozoic era. During the Cretaceous period, the Rocky Mountain geosyncline (or structural depression) became a continuous seaway. During the Laramide Orogeny (several mountain-building events that occurred 65 million years ago), Paleozoic sheets were thrust over Mesozoic rocks which subsequently formed the Candian and Northern Rockies.
    - **The Rocky Mountain trench** is a graben (a downfaulted, flat-bottomed valley) that has been formed through a process of glaciation; the trench is almost 900m deep.
    - **The Columbia icefield** (which includes the Athabasca Glacier) is located on the continental divide of the Canadian Rockies at an altitude of 3-4,000m above sea level. Glaciers in this ice field continue to thin and retreat.

- **The Middle Rockies**: mountain building was mostly caused by compressional folding and high-angle faulting and they were flanked by Paleozoic sedimentary rock such as shale, sandstone and siltstones. The same developmental process of these anticlinal mountains is also happening in the Andes mountains today. Geology in the Middle Rockies has been largely influential to the formation of rivers since the Miocene Epoch. The Yellowstone-Absaroka in Wyoming sub-divides the Middle Rockies. Yollowstone's land surface is in continuous motion due to bulging and emptying of magma chambers by way of volcanic eruptions.

- **The Southern Rockies**: composed of many ranges and are divided by high basins between the east and the west. These ranges were formed by about 1,500m of sediment accumulation during the Mesozoic era. The Southern Rockies have also undergone severe glaciation and erosion, however extraordinary alpine scenery remains. Less erosion has occurred in the Colorado Plateau, therefore only the deepest canyons (e.g. Grand Canyon) have exposed Precambrian rocks.

Source: Marston (2019)

Climate

The climate in the Rockies covers a vast spectrum: ranging from arctic temperatures in the North to subtropical zones in the south. The continentality and high elevations typically reduce the influence of latitude in the south. The lower vertical zone of the Rockies (2,100-3000m in elevation) is relatively colder than the upper zone, with cooler winter and summer seasons. The upper zone consists of tundra-like climates with brief, cold summers and drawn-out winters. Precipitation steadily increases towards the north, where it is approximately three times higher than in the south. The rain-shadow valleys in the south tend to be dry, such as the San Luis Valley in Colorado (which has a mountain-desert climate). The majority of the annual precipitation in the south falls as snow during the winter and as sporadic thunderstorms during the summer. The Northern Rockies on the other hand have more steady rainfall throughout the year as a result of Pacific cyclones. (Marston 2019)

Source: Marston (2019)

Ecosystems

Elevation, latitude and exposure are all factors that determine the wide range of plant life in the Rockies. For example, the strong winds that blow across the arid low-lying landscapes of Colorado and New Mexico often lead to sparse tree coverage. Cedars and pines across these plains are often scattered, weathered and even deformed due to high winds However, the regions along waterways in these areas are often home to deciduous and broad-leafed species clusters. Sagebrush is widespread, occurring as far north as Alberta, Canada. The montane forests of the middle elevations consist primarily of Douglas fir, piñon pine, yellow pine and aspen. The subalpine range is ideal for species such as the Engelman spruce, lodgepole pine, red cedar and hemlock. Tundra-like alpine landscapes cover the tree-line elevation and 'elfin woodland' (composed mostly of dwarf willows) span the northern mountains. These upland forests and meadows are abundant in species such as Indian paintbrush, gentian, columbine, bunchberry and larkspur. (Marston 2019)

Source: Marston (2019)

1.3.5. Other mountain ranges

Reference case

OTHER MOUNTAIN RANGES

During this course, information on other mountain areas will be briefly provided, different than the 4 main study areas already described. The additional mountain areas are:

- **Tatra Mountains**: The Tatra Mountains (area ca. 778 km^2) stretch longitudinally along the Polish-Slovak border in the Western Carpathians. It is the highest and northernmost alpine-type range in the Carpathian chain. (Zasadni and Kłapyta, 2014)
- **Mecsek Mountains**: The Mecsek Mountains are located in southern Hungary and consist of a fractured local fold system of an origin contemporaneous with the Carpathian Mountains, which reaches altitudes over 600 m. (Encyclopaedia Britannica, 2009)
- **Qin-Ba Mountains**: The Qin-Ba mountains are an ecological barrier in central China, spanning 5 provinces (Hubei, Chongqing, Sichuan, Shaanxi and Gansu), with a total land area of 140,000 km^2. They provide habitat for rare animals and plants species. (Xu et al. 2016)
- **Hoang Lien Son Mountains**: Hoang Lien Son mountain range is in Northern Vietnam and represents an extension of the mountainous ranges, which form a border westward from Indochina. (Kruskop and Shchinov, 2010)

Source: Encyclopaedia Britannica (2009), Kruskop and Shchinov (2010), Xu et al. (2016), Zasadni and Kłapyta (2014)

Module 1: Ecological aspects of urbanization in mountain areas

1.4. An ecosystem in change: present and future dynamics in the context of climate change

1.4.1. Climate change in mountain areas: an introduction

Theory

Climate change in mountain areas (an introduction)

Some of the best evidence on climate change comes from mountain areas. (Kohler and Maselli, 2009) Mountain environments appear among the most severely and rapidly impacted ecosystems by climate change (in Fort, 2015). Many scientists believe that the changes occurring in mountain ecosystems may provide an early glimpse of what could come to pass in lowland environments, and that mountains thus act as early warning systems. (Kohler and Maselli, 2009)

Mountains exist in many regions of the world and differ greatly in shape, extension, altitude, vegetation cover, and climate regime. They will therefore face various effects of climate change, even though some common features are shared: (Kohler and Maselli, 2009)

- Firstly, mountain areas have a complex topography and so their climates vary considerably over short distances. Climate change projections are therefore difficult to make, because existing climate models do not yet adequately represent all factors involved. (Kohler and Maselli, 2009)
- Secondly, temperature changes with altitude. The impacts of a warmer climate depend on different elevations. Areas at the snow line or freezing line will be affected particularly heavily. For example, every degree Celsius increase in temperature will cause the snow line to rise on average by about 150 m, and even more at lower elevations. In such regions precipitation will change from snow to rain. The decrease in snow cover will lead to an above-average warming of mountains, because snow-free surfaces absorb much more radiation than snow-covered surfaces. (Kohler and Maselli, 2009)
- Thirdly, glacier shrinkage is a worldwide phenomenon. In mountain areas this leads to an increased risk of glacial lake outburst floods. The level of permafrost will rise resulting in slope instability. On the other hand, there could be more snowfall above freezing level due to the increase of both precipitation and temperature. This might cause more frequent avalanches. The snow cover in general will become unstable and its duration will be shorter. Climate change and melting glaciers will further influence the hydrology in lowlands as well. Aquatic species relying on late summer and early autumn melt might go extinct due to the effects of climate change. Moreover, a longer snow-free season will

result in longer dry periods, thus fires will be more frequent. (Price, 2008)

- Fourthly, mountains themselves play a major role in influencing regional and global climate. They act as barriers for wind flow, which induces enhanced precipitation on windward sides, and reduces precipitation and warmer temperatures on the leeward side. Changes in atmospheric wind flow patterns may induce large and locally varying precipitation responses in mountain areas, which could lead to much stronger regional climate change (IPCC 2007a). (in Kohler and Maselli, 2009)

Source: Fort (2015), Kohler and Maselli (2009), Price (2008)

1.4.2. Study area 1: THE ALPS

Reference case

THE ALPS

In general, Europe has shown a greater warming trend since 1979 compared to the global mean, and the trends in mountainous regions are still higher (Böhm et al 2001). Regional climate projections indicate warming of about 1.5 times the global average, with greater warming in summer. Precipitation is projected to decrease in summer and on an annual average, and to increase in winter. General warming is expected to lead to an upward shift of the glacier equilibrium line between 60 to 140 m per °C temperature increase (Oerlemans 2003), along with a substantial glacier retreat during the 21st century. The duration of snow cover is expected to decrease by several weeks for each degree Celsius of warming at middle elevations in the Alps region. (in Kohler and Maselli, 2009)

Source: Kohler and Maselli (2009)

1.4.3. Study area 2: THE HIMALAYA

Reference case

THE HIMALAYA

Warming in the Himalayas is predicted to be well above the global average. Many climate models project that monsoonal flows will weaken, which would lead to a precipitation decrease. However, it seems probable that this effect is more than offset by enhanced water transport due to greater moisture in warmer air. Model projections show an increase of precipitation in December, January and February. These projections are uncertain, as they depend on poorly known changes in the monsoon regime and El Niño patterns. (Kohler and Maselli, 2009)

Source: Kohler and Maselli (2009)

1.4.4. Study area 3: THE CAUCASUS AND THE ALTAI

Reference case

THE CAUCASUS AND THE ALTAI

In the Caucasus, there is a clear differentiation between the South and North, with the former likely more affected by projected changes in both precipitation and temperature, with strong increase in temperature and decrease in precipitation. Less rain in the future will be associated with less frequent and more intense precipitation episodes in most of the region, especially in the Southern Caucasus. (Limareva et al., 2017)

The Altai has been categorised as severely vulnerable to climate change (Batima, 2006). Current data shows rises in temperature but no decrease in precipitation. However, it is predicted that by 2080, increases in evaporation of surface water will be ten times greater than any possible increases in precipitation. Winters are expected to be milder, with more snowfall, and summers hotter. (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009)

Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Limareva et al. (2017)

1.4.5. Study area 4: THE ROCKY MOUNTAINS

Reference case

THE ROCKY MOUNTAINS

Higher elevation sites in the Rocky Mountains have experienced a threefold increase in warming

compared to the global average during the last few decades. Climate models show above-average warming with the greatest warming at high latitudes from December to February, and from June to August in the mid-latitudes. Annual mean precipitation will increase, except in the South, but precipitation is influenced by El Niño and the North Atlantic Oscillation, for which predictions are uncertain. There will be earlier snowmelt in spring and a shift from snowfall to rainfall, particularly at middle and lower altitudes. (Kohler and Maselli, 2009)
Source: Kohler and Maselli (2009)

Module 1: Ecological aspects of urbanization in mountain areas

2. Urbanisation and mountain areas

Key words

Urbanisation, historical urbanisation, socioeconomic activity, mountain agriculture, animal husbandry, mining, forestry, tourism, mountain architecture

Study areas: the Alps, the Himalaya, the Caucasus & Altai, the Rocky Mountains, Qin-Ba Mountains, Mecsek Mountains, Huangshan Mountain

2.1. Urbanisation in mountain areas: an introduction

Theory

Urbanisation in mountain areas (an introduction)

Groetzbach (1988) distinguishes two main categories of mountainous areas based on human settlement:

- Category 1: Old and relatively densely settled high mountains:
    - Largely intact traditional subsistence agriculture and a tendency to overpopulate
        - Population of mountain peasants

          (Large parts of the Himalaya-Karakorum-Hidukush and Andes)
        - Population of mountain peasants, including nomads

          (High Atlas, mountains of the Middle East, western parts of the Hindukush and Himalaya)
    - Strongly declining traditional agriculture and expanding new activities (tourism, among others) *(High mountains of Europe, especially the Alps and Pyrenees)*
    - Largely collectivized or nationalized agriculture, in parts with new activities (island-like) scattered tourism *(High mountains of the Soviet Union and China, parts of the Carpathians)*
- Category 2: Young and relatively sparsely settled high mountains:

  Areas colonized by European countries, with extensive market-oriented agriculture,

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forestry and recent tourism

(High mountains of North America and New Zealand)

High mountains served as refugee areas for a long time. Population groups that were in need of protection from conquerors or oppressive regimes were able to find a safe place in the mountains, where the authority was not established. Newly inhabited mountain areas in North America and in New Zealand were only used by migratory hunters before the arrival of Europeans. Those mountains have remained sparsely populated until today. Tourism is also usually centred in National Parks or winter resorts. (Groetzbach, 1988)

Nowadays, 12 percent of the world's population live in mountains; the great majority living in developing countries. Mountain populations are quite diverse in their way of life: traditional rural activities such as agriculture, livestock grazing and forestry, coexist with mining extraction, hydropower production and tourism (Beniston et al., 1996). Depending on the socio-economic and demographic context of each country, such activities are either declining or in full expansion. (Fort, 2015)

However, high-mountain areas around the world are experiencing outmigration, unless they have specific climatic advantages or economic opportunities. Global processes such as industrialisation and urbanisation outside mountain areas, an increase in the availability and attractiveness of off-farm employment, and improved road accessibility have changed the way mountain areas are valued by society. Outmigration has also led to the abandonment of traditional settlements and land use in high mountains, such as modest subsistence agriculture and livestock herding - forms of land use that shaped specific cultural landscapes as they evolved. (Gracheva et al., 2012)

It is assumed that outmigration from mountain areas will be replaced by a late-modern immigration phase characterized by globalization. A recently released volume edited by Moss and Glorioso (2014) contains examples of this trend from all over the world. The concepts of counterurbanization (Berry 1976) and amenity migration (Moss 1994, 2004) describe the rediscovery and reevaluation of rural areas as residential and commercial space by primarily urban people (''urban refugees'') (in Löffler et al., 2016). Amenity-led migration represents a shift in preference of residential location from the urban space to remote but attractive rural (mountainous) regions. (in Steinicke et al., 2012) A variety of expressions, such as amenity-led migrants, new highlanders, multi-residence dwellers, lifestyle migrants, or neoruralists, describe the new mountain residents. (in Löffler et al., 2016) Weekend and leisure residences or retirement homes have become more common. As more and more people are no longer confined to their places of work, the motivation to transfer work-related aspects to "new" residences is high. Further reasons for this turnaround are improved infrastructures in terms of telecommunication, traffic and supply, as well as affordable real estate and intensive leisure activities. Amenity migrants intend to settle either permanently, seasonally (one or more periods per year), or intermittently. (in Steinicke et al., 2012) Tourists, seasonal workers, owners of second and holiday homes compose the non-year-round resident population. (Löffler et al., 2014)

Source: Fort (2015), Gracheva et al. (2012), Groetzbach (1988), Löffler et al. (2014), Steinicke et al. (2012)

2.2. Mountains and urbanisation beyond their perimeter

Theory

Mountains and urbanisation beyond their perimeter

Food security, poverty alleviation and overall development are critically linked to mountain ecosystems processes. Mountain environments are therefore essential for the well-being of not only mountain people but of all humankind (FAO, 2011). They play an important role in their adjacent lowlands: they are "water towers" (Liniger et al., 1998; Viviroli et al., 2007) storing and delivering fresh water to downstream areas, and producing energy through hydropower harnessing (de Jong et al. 2009; Viviroli et al. 2011; Beniston and Stoffel, 2013) (in Fort, 2015). Mountains provide freshwater to half of the world's population for irrigation, industry, domestic use and hydropower (Kohler and Maselli, 2009). Furthermore, mountains are a source of habitat diversity; they have a splendour and beauty unmatched by any other environment; they provide recreational, research, and educational opportunities; and they are the loci of numerous resources. (Price, 1986) As an example, mountain agriculture and farming constitute the principal source of food and livelihood for about half a billion people (FAO, 2008). (in Tiwari et al., 2018)

Source: FAO (2011), Fort (2015), Kohler and Maselli (2009), Price (1986), Tiwari et al. (2018)

2.3. Impacts of urbanisation in mountain areas

Theory

Impacts of urbanisation in mountain areas

Mountain environments are "fragile", they can be damaged by many factors such as deforestation, overgrazing by livestock, cultivation on marginal soils, and progression of urbanisation, all of which may result in (1) a rapid degradation of biodiversity and water resources, and (2) an increase in natural hazards, hence putting adjacent populations at risk (Fort, 2015). Erosion rates are higher and the loss of fertility through the leaching of nutrients more accentuated than elsewhere (FAO, 2011).

The type and intensity of disturbances in mountain areas is critical: external disruption is usually more difficult to assimilate than alterations within a mountain system. Most mountain ecosystems evolved in the absence of human activities and are thus not accustomed to anthropogenic disturbances. (Price, 1986)

Cities put heavy pressure on the environment, resulting in deforestation and degradation of their surroundings and pollution of rivers. (FAO, 2011) The activities related to urbanisation which constitute the major sources of impact in mountain environments are: 1) overgrazing and deforestation; 2) the construction of dams and reservoirs; 3) mining; 4) forestry; and 5) recreation and tourism. Because mountains (at least those in middle and high latitudes), have traditionally been among the last regions to be settled, they are also among the remaining pristine and wild landscapes. Thus, damage to these environments by urbanisation reduces the variety and quality of the habitats on the Earth, as well as the richness of their biota. The loss of these landscapes means that people will not have the chance to experience such environments in the near future. (Price, 1986)

Furthermore, damage in the uplands eventually finds its way to the lowlands. Pollution by heavy metals and radioactive contaminants are examples of this. Mountains intercept wind-laden materials both directly from the atmosphere and from precipitation. As a result, they often display a rapid build-up of pollutants compared to the lowlands: they act as pollution sinks. The build-up of pollutants not only has serious local effects but will eventually harm the lowlands too, as the pollutants move downward through snowmelt, groundwater, stream flow, and animal food chains. A serious problem in mountain areas is the occurrence of acid rain, received by mountains downwind of urban-industrial areas (Likens and Bormann, 1974). It causes a lowering of the pH of solutes, which increases the rates of corrosion and weathering of rocks, leaching of salts from the soil, and leaching of nutrients from plant foliage. It leads to acidification of streams and lakes (Cronan and Schofield, 1979). (Price, 1986)

Historically, people have damaged mountain environments with their traditional activities of hunting, grazing, cutting or burning forests, and by modifying the landscape through building terraces, irrigation systems, and other functional structures. These activities have had a definite impact, but small populations and limited technology insured that they were carried out on a relatively small scale. So, while the effects might have been negative, they have not generally been devastating. People in many traditional cultures found ways to adjust themselves to environmental conditions and to live within the potentials and limitations of the natural environment, rather than making major modifications to it. (Price, 1986)

However, the types of activities and their potential impacts have changed along with changing technologies. Human activities have become increasingly disruptive and their effects much more widespread. The major negative impacts came after World War II. Rapid technological developments changed economic development and increased the mobility of middle-latitude populations. The industrialisation of mountain valleys, the production and use of off-road vehicles created greater access to mountain areas, and the uncontrolled boom in building for recreation and tourism were the most obvious signs of this encroachment. More subtle (but perhaps more important in the long run) are air, water and soil pollution, including the build-up of radioactive materials. In addition, there have been both intentional and unintentional introductions of new species and control of animal and plant populations through the use of herbicides, pesticides, and the selective killing of pests and predators. (Price, 1986)

Many traditional mountain cultures, are thus very fragile and vulnerable to disruptions from technology and urbanisation. Apparently well-adapted cultures have nearly collapsed after facing only a few years of pressure by increasing population, migration to lowland cities, and the adoption of new tools and practices. (Price, 1986)

Urbanisation has altered forest ecosystems by fragmenting, or removing them altogether. Indirect effects of urbanisation include changing hydrology, nutrient cycling processes, non-native species introduction and disturbance regimes alteration. Rates of forest loss are typically most prevalent in areas of major communication corridors, near urban centres and recreational areas (such as the Rocky Mountain National Park). Urbanisation and reconstruction of roads, buildings, parking lots etc. accelerate the rate of fragmentation. Native biodiversity is affected by habitat size reduction, interior forest habitat loss, the isolation of already existing populations as well as the alteration of microclimates. The loss of forest habitat corridors and the embeddedness of them within urban landscapes causes stagnation in organism movement. This drastically impacts genetic flow across populations, which in turn leads to mutation and local extinction of species. (Reed et al. 1996)

Source: FAO (2011), Fort (2015), Price (1986), Reed et al. (1996)

2.4. An evolutionary perspective of urbanisation in mountain areas (historical review)

2.4.1. Study area 1: THE ALPS

Reference case

THE ALPS: A prehistory

The Alps are among the earliest-settled regions of Europe. Hunters and gatherers might have established in the Alps as early as the first settlers established in Europe. Nevertheless, there is little evidence of these cultures of hunters and gatherers in the Alps. Numerous indications do exist that humans started to settle in the Alpine regions bordering the Mediterranean at least at around 4000 BC, even though this was only a seasonal activity related to the transhumance to Alpine pastures in summer. Summer settlements were founded and cultivation and animal husbandry were practised. It very likely took 1000-2000 years before humans could inhabit in the mountains for the entire year. The earliest subsistence economies of this type were located in the major valleys, in intermontane dry zones, and in the Mediterranean lower zone at low altitudes, usually below 1000 m. The best areas at low altitudes were reserved for farming, while animal husbandry was practised at Alpine and subAlpine elevations. The next major advances (the discovery and processing of copper, bronze and iron) arrived rather quickly in the Alps from the Near East: copper mining and bronze handiwork from 1800 BC; iron mining and smelting from 800 BC. This intensified agricultural land use in the Alps, since the many miners and metalworkers had to be supplied with food from the immediate surroundings. (Stone, 1992)

Source: Stone (1992)

From the Roman Empire to the industrial revolution

The idea of mountains as being intimidating was shaped by the Greeks and Romans, and was established in the Roman literature around the time of the birth of Christ. It continued to influence the view of the Alps until well into the 18th century. This image characterised the Alps as a hostile region. (Stone, 1992)

Despite this fact, the Alps were already heavily settled and intensively used by the time they received attention from the Roman culture. Between 1000 and 1350 all of Europe experienced great prosperity. In the Alps, heavy population growth, extensive clearing of forests, and a substantial increase in the amount of cultivated land occurred. Alpine culture flourished and was characterised by numerous technological, economic, social and cultural innovations. Two important innovations were introduced. They affected only small areas because the Alps were already densely settled. These were the "Schwaighöfe" (dairy farms) and the Walser economy. Both are farms that specialise purely in animal husbandry and can accordingly exist at very high altitudes. The development and spread of the "Schwaighöfe" and the Walser settlements meant land use was at a maximum in the Alps by around 1350 AD. The Alps as of 1350 AD were little different from the picture they presented in the 19th century. (Stone, 1992)

Source: Stone (1992)

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From the industrial revolution until now

Industrialisation was the main cause of the total breakdown of traditional economic and social structures in the Alps in the 19th and 20th centuries. Large-scale collapse began in the Alps between 1870 and 1880, when Alpine inhabitants ceased farming and migrated to large cities. Along with agriculture, handicrafts and industries also failed. Between 1850 and 1955, there were only three countermovements: tourism, industry and transportation. Nonetheless, the prosperity brought by tourism, industry and transport was only of secondary importance and the entire region became an economically weak area with a high rate of emigration. (Stone, 1992)

Tourism in the Alps was connected with new perceptions of the environment in the industrial age. There was an increasing need to idealise nature and derive aesthetic enjoyment from the beauty of the natural landscape, as nature was being exploited and destroyed by industrial production. Thus, a completely new image of the Alps as an idyllic world arose. This view of the Alps enjoyed its first great vogue during the age of Romanticism and achieved a second peak of popularity during the so-called Belle Epoque (1880-1914), when alpine tourism was beginning to flourish. This image has continued to influence the European perception of the Alps virtually to the present day. It was not until the 1950s, however, that tourism started to play an important role for the socio-economic activity and settlement development in the Alpine regions. Beginning around 1955, the industrialised countries of Europe entered a new phase characterised by the transition towards a service economy. This led to the beginning of mass tourism, which became a part of life in Europe, with summer tourism beginning around 1955 and winter tourism around 1965. Large areas of the Alps were and still are transformed as resort locations. (Stone, 1992)

A second development occurred in the 1980s. Increasing numbers of people began to flee heavily polluted urban areas and seek places to live and work where they would have healthy and pleasant surroundings. New jobs are being created in the edge of the Alps and to some extent in the mountains themselves. (Stone, 1992) The municipalities in close proximity to regional capitals grew in process of suburbanisation (increased mobility) since 1990. Most recently, small towns and their environs have formed larger agglomerations (metropolisation). Formerly rural regions that were in close proximity to agglomerations become permanent residences or weekend/seasonal property for some, being affordable for middle-class as well. This development is tightly connected to increasing mobility and options for daily commuting. (Perlik, 2006)

No longer are the Alps a culturally and economically weak region. They are now a developing European resort area and a newly discovered economic region. (Stone, 1992) The population of the Alps grew from 7.0 to 14.2 million people in the period 1870 and 2000. However, the distribution of population growth was not even. Populations had risen in the French Northern Alps, South Tyrol in Italy and in western part of the Eastern Alps (Bavaria, Salzburg, Tyrol, Voralberg). Populations declined in parts of the Eastern Alps, in some areas of the Italian Alps and also in the French Northern Alps. Switzerland underwent both growth and decline. In general, the population

concentrates in broad mountain valleys, it declines in middle-high altitudes and at high altitudes not used for tourism. (Perlik, 2006)
Source: Perlik (2006), Stone (1992)

2.4.2. Study area 2: THE HIMALAYA

Reference case

THE HIMALAYA: A history

The Himalayas are the most populous of the world's mountains. (Stone, 1992) Its population distribution is the result of a long history of penetrations by Central Asian and Iranian groups from the west, Indian peoples from the south, and Asian peoples from the east and north. (Bishop and Chatterjee, 2015). Opinions are divided about whether the Himalayas were used as a corridor that facilitated human migrations from the Tibetan plateau to South Asia in ancient times, or alternatively remained uninhabited due to their inhospitality until more recent times (Majumder 2008; Gayden et al. 2009, 2013; Qi et al. 2013). Archaeological data suggest that the central Tibetan Plateau was populated during the Neolithic period (Meyer et al. 2017), and there is evidence of early human occupation in the north-eastern Qinghai region (Aldenderfer 2011) (in Arciero et al., 2018). In the Tibetan Plateau, for example, humans underwent an adaptation process to handle low atmospheric oxygen level - respiratory and blood systems had to adjust to those harsh conditions. (Knörzer, 2000)

As a result of the penetration of distinct population groups, the Himalayan region is culturally complex (Karan, 1987). It is one of the most complex linguistic areas in the world (Arciero et al., 2018). Its population comes from four distinct ethnic groups: Indic people, Tibetan people, Afghan-Iranian people, and Burman/South-east Asian people (Apollo, 2017). In general, people of Hindu culture are dominant in the sub-Himalaya and middle Himalayan valleys from Jammu to Nepal. To the north, people of Lamaist Buddhist culture inhabit the High Himalaya from Ladakh to north-eastern India. In an area from 1,829 to 2,439 m and occasionally up to 3,048 m in central Nepal, the Indian and Tibetan cultures have intermingled, producing combined Hindu and Tibetan traits. The Eastern Himalaya is inhabited by people whose culture is similar to that of the people living in northern Burma. People of western Kashmir have a culture similar to the inhabitants of Iran and Afghanistan. (Karan, 1987)

The principal features of Hindu culture include the Indo-Aryan languages and settled agriculture. Distinctive features of Lamaist culture are the Tibetan language and a combination of pastoralism

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and settled agriculture. Buddhist monasteries, located in secluded places but within easy reach of the main trans-Himalayan trade routes, developed as centres of religious and economic life where artistic and intellectual expression and culture flourished. From Iran and Afghanistan came major features of Islamic culture, i.e. non-Indic Aryan languages, Moslem-influenced art forms, pastoralism, and irrigated, settled agriculture forms. Animist culture features associated with the Burman or Southeast Asian area are the Tibeto-Burman languages, art forms associated with indigenous religious systems, and shifting agriculture. (Karan, 1987)

The Himalaya has experienced a rapid process of mostly unplanned and unregulated urbanisation during last three decades (Anbalagan, 1993). More recently, less accessible areas have also faced rapid urbanization mainly due to improved road connectivity, publicity and marketing of new tourist sites and the resultant growth of domestic as well as international tourism. Other influential factors are: 1) the development of horticulture; 2) economic globalization and a gradual shift from primary resource development practices to secondary and tertiary sectors; and 3) the absence of urban land use policy (Ghosh, 2007). Consequently, there has been a tremendous increase in size, area, number and complexity of urban settlements, resulting into the expansion of urban processes (i.e., expansion of urban land use in surrounding agricultural zone, forests and rural environments) as well as increase in the intensity of urban land use (i.e., increase in the density of covered area, density of building, and increase in the density of population) within the towns (Walker, 2011). The sprawling and unplanned urban growth has disrupted the ecosystem services, depleted natural resources, increased socio-economic inequalities and increased vulnerability of towns and their fringe areas to a variety of natural risks (Anbalagan, 1993). (in Tiwari et al., 2018)

Consequently, the Himalaya’s population reached 52.77 million people in 2011. Of this, 25.59 million reside in Western Himalayas (48.5% of the total Himalayan population), 19.22 in Central Himalayas (36.4%) and 7.96 in Eastern Himalayas (15.1%). In the last fifty years (1961–2011), the Himalayan population has grown by 250%, from 19.9 to 53.8 million, with the lowest annual growth occurring in Bhutan’s Himalaya (0.32%). (Apollo, 2017) Most of the population is concentrated in the Ganga and Indus valleys along the southern aspect of the main Himalayan arc, and in the north-eastern parts of the region in the western Sichuan and Yunnan provinces of China. (Stone, 1992) Such a significant increase in the sizes of the Himalayan population has also left its mark on the population density, which also increased greatly. In 1911, the average population density for the Himalayan arc (without Nepal and Arunachal Himalaya) amounted to over 22 persons per km^2. This value had increased by nearly 150% (to 36.31) by 1961, and by 2011 reached over 96 people per km^2, which is almost twice the world average (54). The regions of Arunachal and Bhutan Himalayas are the least frequently populated areas of the Himalayas with less than 20 people per square kilometre. (Apollo, 2017)

Source: Apollo(2017), Arciero et al. (2018), Karan (1987), Knörzer (2000), Stone (1992), Tiwari et al. (2018)

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2.4.3. Study area 3: THE CAUCASUS AND THE ALTAI

Reference case

THE CAUCASUS AND THE ALTAI: A history

The Caucasus

The Caucasus is one of the oldest centres of world civilization (Gasimov, 2011) and was one of the most ancient centres of bronze working, which began at the first half of the 2nd millennium before Christ. In the centuries between pre-Classical antiquity and the 14th century after Christ, the Caucasus underwent successive invasions by the Scythians, Alani, Huns, Khazars, Arabs, Seljuq Turks, and Mongols (Gvozdetsky et al., 2019). This has resulted in the transformation of the area into a multi-ethnic, multi-lingual, and multi-confessional area (Gasimov, 2011). The complex of regions nowadays harbours more than 50 cultures, ranging from language communities with only a few hundred speakers to large national groups numbering millions. This includes: the Georgians, the closely related Mingrelians and Laz, the Chechens, the Kabardians, the Ossetes, the Azerbaijani, the Kipchak Turks, etc. Likewise, the Caucasus are at the crossroads of many religions, the better represented in the area being Islam, the Eastern Orthodox church, the Armenian Gregorian church, and Judaism (Encyclopaedia Britannica, 2001).

The later history, beginning with a long period of rivalry between Ottoman Turkey and Iran, is marked by the advance of Russian culture, which penetrated further and further into the Caucasus from the 16th century onward. Throughout this process, individual ethnic groups, under pressure from stronger neighbours, took refuge in the ravines of the mountain ranges to preserve themselves in isolation (Gvozdetsky et al., 2019). During this period, all areas were subjected to heavy Russian influence (Encyclopaedia Britannica, 2001) and the Caucasus became one of the more economically developed regions of the Soviet Union, due to the abundance of mineral resources allowed (Gvozdetsky et al., 2019).

Currently, the population within the boundaries of the Caucasus range has been estimated at 1.25 million in an area of 103,000 km^2 (Thorez, 1983, pp. 661-62). (Thorez, 1990) Everywhere in the Caucasus are traces of a patriarchal clan system and a tribal organization of society. These features have been best preserved among mountaineers. In general, however, the tribal system gradually gave way to a system of village communities (Encyclopaedia Britannica, 2001), and now village/city dwellers account for nearly three-fifths of the entire population. (Gvozdetsky et al., 2019) Feudal relations developed especially in Georgia, Armenia, and Azerbaijan and in some parts of the northern Caucasus (Encyclopaedia Britannica, 2001).

The rural population of the Caucasus is unevenly distributed. (Gvozdetsky et al., 2019) In fact, a large part of the western Caucasus is almost uninhabited, as are several valleys in the central Caucasus, whereas in the eastern Caucasus the population density is often extremely high. The population has been shaped by the multiple conflicts occurring in the area and is still experiencing the effects of the Russian conquest of the northern piedmont. For example, after their defeat in 1864, the Circassians were driven from the mountains; this displaced population has been estimated at about half a million (Pokshishevskiĭ, 1984 pp. 514-28). The western Caucasus remains almost entirely uninhabited because no group has come to replace the Circassians. In the central and eastern Caucasus colonization of the piedmont by the Cossacks drove the Caucasians into the mountains. Then, when the Cossacks went to war in 1914, their departure was followed by massive migrations of mountain dwellers into the abandoned villages in the lowlands. Between 1942 and 1945, during war times, many inhabitants of the Caucasus were evacuated or deported. Although a number of them returned to their lands after 1956, the population density has never reached its prewar level. As such, today the population of the mountains remains almost exclusively rural. Within this time, beside the traditional migrations associated with transhumance, new forms of temporary migration have appeared; many of those who have left the villages to work in the cities return in the summertime. There are also a few larger towns scattered in the mountains. Most often they are characterized by single economic activities (e.g., extractive industries at Tyrnyauz, Sadon, and Chiatura; tourism at Teberda; hot springs at Tskhaltubo). (Thorez, 1990)

Source: Encyclopaedia Britannica (2001), Gasimov (2011), Gvozdetsky et al. (2019), Thorez (1990)

The Altai

The Altai has had a long history of human occupation, and there are numerous archaeological sites, including deer stones, tombs, cave-paintings and the ruins of former settlements in the area (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009). Primary settling of Altai was generally "peasant colonization" and mostly developed alongside the rivers network. Traditional farming settlements can be divided into two groups: permanent and seasonal. The first group includes villages-centres, which are administrative, religious, economic and trade centres for several surrounding villages and other settlements. Seasonal settlements are situated close to permanent settlements and economically inseparable from them. Their inhabitants live in another village and go there for land cultivation, therefore seasonal settlements are built close to farming land. The other type of seasonal settlement are hunting houses, located in remote districts and occasionally used by fur-hunters; they are rare in the Altai (Gregoritchev, 2019).

The inflow of settlers from the European part of Russia since the second half of the XIXth century resulted in a large sprawl of settlements. Intense development in the XXth century of inner and outer economical contacts brought to life a network of roads and a significant increase of their importance. The consequence of this process was a boost of settlements related to large highways. Prevalence of connection to social and economic objects, first of all to the roads (including railroads) became the trend of settlement evolution in the XXth century (Gregoritchev, 2019).

Today, the population density in the region is 1.5 people per km^2 (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009). The Altai people can be divided into two distinct groups: the Northern Altai, or Chernnevye Tatars, consisting of the Tubalars, the Chelkans or Leberdin, and the Kumandins; and the Southern Altai, comprising the Altai Kizhi, the Telengit, the Telesy, and the Teleut (Gladman, 2004). Their principal occupation is livestock raising, including the breeding of cattle, sheep, and horses (Mikhaylov and Owen, 2009).

Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Gladman (2004), Gregoritchev (2019), Mikhaylov and Owen (2009)

2.4.4. Study area 4: THE ROCKY MOUNTAINS

Reference case

THE ROCKY MOUNTAINS: A history

Since the last Ice Age, the Rocky Mountains were home to Paleo-Indians, and then later to many different Native American tribes. These were migrating groups that most likely resided in the lowlands and plains during the winter and autumn, and in the mountains during the spring and summer (following hunting abundance). Recent human history in the Rocky Mountains has witnessed rapid change. Since 1540, Francisco Vasquez de Coronado, along with African slaves, missionaries and soldiers entered the mountainous regions. This movement drastically altered Native American cultures and pushed their communities out of their historical places of settlement. From 1720 onwards, the French, Spanish, and British entered the Rocky Mountains in search of minerals and furs. Later in 1846, Mormons began to settle near the Great Salt Lake and shortly thereafter gold was discovered in Colorado. This led to a transformation in economic vitality in the Rocky Mountains region. The establishment of a transcontinental railroad increased the number of settlers in mining towns, escalating population trends in mountain areas. Simultaneously, conservation and preservation ethics fortunately began to form, during which Yellowstone National Park was created, as well as several forest reserves including the Medicine Bow Forest Reserve in the Rocky Mountain National Park. Economic development through mining, forestry, agriculture and recreation grew, as did populations and urbanised areas. Since the 1960s, population growth has steadily increased in the Rocky Mountains. During the period between 1958 and 2018, the region’s population rose from 4,139,000 to 12,250,919. In 2018, the population of

the entire USA was 327,167,434 meaning that the Rocky Mountains composed 3.7% of the US population last year. The overall population rate of the Rockies during that time was 196%, with an annual rate of about 2%. (US REAP 2019)
Source: US REAP (2019)

2.5. Urbanism and socio-economic activity, two interrelated spheres

2.5.1. Farming and animal husbandry

Theory

Farming and urbanisation

Mountain agriculture is affected by two major constraints - relief and altitude. With increasing incline of the slopes, the energy input rises while productivity declines. Agricultural land use in mountains becomes more uniform and extensive with growing altitude. The highest areas of agriculture usually lie above the forest line and represents pasture zone. Growing crops and field cultivation is not economically feasible. (Groetzbach, 1988)

The best areas at low altitudes are reserved for farming, while animal husbandry is practised at Alpine and subalpine elevations. This model of Alpine subsistence economy is found in all mountain areas of the world wherever there are settled farming societies influenced by Near Eastern patterns of development, i.e. in the entire "alpine" arc from the Pyrenees to the Himalayas. (Stone, 1992)

Source: Groetzbach (1988), Stone (1992)

Negative impacts

The main impacts of farming and animal husbandry in mountains have been traditionally related to overgrazing and deforestation, which are among the earliest destructive activities of humans in mountains. An example of their disruptive effects can be found in the grazing of sheep and goats. Livestock crop vegetation so closely that plants cannot grow back, and they tenaciously consume every bit of living vegetation until there is nothing left. In an area where rates of plant growth and soil development are already exceedingly slow, uncontrolled grazing of such animals can have a profound effect. Perhaps nowhere is the impact of grazing and deforestation more severe than in

the arid and semiarid mountains of the Middle East and the Mediterranean. Vegetation removal results in the exposure of the surface of dry soils to the elements, which makes them very vulnerable to high rates of erosion. Where population pressure and land use have been more concentrated, the forests have become much smaller than they once were. (Price, 1986)
Source: Price (1986)

2.5.1.1. State-of-affairs in the 4 study areas

2.5.1.2. Study area 1 - THE ALPS

Reference case

THE ALPS: An overview on agriculture

Before the mid-19th century the economic basis of the Alps was predominantly agricultural and pastoral (Poulsen et al., 2009). In many areas of the Alps, the upper forests were destroyed during the centuries of agricultural expansion (Price, 1986). However, since then there has been widespread abandonment of farms, especially in the high valleys of France and Italy and in western Austria. On the other hand, agriculture still survives in a more intensive form in favoured locations both in the main and lateral valleys. As an illustration, the hot and dry Rhône valley in Switzerland is an intensive area of irrigated fruit and vegetable cultivation, and both the valley floor and slopes of the mountains have extensive vineyards. Most of the agriculture and pastoralism in the high valleys exists as hobby farming or second-income enterprises. (Poulsen et al., 2009)

Source: Poulsen et al. (2009), Price (1986)

2.5.1.3. Study area 2 - THE HIMALAYA

Reference case

THE HIMALAYA: An overview on agricultural

The principal economic activity in the Himalayas is animal husbandry, but agriculture also plays an important role (Chatterjee and Bishop, 2015). The majority of farmers (especially in the subtropical

mountains of India and Nepal) operate in mixed-crop livestock farming systems. Both geographical and topographical differentiations across the Himalayan ranges have influenced the region's agricultural systems. The most common livestock in upland communities are cattle, sheep and goats. Animal husbandry is directly linked with crop production in the Himalayas. In this circular farming system, crops produce feed and fodder while livestock produce milk, meat and products such as cheese and 'ghee' for subsistence purposes. "Livestock are integral to the sustainability of hill and mountain farming" (FAO 1992). Different levels of commercialisation and mobilisation have had major impacts on traditional mixed crop-livestock farming systems. Population growth in the Hindu Kush Himalayas has led to increased land fragmentation and thus decreased land resources per household. It has therefore also increased the number of farms in the region, but decreased farm size. Overall increase of livestock has caused significant impact on natural resources, and has in turn required more land to be cultivated for animal feed. (FAO 1992)
Source: Chatterjee and Bishop (2015), FAO (1992)

2.5.1.4. Study area 3 - THE CAUCASUS AND THE ALTAI

Reference case

THE CAUCASUS AND THE ALTAI: An overview on agricultural

The ***Caucasus*** region has some of the best conditions for agriculture in Eurasia. Mixed agriculture is practiced on the rich black soils of the western and central Caucasus. Tea, citrus fruits, the tung tree, and bamboo are grown in the humid subtropical lowlands and foothills regions. Other areas produce tobacco, grapes, and various fruits. In the higher elevations, the primary activity is livestock raising (mainly sheep and cattle), although people also grow some mountain crops and pursue a few domestic crafts. (Gvozdetsky et al., 2019)

Most people in the ***Altai*** are involved in agriculture, mainly transhumant pastoralism, with some crop cultivation. Raw livestock products, mainly meat, leather, wool, cashmere and dairy, provide the main source of income for rural families. The proportion of the population that is rural is approximately 70%. The harvesting of wild animals and plants is also common practice. (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009)

Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Gvozdetsky et al. (2019)

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2.5.1.5. Study area 4 - THE ROCKY MOUNTAINS

Reference case

THE ROCKY MOUNTAINS: An overview on agricultural

Colorado has faced a booming agricultural industry over the years, and the state is composed of approximately 12.5 million hectares of agricultural land that spans across the highest mountains and lowest valleys. The agricultural land in Colorado can be categorized into three regions: the plains, the Western slope and the mountains.

- **Colorado Plains region:** bordered by the foothills of the Rocky Mountains and Kansas, the plains region has a semi-arid climate and has little rainfall; high temperatures and snow-melt irrigation allow for ideal farming conditions. Small farming communities in the area produce sunflowers, oats, sorghum, millet, corn wheat and hay. There are also large-scale dairy farms and hog operations. Like other areas, farmers face challenges of natural hazards such as hail, drought and tornadoes.

- **Western Slope of Colorado:** this region is not heavily populated, but it composes about 40% of Colorado's land area. Farmers mostly grow sweet corn and tree fruits (especially apples, peaches, as well as berries and grapes for wine production). The temperature swings allow for optimal sugar levels in crops. Irrigation poses a challenge in this region.

- **Mountains:** cattle and cool weather crops benefit from the shorter growing seasons in the mountains. Cool season grasses allow for low input feeding with high gains for cattle and sheep. This location is prime for growing perennial grass hay, and thus ideal for livestock grazing grounds. (Walden 2018)

Source: Walden (2018)

2.5.1.6. Examples

Case study 1

Study area 2 - THE HIMALAYA - Mountain agriculture in the Himalayas, Nepal

The severe terrain and climate in the Hindu-Kush Himalayas makes for a very challenging environment for the 150 million inhabitants in the region. Most are agriculturalists and pastoralists, depending on their location, and these communities are often entirely reliable on their own resources. These subsistence farmers have historically been extremely isolated, however over the last 50 years a rapid change in communication between the highland and lowland communities has occurred. For example, seasonal migration and access to new transport systems have become normalized, meaning that an increase in education has led to a major change in understanding and perception of resource use. The biggest challenge remains the need for adequate production in order to sustain a rapidly growing population, whilst avoiding environmental degradation of the mountain region. Fragile mountain ecosystems require an integrated, holistic approach that encompasses climate, socio-economic and future resilience strategies for sustainable mountain agriculture (ICIMOD 2001).

One implemented technique in the Hindu-Kush region is the **System of Rice Intensification (SRI)** which was originally developed by Henri de Laulanie in 1980, in Madagascar. The method is based on agroecological principles that strengthen soil microbiological abundance and increases root growth for the production of upland rice. This concept has been successfully established in Nepal's middle mountains such as the Jhikhu Khola watershed located at 800-2200 m. (ICIMOD 2019)

Sloping Agricultural Land Technology (SALT) is another system (originally developed by the Mindanao Baptist Rural Life Centre in the Philippines). Ricke et al. define SALT as an agroforestry practice designed for the "intensification of sustainable agriculture on sloping land" (Folving et al. 2014) and it has become widespread in Southeast Asia. It has now effectively been implemented in many countries such as Cambodia, Indonesia, India, Vietnam, Nepal etc. for the purpose of improving eroded hillsides in upland environments (FAO 1992). SALT is a method in which hedgerows of perennial nitrogen-fixing shrub species are planted along contours of terraced land (e.g. upland rice paddies). Nitrogen fixation improves soil fertility while the 'living barrier' of the hedgerows prevent soil erosion as well as excess water runoff. While the SALT method was designed for tropical climates, it has been successful in the Hindu-Kush Himalayas on sloping farmland with a gradient of 5-25% (ICIMOD 2019).

Source: ICIMOD (2011, 2019)

Case study 2

OTHER MOUNTAIN RANGES - Mountain agriculture in Vietnam

The mountainous regions in the north of Vietnam are widely known for their ethnic diversity and unique agricultural practices. The Suoi Muoi catchment in Son La province and the Sa Pa district in Lao Cai are especially known for their rapidly changing land use practices. Over the years these regions have undergone significant land use change, which is known to be a major contributor to global environmental challenges (Kim Chi Vu et al. 2015). Several efforts to monitor global land use change have been made, including the program initiated in 1993 by the International Human Dimensions of Global Environmental Change Programme (IHDP) and the International Geosphere-Biosphere Programme (IGBP) (Vu et al. 2015).

It has been shown that there is an increasing demand for agriculture which has led to declining land cover in mountainous areas of Vietnam. Between 1954-1999 there was a decrease in 67% of both open and closed canopy forest. On the other hand, upland fields had also increased by 60%, as well as rice paddies by 20%. During that time the northern provinces also faced a rapid expansion of residential areas. There was also a major conversion from shrubland to upland (42%): a direct cause of the traditional fallow practice (in which cropland is purposefully left out of production for approximately four or five years) (Vu et al. 2015). The length of fallow has been shortened over the years due to an increase in population, and thus higher agricultural demand. The intensification of land use (especially for rice cultivation) has also led to deforestation and degraded land.

Since the 1990’s several farming systems have changed in northern Vietnam, including the adoption of the **Sloping Agricultural Land Technology (SALT)** (Folving et al. 2014). Vietnam’s governmental upland development programs supported the implementation of SALT in various upland regions, such as the Son La Province. The landscape in this area is varied in topography: ranging from flat river lowlands to steep hillsides, with diverse soil textures. (Folving et al. 2014)

Source: Folving et al. (2014), Vu et al. (2015)

2.5.2. Mining

Theory

Mining and urbanisation

While mining has significant benefits for socio-economic growth in mountainous areas, there are many secondary impacts that have severe consequences. These primary impacts are urbanisation and development of transportation systems; on one hand, this contributes to modernisation and mobilisation of mountain communities while providing employment opportunities. However, this can lead to issues such as further exploration, site preparation, milling, waste management, decommissioning, reclamation and even abandonment. All of these factors directly cause land use alteration and environmental damage if land use regulations are not upheld effectively. The common ‘boom and bust’ cycles of mining industries in mountainous areas heavily impact fragile

alpine ecosystems. (Starnes et al. 1995)
Source: Starnes et al. (1995)

Negative Impacts While mining has significant benefits for socio-economic growth in mountainous areas, there are many secondary impacts that have severe consequences. These primary impacts are urbanisation and development of transportation systems; on one hand, this contributes to modernisation and mobilisation of mountain communities while providing employment opportunities. However, this can lead to issues such as further exploration, site preparation, milling, waste management, decommissioning, reclamation and even abandonment. All of these factors directly cause land use alteration and environmental damage if land use regulations are not upheld effectively. The common 'boom and bust' cycles of mining industries in mountainous areas heavily impact fragile alpine ecosystems. (Starnes et al. 1995)
Source: Starnes et al. (1995)

2.5.2.1. State-of-affairs in the 4 study areas

2.5.2.2. Study area 1 - THE ALPS

Reference case

THE ALPS: An overview on mining

Besides farming, the other mainstay of the Alpine economy was mining. As long ago as the first millennium BC there was a flourishing salt trade in the Austrian Alps, much of it centred around mining towns such as Hallein, where salt deposits were worked until as recently as 1989. Towns such as Hallein are still full of burghers' houses from the 17th century: the homes of merchants who had grown wealthy administering the salt trade. While most salt workings were around the city of Salzburg (its name translates to "salt town"), there were also salt mines in e.g. Bex, in the Valais. A long history of metal ore mining also exists in the Alps. Iron ore was mined in the Val Varrone as long ago as the Bronze Age, whereas the powerful Celtic kingdom of Noricum grew rich because of the iron ore in the hills of Carinthia. Other mining activities include slate and coal (both undertaken e.g. in the department of Isère, France) (Beattie, 2006). Furthermore, in parallel to

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mining, manufacturing activities also developed. Near Cluse, in the pre-Alps of Haute-Savoie, a region of watchmaking, screw cutting, component manufacturing, and related industries emerged in the first quarter of the 19th century and evolved into one of the most concentrated industrial locations of its type in the world. Large steel mills were located in Aosta and in the Mur and Mürz valleys. In addition, pulp and paper plants were established in the Eastern Alps of Austria. With the development of hydroelectricity in the late 19th and 20th centuries, heavy metallurgical and chemical industries were attracted to the major transverse valleys of France, southern Switzerland, and western Austria. Later, factories producing such consumer products as textiles (in the Rhine valley of Austria) and sporting goods (the Annecy area in France) were established. However, many of the early industrial enterprises are no longer viable. (Poulsen et al., 2009)
Source: Beattie (2006), Poulsen et al. (2009)

2.5.2.3. Study area 2 - THE HIMALAYA

Reference case

THE HIMALAYA: An overview on mining

There has been no extensive detailed exploration for mineral resources in the Himalaya. Inaccessibility is itself a major obstacle and the feasibility of transporting the minerals economically is equally doubtful. The stratigraphy of most parts of the Himalaya is such that the process of mineral prospecting becomes a tortuous affair because of the discontinuities induced by thrusting and faulting. However, export of mineral salt from Tibet is a very old practice. (Stone, 1992)

Source: Stone (1992)

2.5.2.4. Study area 3 - THE CAUCASUS AND THE ALTAI

Reference case

THE CAUCASUS AND THE ALTAI: An overview on mining

The geologically recent rock layers around the Greater ***Caucasus*** contain oil-bearing deposits. These also occur with natural gas, in the older rocks of the Caucasus, while in Dagestan (north-east of the Caucasus) there are oil, natural gas, and coal deposits. Metallic ores encompass: magnetite iron, copper, molybdenum, and manganese. Building materials include cement marls and rose-coloured tuffs (tufas). This abundance of resources has translated into large extraction of nonferrous metals, hydrocarbons, and coal. (Gvozdetsky et al., 2019)

Mining, mainly for coal, gold and tungsten also plays a significant role in the ***Altai*** region economy. The number of active mines at present is nonetheless relatively small: there are 66 mining licences, and 29 exploration licences. Artisanal mining is to be stressed, in which about 2,000 people are thought to be involved. This mining is carried out by private individuals often gathering in big camps around a mineral deposit. (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009)

Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Gvozdetsky et al. (2019)

2.5.2.5. Study area 4 - THE ROCKY MOUNTAINS

Reference case

THE ROCKY MOUNTAINS: An overview on mining

The economy of western America has relied upon mining natural resources since the beginning of human settling in the region. The Rocky Mountain region is home to a wide variety of minerals such as gold, silver, zinc, copper, lead etc. and these can be found across Colorado, Idaho, Montana, Washington, and Wyoming. Prominent areas that service the mining industry are the Anaconda-Butte Region in Montana, the Southwestern Wyoming Region and the Green River Basin.

- **Anaconda Butte Region:** silver was discovered in the 1800's and has spurred the mining industry in this area since then. Over time, copper was also discovered and eventually came to outgrow the silver mining industry.
- **Southwestern Wyoming Region:** after mining in the Butte region came to an end, the Southwestern Wyoming region was reborn due to the high availability of coal, iron and trona (otherwise known as soda ash). Wyoming leads trona production in the increasingly globalised mining industry, and it is widely used in pharmaceutical products, soaps, glass, baking soda and others.
- **Green River basin:** includes S.W. Wyoming, N.W. Colorado and N.E. Utah, and is well

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known for its coal and trona mining operations. The Rocky Mountains have faced severe boom and bust swings throughout their historic development, but mineral wealth in recent decades have led to a re-stimulation of the area's economy. Marston et al (2019)
Source: Marston et al. (2019)

2.5.2.6. Examples

Case study 1

OTHER MOUNTAIN RANGES - Mining and urbanisation in the Qin-Ba Mountains, China

While land development promotes economic growth and can sustain growing populations, it also results in shifting ecological environments, degradation and increased pollution. Since China's economic reform in 1978, the country experienced mass urban sprawl, infrastructural growth, agricultural expansion and rapid industrialisation; all causing strong environmental impacts. Although the Qin-Ba Ecological Functional Zone is under environmental protection, the Chinese government has permitted mining, tourism and urban development in the area for the purpose of national economic progress and poverty alleviation. This region is rich in vegetation and provides diverse habitats for wildlife and over 4100 species of vascular plants. 57% of the land is forested, while 20% is cropland, another 20% is grassland, and approximately 1% is water. Urban encroachment and mining in the Qin-Ba Mountains has led to drastic deterioration of its ecosystems. The total mined area in 2013 was 22km² and has continued to grow since then. Urbanisation in the mountainous areas of Fengxian County, Shaanxi Province and Baokang County, Hubei Province were most significantly affected, and had faced an increase in urban land use of more than 85km² between 2010 and 2013. Infrastructure development (including real estate, resorts, airports etc.) has led to large-scale deforestation which in turn has caused an extreme disturbance to native biodiversity.

The China Geological Survey states that there are more than 105 types of mineral resources in Qin Ba, the most common being limestone, molybdenum, mercury, asbestos and graphite. The mining industry paired with rapid urban development requires mass energy and water consumption, which leads to major environmental issues. Hydro-geological alterations are quickly taking place in the Qin-Ba Mountains: toxic leaching occurs throughout water bodies causing health impacts for both humans and wildlife. Land intrusion for mining has reduced biodiversity, increased species extinction and soil erosion, and has also caused hazards such as landslides.

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This is an example of a mountainous area chosen specifically to build ecological security in China for "protecting, restoring and maintaining the sustainability and balance of wildlife population and species", yet it is faced with mineral exploitation. (Xu et al. 2016)

Source: Xu et al. (2016)

Case study 2

OTHER MOUNTAIN RANGES - Urbanisation and mining in the Mecsek Mountains, Pécs, Hungary

Anthropocentric impact through urbanisation and industrialisation is apparent in Pécs, a Southerwestern town in Hungary. During the time of the Ottomon Occupation (1543- 1686), Hunagrians began to settle in the foothills of the Mecsek mountains. Until then the land had only been used for agricultural purposes, and only after 1780 did Pécs really begin to establish itself with an abundance of local resources. Economic growth allowed industry to develop around the karst springs in the Mecsek valleys, and urban development began to spread. While agricultural land has been encroached upon by urbanisation over the years, both underground and surface mining have been influential to the landscape formation of the region. Several geomorphic impacts of mining in the area include surface instability, altered runoff, ground subsistence and slope change. The effects on landscape change include aesthetic damage, microclimate alterations, loss of vegetation, air, water and soil contamination, ponding and dust storm hazards. Furthermore, transportation systems are built and clearcutting of forests occurs for growing mining sites; this causes habitat loss and fragmentation. Several hydrological changes had been made as well such as stream diversions and channeling: these led to downstream erosion and flooding. (LÖCZY 2010)

Under Socialism, the coal-mining centre of Pécs faced spatial expansion, population growth and the need for an increased labour force. This meant that the social housing demand rose to its peak. By the end of the 20th century Pécs had a total population of 185,000 people. The city's structure became a dense industrial hub, consisting of 50-60% paved surfaces, transformed urban soils and its own, severe microclimate. During the time of underground mining (between the World Wars), spontaneous combustion was not uncommon and air quality quickly deteriorated. By the 1980's underground mining was no longer profitable and shafts began to close, leaving an immense amount of waste and spoil heaps behind. (LÖCZY 2010)

Source: LÖCZY (2010)

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2.5.3. Forestry

Theory

Forestry and urbanisation

Forestry is a major industry in mountain areas. Forests are the dominant vegetation type of humid-climate mountains, and upland forests have tended to persist more or less intact, since the focus of most human activities is in the lowlands, where agriculture is more favourable. With ever-increasing demand for timber, however, mountain forests have become steadily more valuable as natural resources. Most modern forestry takes place in the lower mountain forests, where tree growth is rapid. The principle of sustained yield dictates selective cutting of older and larger trees, replanting of trees, fertilisation, thinning, and spraying of insects, so that the forest continuously regenerates. (Price, 1986)

Source: Price (1986)

Negative impacts

The environmental impact of forestry has many facets. Tree removal increases slope instability and erosion. Some rock and soil types make certain areas especially prone to erosion, such as granites that have coarse and sandy soils with little cohesion. Furthermore, non-forested slopes are less efficient at retaining snowpacks and absorbing water, which often leads to avalanches and flooding in the lowlands, respectively (Anderson and Hobba, 1959). An increase in stream sedimentation and nutrient discharge is also observed, which generally impacts aquatic life (Chapman, 1962; Leaf, 1966; Platts, 1970). (Price, 1986)

The clearing of forests changes climatic conditions nearer to the ground, where there is greater frost and sunshine penetration. Aside from the cutting of trees, the single greatest impact of logging on the landscape is road-building, as these sites become optimal for slumps and landslides and are major contributors to sedimentation (Megahan, 1972; Megahan and Kidd, 1972; Swanston, 1974; Swanson and Dyrness, 1975). (Price, 1986)

Source: Price (1986)

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2.5.3.1. State-of-affairs in the 4 study areas

2.5.3.2. Study area 1 - THE ALPS

Reference case

THE ALPS: An overview on forestry

Forest cover represents 40% of the Alpine landscape (Spinelli et al., 2013). Trees have been felled for timber and fuel in the Alps since time immemorial (Beattie, 2006). Timber and fuelwood were the key resources for the mining and refining of salt e.g. in Tyrol. According to Palme (1975) the total timber consumption of a single mine amounted to more than 100.000 m^3 in the 16th century. Even today, the Engadin-valley in Switzerland still shows the scars of deforestation and its consequences in an alpine landscape. Nowadays, the timber industry still plays a key role in the economy of some regions in the Alps, (Stöhr, 2009) with the boom of engineered wood products and energy biomass (Onida, 2009) (in Spinelli et al., 2013).

Source: Spinelli et al. (2013)

2.5.3.3. Study area 2 - THE HIMALAYA

Reference case

THE HIMALAYA: An overview on forestry

Forests in the Himalayas have been used extensively for thousands of years as sources of food, fodder, fuelwood and other biomass. Extensive commercial felling of forests for timber has gone on in the current century, especially in the last few decades, when urban centres began to grow in areas near the forests. (Stone, 1992)

Source: Stone (1992)

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2.5.3.4. Study area 3 - THE CAUCASUS AND THE ALTAI

Reference case

THE CAUCASUS AND THE ALTAI: An overview on forestry

In the Caucasus, logging is actively conducted in the Krasnodar Region, Adygea and the Republic of North Ossetia-Alania (WWF Russia, 2019). Likewise, the Altai has a fairly well-developed forestry and wood-products industry (Mikhaylov and Owen, 2009)

Source: Mikhaylov and Owen (2009), WWF Russia (2019)

2.5.3.5. Study area 4 - THE ROCKY MOUNTAINS

Reference case

THE ROCKY MOUNTAINS: An overview on forestry

Prior to the establishment of the Rocky Mountain National Park, vast timber resources in the region were in high demand. Milled lumber was highly exploited along the Front Range and the Estes Park and Grand Lakes areas. Many different sawmills were established along Mill Creek, Fall River, Wind River, Black Canyon and the Colorado River. Initially, water-powered mills were run on rivers and streams (hazardous to aquatic ecosystems and surrounding habitats), and later they were powered by internal combustion engines. The logging industry at the time was unregulated and insufficient, and this was one of the primary reasons why conservationists such as Enos Mills advocated for the protection of the mountainous areas by way of creating a national park (Jessen 2015). Outside of the protected areas, forestry still plays an important role in the economy of communities in the Rocky Mountains. In Alberta (Canada), 50 foothill communities depend on forestry, and among them 12 depend on it exclusively. Logging frequency and intensity have, however, been reduced e.g. in Michigan (USA), where forests are harvested as a crop every 30 to 40 years. (Mayda, 2013)

Source: Mayda (2013)

2.5.4. Tourism

Theory

Tourism and urbanisation

One of the most insidious impacts on mountain landscapes stems from the large number of people coming to enjoy them. This began after World War II, due to rapid development of highways, increasing number of automobiles, and increasing amounts of leisure time. As more and more people came to visit mountainous areas, and facilities have been constructed to accommodate them, they have begun to resemble the places that visitors were initially trying to escape (due to overcrowding, high-rise buildings, noise, and pollution) (Price, 1986). Among the construction of tourist accommodation and other facilities, the establishment of second homes has become a mounting and worrisome phenomenon in many tourist towns. According to Gallent et al. (2005) and Sonderegger (2014), second homes are houses or flats that are empty nor in permanent use by either somebody registered in the same municipality or for work or education. The contribution of second home construction to the regional development is mostly identified to be of an economic nature: it creates added value and jobs within a region. (in Sonderegger and Bätzing, 2013)

Source: Price (1986), Sonderegger and Bätzing (2013)

Negative impacts

The kinds of impact that tourists and those seeking recreation in mountain areas are as varied as the activities in which they engage: (Price, 1986)

- Hiking and climbing: Back-country travel by hikers and climbers is more dispersed, so fewer problems are involved. In addition, people who engage in these activities are usually more sensitised to nature. Impacts are mostly associated to the increase in the number of hikers and climbers in the last decades and technological developments. They include: damage of Alpine vegetation by trampling, which can be especially serious in wet mountainous areas; accumulation of waste, including oxygen bottles, nylon fabric, etc.; and erosion due to direct ascent paths created by hikers. These problems remain, however, less significant, when compared to the negative consequences associated to all related tourist infrastructure and ski tourism. (Price, 1986)
- Ski tourism: Cutting of timber to create ski runs increases slope instability, erosion rates,

and the potential for snow avalanches. Furthermore, if the cutting is improperly done, resorts may display bare and ugly slopes during summer (Klock, 1973; Welin, 1974). (Price, 1986)

- Mobility infrastructure: The building of roads results in a profound alteration of the environment, including the distortion of slopes and a change in the local drainage patterns. The greatest harm done by roads, lifts, cable cars, trams, etc., however, is that they allow ingress of large numbers of people into formerly isolated areas which may be extremely susceptible to disturbance. Further, roads serve as avenues of access and provide specialised habitats for the introduction of alien species. Automobiles and other off-the-road vehicles (e.g. snowmobiles) have a considerable impact in their own right. They take up space, require service facilities, substantially contribute to atmosphere/noise pollution, compact the snow (off-the-road vehicles), etc. The contribution of automobiles to air pollution is especially great at high altitudes because combustion processes are inefficient in the low-oxygen atmosphere. The gas in smog that is most damaging to life is ozone (O_3). It impairs reproduction in certain species of plants. (Price, 1986)

- Tourist facilities: The number of facilities required to accommodate the influx of tourists and other recreation demands (ski lifts, hotels, restaurants, gift shops, sports outfitters, service stations, car parks, second homes, etc.) can generate a high impact on the environment. (Price, 1986) The problems range from urban sprawl, loss of valuable landscapes and village appearance, water shortages, traffic congestion, all the way to the exclusion of local people from the housing market. In tourism municipalities, the growth of second homes poses a problem when the real estate market begins to separate from the main tourism economy and gains momentum on its own, a situation that has occurred in many places in e.g. Switzerland (Plaz and Hanzer, 2006). When buoyant on account of contracts for second homes, the building sector itself generates new contracts and in many places starts to become the driving force in real estate development. New contracts lead to further growth in the building sector, which in turn attracts new orders, thus triggering cycles of growth that generate short-term benefits for municipalities in the form of levies and fees and long-term benefits from property tax revenues. The result is a self-reinforcing and self-perpetuating regional economic cycle that functions on a logic entirely disconnected from tourism (Sonderegger, 2014). (in Sonderegger and Bätzing, 2013)

Source: Price (1986), Sonderegger and Bätzing (2013)

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2.5.4.1. State-of-affairs in the 4 study areas

2.5.4.2. Study area 1 - THE ALPS

Reference case

THE ALPS - An overview on tourism

Tourism is presently the strongest economic force in the Alps. (Stone, 1992) The Alpine regions are the central recreation area for the increasingly urbanised surrounding areas. Each year the number of visitors staying overnight increases and today it is at about 150 million. (Aulitzky, 1971) Bender & Kanitscheider (2012) identify amenity migration as a major process in population development in the Alps. However, tourism is a phenomenon with a high spatial concentration in the Alps – only about 10% of the municipalities depend on tourism (Bätzing, 2005). (in Sonderegger and Bätzing, 2013)

An influx in Tourism led to the development of a wide range of infrastructure, including cable cars, roads, leisure centres, and accommodation facilities such as hotels and second homes. Concerning the latter, it is estimated that there were 1.85 million second homes in the Alpine region in 2012, making up more than 25% of the total number of all dwelling units. A significant and stable growth in second home stock has been observed in recent decades, most of which are used for tourism and leisure purposes. Major differences exist among the Alpine countries regarding both the number and the concentration of second homes. Almost half of all second homes are concentrated in only about 300 of the total 6,000+ municipalities, which excludes the major part of the Alps. France and Italy have the largest second home shares of the total number of units and the highest densities of second homes (per inhabitant and per square kilometre). In this regard, Bätzing (2005) distinguishes between five major tourism markets in the Alps: (in Sonderegger and Bätzing, 2013)

- In France, purpose-built centres dominate. These centres are the result of a national tourism policy in the form of second home construction for holiday use after World War II. In combination, the French Alps account for more than a fourth of all second homes in the Alps.
- Italy (excluding South Tyrol): Besides the approximately 15 integrated purpose-built centres, the Italian Alps have undergone intense second home construction in existing settlements. In addition, large swaths of the Italian Alps are experiencing strong migration away from rural regions, giving rise to an enormous number of second homes, often ranging above 80% of the total number of homes in a municipality.

- Switzerland: The Swiss model is based on leisure home construction, mostly in existing settlements in amenity rich areas (ARE, 2013). Most second homes are privately owned by people from the urban regions in Switzerland. Very high shares of second homes (above 90%) are found in the southern Swiss Alps due to out-migration. Since 2012, there is a ban on second home construction in municipalities with a share of second homes of more than 20%.

- Germany, Austria, and South Tyrol: Tourism has developed in a decentralised and scattered manner (Bätzing, 2005). Shares of second homes exceeding 20% are rare. Strong government regulations of the real estate market, promotion of construction by local people of private room rentals and apartments, and restrictive zoning policies have all contributed to these relatively small shares of second homes.

- Slovenia, Liechtenstein and Monaco: Only a few relicts of the old spa tourism survived during the period of socialist government in Slovenia until 1991. After 1991, the tourism regions underwent a dynamic phase of second home construction, but the overall number only totalled around 30,000 in 2002. The small states of Monaco and Liechtenstein have only 7,000 second homes combined.

Source: Aulitzky (1971), Stone (1992), Sonderegger and Bätzing (2013)

2.5.4.3. Study area 2 - THE HIMALAYA

Reference case

THE HIMALAYA - An overview on tourism

In recent years, tourism throughout the Himalayan mountain range has rapidly increased urbanisation. Development of infrastructure for increased road connectivity as well as major development of new tourist sites has led to a tremendous increase in expanded human settlements throughout the upland regions of the Himalaya. Due to a lack of effective urban land use policies, both an *expansion* of urbanisation in agricultural zones, forests and surrounding rural environments as well as an increase in *intensity* of urban land use (density of covered land, populations and buildings) has occurred. On one hand, urbanisation has created employment opportunities and progressed socio-economic activities in the region, while on the other hand, urban sprawl has led to disruption of the fragile mountain ecosystems. “Effective land use policies need to be evolved and implemented for the protection and conservation of forests, biodiversity,

water resources and agricultural land." (Tiwari et al. 2018)
Source: Tiwari et al. (2018)

2.5.4.4. Study area 3 - THE CAUCASUS AND THE ALTAI

Reference case

THE CAUCASUS AND THE ALTAI - An overview on tourism

The ***Caucasus*** has become a popular resort area. Its mineral springs and year-round mild climate make it a conducive environment for the treatment of many illnesses. Millions of people from Russia and other countries come to the Caucasus each year to rest, receive medical treatment, and enjoy recreational activities such as mountaineering and skiing. (Gvozdetsky et al., 2019) On the other hand, tourism has grown rapidly over the last few years but is still low in terms of absolute numbers of visitors in the ***Altai*** Mountains. The chance to see Argali and Ibex and to be near Snow Leopards draws naturalists and those who like wild open spaces. Sport hunters come to the Altai to hunt Argali and Ibex, and Red Deer, Roe Deer and Wild Boar. There is some sport fishing and wildfowling too. (Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai, 2009)

Source: Aimag Governments of Uvs, Khovd, Bayan Olgii and Govi Altai (2009), Gvozdetsky et al. (2019)

2.5.4.5. Study area 4 - THE ROCKY MOUNTAINS

Reference case

THE ROCKY MOUNTAINS - An overview on tourism

The Rocky Mountain National Park is world renowned for its exceptional natural beauty and access to some of the world's most awe-inspiring wilderness recreational areas. It is home to one of the largest protected alpine tundra ecosystems in the United States. The park is a UNESCO international biosphere reserve and is designated to research and educational initiatives. The 571km of trails throughout the dramatic elevation ranges in the Rockies allows for diverse terrestrial and aquatic ecosystems to be experienced by visitors each year. Over the years, many different attractions, recreational facilities, education centres, and mountain accommodations have been built to attract tourists to the area. While tourism in the Rocky Mountains has been beneficial in many ways by increasing economic viability in the area in order to develop educational means for environmental protection, the influx of visitors to the region each year has caused further damage. Overpopulation throughout the preserves has led to exhausted land use and mismanagement of waste. Increased tourism has expanded settled areas, and this has fragmented forest habitats, altered native ecosystems and increased pollutants caused by motorized vehicles. Such negative impacts must be mitigated through more stringent visitor use regulations and limited tourism development. (UNESCO 2019)

Source: UNESCO (2019)

2.5.4.6. Examples

Case study

Study area 2 - THE HIMALAYA **- The case of the city of Nainital, India**

Nainital is a lake city and famous tourist destination situated in the catchment of Naini lake at the southern extremity of the Lesser Himalayan ranges in Kumaon division of Uttarakhand. The city encompasses a geographical area of 14.32 km^2 with an altitude between 1938 m and 2611 m above the sea level. The habitation in Nainital started towards the end of the first half of the nineteenth century, and according to the data available, Nainital had already become a popular hill resort by 1847. The picturesque surroundings of the valley, together with the panoramic beauty of the lake, its proximity to plains in the south and its salubrious climate conditions, were the main reasons that promoted the development of Nainital as a famous health and recreation resort (Joshi et al. 1983). Especially in the second half of the nineteenth century, the city witnessed a phenomenal growth in urban functions, and a range of facilities and services emerged to cater the growing needs of the town. (information provided by Prakash C. Tiwari)

Nainital is still fast growing and one of the most heavily visited hill resorts in northern India. The increased tourist arrival has not only an impact on the economy of the town, but it equally influenced its evolution and the functional morphology. Conforming to the needs of growing tourism, hotels, restaurants, parks, picnic spots, gardens, shopping centres, parking areas, facilities of recreation, tourist guidance, and transport now constitute important components of the morphology of the town (Joshi et al. 1983). Tourists arrival has also resulted in a large floating population in the city, particularly during summer months, and a demographic evolution heavily influenced by tourism activity (information provided by Prakash C. Tiwari).

The increase in population and rapid urbanisation has led to expansion of construction activities in fragile terrains and has catapulted the frequency of landslides to dramatic proportions since the evolution of the city. Studies indicate that the lack of proper surface drainage and unplanned anthropogenic intervention emerged as the major reasons for slope instability in Nainital. A remarkable feature is that before 1981 the population increased only in those areas which are characterized by gentle slope and lower altitude. However, after 1981 higher elevation areas, steep slopes and fragile zones registered an exceptional population growth, and now a very high concentration and density of population is present in these areas too. The geo-hydrological disasters not only transformed the urban and natural landscape, but also highlighted the need to understand the local geo-tectonic and geomorphological conditions before allowing the expansion of urbanization in fragile mountain terrain (information provided by Prakash C. Tiwari).

The unplanned and unregulated construction on fragile slopes resulted in the degradation of forests and biodiversity, and the depletion of water resources. Sher ka Danda area has registered a 10% loss of vegetal cover, and almost a 24% decrease in the dense forest area during 2005 - 2010 (Rautela et al. 2014). Steep slopes in this area are presently being levelled for construction, and excavated debris is being disposed of along the hill slopes and along surface drains. As a result, the natural drainage network is being obstructed and obliterated, increasing the vulnerability of the slopes and large population to climate change induced risks (Disaster Management and Mitigation Centre, Government of Uttarakhand 2011). Furthermore, the rate of sedimentation has been increasing progressively posing serious threat to the quality of water and the lake's organisms. This is particularly worrisome, as nearly 40% of the total water supply comes directly from the lake (Singh and Gopal 2002) (information provided by Prakash C. Tiwari).

Source: information provided by Prakash C. Tiwari (Kumaun University)

2.6. Interrelation nature - inhabitants: a relation in change?

Theory

Social-ecological dynamics and changed perceived value of the environment

Global mountain environments (especially in developing territories) have undergone extensive urbanisation, which has often led to unregulated growth. This has had a significant impact on both the social and ecological dynamics of our increasingly anthropocentric world. Human-nature relationships have shifted and transformed along with population growth, globalisation, industrialisation and urbanisation. An attachment to place (or a bond between people and places) has existed since the beginning of human settlement, and it is shaped throughout history, but also across individual lifespans. People perceive place in various ways and everyone constructs place meaning based on how they experience, interpret and interact with the world. The environment, history, culture, economics and politics all influence 'a sense of place' in cities, as well as determines the boundaries between the natural and built environments. In the context of rural-urban migration, it is important to consider cities as socially constructed places that are both inherited and re-developed by new inhabitants (Relph 2018).

The concept of place has changed quite significantly since the 1970s. For example, after the UNESCO convention in 1972, heritage protection became increasingly important. Cultural and natural heritage was subsequently incorporated into legislation and policy in order to preserve a sense of identity throughout urban development. Similarly, prior to the 1970s, the protection of natural environments barely existed; they were often radically engineered for industry and housing development. However since then environmental conservation emerged and there is now a widespread understanding of sustainability issues. This has changed the distinctiveness of environmental spaces (especially within the built environment), as well as their perceived value. (Relph 2018)

Source: Relph (2018)

2.7. Cities in mountain areas: distinctive traits

Theory

The long-term isolation of mountain peoples, severe environments for human life on the periphery of more developed and fertile lowlands, strong blood ties, etc., all gave rise to the phenomenon of a mountain culture independent of the geographical location of human habitats. Until recently, many mountain regions (especially remote areas) can be compared to living ethnographic museums. (Stone, 1992)

Source: Stone (1992)

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2.7.1. Mountain architecture

Theory

Mountain architecture - an introduction

In architecture, mountain distinctive traits are reflected in the type of housing (Stone, 1992). The concept of Mountain architecture varies depending on geographical location and culture, but typically encompasses designs that are able to withstand rugged mountain environments. Mountain style architecture can be related to several architectural vernaculars such as Montana ranch, rustic western styles, Adirondack and historic logging and mining styles (in the USA), as well as Craftsman, Chalet, Prairie, Japanese and even Tuscan elements elsewhere. Architectural volumes in mountain architecture should be kept in scale with the local terrain and site in order to avoid being obtrusive. Sheltering roofs are typically also incorporated in designs as a protective measure against winter snows, spring and summer rains. Further functional structural elements such as columns, beams, and rafters are designed using timber frame or post and beam construction to be able to withstand heavy snow loads. Landscaping is also essential to effective mountain architecture plans: sites should be envisioned with minimal grading and disruption of natural drainage, and homes should be designed in minimal visibility and with maximum privacy. Effective designs should also limit retaining walls. Sites should be kept as natural as possible by containing water runoff and all designed elements should enhance existing features. Other characteristics include native hardscaping, such as patios, walkways, etc. (Hendricks 2009)

Source: Hendricks (2009), Stone (1992)

2.7.1.1. Mountain architecture in the 4 study areas

2.7.1.2. Study area 1 - THE ALPS

Reference case

THE ALPS - An overview on mountain architecture

Throughout architectural history in the Alps, modernity and tradition have been in long standing battle. The 20th century has seen a renewed request for mountain living, and an increase in construction and building of upland regions in the Alps has responded to both economic needs as well as new settlement demand. During the sprawling urban movement, actions for conservation, regeneration and replacement have remained feeble, and a major part of heritage construction during that time did not meet sustainability regulations. In more recent years the drive to improve architectural quality in the Alpine landscapes has brought together quality engineering and in depth landscape studies; incorporating complex interpretations of aesthetics, geo-philosophy, geography and economics. Since the negative housing boom, the Alps have become the focus of many architects specialised in mountain architecture. Architects such as Lawrence Savioz aim to work directly from alpine landscapes by using raw and mineral materials, and concept designs that draw from surrounding mountain topography. The European Alps have become world renowned for cutting edge architectural design in mountain regions. (Bertagnin et al. 2013)

Timber and stone, as building materials, are both common throughout the Alps. (Deering, 1986) Despite their instantly recognisable popular image, the buildings' architectural styles can be seen to vary greatly from one region (or even one valley) to another in response to the availability of construction materials (Moss, 2019). On the north slopes, wooden buildings, with their larger overhanging eaves, are more plentiful, whereas on the southern slopes more stone structures are found (Deering, 1986). The most typical approach includes a stone-built ground floor, divided into two or three areas and often partly recessed into the mountainside to afford a degree of protection from bitter prevailing winds. The presence of cattle and other livestock stabled here generated some extra warmth for the human accommodation above, while undesirable odours were carried away by the passage of air through small window openings in the stonework. This provided a solid foundation for the more visible timber upper stages, supported by a framework of massive piers and joists. The first floor was destined for human habitation. The second or upper floor was used for storing hay, timber and other bulky materials. (Moss, 2019)

Source: Bertagnin et al. (2013), Deering (1986), Moss (2019)

2.7.1.3. Study area 2 - THE HIMALAYA

Reference case

THE HIMALAYA - An overview on mountain architecture

Master carpenters in the Himalayas often build in strict accordance to natural materials available while drawing from Buddhistic texts. Practicality and symbolism as reflected in Tibetan society are incorporated into traditional building practices through high quality craftsmanship and woodwork.

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Tradition and the collective importance of resources comes across in the choice of building materials and the architectural style chosen. Aesthetics are highly valued in traditional Tibetan architecture, and both columns and capitals are designed with a high level of carved and painted detail representative of Buddhist iconography. Typical Tibetan architectural principles incorporate passive solar designs to maximise energy efficiency, while interior timber framing and load bearing structures are built wholly with natural materials. The mountain regions bordering Tibet and Nepal tend to fuse architectural styles, especially in temple designs. For example, a temple may be composed of Nepali style doorways, enhanced with Tibetan detailing. Such stylistic blending occurs in many regions of the globe, especially in remote, and isolated areas such as mountain communities. Traditional architecture on the Tibetan Plateau is highly dependent on thriving forest ecosystems. The town of Ladakh in the northeastern corner of the Indian state of Kashmir is an example of a mountain community severely affected by excessive timber harvesting. Carpenters that have inherited traditional building techniques from their forefathers who remember sourcing wood within a days walk from their villages, now have to travel an average of 3-4 days in order to source enough building materials. Widespread deforestation and poor land use management in the Himalayas has led to the depletion of artful traditional architecture. Sustainable forestry holds the potential to play a major role in cultural and environmental sustainability within the field of mountain architecture in the Himalayas. (Semple 2005)
Source: Semple (2005)

2.7.1.4. Study area 3 - THE CAUCASUS AND THE ALTAI

Reference case

THE CAUCASUS AND THE ALTAI - An overview on mountain architecture

Caucasus: In the treeless highlands, villages consist of stone houses clustered together and built into the mountain slope. In the western Caucasus, villages consist of individual homesteads surrounded by fences. The buildings are made of wood or wattles coated with clay. In the central and eastern Caucasus, houses have a cupola-shaped vault on pillars, with an opening at the top that serves as a window and smoke vent. ***Altai***: Traditional building techniques include timber processing and natural fibre packing. Residents seek to build one- to two-floor houses by combining different types of wood. This supposes three horizontal belts of different sorts according to the divergent effect of precipitation in each of them. The lower belt is made of larch as it is more solid and steady to moisture. From the window level up to the ceiling, pine is preferred as it is warm and ecologically propitious. When pine is not available, fir timber is used.

The last horizontal row is made of larch. Finally, the roof is built with larch and/or pine. If diversity of wood is not available, a house is made of coniferous wood growing in high and dry places: in the foothills of South-Eastern Altai pine and larch are used, whereas in the South-West fir-tree is employed. In severe climate areas the preservation of warmth in houses plays a big role, which is achieved through warm packing. The most frequent material used are mosses. (Fedorenko and Scheglova, 2019) As a particular example, nomadic pastoralists erect temporary dwellings called yurts or gers, which are round structures consisting of felt and hides lashed to lattice frames. (Mikhaylov and Owen, 2009)
Source: Fedorenko and Scheglova (2019), Mikhaylov and Owen (2009)

2.7.1.5. Study area 4 - THE ROCKY MOUNTAINS

Reference case

THE ROCKY MOUNTAINS - An overview on mountain architecture

Henricks Architecture is a firm that specifically works with mountain architecture principles in the Rocky Mountains, and their core concept is that the home exterior should be built in a way that all designed structures seem to emerge out of natural forms, rather than being ‘dropped’ onto them. They believe that mountain homes should blend in with the topography of surrounding mountain environments as much as possible; and often mimic linear characteristics found in landscapes in order to echo natural features. The architects do this by using ample natural materials and glazing techniques that emphasize natural qualities, and by using decks, terraces and other extensions of indoor living spaces towards the outdoors. This form of architecture often encompasses a ‘rustic elegance’ not only because of material choice, but also because the buildings are usually tapered down into the existing site. Mountain architecture in the Rocky Mountains is most prevalent in the Northeast and Southwest (in cities such as Lake Tahoe, Whitefish, Big Sky, Jackson Hole, Vail and telluride). Other areas well known for their mountain architecture are Aspen, Steamboat Springs and Crested Butte in Colorado, as well as Banff and Whistler in Canada. (Hendricks 2009)

Source: Hendricks (2009)

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2.7.1.6. Examples

Case study 1

Study area 2 - THE HIMALAYA - Himalayan mountain architecture - The Kumaon Hotel, India

The Zowa Architects (a Sri Lankan company) developed a boutique hotel in the Indian Himalayas. The village of Kasar Devi is located in Kumamon, set against the ride of the Nanda Devi mountain. The Binsar Wildlife Sanctuary and a Rhododendron forest are a walk away from the site. The hotel lies 1600m above sea-level, with expansive views over the surrounding mountain ranges. The vernacular architecture emphasizes traditional culture and local building materials. Locally quarried stone is used for the foundation of the buildings, while ash bricks and bamboo finishing compose the rest. A type of Indian granite called Kota was used for the terraces and balconies, and local pine wood was used for flooring. These materials were chosen to depict a 'rustic simplicity' while allowing the architecture to blend in with the environment. By virtue of being located amidst steep, terraced hillsides, the architects took advantage of ample rainwater harvesting; this was enough to source every building. Furthermore, the architects planned to use the remaining land on the site for the purpose of planting edible crops to serve as a kitchen garden. (Levy 2018)

Source: Levy (2018)

Case study 2

Study Area 4 - THE ROCKY MOUNTAINS - Rocky Mountain architecture - The House in the Mountains, Colorado

The House in the Mountains was built by the architect firm Gluck+ in 2012 using the concept of an extended 'Landscape House'. This mountain guesthouse was designed with the aim of blending the architecture into the surrounding alpine landscapes. The house is built into the alpine meadow, angling the sloping planes of the rooftop just enough to create a linear cut into a nearby hillside. The rooftop is also covered in a myriad of grass species that extend the local vegetation. This feature makes the structure almost invisible from the road entryway, and further emphasizes landscape integration. Continuous clerestory glass is consistent throughout the entire facade of the design, allowing for panoramic views of the mountains from the guest house interior. This takes full advantage of the expansive vista overlooking the Rocky Mountains and allows light to fill all the rooms. The solar system installed is enough to heat the house, outdoor pool and hottub, and the interior floors are purposefully overheated during the day in order to avoid mechanical heating at night. A real-time sensor is also used to ensure active monitoring of changing environmental conditions, meaning that fossil fuels can be reduced by 60% when optimized over time. (Gluck+ 2017)

Source: Gluck+ (2017)

Case study 3

OTHER MOUNTAIN RANGES - Chinese mountain architecture - Huangshan Mountain Village, China

Huangshan is a Mountain Village in Anhui province, China that was developed by MAD Architects It has become a UNESCO World Heritage Site due to its striking mountainous landscapes. This project is part of a larger tourist development near the Huangshan Taiping Lake, and aims to incorporate architectural aspects of modern living while maintaining a strong connection with the surrounding mountain range. The buildings are designed in a way to work with the topography of the landscape; meaning that each structure is unique in height and appearance in order not to impose on the mountainous environment. The architects envisioned a village in which the borders between architecture and nature are softened. The organic contours of the architecture find repetition in the hillsides and tea fields, echoing the geomorphology of Huangshan's terrain. (Castro 2017).

Source: Castro (2017)

Assignment 2 (5hrs)

Urbanisation in mountainous areas

1. Watch several videos provided on urbanisation processes in distinct mountainous towns Complement this with provided articles.
2. Discuss the effects of urbanisation in the forum.

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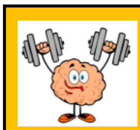

Assignment 3 (5hrs)

Group Project - Basic analysis ⅓

1. Create 4 working groups. Each group will be working on a different mountain town (either Rosa Khutor or Shimla or Zermatt or Telluride), representative of the different main contexts that are embraced in the module: the Alps, the Himalayas, etc. Different perspectives will not be worked here, but each group will be allowed to develop its own, according to the information provided and the data that they gather.
2. Use the videos and papers provided in the previous exercise to analyse your study area from your chosen perspective - natural conditions, history, demography, land use, facilities, attractiveness, ecological development. Complement this data with a literature search.

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3. Risks and challenges

Key words

Risks & challenges, natural disasters, forest fires, floods, landslides, avalanches, earthquakes, whirlwinds, demographic flux, population loss, climate change, mountain habitat protection

Study areas: the Alps, the Himalaya, the Caucasus & Altai, the Rocky Mountains, the Tatra Mountains

3.1. Introduction

Theory

Risks and challenges - an introduction

Mountainous areas have always faced the risk of natural disasters. Over centuries, the approach towards disaster management was the same: people were conscious of the threat, they accepted the risk and if possible, avoided the most dangerous areas. The severity of natural disasters is measured by economic loss, the number of lives lost as well as the capacity to rebuild a population. Over the years, natural disasters such as mega storms and earthquakes have become more frequent, and heat storms have intensified. Technological advancement has allowed more weather-related disasters to be predicted, yet numerous disasters (such as wildfires, landslides and volcanic eruptions) occur unexpectedly. (Basic Planet 2018).

Disturbances are a common phenomenon in e.g. European temperate and boreal forests. In general, they are a natural and essential part of forest ecosystems. Natural disturbances have an important role in the successional cycle of natural forests as well as in plant community dynamics. Moreover, they also influence the biodiversity, which should be the highest at such sites that are neither too rare nor too frequently disturbed. Natural disturbances contribute to the selective pressure between organisms. This chapter is going to introduce several risks and challenges that mountain areas face on a daily basis. (Budzáková et al. 2012).

Source: Basic Planet (2018), Budzáková et al. (2012)

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3.2. Natural conditions which can cause disasters

Theory

Natural conditions which can cause disasters - an introduction

Disasters have a multi-level impact - they cause physical damage but moreover, they also lead to social and ecological changes. A disaster is an unexpected occurrence with disastrous consequences on its surrounding area. (Peters and Pikkemaat, 2006)

Shifting tectonic plates cause mountain communities to live under continuous threat of volcanic eruptions, earthquakes and other hazards. Sloping lands and steep ridges are particularly susceptible to floods, landslides, and avalanches, and unsustainable natural resource management of mountainous areas is causing an increased risk of mountain hazards. Market-driven agricultural production and commercial logging are examples of external agents that put pressure on mountain ecosystems, and these lead to mass deforestation and land degradation. Forest cover plays a crucial role in risk mitigation against natural disasters. Forests contribute immensely to mountain resilience. (Mountain Partnership 2015)

Source: Mountain Partnership (2015), Peters and Pikkemaat (2006)

3.2.1. Geological structures

Theory

Natural disasters which can cause disasters - an introduction

Folds, faults and other geological features influence the large movement of tectonic plates as well as the minute stress of gravity on steep mountainsides. Ductile rocks are gradually folded in response to stress; whether severe and sudden or steady and slow. The faster folding occurs in shallow rock, the more brittle and susceptible to break it is. The most basic types of folds are anti-synclines (‘up folds’, or ridges) and synclines (‘down folds’, or valleys). Plunging anti-synclines and synclines are folds that have tilted axes that tilt down into the earth. These make either U-shapes or V-shapes that point in the direction of a plunge. In structural geology, anti-synclines are convex upwards and are composed of progressively older layers of rock towards their centres. Convex

folds are also called antiforms (in purely descriptive terms), and they have crests which are the highest points on a given stratum at the top of a fold. Axial planes and surfaces are three dimensional surfaces that connect hinges or points of maximum curvature in folds. Structures that plunge in all directions are called domes, and are usually created by a deformation event or by magmatic activity moving upwards. Plunging or faulting anticlines, structures and domes are typically selected for oil and natural gas drilling. Sinclines on the other hand are composed of rock layers that grow progressively younger towards their centres on one side of the hinge and a reverse sequence of layering on the other. These usually form during a crustal deformation during orogenic mountain building. In brief, converging and diverging plates cause mountains to grow, and volcanic arcs are grown through subduction of oceanic crusts under continental or oceanic plates. Basin and range topography is created through tensional forces that create block faulting. Geological structures and mountain building processes can cause natural hazards such as earthquakes, volcanic activity and movement can lead to landslides, avalanches, flooding etc. (Lumen 2018)
Source: Lumen (2018)

3.2.2. Climate and hydric conditions

Theory

Natural disasters which can cause disasters - an introduction

Global warming patterns are clearly evident in glacier retreatment and melting of alpine permafrost. Ice retreat in elevated regions is directly correlated with land-surface instability and increased sedimentation from mountain slopes to valley basins. Therefore, hazard location, type and frequency is determined by the acceleration and continuity of ice loss caused by global warming. Furthermore, increased debris flow towards valleys leads to floodplain aggradation and higher downstream hazard risks in alpine environments.

For example, the European Alps are particularly susceptible to changes in climate and hydric conditions because 1) they are located on the boundary between different moisture regions, 2) their glaciers and permafrost is undergoing extensive decay, and 3) hazards have a severe impact on densely populated alpine valleys. (Keiler et al. 2010)

Source: Keiler et al. (2010)

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3.3. Risks

Theory

Risks - an introduction

Risks are different to hazard as is defined by Matjaž: "Risk is the probability of harmful consequences or expected loss (of lives, people injured, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions." (Matjaž 2013). Another way to conceptualize risk is by using the following equation: Risk = Hazard x Vulnerability

Risks in mountainous areas affect both upland and lowland communities. When designing a framework for disaster risk management, all factors concerning environmental degradation, fragile ecosystems, poverty and frequency of risk should be integrated. Mountain habitats, their severe topography and thus limited accessibility worsen the effect of these risks. (Zingari 2018)

Risk preparedness is structured around 1) preparation, which involves effective land use (physical and spatial planning), as well as 2) prevention, which requires concrete training and civil protection through means of rescue units and implemented insurance policies.

Structural, biological and technical means can be taken to abate natural hazards. (Matjaž 2013).

Source: Matjaž (2013), Zingari (2018)

3.3.1. Forest fires

Theory

Forest fires - an introduction

Wildfires (otherwise known as forest fires or brush fires), can be vastly destructive to natural areas. They require three conditions in order to burn: fuel, oxygen and a heat source (otherwise referred to as the 'fire triangle' by firefighters). The fuel in wildfires can be any material that is flammable (including vegetative cover, as well as many materials used in the built environment). The larger the area of flammable material (e.g. grasslands), the greater the intensity of the fire. Oxygen is

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needed for fire to burn. The heat source is what ignites a wildfire: this can range from campfires, strong winds (causing combustion), to cigarettes or even the sun.

Although wildfires can cause tremendous damage to both humans and natural environments, they can be beneficial to the improvement of soil nutrition. Several positive factors of wildfires can include returning the nutrients of decaying matter back to the soil, while eliminating diseased vegetation. By performing a natural clearing of undergrowth, it can also allow sunlight to filter through dense forest canopies; thus stimulating new seedlings to regenerate. (Thiessen 2018)

Source: Thiessen (2018)

Case study 1

Study area 4 - THE ROCKY MOUNTAINS - an overview of wildfires

During the transformative period of mining and early settlement in the Rocky Mountains between 1850 and 1900, rampant man made fires swept throughout the region. Since then, vast areas of forested lands have naturally regenerated. Once the Rocky Mountain National Park had been established in 1915, however, the concept of fire suppression began. Following the dated ideology that ‘all fires have negative impacts and therefore must be put out’, the montane forests of the Rockies became consistently denser. This meant that they were much more vulnerable to crown fires (the spread of wildfires across forest canopies), which in turn led to a decline in forest health. The denser a forest becomes, the more susceptible it is to pests such as the pine beetle and spruce budworm (both having caused outbreaks in the Rocky Mountains). When natural forest fires occur, they typically spread unevenly, this leads to healthy depletion and regrowth. However, after a long period of forest suppression, fallen brush and dry wood accumulate to an extent that can no longer be managed once a fire breaks out.

Over the years, the fire patterns in the northern Rockies have been carefully monitored and a ‘historical fire regime’ has been studied. Thus, the occurrence of fires and their severity is determined by the historical framework of land-use in the region, the environmental conditions as well as the forest types (i.e. upper subalpine, lower subalpine, moist montane, dry montane). Due to the climatic and ecological diversity of the Rocky Mountains, they are categorized by a mixed-severity fire regime. In short, fire management strategies and restoration practices can differ significantly, not only across the Rocky Mountain, but across states and at different elevations.

Historically, the ‘Great Idaho Fires’ were perhaps the most infamous wildfires in the history of the United States. Multiple fires coalesced in the northern Rocky Mountains in 1910 and ended up burning 1.2 million hectares, killing 87 people. It was recorded to be an exceptionally warm year with strong winds. In light of global warming, understanding the climatological conditions contributing to wildfire outbreaks has become crucial. Records show an appalling 73% increase in wildfires between 1984 and 2011. (NPS 2019)

Source: National Park Service (NPS) (2019)

Case study 2

OTHER MOUNTAIN RANGES - *The Tatra Mountains - an overview of wildfires*

Since 1949, the Tatra Mountains in Slovakia were 75% covered by Taiga-like forests. Several events led to the natural diminishing of forests across the Tatra Mountains, these include: increase in windfalls, more extreme weather changes, extended pollution impacts as well as several bark beetle outbreaks. The highest form of fire resistance is healthy forest density, while the least effective form of resistance are man-made monocultures. (Strelcová 2009)

On May 3, 2018 the area of Kežmarské Žľaby in the High Tatra Mountains caught fire. Although Slovakia's Interior and Defense ministries, as well as 50 firefighters were at the site during the wildfire, it spread approximately 30 hectares. 800-1,200 tourists had to be evacuated from walking routes. The fire was especially difficult to control due to the altitude of its location; the rugged terrain also made accessibility problematic. The aftermath of this wildfire will likely cause long-term damage to soil nutrition and stability, and the Tatra forests will require a lengthy period of time to regenerate itself. (SME 2018)

Source: SME (2018), Strelcová (2009)

3.3.2. Floods

Theory

Floods - an introduction

Mountain areas are often considered 'natural water reservoirs' because significant amounts of water are transported from the uplands to surrounding lowlands; towards the Earth's largest river systems. Floods in mountain environments usually occur suddenly, and at high rates, which means

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that they are often exceptionally difficult to measure at the time of the event. Mountain floods are challenging to characterize due to the numerous processes that take place during the event: e.g. debris flow, hyperconcentrated flow, and clear water flow. The quasi-circular morphology and steepness of mountain slopes cause direct responses to intense rainfall in alpine regions. (Stoffel et al. 2016)

Source: Stoffel et al. (2016)

Case study 1

Study area 1 - THE ALPS - Impact of floods on the Pfunds community, Tyrol, Austria

The community of Pfunds is located on the Stubenbach river, with a catchment area of 32km². During the 2005 floods mentioned above, approximately 65 000 m3 of debris (reaching 6m deep) was deposited. Partial erosion of vegetative cover and upstream sedimentation (dating back to the Pleistecone era) was transported, meaning that the state of the catchment was altered. There are 2500 community members and 265 buildings (89 of which were destroyed) in Pfunds. Total damage costs were 11 million euros. Apart from infrastructural damage, lateral river erosion caused about 100 days of discontinued transportation service of the railway between Tyrol and Voralberg, which was the main connection between Vienna and Zurich. (Keiler et al. 2010)

In 2005 relentless flooding, riverbank erosion and sediment transportation occurred in the European Alps. The most serious rainfall took place on the northern alpine ridge. The severity of the floods were caused by high precipitation, intense rainfall across large catchments and valleys, pre-saturated soils (leading to rapid, high surface runoff), and high summer temperatures (causing minimal snow buffers). This caused massive river discharges over a long period of time. Subsequently high erosion rates and debris flow were activated. Some of the debris was transported to mountain rivers. This flood event caused new channels to form and riverbank overtopping, which impacted flood damage to infrastructure and inhabited areas along the rivers. (Keiler et al. 2010)

Source: Keiler et al. (2010)

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Case study 2

Study area 2 - *THE HIMALAYA - Impact of floods in the Jammu and Kashmir State and the city of Srinagar, India*

Srinagar is the main Metropolis and fastest growing city of Jammu and Kashmir State. It has a total population of 1,180,570 inhabitants, concentrated within an area of 300 km^2 at a mean altitude of 1,585 m above the sea level. Its locational centrality has given it an advantageous position in the process of settlement. This urban centre has developed all the characteristics of a tourist paradise, with tremendous growth in the development of handicraft and cottage industries, hotels, houseboats, guest houses and tourist transport.

The Jammu and Kashmir State has a long history of flooding events. Floods in the state are linked to the Jhelum River, which traverses the city of Srinagar. The construction activities in low-lying areas of Srinagar, especially along the banks of the Jhelum, have blocked discharge channels of the river, which is aggravating the occurrence of flooding events. The Jammu and Kashmir State experienced the worst floods in the past 60 years during the first week of September 2014, due to unprecedented and intense rains. The Jhelum River overflowed and caused huge damage in various districts of the Kashmir Valley. In Kashmir, 260,000 structures got damaged, including 95,000 houses in Srinagar, and more than 200 people died.

After the 2014 event, a comprehensive disaster management strategy along with a Climate Change Adaptation (CCA) plan were included for the first time in the master plan of Srinagar (2035). The planning approach encompasses the major risks that the city faces, and geographically major risk zones are identified. It takes risk sensitive urban planning into consideration for future urban and peri-urban growth, through the mainstreaming of Disaster Risk Management (DRM) within the spatial planning, governance and operations of public and private spaces, buildings and infrastructure. It provides directions for zonal plans to protect environmentally sensitive areas, reduce vulnerability and risk, mitigate climate change and increase resilience. In terms of flooding, the master plan establishes a need for:

- Comprehensive watershed mapping, including a mapping of the rivers, land use and existing infrastructure.
- Make concerted efforts for afforestation, forest regeneration and slope stabilisation for retention of water in the upper reaches during rains and create a time lag to alleviate the scale of flood intensity in the valley floor.
- Construction of mini-check dams, reservoirs, ponds, diversional canals, and natural embankments to mitigate the impact of floods.

- Preservation of the natural flood absorption of the basin from Lethpur to Lasjanon.
- Demarcation of a flood zoning and classification of the area as a Protected Natural Flood Absorption Basin to be used as city forest for enriching biodiversity and promoting tourism. (information provided by PK Joshi)

Source: information provided by PK Joshi (Jawaharlal Nehru University)

3.3.3. Landslides

Theory

Landslides - an introduction

Landslides refer to the movement of weathered materials (e.g. rocks, soil, debris etc.) down an angled slope due to gravity. They are also known as 'mass movement' or 'mass wasting'. The causes of landslides can be categorized into the following: 1) potential factors: groundwater traits, geological characteristics, topology, earthquake frequency; and 2) triggering factors: human development/urbanisation, rainfall, climate, steam scouring and the occurrence of earthquakes. Another significantly influential factor is vegetative cover: it not only lessens ground surface erosion, but it acts to retain rainfall by creating strong root systems that stabilize the earth. Therefore areas of low vegetative cover are more prone to landslides than densely vegetated terrain. Road construction is a major anthropogenic imposition on slope drainage (as roads interrupt water flow), and thus weakens surface stability. Logging, and deforestation practices also indirectly affect the occurrence of landslides because soil infiltration and evapotranspiration rates are altered, and therefore soil stability is too. (Chuang et al. 2017)

In 2003, for instance, the thaw-depth of permafrost on bedrock slopes in the Alps was significantly higher than other years which in turn increased rockfall hazards. Permafrost warming is a direct cause of slope instability. Cryospheric responses to climate change increase 'downstream' geomorphological impacts, such as weakened land-surface stability. Landslides are an example of downslope hazards, especially in high-relief (i.e. alpine) regions due to slope angle, moisture and sedimentation. (Keiler et al. 2010)

Source: Chuang et al. a (2017), Keiler et al. (2010)

Case study 1

Study area 2 - THE HIMALAYA - Impact of landslides in Nainital, India

Nainital has experienced devastating landslides of variable magnitude ever since the evolution and development of town (Oldham 1880, Auden1942, Nautiyal 1949, Hukku et al.1977, Pant and Kandpal 1990, Sharma 2006). The entire northwest portion of the town is developed over landslide debris that accumulated in the past due to successive landslides. Five disastrous landslide events occurred in 1867, 1880, 1898, 1924 and 1998, causing massive devastation of urban infrastructure and loss of lives. The first recorded landslide event in Nainital was in the north-eastern part of the city in 1866, which reactivated in 1869 and resulted into the massive loss of human and emerging settlements. However, the most disastrous landslide that damaged a large part of township was on 18 September 1880, following a continuous heavy rains of 84 cm in 36 hours. The slide debris washed away a number of settlements on down-slopes in the northern end of the lake causing the death of more than 193 people. The most important landslide that occurred in Nainital in the recent past was on 17 August 1998 on the Ayarpatha slopes, and damaged the government house road, part of a building, and affected the lake. (information provided by Prakash C. Tiwari)

The Naina peak is an active landslide zone contributing debris at its base and endangering some of the densely populated zones of the city. The old landslide debris deposited at the toe of the escarpment is accreting and poses the risk of sliding down and destroying the habitation zone as well as the existing infrastructure. The debris is exposed at a height of approximately 2450 m below the cliff and extends down to the rim of the lake in the form of a huge fan deposit, part of which in lower reaches is densely populated. (information provided by Prakash C. Tiwari)

In light of this, a detailed network of surface drains was developed in the watershed, and human intervention and construction on unstable slopes were prohibited. Construction activities are not allowed in areas having more than 50% slope. Besides, the issue of environmental instability around Nainital has also been raised by various civil society groups and individuals in the apex court of the country (Supreme Court of India) and in the High Court of Uttarakhand. Both courts advised against undertaking construction activities on the vulnerable slopes around the lake. Nevertheless, the built area has significantly increased in all locations prohibited for construction. During 2005 - 2010 the built up area had increased by almost 50%, resulting in intensive land use changes. (information provided by Prakash C. Tiwari)

Source: information provided by Prakash C. Tiwari (Kumaun University)

Case study 2

Study area 3 - THE CAUCASUS AND THE ALTAI - Impact of floods and mudslides in Tyrnyauz, Russia

Tyrnyauz is the highest city in Russia (1300 m above sea level). It is located in the Elbrussky District of the Kabardino-Balkar Republic and was founded in 1934 around a tungsten mine and processing plant (built in 1937), which is no longer in operation. In July 2000, the town was devastated by a massive flood and mudslides. Apartment blocks were buried in mud up to the second or even the fourth floor. No reliable figures exist for the number of casualties, but according to some documents 8 people died, 8 were injured, and about 40 went missing. Two strong mudslides occurred again in 2017, within a period of one week, the reason why 1000 people had to be evacuated. There was a high probability of a strong mudslides in 2018. (information provided by Natalia Lurkova)

Related videos:

1) Mudslide in Tyrnyauz in 2017:

https://www.youtube.com/watch?v=Kl0x70gUd3k,
https://www.youtube.com/watch?v=fEYL0untmnE;

2) Mudslide in Tyrnyauzb in 2010: https://www.youtube.com/watch?v=CJJDKxbalAs

Source: information provided by Natalia Lurkova (Gorno-Altaisk State University)

3.3.4. Avalanches

Theory

Avalanches - an introduction

Avalanches are a kind of disaster event that are a threat to both settlements and infrastructure. Many avalanches today are caused by downhill skiers or during ski touring and up to 90 % of avalanches are triggered by humans. (Peters and Pikkemaat, 2006)

Avalanches occur in high mountainous areas such as the Alps, the Himalayas and the Rocky

Mountains. They can simply be defined as a snow mass that breaks free from a slope and moves downwards, gradually growing in snow mass with momentum. Avalanches have the capacity to reach a speed higher than 1000km/hour and can radically damage forests, habitats, villages etc. that lie in their path. Snow composition plays a large role in determining the severity of an avalanche: once snow comes in contact with the ground, micro temperatures cause layer upon layer to form. These snow structures along with angle of a given slope (typically ranging from 30-60 degrees), determine the speed and power of the avalanche. On a gradual slope, snow may accumulate more than on a steep slope on which it can break off in fragments. Several avalanche triggers include snow buildup, wind deposition as well as movement by alpine skiers, hikers etc. Avalanches are typically divided into three sections: the origin (usually the highest point of snow movement), the path or the track (which can be several 100 meters long), and lastly the runout zone where it comes to a stop. There are also many different kinds of avalanches, including: powder avalanches (moving up to 400km/hr), wet snow avalanches (when temperatures increase, and snow becomes wetter, and usually move sideways), and slab avalanches (the most common, in which alpine tourists trigger top layers to move over hardened layers below).

Source: Peters and Pikkemaat (2006)

Case study 1

Study area 1 - THE ALPS - Impact of avalanche in Galtür

The 'avalanche winter of 1999' was an exceptionally severe season in the Alps during which strong northwesterly winds and long periods of precipitation caused more than 1300 avalanches in Switzerland alone. These storms led to valleys being cut off as well as many road closures, causing total damage costs to exceed 600 million Swiss Francs at the time. Within 30 days, a record of 5m snowfall occurred. A similar season in terms of severity took place in 1951, in which 98 people were killed in the Swiss Alps. That was the beginning of modern avalanche prevention methods: these included avalanche warning systems, hazard mapping and paravalanche constructions. Further preventative measures included silvicultural control to protect forest cover. (Wilhelm 2000).

Avalanche in Galtür

Galtür and its neighbouring resort Ischgl are one of the most popular tourism resorts in the area of Paznaun valley. The avalanche of February 1999 was the worst in Austria since 1953. The avalanche followed a heavy snow event when it was snowing constantly for 10 days, resulting in more than 3,7 m of new snow within one month. Some roads were closed and thus some areas, mainly in the valleys were inaccessible. Unfavourable natural conditions caused an avalanche on 23 February. The total of 330 000 tons of snow hit the town Galtür, where about 8 000 locals and 20 000 tourists stayed at that time. The avalanche started at an altitude of 2 700 m and hit the town in only 60 seconds with the speed of 290 km/h. Sixty persons were buried by the avalanche. The authorities started with emergency actions, nevertheless, 31 people died and 22 people were injured. Six residential houses were completely destroyed, 7 were heavily damaged and 11 were damaged only lightly. Due to ongoing bad weather conditions in Galtür, the first external help arrived 14 hours after the avalanche hit the town. The consequent measures included mass evacuation of inhabitants and tourists, which was the largest ever in Austria and with military help from NATO. The evacuation was only possible with the help of 47 helicopters, 2500 emergency workers and total of 782 flight hours. The case of Galtür is exceptional not only due to the extent of the disaster, but also due to the success of crisis management that enabled fast rescue efforts. A competent core contingency team is a key factor in crisis management.

It took Galtür one year to re-establish routines in the community. The number of tourists decreased immediately after the disaster and got back approximately after 2 years. As a consequence of this disaster, protection measures and risk assessment plan had improved. More avalanche barriers were installed, the access road to Galtür acquired improved avalanche protection, the slopes were reforested to improve their stability and decrease the risk of new avalanche formation. Moreover, beside those tangible measures, the city also established new crisis team. As a consequence, new information building called Alpinarium was established. Its building work as an avalanche barrier and also informs tourists about avalanche disasters. It is also an institution that collects data about natural alpine disasters and fosters cooperation with other institutions. Alpine Safety and Information Centre is another facility that was established based on the avalanche disaster. Its aim is to promote safety and security in mountain environment, it works as a bridge between different institutions and organisations. (Peters and Pikkemaat 2006)

Source: Peters and Pikkemaat (2006), Wilhelm (2000)

Case study 2

Study area 4 - THE ROCKY MOUNTAINS - impact of avalanches in Colorado

Colorado (located in the Southern Rockies) is known for its heavy snow accumulation, and avalanches. The history of avalanches in the Southern Rockies has been correlated to the economic development of the area. Avalanches have had major impacts on the destruction of infrastructure, transportation systems, and the exchange of services in the mountainous regions of Colorado.

During the second half of the 19th century (in which mining dominated the resource economy), the state faced its worst experiences with avalanches. Between 1859 and 1920, avalanches caused an average of seven deaths per year. Miners were especially vulnerable to avalanches, simply due to their residency in hazardous areas for long periods of time, which thus greatly increased their risk. Once Colorado's natural-resource-based economy began to transition towards an industrial economy, miners and their families began to move away from the upland regions, out of the mountains. This significantly decreased the deaths per year until winter recreation started to grow. Most recently, the Modern Era in Colorado has led to the transition from an industrial to a service-based and technological economy: this has in turn increased the number of deaths caused by avalanches. The Southern Rockies have therefore encountered the 'boom and bust' relation of economic development and paralleled risk of avalanche occurrence. Today, the Colorado Avalanche Information Centre and other organisations are working to address and minimize avalanche safety. (Atkins 2010)

Source: Atkins (2010)

3.3.5. Earthquakes

Theory

Earthquakes - an introduction

Earthquakes occur during a process of obduction: when two plates collide in the process of mountain building. The Himalayan mountain range, the Alps, etc. were formed this way, and are some of the largest and most active continental regions influenced by earthquakes (Avouac). Large earthquakes tend to cluster around plate boundaries but major faults are located under oceanic surface, making them much more difficult to monitor. At transform boundaries, plates slide under each other and cause a build-up of magma; thus resulting in volcanic activity. Active volcanic movement continues in areas of converging plates during continuous subduction. (PNSN 2019)

Source: Pacific Northwest Seismic Network (PNSN) (2019)

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Case study 1

Study area 2 - THE HIMALA - impact of earthquakes in Himachal Pradesh, India

Himachal Pradesh is a state in the northern part of India, in the North-Western fringe of the Himalayas. It comprises a total area of 55,673 km^2, with an elevation ranging from 350 to 6975 m above the sea level. Its population equals to 6,864,602 inhabitants (data from 2011) and its capital city is Shimla. (Himachal Pradesh Government, 2019) The North-Western fringe of the Himalayas is bounded by two major thrusts, namely the Main Central Thrust and the Main Boundary Fault. As a consequence of their presence, alongside with the existence of smaller faults (e.g. the Kaurik Fault), the Himachal Pradesh State is characterised by an active seismic activity (it falls within the seismic zones-IV and V). It weathers dozens of mild earthquakes every year, and large earthquakes have occurred in all parts of the state. According to the available registers, the most destructive occurred on 4 April 1905 in Kangra. I had a magnitude of 7.8 in the Richter scale and entailed the death of 20,000 people and 53,000 domestic animals, in addition to the destruction of 100,000 houses. Other calamities include the earthquakes of Kinnaur and Dharmshala, on 19 January 1975 and 26 April 1986, respectively. Due to the former (magnitude of 6.8 in the Richter scale), 60 people died, 100 were badly injured, 2,000 dwelling were devastated and 2,500 people were rendered homeless. In the case of the latter (magnitude of 5.5 in the Richter scale), 6 people died and buildings were extensively damaged. (City Disaster Management Cell, 2012) (information provided by Prakash C. Tiwari)

Source: City Disaster Management Cell (2012), information provided by Prakash C. Tiwari (Kumaun University)

Case study 2

Study area 4 - THE ROCKY MOUNTAINS - impact of earthquakes in Colorado

Historic earthquakes in Colorado have been recorded since 1867, and the Colorado Geological Survey has been monitoring seismic activity ever since. More than 700 earthquake tremours have been recorded at a magnitude of 2.5 or higher. During the 1960's, Colorado faced a flurry of earthquakes within a short period of time which were caused by the pumping of waste into a deep well at the Rocky Mountain Arsenal (CGS 2018). One of these was a 4.8 magnitude earthquake occurring in the northeast metropolitan area of Denver (it was the most economically damaging of Colorado's earthquake history). Three months later, another earthquake of a 4.5 magnitude occurred. Since 1971 (well after the primary injection of liquid waste at the Rocky Mountain

Arsenal), 15 more earthquakes occurred in the northern Denver suburbs. Research has shown that the fault running underneath the Rocky Mountain Arsenal is capable of causing 6.0 magnitude earthquakes; this could lead to an economic damage of $10 billion. Through ongoing research, it has been found that approximately 90 faults located in Colorado have been potentially active during the Quaternary period (over the last 2 million years). The National Seismic Hazard map created by the US Geological Survey shows that the Sangre de Cristo fault and the Sawatch fault are both potentially active, and capable of producing 6.5-7.5 category earthquakes. Continued economic growth and population expansion in Colorado's mountainous areas suggests that thorough research of seismic activity as well as emergency response strategies is necessary. (CGS 2018).
Source: CGS (2018)

3.3.6. Whirlwinds

Theory

Whirlwinds - an introduction

The occurrence of extreme wind and its consequences in forests can be, for example in Central Europe, dated back to the 13th century when it was first mentioned in written chronicles. The wood was becoming a more important business article with development of mining, metallurgy, glassblowing and other industries. Natural forests were being devastated by unregulated logging and also pasture. This development was typical for almost the whole of Europe. Damaged forests were not able to withstand strong winds and so the damage by whirlwinds was quite common. Later, in the 19th and beginning of the 20th century the forests were afforested, however, they shifted to more artificial ones with homogenous age and species structure, mainly to spruce monocultures. Those forests were thus much more susceptible to damage by wind. (Kunca and Zúbrik, 2006)

Forests damaged by whirlwinds bring several potential threats to:

soil

- increased transpiration and decreased soil moisture

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- increased erosion
- change in microbial activity
- increased mineralisation of organic matter, nutrient leaching

water

- faster water run-off
- increased risk of floods due to the change in hydric regime
- decreased quality of water sources

air

- air flow change in the ground level - higher windiness
- air temperature gets more continental characteristic - increase of maximum and minimum temperatures

flora

- direct damage during processing of fallen trees
- indirect damage by invasion of non-native species to affected areas
- increased risk of bark beetle damage on healthy trees

fauna

- loss of original habitats - outflow of populations
- increased pressure of predators on high-mountain species
- change of original habitats - inflow of non-original populations

landscape

- temporary decreased functions of forests, including recreation
- decreased air quality (increased dustiness, decreased humidity)
- droughts and decrease of volume and quality of drinking water

- visual change of the mountain landscape

The risk is highest immediately after the whirlwind calamity. The most significant risk is that of bark beetle population overgrowth, risk of floods and forest fires. (Kunca and Zúbrik, 2006)

Source: Kunca and Zúbrik (2006)

Case study

OTHER MOUNTAIN RANGES - The Tatra Mountains - Impact of wind calamity in Slovakia, 2004

Tatra Mountains are one of the most special national parks in Slovakia, also being a UNESCO world heritage site. Human activities in the past included excessive exploitation of forests and subsequent planting of a spruce monoculture. This lasted from the 16th century up to the year 1949, when the national park was established.

Tatra Mountains National Park was heavily damaged by a whirlwind in 2004. A centre of cyclone passed over Slovakia together with a significant cold front on the 19 November 2004. This was accompanied by strong winds reaching speeds of 230 km/h. The worst damage took place in High Tatra Mountains and Low Tatra Mountains. The volume of damaged wood was as high as 5 300 000 m^3 to 31 December 2005. Most of it - 90 %, was spruce and the area of more than 12 000 ha of forests in the National Park Tatra Mountains was devastated by this extreme wind calamity. This made it the biggest natural disaster in Slovakia in more than over 100 years. (Kunca, Galko and Zúbrik, 2014)

The affected area lies in altitude of 750-1450 mamsl. Most of the affected trees was mature, the average spruce age being 80 years and 75 of pines, the second most common species in the damaged area. The forests of Tatra National Park are divided into 5 protection zones. The fifth zone with the highest level of protection had a lot of affected wood. It was decided to keep this zone without any measures and the fallen trees were left at their place. Damaged trees could be processed only after special authorization. In the fourth zone, 30 % of damaged trees and in the third zone, 10 % of damaged trees were kept untouched. Thus, predominant part was cleared and only some parts were left for natural development. The main aim of following works in 2005 was eliminating bark beetles. Due to the location in a national park, application of insecticides on bark beetle affected trees was not possible. Similarly, it was not possible to process and remove all the trees damaged by the whirlwind. Thus, the population of bark beetle increased. In the year 2005, 3500 pheromone traps were installed across the national park. Forest areas that were not part of the national park, were also equipped with pheromone traps. Moreover, they were treated with insecticide Vaztak (0,5 % concentration in 100 l/ha), applied by an airplane. (Kunca and Zúbrik, 2006)

Forest fire was another risk that needed to be handled. The area affected by the whirlwind consequently suffered from 27 forest fires in 2005. Those fires damaged another 293 ha of forests including young ones. The location of the calamity in inaccessible terrain without road network that made all the works harder. The Nature and Landscape Protection Act was another factor since the processing works needed to acquire an exception to this law. (Kunca and Zúbrik, 2006)

A study by Budzáková et al. published in 2012 investigated the natural development of spruce forest at sites with different management schemes. Four different study sites with different habitat types after the windstorm and fire were selected for the study:

- A disturbed site that was left to natural development. This area was rich in many types of microhabitats, where many plant species with different demands could grow. There were sites with bare soil, shaded and open areas and areas with decaying logs.
- A disturbed site where all fallen trees were cleared and new trees were planted. This site caught fire in the summer of 2005: it travelled on the surface and did not damage the root systems. The area was mowed, biomass was removed and the following tree species were planted: *Picea abies, Larix decidua, Pinus sylvestris, Acer pseudoplatanus*.
- A disturbed site, where all the fallen trees were cleared and new trees were planted: *Picea abies, Pinus sylvestris, Larix decidua*. This area was also mowed with subsequent biomass removal.
- A reference site undisturbed by windstorm nor by fire. This site was selected for comparative purposes.

The highest number of naturally regenerated spruce seedlings was found at uncleared areas. This may be due to high number of various microhabitats. Lower regeneration of spruce in extracted areas is probably due to absent dead wood, which is not an optimal substrate for some competitive species that thrive better at those sites and spruce seedlings were unfavoured. The importance of dead wood in regard to forest regeneration increases with higher altitudes, it helps to maintain essential microclimate and also works as a protection against sunlight. The highest number of spruce seedlings can generally be found on lying dead logs, followed by seedlings at the foot of standing trees. The lowest number of seedlings was found at the site affected by fire, where tussock-forming grasses such as *Calamagrostis villosa* and *C. arundinacea* grew extensively.

These grasses regenerate well after fire and their dense root systems decreased the number of spruce seedlings. The most common seedlings at those sites were pioneer species *Populus tremula*, resistant *Salix caprea* and nitrophilous *Sambucus racemosa*. Areas affected by fire showed the greatest differences to other sites. The fire caused a significant change in soil and ecological factors such as nutrient content and pH. Moreover, the fire moved the succession to its very initial stages. The plant composition, species abundance and diversity was very different when compared to other sites that were not affected by the fire. The study proved that forest regeneration was possible without human intervention. In short, this study shows that no-intervention management in national parks may be the best option for forest regeneration since it requires no financial investments and the newly growing forest is both natural and healthy. (Budzáková et al., 2012)

Source: Budzáková et al. (2012), Kunca and Zúbrik (2006), Kunca, Galko and Zúbrik (2014)

3.4. Challenges

3.4.1. Seasonal demographic flux

Theory

Seasonal demographic flux - an introduction

The concept of 'seasonality' describes the unevenness or fluctuation during the course of a year, with the 'season' including (at least one) peak period. (Bender et al., 2005) Commons and Page (2001) have suggested that seasonality is inextricably linked to tourism, thus severely affects mountain tourist towns. Seasonality can also be linked to other activities different than tourism, such as the development of the town as an education hub, as the example of Nainital (India) that will be explained afterwards shows. Therefore, demographic seasonality can occur in other mountain towns where tourism activity doesn't play an important role. The most significant negative impact of seasonality is a reduction in business revenue (Scott and McBoyle, 2007). "The viewpoint that seasonality is a problem is primarily taken from an economic position and reflects concerns with the difficulty of ensuring efficient utilization of resources" (Hudson and Cross, 2005). Due to fluctuations in demand during the off-season, operations are often challenged because of their over-capacity, the non-utilization of infrastructure, a reduction in the workforce and the non attraction of investments during this time frame. "Seasonal unemployment is also often cited as a negative consequence of seasonality and it is frequently implied that unemployment in the off-

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season is an involuntary state in which seasonal workers are regarded as victims" (Hudson and Cross, 2005). (in Pegg et al., 2012; Bender et al., 2005)

In addition, during peak seasons overcrowding and congestion occurs and saturation levels are often reached (Hudson and Cross, 2005). Many tourist destinations experience an increase in their visitor rates during high season months, leading to the overuse of infrastructure and heavy demand on services. This can result in a reduction in the quality of service and attention to detail (Dickson and Huyton, 2008). This decline in standards is not just impacting the tourist, but also "the resident, who is called upon to pay this social cost of the peaking problem" (Murphy, 1985: 81). Consequently some destinations experience resentment and antipathy toward tourists and their activities. Seasonality also means an intense pressure on often fragile natural and cultural environments, because of crowding and overuse during the busy seasons. Alpine areas are now regarded as threatened wilderness, with skiing and other snow-based recreational pursuits being central to this crisis. (in Pegg et al., 2012; Bender et al., 2005)

On the other hand, seasonality might be highly beneficial for some stakeholders (Murphy, 1985). This is because of the needs of high altitude environments to have a period of recovery in order to overcome overuse during the peak season. An off-season is also often vital for renovations, and for permanent residents, who can thus recover from feelings of being overwhelmed by the large volume of visitors at peak times. (in Pegg et al., 2012)

According to Butler and Mao (1997) seasonality has two main dimensions: natural (physical) and institutional (social and cultural), involving both the origin and destination regions. Natural seasonality refers to variations in natural phenomena such as the climate, weather and seasons of the year, and may include cycles or differences in temperature, hours of sunlight, levels of rainfall and snowfall. Institutional seasonality is primarily linked to the following three factors: holidays (school/university and public/religious) and the availability of leisure time; travel habits and motivations (which are affected by changing tastes, social pressure and fashion), and the hosting and timing of events. In alpine ski resorts where a single peak pattern is common, the winter season generally attracts large numbers of visitors to the region which is regulated by both natural (climate & snowfall) and institutional (school holidays & travel motivations) on a seasonal basis. (in Pegg et al., 2012; Bender et al., 2005)

Even though seasonality is still very pronounced in e.g. the Australian Alps and some parts of the Himalaya, in several parts of the world, there is clear evidence of a significant shift toward all-season operations with the incorporation of a wide range of different types of summer outdoor recreation and adventure recreation programs in many traditional ski regions. Alpine operations in various parts of Italy and Switzerland offer particularly good examples of such adaptations. Sainaghi (2008) noted the strategic repositioning of many European destinations away from their principal focus on skiing based operations, in order to attract a broader range of potential customers in historically off peak or shoulder periods. Following a similar trend, a number of resorts in North America have begun to aggressively promote their meetings and conference market agenda, with recent figures suggesting that many visitors to ski resorts are there for work related activities or non-skiers seeking an alternative travel experience and want to participate in a range of summer recreation activities (Hudson, 2000; Scott and McBoyle, 2007). This has resulted in a subtle yet discernible shift to all season operations. (in Pegg et al., 2012)

Source: Bender et al. (2005), Pegg et al. (2012)

Case study

Study area 2 - THE HIMALAYA - the case of the city of Nainital, India

As per the Census of India 2011 record, Nainital has a total permanent population of 41,461 people. The city also hosts a large floating population, which without including tourists approximately equates to 10,000 people during the peak tourist season, who mostly work as vendors, coolies, boatmen, riders, and waiters. If tourists are considered, this figure rises to 424,000, when data from 2003 is taken. This increased to 518,000 by 2005. Most tourists arrival takes place in the three summer months (April - June) and in two months in autumn (October - November). If the tourist population of 2005 and an average stay per tourist equal to 15 days are taken, the average tourist load per day adds up to 34,533 (Singh and Gopal 2002). Furthermore, the educational and training institutions account for at least 20,000 additional floating inhabitants. The fact that the city is the district head quarter town and hosts the district court and High Court, and the office of the Divisional Commissioner, also implies that a large number of people visit the city on working days. The estimated number of such visitors is equal to around 7,000 (Singh and Gopal 2002). Thus, the total floating population in Nainital has been estimated to be about 129,000 in 2015. (information provided by Prakash C. Tiwari)

Inter alia, this has translated into a substantial increase in the number of light vehicles entering the city during the peak tourism months, and thus a rise in vehicular pollution and traffic congestion. This becomes a major problem to human health and pedestrians' movement especially during summer months, and particularly in the event of disasters. Overall, the pressure of heavy influx of tourists and other seasonal population has far exceeded the carrying capacity of urban amenities in Nainital during the peak tourist season, despite rapid urban growth and unplanned construction of houses and hotels. (information provided by Prakash C. Tiwari)

Source: information provided by Prakash C. Tiwari (Kumaun University)

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3.4.2. Population loss

Theory

Population loss - an introduction

A decline in population is understood as the reduction in the number of inhabitants of a territory as a consequence of e.g. long-term demographic trends. In mountainous areas, this process must be understood in the context of a fundamental economic shift from (rural) agriculture towards an (urban) service economy (Bätzing, 2005) (in Sonderegger and Bätzing, 2013). Global processes such as industrialisation and urbanisation outside mountain areas, an increase in the availability and attractiveness of off-farm employment, etc. have changed the way in which mountain areas are valued by society. (Gracheva et al., 2012)

Mountain population loss underlies a change in local economies, livelihood options and social structures (FAO, 2011). Results by Gracheva et al. (2012) and Tappeiner et al. (2008) on the Caucasus and the Alps show an imbalance between the younger and the elderly population as a result of depopulation processes. Data show a pronounced underrepresentation of the age classes below 15 years, and an overrepresentation of those above 65 years, as compared to the rural piedmont. Furthermore, the persistent loss of population leaves a mark on settlements, land use, and land management. This can be illustrated by the fact that many still inhabited settlements facing this problem are dotted with ruins/ dilapidated buildings, which are indicative of larger populations in earlier times. In addition to making life more difficult for those who stay behind, the abandonment of settlements also represents a loss of cultural heritage (Stadelbauer 1992). Traditional hamlets have a specific and unique style. They can be additionally accompanied by diverse stone monuments. Many of these features and artefacts are disintegrating and will gradually disappear. This loss of heritage is further accentuated by current construction trends in many places: renovation of buildings in the last decades has generally been done using non-traditional materials. The same holds true for new buildings. Moreover, these are often erected outside the traditional village perimeter, which destroys the traditional nestled settlement structure. (Gracheva et al., 2012)

Regular grazing based on the specific potentials of the different altitudinal zones and involving both nearby and remote areas is crucial for maintaining the high quality of pastures and high levels of biodiversity, and hence has played a key role in sustainable management and in safeguarding the cultural landscape heritage in mountain areas. Cessation of grazing and farmland activity associated with population loss leads to an increase in organic debris and, as a result, to an increase of sod thickness. This inhibits the regeneration of species and thus changes the vegetation composition (Gracheva and Belonovskaya, 2010). Rapid and widespread natural forest regrowth can be observed in many areas, as a result of this process. In the Caucasus, the opposite reality has also been concurrently denoted. Pastures within easy reach for grazing present signs of degradation due to overuse. (in Gracheva et al., 2012)

As many other mountain areas within the former Soviet Union, the mountains of North Ossetia (Caucasus) have been characterized by a massive overall loss of population, which forms a marked contrast to the development pathways in the lowland and piedmont area. The number of mountain settlements in North Ossetia was cut in half over the last century, from 160 in 1897 to 100 in 1959, and to a mere 64 in 1989 (Gracheva et al., 2012). This process is also observed in e.g. the Alps and the Himalaya, however, it is not uniform in space. (Sonderegger and Bätzing, 2013; Siddiqui, 2019; Apollo, 2017) In spite of a general growth in population in the Alps, the Himalaya and the Rocky Mountains, (Stone, 1992; Ravuri, 2010; Apollo, 2017) wide areas of e.g. the Italian Alps, of the Southern French Alps and the eastern part of the Eastern Alps lost population. (in Sonderegger and Bätzing, 2013) While in the west the communities gradually recovered from the massive migration phase, the situation in the East now appears precarious. Specifically, the areas east of the European region Tyrol-South Tyrol-Trentino emerge today with large population declines. (Löffer et al, 2014) Except for attractive tourism destination, regions of out-migration usually not show a high demand for real estate (Gallent et al., 2005) which supports the retention of family properties. As a direct consequence, much of the remaining housing stock is reused only for holiday and leisure purposes (in Sonderegger and Bätzing, 2013).

Out-migration has translated into overpopulation problems in larger cities. This is better illustrated by the Himalayan case. In Nepal, for example, since the 1980s urban growth related to migration from rural areas has accelerated from 6.8% in 1981 to 16.2% in 2001. The cities are not prepared for this very rapid rate. Furthermore, in most cases development plans do not even exist. (Apollo, 2017)

Source: Apollo (2017), Gracheva et al. (2012), Löffer et al. (2014), Ravuri (2010) Sonderegger and Bätzing (2013), Stone (1992)

Case study 1

Study area 1 - THE ALPS - population loss in the Canal del Ferro, Italy

The Canal del Ferro, a valley in the far northeast of Friuli (Italy) can be viewed as an extreme case with regard to depopulation. Between the years 1951 and 2011, the population decreased in this area from 15,107 to 5,703 (minus 62%); as a consequence, in the 1980s and 90s even entire villages were deserted. This process affected particular side valleys and zones at higher altitudes

(Steinicke, 1991). After the earthquake disaster of 1976, a majority of the inhabitants of North Friuli moved by necessity into prefabricated cottages and this initiated the emergence of so-called ghost towns: uninhabited towns. For 1988, Steinicke (1991, p. 116) registered 18 totally and seven partially deserted communities; while in 2005, Čede and Steinicke (2007) mapped nine abandoned villages with largely desolate buildings, and another nine where most of the houses were still intact. (Löffler et al., 2014)

Nevertheless, the new immigration has changed the conditions in recent years. In autumn 2013 only two completely abandoned villages in ruins were found throughout the area. Many of the other former ghost towns are presently inhabited during the warm season by amenity migrants, who have established their second homes in the villages. Likewise, the settlements formerly endangered of abandonment have gained new residents, often from abroad. An example is a young newcomer couple from London that lives among the approximately 50 inhabitants of the village of Dordolla. The young immigrants' motives for relocating here were "a life with people instead of against them," the desire to grow their own vegetables, and "to have more time for meaningful work and at the same time require less money." Undoubtedly, without the seasonal residents, whether local or from outside, there would be considerably more signs of village abandonment in the Canal del Ferro. (Löffler et al., 2014)

Source: Löffler et al. (2014)

Case study 2

Study area 3 - THE CAUCASUS AND THE ALTAI - population loss in Kamunta (Russia)

Kamunta is a village situated at an altitude of 1,900 meters on a mountain ridge in the subalpine zone of the Caucasus. It is one of the highest settlements in the mountains of North Ossetia. In 1886, it had 609 inhabitants who lived in 69 households, which equates to 8.8 people per household. These figures have drastically dropped in 2006, when there were only 15 inhabitants in the village, living in 7 households (2.1 persons per household). Kamunta nowadays covers only a fraction of its earlier urban area (Gracheva et al., 2012).

Source: Gracheva et al. (2012)

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3.4.3. Climate change

Theory

Climate change in mountain areas - an introduction

Owing to the relevance of mountain goods and services, changes occurring in mountain areas reach far beyond the mountains. For instance, climate change will compromise the role of mountain ecosystems as the world's water towers. Decreasing water flow from mountains will seriously affect: 1) agricultural production and food security, for both mountain communities and the millions of people who live in lowland areas and depend on irrigation water from mountain streams; 2) the supply of water to large urban centres in the lowlands; and 3) the production of hydropower. In arid and semi-arid areas, which are particularly dependent on mountain water, increased water scarcity may even lead to conflict. Water shortage has also been associated with a decline in water quality, which may increase the risk of water-borne diseases (FAO, 2011). Furthermore, continued warming temperatures will have a major impact on winter tourism in mountain areas and will also cause drastic changes in habitats and natural species equilibrium, which in turn may lead to higher rates of pestilence and degraded landscapes.

Source: FAO (2011)

The case of biodiversity loss

In general, mountain climates are typical with great diurnal and seasonal variability and cycles, creating natural stress for many species. The primary cause of climate change - increasing level of CO2 in the atmosphere, may have significant impact on mountain biodiversity due to different species responses (Price, 2007).

Conducted surveys show an increasing number of plant species in many mountain areas in Austria, Norway and Switzerland. The vegetation climatic belts move upslope likely due to climate change. This can also mean that their area decreases and that the coldest climatic zones disappear. The upslope migration can also lead to fragmentation of species populations. (Price, 2007)

The climate change affects the length of snow cover (gets shorter), soil temperature (gets higher) and lengths of seasons in general. Those changes influence the competitiveness of native species and thus, non-native and invasive plants can take over. This interspecific competition will cause changes in plant community composition. Rare and endemic species might get extinct, with species from the highest altitudes being more vulnerable to extinction. All those changes can significantly

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influence the floral diversity. (Price, 2007) Similar changes will happen in the animal world too. Fauna will have to adapt or migrate upwards and polewards. Some species, especially carnivorous and insectivorous, might lose their essential diet elements due to climate change. (Price, 2007)
Source: Price (2007)

The case of winter tourism The winter tourism will be very likely affected by climate change due to rising temperatures and changes in precipitation. The effect of snow cover on ski tourism is undoubtable. However, disappearing glaciers will have also effect on the mountain landscape in summer. Traditional mountain aesthetic will transform and moreover, melting of permafrost can cause landslides in some areas, which makes them more dangerous. A substantial amount of money will be required to stabilise cableway stations, lift masts and other structures built on permafrost. (Abegg, Bürki and Elsasser, 2008) Traditionally, summer weather is quite variable, which is not very appealing to tourists. This could however change in the future. Summer should get warmer and dryer, which can attract tourists. Increasing temperature in traditional summer destinations such as Mediterranean can hinder tourist flow and summer tourist flow in the Alps can therefore increase. Possible increase of summer tourism could partially compensate the losses caused by decreasing winter tourism. (Abegg, Bürki and Elsasser, 2008)
Source: Abegg, Bürki and Elsasser (2008)

The case of water demand for snowmaking Snowmaking is generally accepted as the most important adaptation strategy to alpine climate change for winter resorts. During the past 20 years, the production of snow has become increasingly important in many ski areas of the world (OECD, 2007). For instance, in Austria today, 55% of the total ski slopes are covered by artificial snow (Fachverband der Seilbahnen Österreichs, 2007). Snowmaking as a water demand stakeholder and its effect on water resources management is therefore a main important issue. In an alpine environment, the winter period is critical to water resources management, due to low water availability and high water demand (Vanham et al., 2008b). (in Vanhan et al., 2008). The reduction of frost days during the winter season will be problematic (Auer et al., 2005), as

snowmaking is dependant on temperatures below zero. (in Vanhan et al., 2008)
Source: Vanhan et al. (2008)

Case study 1

Study area 1 - THE ALPS - winter tourism in the Kitzbühel region and Upper Ötztal, Austria

Climate change affects the winter tourism industry in Kitzbühel due to the region's low elevation. The lowest and highest elevation of ski slopes is equal to 627m and 2014m, respectively. With an average temperature rise of 2°C without precipitation change (Breiling and Charamza, 1999), the natural snowline (now at 1,200 m) would rise to 1,300m. In this climate change scenario, the production of more artificial snow to maintain snow reliability will be necessary and water demand will significantly increase. In contrast, for the Upper Ötztal, the rise of the snowline has a minimal effect, as all ski slopes are located above this elevation: lowest and highest elevation of ski slopes equal to 1,350 and 3,250m, respectively. However, as ski slopes in the Upper Ötztal are partially located on glaciers, they could be affected by climate change impacts on glaciers. In any case, snowmaking would not result in water scarcity in either of these regions within the near future. On a local basis, water stress triggered by snowmaking could occur, but water storage and distribution infrastructures could mitigate local water stress. To solve local problems, a regional water resources management plant could be developed. (Vanhan et al., 2008)

Source: Vanhan et al. (2008)

Case study 2

Study area 4 - THE ROCKY MOUNTAINS - pine beetle outbreaks as a result of climate change

Mountain pine beetles are highly sensitive to temperature and precipitation changes. Global warming has led to pine beetles being able to complete their life cycles within one year instead of their typical 3,5 year cycle. Rising temperatures in the Colorado Rockies has meant that more pine beetles have survived the winters over the years. Between 2009 and 2010, pine beetle activity increased ten-fold, causing degradation to more than 80,000 hectares of forest cover. This infestation occurred on the Front Range, located on the fringe of urban areas. Pine beetle outbreaks across North America have been so severe that lodgepole and ponderosa pine forests have become major sources of carbon atmosphere (as trees die, decay and at times spark wildfires). Mountain pine beetles can multiply rapidly and can cause vast devastation across mountain forests. Rocky Mountain National Park is among the most severely affected areas. There are no concrete ways to completely eradicate beetle outbreaks in such large natural areas, however annual spraying can have some positive impact. This method also requires all recreational areas (trails, campgrounds, etc.) to be shutdown during the process. A major concern of pine beetle outbreaks is the accumulation of standing dead trees that pose a threat as they begin to fall. Critical infrastructure such as roads, power lines and watersheds are also at risk in such situations. Warming trends in the interior of British Columbia, Canada has also led to a rapid increase in pine beetle populations as well. Outbreaks are so prevalent across North America that unprecedented devastation to mountain forests can occur if global warming continues to cause growing population trends. (Wilson 2011)

Source: Wilson (2011)

3.4.4. Protection of mountain habitats

Theory

Protection of mountain habitats - an introduction

Mountain areas cover 27% of the world's land surface, and support up to 22% of the global human population. "Mountain biodiversity plays a key role in the support of global environmental, economic, social and cultural sectors through connections to; invasive species, air pollution, climate change, mining, hydropower, tourism, forests, agriculture." (CBD). Sustainable mountain management is therefore crucial to controlling degradation and preventing increased poverty and hunger.

Over the years, conservation planners have established systems within national parks to protect communities and ecosystems, which has been a very important first step. However, further action to protect areas across borders as well as increased international efforts to create biosphere preserves and ecological corridors are necessary. In order to effectively manage forest resources and prevent drastic land-use changes from happening, ecological and silvicultural techniques should become widespread for the implementation of sustainable forest management in alpine areas. Furthermore, environmental education plays a major role in raising awareness about the pertinence of sustainable resource management and protection of wildlife habitats and upland

plant communities. This requires regular assessment and monitoring in order to ensure learning outcomes are being reached. (Polini 2018)
Source: Polini (2018)

Case study 1

Study area 2 - THE HIMALAYA - an overview of mountain protection

Organisations such as WWF are partnering with governmental bodies, local communities and international supporters to contribute to the conservation and sustainable future of the Himalayas. For example, since the United Nations International year of biodiversity in 2010, IUCN has worked together with legislators in Nepal, India and Bhutan to implement “Access to Genetic Resources and Benefit Sharing”, “Protection of Traditional Knowledge” and “Biological Resources, Traditional Knowledge and Intellectual Property Rights”. This is to say that many different stakeholders (across both global and regional environmental sectors) are working together to effectively formulate biodiversity and conservation regimes for the Himalayan mountains. (Bouwman 2011)

Source: Bouwman (2011)

Case study 2

Study area 4 - THE ROCKY MOUNTAINS - an overview of mountain protection

Many efforts are being made to protect the Rocky Mountains and their invaluable ecosystems. The Wilderness Land Trust, the Rocky Mountain Conservancy as well as the National Park Trust (NPT) have been collaborating to implement rewilding practices in the Rocky Mountains. These efforts include the reclamation of land parcels for the purpose of reinstating areas of wilderness in mountainous regions. The protection of areas such as the Rocky Mountains faces ongoing ecological and conservation challenges. While the management of invasive plant and animal species has been a major concern over the years, the National Park Service has mostly been able to control these issues in both uplands and valleys. Climate change is without a doubt the most threatening concern with regard to the preservation of mountain ranges. The rapid increase in natural disasters such as wildfires and floods, early glaciation and drought will lead to the collapse of mountain ecosystems and habitats unless sound tourism infrastructure, industrial development, resource management and land-use strategies are upheld. (IUCN 2017)

Source: IUCN (2017)

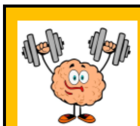
3.4.5. Improvement of living standards of inhabitants

Theory

Improvement of living standards of inhabitants - an overview

General ways to improve living standards for inhabitants of mountain communities are as following. The UN's Strategic Development Goals often emphasize the importance of 1) ensuring energy security and efficient use of electricity; and 2) ensuring food security and access of population to quality nutrition. Effective sustainable development must include the improvement of living standards for *all* members of mountain communities. To better wellbeing and living qualities for inhabitants, steady economic viability has to be achieved in order to ensure that adequate communication and transportation systems are available and to provide sufficient employment and education opportunities. This aim is clearly multifaceted and requires long-term planning with careful monitoring of developmental impacts on the natural environment. Both domestic and international investments should support local businesses of different scales, and agricultural production should carefully be regulated to avoid major land use changes while sustainably making use of existent land resources. Issues of industrialisation, infrastructure and innovation all require scrutinized energy regimes for optimized and efficient use. Furthermore, adaptation and resilience planning should be implemented in upland communities to minimize the impact of climate change and to adequately prepare alpine inhabitants for the consequences of global warming. (UN SDGs 2019)

Source: UN Sustainable Development Goals Strategies (UN SDGs) (2019)

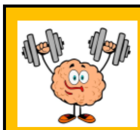


Assignment 4 (1.5hrs)

Interpretation of scientific literature

1. Read the article provided to you and identify the main challenges and risks that the area described faces.

2. Discuss the challenges and risks that you and other students identified in the online forum.
3. Continue to discuss the possible reasons behind the dissimilarities denoted among sites.



Assignment 5 (15hrs)

Group Project - Identification of critical areas ⅔

1. Continue working on the project. Is your area facing any other issues that were not mentioned during the lecture and in the papers you discussed?
2. Choose the issue(s) that are most critical to your area. Do research on this issue, this can include telephone interviews, mapping etc.
3. Perform a brief comparison between your areas and those described in the papers by drafting a brief risk assessment

Module 1: Ecological aspects of urbanization in mountain areas

4. Towards a more sustainable future?

Key words

Sustainable development, renewable energy, water management, Alps Convention, energy cities, eco-cities

Study areas: the Alps, the Himalaya, the Caucasus & Altai, the Rocky Mountains

4.1. Strategies for a more sustainable future

Theory

Strategies for a more sustainable future - an overview

Climate change, increasing natural disasters, food and energy crises, population growth, water scarcity and desertification, loss of biodiversity, degradation of ecosystems, migration, and growth of cities – the planet is currently facing a multitude of challenges. Mountain regions and their inhabitants are disproportionately affected and it is very difficult to reverse environmental degradation. Therefore, timely action is required to prevent such processes and trends through long-term approaches that combine the management of water, soils, pastures and forests. The global importance of mountains as water towers, biodiversity hot-spots, indicators of climate change and hubs of traditional indigenous knowledge means that mountain regions offer strategic opportunities in the search for solutions. Sustainable mountain development is a global priority for addressing current challenges. Mountain people, who are among the world's poorest, are key to maintaining mountain ecosystems. Thus, they need to be empowered and their livelihoods improved, to enable them to take responsibility for the preservation of natural resources and to fulfil their role as mountain stewards. (FAO, 2011)

Holistic, participatory and integrated approaches that address all aspects of sustainability are required. Sustainable mountain development demands that all concerned stakeholders living and depending on the mountain environments are involved, and that awareness is raised about mountain ecosystems, their fragility and prevalent problems, and about ways of addressing them. The experiences of indigenous mountain communities should be taken into account and traditional practices and land-use systems supported. New technologies and approaches such as conservation agriculture and soil and water conservation techniques need to complement and be integrated into local practices. To divert the pressure on land resources and improve the livelihoods of mountain inhabitants, alternative income-generating activities such as ecotourism should be promoted. Because of the fragility of mountain ecosystems, development activities should always be preceded by a careful assessment of local conditions and accompanied by impact monitoring. This is especially important when successful projects are scaled up to larger areas or applied in new settings with different characteristics. (FAO, 2011)

Source: FAO (2011)

4.1.1. Energy management

Theory

Energy efficiency - the passive-house concept in cold climates

A passive house is a building in which thermal comfort [ISO 7730] can be ensured without additional air recirculation, simply by heating and cooling the flow of incoming fresh air to ensure sufficient air quality in accordance with DIN 1946.

So far, several projects of passive houses were completed in extremely cold climate. For example school building “Biohaus Waldsee” in Bemidiji, Minessota, dormitory in Ratmirov, Russia or NorONE project in Sorumsand, Norway. There are two main technological components of passive buildings in extreme cold conditions. Those are better windows and highly efficient heat recovery. First, the windows need a special low-emittance coating on the outer side of the glazing. This high insulated windows will have no problems with condensation. The heat recovery can decrease the relative indoor humidity ad very dry outdoor air is blown into the building. This can be avoided by the use of highly efficient heat and moisture transmitters that recover part of indoor humidity and prevents formation of ice on the cold side of the exhaust air duct. (Feist, 2007)

Source: Feist (2007)

Renewable energy

There are considerable differences between alpine environments and lowland regions regarding the technical and economic applicability as well as the ecological sustainability of renewable

energy sources. (Schön et al., 2008) ● Solar energy: Highest energy outputs can be gained for photovoltaic sites at higher altitudes due to clearer sky and snow reflection, better cooling of the panels through lower temperatures and higher wind speeds. This especially applies in autumn and winter, when haze and fog cause less energy output in the valley (Bergauer-Culver and Jaeger, 1998). Furthermore, there are adverse effects on solar energy facilities in valley sites, as insolation time is reduced by the mountains. Nonetheless, there are only few non-valley sites which could be quantified as feasible because of factors like available space and impairment of nature or landscape (Schön et al., 2008) ● Wind energy: Besides offshore sites, mountainous regions are preferred locations for wind farms, due to reduced air viscosity and the phenomenon of topographic acceleration, which can make large differences to the amount of energy that is produced. Nevertheless, only hilltops are suitable for the installation of wind power plants. The development of these sites involves however difficulties like accessibility, grid incorporation, competing land uses and landscape aspects (ADTL, 2003). (in Schön et al., 2008) ● Biomass: Among other aspects, the potential capacity of a biogas plant depends on the available feedstock which in turn depends on the available acreage and livestock. As in alpine regions farm structures are rather small-sized, most plants have to be designed for small scale operation. (Schön et al., 2008) ● Hydropower: In alpine regions, most hydropower is produced by impoundment. Plants access large heads, but rather widely branched catchment areas, which imply storage facilities. Subsequently, its potential in terms of available water resources is very sensitive to the impacts of climate change, like a shift precipitation patterns and snow and glacier melt (De Toffol et al., 2007). It corresponds to the most efficient mode of energy conversion to electricity (around 90% of efficiency) (Verbund, 2006) and is more economically attractive than other options (UNDP, 2000). Drawbacks involve changes in the downstream river environment (e.g. scouring of river beds and loss of riverbanks, fluctuations in river flow) and disruption of surrounding aquatic ecosystems (e.g. hindering fish migration). (in Schön et al., 2008) ● Geothermal energy: Geothermal power plants are unaffected by changing weather conditions and diurnal variations. Thus, they are able to provide baseload power and have plenty of potential in alpine valley settlements as decentralised heat pump systems in business and industry facilities. Upper reach regions of alpine rivers can be favourable for geothermal applications using groundwater. (Schön et al., 2008)
Source: Schön et al. (2008)

Module 1: Ecological aspects of urbanization in mountain areas

4.1.2. Water management

Theory

Water management - an introduction

Due to the mountains' major role in the global water cycle, a careful, wise and efficient use of mountain water is a global priority in a world heading towards a water crisis. Without sustainable mountain development, the world will not be able to solve the global problem of increasing water scarcity (FAO, 2011). As such, an integrative management of watersheds in mountain areas is required. This approach combines forestry, agriculture, hydrology, ecology, climatology and other sciences to find better ways of conserving and using land resources. It is also based on the participative decision-making procedure mentioned above. (Price, 2004) In particular, in Agenda 21 (Chapter 13), the following management-related activities were highlighted:

- Undertake measures to prevent soil erosion and promote erosion-control activities in all sectors;
- Establish task forces or watershed development committees, complementing existing institutions, to coordinate integrated services to support local initiatives in animal husbandry, forestry, horticulture and rural development at all administrative levels;
- Enhance popular participation in the management of local water resources through appropriate legislation;
- Support non-governmental organizations and other private groups assisting local organizations and communities in the preparation of projects that would enhance participatory development of local people;
- Provide mechanisms to preserve threatened areas that could protect wildlife, conserve biological diversity or serve as national parks in watersheds;
- Develop national policies that would provide incentives to farmers and local people to undertake conservation measures and to use environment-friendly technologies. (UN, 2019)

Source: FAO (2011), Price (2004), UN (2019)

4.1.3. Forest management

Module 1: Ecological aspects of urbanization in mountain areas

Theory

Forest management - an introduction

Many forest management approaches and techniques used in the lowlands are unsuitable for mountain forests. For example, the clearcutting of large areas or the construction of access roads can destabilize entire mountain slopes and lead to high soil erosion rates. Mountain forests should be managed with an ecosystemic approach, taking into account the biological characteristics and different ecological functions of a forest. Diverse forest stands with a variety of species and a differentiated age structure should be maintained, and selective harvesting techniques applied. Such stands are much more resilient and therefore better able to fulfil their slope stabilization and soil protection functions. (FAO, 2011)

Source: FAO (2011)

4.2. What has been realized so far? - Towards a more sustainable mountain city?

Theory

Towards sustainable mountain development - an overview

Despite their importance, mountains have received little attention in global discussions of environmental and development issues. This changed in 1992 with the adoption of Chapter 13 of Agenda 21 at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil (UNCED). Chapter 13 promotes the sustainable development of mountain regions, points out the need for better understanding of the ecology of mountain ecosystems, and clearly acknowledges mountains' importance for humankind. For the first time, sustainable mountain development was placed on a similar footing to other major global issues. In 1998, the United Nations General Assembly proclaimed that 2002 would be the International Year of Mountains (IYM). This year provided a catalyst for long-term and effective actions for implementing Chapter 13. It contributed significantly to raising awareness about mountain issues, supported the establishment of 78 national committees, and strengthened partnerships among different stakeholders, culminating in the launch of the Mountain Partnership at the World Summit on Sustainable Development, in Johannesburg, South Africa, in 2002. The Mountain Partnership is an international, voluntary alliance dedicated to improving the lives of mountain people and protecting their environments around the world. It promotes results-based collaboration, projects and information exchange on mountain issues at the national, regional and global levels. It is also a mechanism for networking and advocacy to support the cause of sustainable mountain development in relevant international processes and United Nations Conventions. Currently it has about 180 members from governments, civil society, intergovernmental organizations and the private sector. (FAO, 2011)

Chapter 13, the Johannesburg Plan of Implementation and the Millennium Development Goals form the overall policy framework for sustainable mountain development at the regional and global levels. Mountain issues are addressed in Chapter 24 of the Millennium Ecosystem Assessment (2005) and in the UNCBD Programme of Work on Mountain Biological Diversity. Numerous global and regional networks in addition to the Mountain Partnership have been set up, and international and regional conferences and workshops have been organized. Nevertheless, sustainable mountain development does not yet receive sufficient attention on the international agenda, and there are still significant constraints to alleviating poverty, mitigating environmental degradation and attaining sustainable development in mountain regions (FAO, 2011). Ambitious action plans have been already created and realised at some particular locations, at least at the local level. This encompasses ideas such as the energy cities network in Switzerland, the carbon-neutrality and sustainable development plan of Santa Fe (USA), and the development of the eco-city concept in Grenoble (France). While plans and action at the regional/national/transnational level remain rarer, tools have already been provided in some particular areas, such as the Indian Himalayas, where the national government has launched reports offering guidance on sustainability strategies. In this course, we will focus on the establishment of the Alps convention, a transnational treaty for sustainability in the Alps.

Source: FAO (2011)

4.2.1. The Alps convention – network of the Alps municipalities

Reference case

Study area 1 - THE ALPS - The Alps convention - Alliance in the Alps

The Alliance of the Alps is a community network that was founded in 1977, and represents an association of seven alpine regions in the Alps. The Alpine convention is an international treatise between the following countries: Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland that was established in 1995. The treaty aims to implement the general protection and sustainable development of the Alps region.

Objective of agreement: "To pursue a comprehensive policy for the preservation and protection of the Alps by applying the principles of prevention, payment by the polluter (the 'polluter pays' principle) and cooperation, after careful consideration of the interests of all the Alpine States, their Alpine regions and the EEC, and through the prudent and sustainable use of resources". The treaty covers 10 protocols: 1) On the accession of the Principality of Monaco to the Convention on the Protection of the Alps 2) On tourism 3) On energy 4) On soil conservation 5) On mountain farming 6) On spatial planning and sustainable development 7) On conservation of nature and the countryside 8) On transport 9) On mountain forests 10) On dispute settlement
Source: Alliance in the Alps (2019)

4.2.2. Energy cities (Switzerland)

Theory

Definition: what is an energy city?

An energy city is a city that continuously strives for the efficient use of energy, climate protection, renewable energy and green mobility. In Switzerland, the efforts of cities in this direction are recognised by the awarding and renewal of the "energy city" label every four years from the sponsoring association Energiestadt. Not only cities, but also regions and schools can apply for it and an energy gold label has been as well launched, in order to recognise those organisations exercising major efforts. Organisations that have implemented at least 75% of the measures within reach for them are granted with this latter label. The measures adopted to attain the objectives

remain voluntary. (EnergieSchweiz, 2019)
Source: EnergieSchweiz (2019)

Brief historical background

The start of the project "Energy City - Development Platform for Municipal Energy Policy" took place in Switzerland in 1998, under the auspices of WWF Switzerland, the Swiss Energy Foundation, and the Swiss Society for Environmental Protection. In 1990, the initiative received support from the Swiss Federal Government for the first time and immediately afterwards, in 1991, Schaffhausen was awarded as the first energy city. Other energy cities that followed were: Olten, Birsfelden, Lenzburg, and Münsingen. The same year, the Federal Council launched the Energy 2000 programme, which included the promotion of the Energy City concept in the country. This led to the foundation of the sponsoring association Energiestadt. In December 2018, a total of 437 cities had been labeled as energy cities, 45 of which as gold energy cities. This translates into a 60% of the Swiss population living in energy cities. Moreover, the concepts has crossed the national borders and has been implemented in 1,400 cities in eleven countries under the name of the European Energy Award. Despite the fact that most of these cities are located in lowlands, some of the cities awarded are situated in mountainous regions, such as the ski town of Saas Fee (Switzerland) (EnergieSchweiz, 2019)

Source: EnergieSchweiz (2019)

Case study

Study area 1 - THE ALPS - - Saas Fee

Saas-Fee (1,800 m above sea level) lies at the foot of the highest mountain in Switzerland, the Dom (4,545 m above sea level), and has a permanent population of about 1,600 inhabitants. In June 2002, Saas Fee was distinguished with the label “energy city”. Further, the town is part of the network of municipalities “Alliance of the Alps” (Alps Convention) since 1996. Within this frame, for the period 2012-2025, the municipality has set up the following objectives: (Gemeinde Saas Fee, 2019; Saastal Tourismus AG, 2019)

- A reduction of the total energy consumption in the municipality by 10%, based on population and overnight stays.
- An energetic rehabilitation (heat consumption) of 2% per year (equivalent to 10 buildings)

of the actual building stock in the municipality.

- A reduction of the electricity consumption (including heating) in public buildings by 20% through renovations.
- A replacement of electric heating devices in public buildings with renewable energy sources.
- An increase of the share of renewable energy sources (electricity and heat) in the municipality to 50%, primarily by improving energy efficiency and by replacing electric and oil heating systems with district heating. In the long term, a CO_2-neutral energy balance is sought.
- A fivefold increase of the solar collector area and the average annual construction of 1000 m^2 of photovoltaic area. (Gemeinde Saas Fee, 2016)

Indeed, all electricity in Saas Fee is already obtained 100% from renewable sources, including the used to propel the lifts and railways, thanks to the supply of hydroelectric power. It is to be stressed that the open-air car parks are lighted by means of the Omniflow system, a system which is now in an experimental phase in the town. It consists of LED lamp posts which are energetically self-sufficient, i.e. they produce and store their own electricity through solar panels, a wind turbine and a storage unit integrated within the lamp post. Light intensity can equally regulated. Additionally, low energy standards have to be accomplished in all new public buildings and when renovating the old stock of public buildings, if economically viable. The town council also promotes the application of low energy standards among private individuals. (Gemeinde Saas Fee, 2016; Gemeinde Saas Fee, 2019)

In order to increase the share of renewable power within the heat energy sources, a district heating network was built and put into practice in 2015. Through it, hot air is pumped and stored underground in summer, by using photovoltaic energy, and used in winter for the heating of buildings. The size of the underground storage unit is equivalent to the size of a football field. (Gemeinde Saas Fee, 2019)

Saas Fee is a car-free town and all private vehicles have to be parked in one of the car parks located in the entrance of the town. Only pedestrians, and public transportation and car sharing vehicles, as well as electric taxis, are allowed to enter the urban area. Electric buses totally recharged with renewable energy enable skiers to reach the skiing slopes. A framework has been created for the provision of comprehensive information and the raising of awareness among the public on energy and environmental issues. Inter alia, the town council provides a tool for the calculation of the carbon footprint to all its residents and several recommendations on ways to reduce energy consumption. Intra- and inter-municipal cooperation among all stakeholders is equally promoted. (Gemeinde Saas Fee, 2016; Gemeinde Saas Fee, 2019; Saastal Tourismus AG,

2019)
Source: Gemeinde Saas Fee (2016), Gemeinde Saas Fee (2019), Saastal Tourismus AG (2019)

4.2.3. Eco-cities

Case study 1

Study area 1 - THE ALPS* - Grenoble, France and its eco-quarter “ZAC De Bonne” - *an introduction

Grenoble is a French city of 160,000 inhabitants, capital of the department of Isère, in the Alps. Located on the alluvial plain of the Isère at an altitude in between 204 and 600 m, Grenoble is a municipality located on a large plateau with a very low relief, but surrounded by four mountain ranges with summits higher than 2,000 m: the Vercors Massif, the Chartreuse Mountains, the Taillefer Massif and the Belledonne Range (MEDDTL, 2011)

Source: MEDDTL (2011)

The ZAC Vigny-Musset, experimental project for sustainable development in Grenoble

This vast neighborhood, started in the early 90s. In 2001, with the arrival of the new municipal assistant for urban planning and the environment, the realization of the ZAC experienced a sharp acceleration and affirmed its environmental focus. It was decided to insist on high environmental quality concerns, particularly in the field of renewable energies, external insulation and the durability of materials. In addition, to meet the expectations of families wishing to live in town in quality housing, the municipality affirmed its desire for a mix and diversity of urban fabric, by developing in each building cluster public and private dwellings and by involving different architects (PUCA, 2011a).

New methods and procedures were developed, strongly encouraged and supported by the local authorities, who tried to organize other modes of collaboration in the long-term, and even to initiate a change of mentality among architects and developers (PUCA, 2011a).

Since 2001, the city has tested and experimented with exterior building insulation, solar thermal power and the implementation of sustainable modes of building construction. This operation also made it possible to test compact urban forms and new ways. Additionally, the city and its development company were able to test the reactivity of the actors and their willingness to get involved in this approach of environmental quality. Most of the stakeholders became aware of the need to evolve and were ready to accept the new approaches. A vast consultation of the inhabitants was also organized. The results of the operation revealed, however, a number of shortcomings and imperfections, especially in the measures implemented by companies still little experienced. (PUCA, 2011a)

Very quickly, this neighborhood renewal became exemplary, in terms of the organization of its modes of collaboration with the partners and of the dialogue developed with the inhabitants. The principles expressed around this operation constitute the beginnings of the action plan that the municipality wanted to establish in Grenoble and are the basis of the approach implemented in the ZAC De Bonne. It is thanks to the Vigny-Musset project, not least thanks to the targets set up, that the use of the environmental specifications on sustainable modes of construction, etc. was systematized and reinforced, to become the basic tool and the essential prerequisite of operational urban planning in Grenoble. (PUCA, 2011a)

Source: PUCA (2011a)

The eco-quarter "ZAC De Bonne": an introduction

The operation of the ZAC De Bonne fills the void left by the military enclave in the heart of the city, unoccupied since 1994. It is one of the last major mutable sites in the center of Grenoble. In 2000, the city and the Ministry of Defense launched a competition in order to establish a development program for the barracks of the De Bonne site. The DEVILLERS project (winning project) made the choice to create a neighbourhood: 1) offering a high mixture of activities and a generational mix, 2) bordering a park, and 3) restoring the urban continuities. The operation sought exemplary high environmental quality (HQE). The choice of materials, construction processes, energy efficiency and the use of renewable energies have translated into the support of the European research and development program Concerto (Sesac) (eco-quartiers, 2019). Since the Concerto support, the ZAC De Bonne became emblematic of the urban and environmental policy of the city of Grenoble. The partnership and involvement that resulted from the European commitment created a leverage effect on the actors, whose behaviour and practices changed. This dynamic favoured the development of a specific system of contracting and management of development projects. The operation became the reference of the interventions of the agglomeration of Grenoble and represented a real political opportunity (PUCA, 2011a.) The environmental and energy objectives have determined the main orientations of the project: (PUCA, 2011b)

- To provide summer comfort in the public space (greening of roof terraces and courtyards, etc.);

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- To limit the space devoted to cars (small dimension of roads, zone 30), and give priority to pedestrians, by creating pleasant and safe circulation pathways for walkers;
- To favour the usage of site resources and local renewable energies;
- To enhance the presence of water on the site;
- To develop cycle lanes, and integrate cycle parking on public and private space;
- To fight against massive soil sealing and ensure the infiltration of rainwater into the subsoil in the public space;
- To plant numerous alignment trees in the streets as well as in gardens and public parks;
- To connect the "Bonne Park" with Paul Mistral Park (ecological corridor);
- To achieve a high levels of energy efficiency in all buildings. (PUCA, 2011b)

The project also aimed to build a repository of experience feedback, or even standards for European vocation, based on monitoring intended to evaluate performance accurately. (PUCA, 2011a)

Source: PUCA (2011a,b)

The eco-quarter "ZAC De Bonne": energy

The bioclimatic design and the insulation from the outside make it possible to optimize the energetic performance of the buildings, as well as their comfort, both in winter and in summer. They result in heating requirements limited to 50 kWh / m2 / year. The electricity needs of homes are covered by natural gas cogeneration. The buildings are also equipped with solar collectors covering 50% of hot water needs. The roof of the shopping center is covered by 1,000 m2 of photovoltaic panels. A solar equipment of this size in the city center is unique in France (eco-quartiers, 2019).

Source: Eco-quartiers (2019)

The eco-quarter "ZAC De Bonne": water

The measures required were: 1) valorisation of water in the city; 2) limitation of impervious surfaces; 3) retention and infiltration of rainwater; and 4) rainwater harvesting. Four ponds and water gardens were deployed to that end, to enhance the presence of water, for visual comfort, recreational uses and summer thermal comfort. The largest pond, with an area of 1700m², recovers and stores rainwater for the watering of parks. Plant species have been chosen by using climate adaptation criteria. The basic principle behind the ponds is the reconstitution of the natural functioning of an aquatic environment; that is to say, no human intervention will be necessary to maintain a good state of the ecosystem. (MEDDTL, 2011)

Rainwater is managed locally by means of an infiltration system, consisting of draining trenches and wells. The relief within the district directs runoff to these infiltration networks. In the case of public buildings (mainly the commercial space and the school), infiltration is performed via green roofs and infiltration systems on the ground (draining trenches) that recover rainwater from roofs. Major freedom was given to developers vis-à-vis the SuDS types to be used in private parcels, where rainwater is managed at the scale of each building cluster: Savings in water consumption are provided by various devices including double-flush toilets. (MEDDTL, 2011)

Source: MEDDTL (2011)

The eco-quarter "ZAC De Bonne": governance

Many consultations were held with partners and the public, around the identity of the project and its definition. A think tank met several times; three public meetings as well as neighbourhood meetings and visits to the site have largely mobilized residents. (PUCA, 2011a)

Source: PUCA (2011a)

Case study 2

Study area 4 - THE ROCKY MOUNTAINS - Santa Fe Sustainable Development Plan (Midtown Eco-District Project & Biohabitats River Greenways Project) - an introduction

Santa Fe (the capital of New Mexico) is located in the foothills of the Sangre de Cristo mountains in the Southern Rockies. The city is the oldest in the United States, and was originally established as a Spanish colony in 1610 and is well-known for it's striking Pueblo-style architecture and flouring art scene. Over the years, the foothills of the Southern Rockies have faced stock grazing, timbering and rapid increases in recreational use of national forests in the area. The initial settlement of ancestral Pueblan farmers began with the progress of terraced agricultural practices, and population numbers subsequently continued to grow. Anthropocentric expansion and encroachment on the mountain landscapes continued, and urban development has had a significant effect on the region surrounding Santa Fe. Organisations such as the Santa Fe Conservation Trust, as well as governmental initiatives are working towards sustainable development in Santa Fe. For example, Santa Fe's City Council has developed a 25 year plan to achieve carbon neutrality and sustainable development.

SUSTAINABILITY VISION

"We envision a thriving community where climate impacts are neutralized, natural resources are abundant and clean, and sustainable economic activity is generated through enhancing social equity and the regenerative capacity of the environment." (SFNM Government 2018)

Source: Santa Fe, New Mexico Government (SFNM Government) (2018)

OBJECTIVES

<u>**Carbon Neutrality**</u>

Carbon neutrality by 2040

- Transition to 50% renewable energy by 2025
- Integrate energy efficiency in the built environment
- Increase low-carbon transport options

<u>**Ecological Resilience**</u>

Energy

- Reduce community electricity & natural gas consumption, 1%/year
- Identify & increase community participation in renewable energy programs (e.g. solar-installation; both on-site and community projects)
- Reduce annual electric consumption at city facilities
- Increase renewable energy and city facilities
- Ensure electric vehicle charging stations are located every 8 kilometers across Santa Fe

Ecosystems

- Quantify impacts of air pollutants on health in Santa Fe and develop appropriate response plan
- Enhance the connectivity of greenbelts and habitat corridors across the community
- Determine a baseline for carbon sequestration levels from plants & soils, and increase carbon sequestration

Water

- Continue normalized decrease in total potable water use by all sectors
- Increase use of reclaimed water for municipal operations
- Increase the number of residential and communal greywater systems
- Create at least two neighbourhood-scale water conservation projects and programs
- Increase number of public and private use of rain gardens and other infiltration projects

Waste

- Provide universal recycling for both residents and customers throughout Santa Fe
- Achieve 90% participation rate of residential recycling
- Improving internal city recycling program, establishing new operational policy to move towards 100% recycling participation in all city offices and at all city events
- Incorporate criteria about recycled content and Extended Producer Responsibility into guidelines for city purchasing

Economic Vitality

Community development

- Simplify/modernize business licences and permitting processes
- Increase exports, limit imports (to minimize overall leakage)
- Increase entrepreneurship, public-private partnerships, and philanthropic funding
- Develop a baseline to monitor local sustainability-related employment levels and average wages

Built environment

- Meeting the 2030 Challenge of net-zero greenhouse gas emissions: adopt increasingly regimented building codes on a three-year cycle
- Require healthy indoor air exchanges in all new buildings and larger remodels/additions, and with energy efficiency retrofit projects
- Require strict radon mitigation in all new and existing buildings
- Increase percent of or mixed-use developments permitted annually by 10%
- **Pilot an eco-district or planned sustainable development project**

Transportation

- Achieve annual reduction in daily kilometers traveled
- Achieve annual increase in total kilometers of sidewalks, on-road bicycle lanes and multi-use paths
- Increase public transport ridership annually
- Increase the proportion of low and zero emissions City fleet vehicles
- Increase the proportion of low and zero emissions vehicles used in the community

Quality of Life and Social Equity

Education and training

- Ensure that every employee within Santa Fe is aware of the 25 sustainable development plan
- Increase coordination and outreach on sustainability issues in Santa Fe
- Ensure that every K-12 (elementary, middle and high schools) have access to adequate sustainability-related curriculums & experiential learning programs
- Increase number sustainability courses offered at higher level education

Health and wellness

- Increase city employee participation rates in health & wellness, nutrition and exercise programs
- Increase community participation in health & wellness, nutrition and exercise programs

- Increase number of participants during bike-to-work and bike-to-school weeks

Food systems

- Achieve annual increases in procurement of New Mexico's grown produce
- Increase community access to food outlets
- Increase opportunities for local food producers to sell and distribute food locally

Social equity

- Adopt/apply triple bottom line analyses for Santa Fe's decision making
- Establish a recurring and reliable revenue source to invest in community social equity and sustainability initiatives
- Ensure that all households and businesses can access 100 percent clean renewable energy
- Reduce community homelessnes

Source: Santa Fe, New Mexico Government (SFNM Government) (2018)

MIDTOWN ECO-DISTRICT PROJECT

The midtown campus in Santa Fe is a 63 acre property owned by the city which was originally developed for the purpose of higher education. It is located in the geographic center of Santa Fe, amidst bustling state and city parks, public transport hubs and education facilities. Almost 60% of the property was underdeveloped and was considered to be ideal for a mixed-use development project. The *Surroundings* Landscape Architecture firm in collaboration with *Biohabitats* have designed a sustainable infrastructure plan and development proposal for the Eco-District in Santa Fe. The general concept of the design follows a sustainable planning framework that prioritizes people and the planet. The Eco-District initiative has highlighted the following issues to include in the development scheme: 1) Mobility Options & Connectivity, 2) Living Infrastructure, 3) Resource Efficiency & Regeneration, 4) Habitat Creation & Preservation, 5) Green Building, 6) Health and WellBeing, 7) Public Spaces & Community Identify, and 8) Equitable Development & Prosperity. Primarily, the planners focused on the conceptual link between Connections, Energy and Water.

- **Connectivity:** was intended to be furthered through the revitalisation of infrastructure; specifically by transforming existing road infrastructure into a block grid of flexible infrastructure corridors. The 'reuse and renew' approach is intended to reduce infrastructure costs overall. Furthermore, the Eco-District plan proposes both physical and digital connectivity through increased opportunities for pedestrians, bikers and transit

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users in order to reduce CO_2 emissions.

- **Energy:** the Eco-District's target is to generate 100% of all energy on the property itself. The planners have estimated that with a complete roof-mounted solar panel installation, the site could generate an annual output of 21M kilowatts/hour. Furthermore, the team plans to implement a 'smart grid' energy optimization system to control the supply and demand of energy across the district.
- **Water**: the designers aim to achieve a net-zero gain in potable water use over current water use in the district. The built infrastructure would be designed in a way to harvest storm water in order to support existing natural areas within public spaces. Stormwater will also be used to irrigate green infrastructure and park irrigation. Wastewater will be collected and treated in a localized treatment facility; treated water would be used to supply septic systems and digital cooling fluid where necessary.

Source: Santa Fe, New Mexico Government (SFNM Government) (2018)

BIOHABITATS: Santa Fe River Greenways Project

The Santa Fe River is a tributary of the Rio Grande, originating in the Santa de Cristo mountain range and is approximately 120km long. Santa Fe's river valley basin has undergone severe transformation from small irrigated farms to urban development. This change in land-use has led to water diversion, overgrazing, mining and urbanisation. The Santa Fe County in collaboration with *Biohabitats* (a company focused on restoration and ecological stewardship) has developed the Greenways project to create parks and to restore the river corridor. The project also included the development of a 19km pedestrian/biking trail along the river. The severity of channel incision in the Santa Fe river is very high, caused by mining disturbances and urban runoff. The river banks have eroded in several places and the floodplain has become fragmented; resulting in soil instability and non-native plant species invasion. After conducting geomorphic surveys, Biohabitats planning team analysed the data to measure channel depth and width parameters. The team then engineered a regenerative design for the river's channel restoration, using natural materials. For example, boulder grade control structures are included in the design as a method of raising the channel bottom. Furthermore, boulder side-slope protection along with willow plantings are used to mitigate high water velocity in the river's bends. Channel grades are used as a way of re-establishing normal flows that would be able to reach the floodplain. Lastly, the plan targets the removal of non-native tree species and the re-establishment of native species. This project is an example of ecological restoration management of the river catchment in the Southwest Basin and Range region to prevent exacerbated natural disasters such as flooding, and to protect native ecosystems. (Biohabitats 2019)

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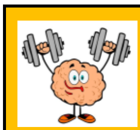
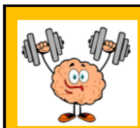
Source: Biohabitats (2019)



Assignment 6 (19hrs)

Group Project - Development of sustainability strategies $^{2}/_{3}$

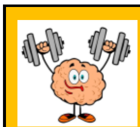
1. Finish your project with a sustainable development plan. Think of measures to solve the issues identified, suggest new ways of handling these issues in your area. You can support your ideas by referencing images, maps, figures, drawings, etc.



Assignment 7 (0.5hrs)

Diverse online questions/games

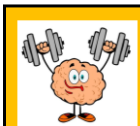
1. Summary of the contents in part III



Assignment 8 (1hr)

Group Project - conclusion

1. Prepare a PowerPoint/poster/video on your work, including all information gathered in all parts of the project, and upload it on the web, so that all course participants can view it.



Assignment 9 (2hrs)

Final online discussion

1. Discuss the projects and differences between groups. Focus on the reality faced in distinct areas and on the different strategies that should be implemented in these specific contexts in order to respond to current sustainability challenges.

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