Learning module

“Ecological aspects of urbanization in mountain areas” (S2)

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SUNRAISE

Co-funded by the Erasmus+ Programme of the European Union

Module 1: Ecological aspects of urbanization in mountain areas

S2: The case of urban nature and urban rainwater management

Contents

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).

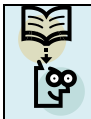
Alongside to the scientific-analytic attempt of understanding nature (e.g. Brämer 2006, 2010; Trepl 1992), there is perceiving nature, which can be particularly found in romanticism (Kirchhoff and Trepl 2009). Understanding nature, perceiving nature and using nature has to be approached well in cities. 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:

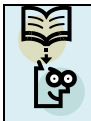
- Adjusting usability and capacity of nature to the demands
- Thereto developing strategic plans
- Connecting nature
- Promoting multiple use and functional diversity
- Allowing unaffected development of nature and reducing cultivation and management

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 m^2) 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 m^2	Private /private	individual
	Allotment garden	Patch of rented land used for recreation and food production 200 – 400 m^2	Private / publicly visible	individual
	Green buffers	Garden area between more storied apartment building several 1000 m^2	Semi-public / semi-public	maintenance company
	Community gardens	Kitchen gardens, 100 – several hundred m^2	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.

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- 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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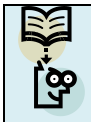
1.4. Urban ecosystem services

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

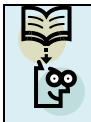
The terminology surrounding ecosystem services has not yet been standardized (Bastian et al. 2012a,b). De Groot et al. (2002) cite "ecological functions" as the basis of "ecosystem services". Bastian et al. (2012a,b) include ecological functionality (structures, components and processes) in "ecosystem 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

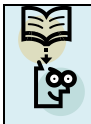
The "Millennium Ecosystem Assessment" (MEA) (2005), published by the United Nations, uses three categories for ecosystem services that provide direct benefits for humans:

- 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

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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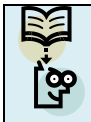
1.5. Urban biodiversity

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).

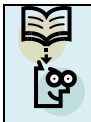
Source: Breuste (2020a)

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).

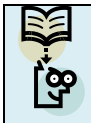
Source: Breuste (2020a)

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)

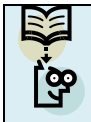
Case study

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:

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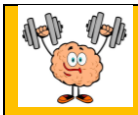
- Fresh air supply and healthy urban climate;
- Sufficient regeneration of groundwater;
- Flood prevention, water retention and water development;
- Recreational spaces for humans;
- Habitats for plants and animals, migration corridors; and

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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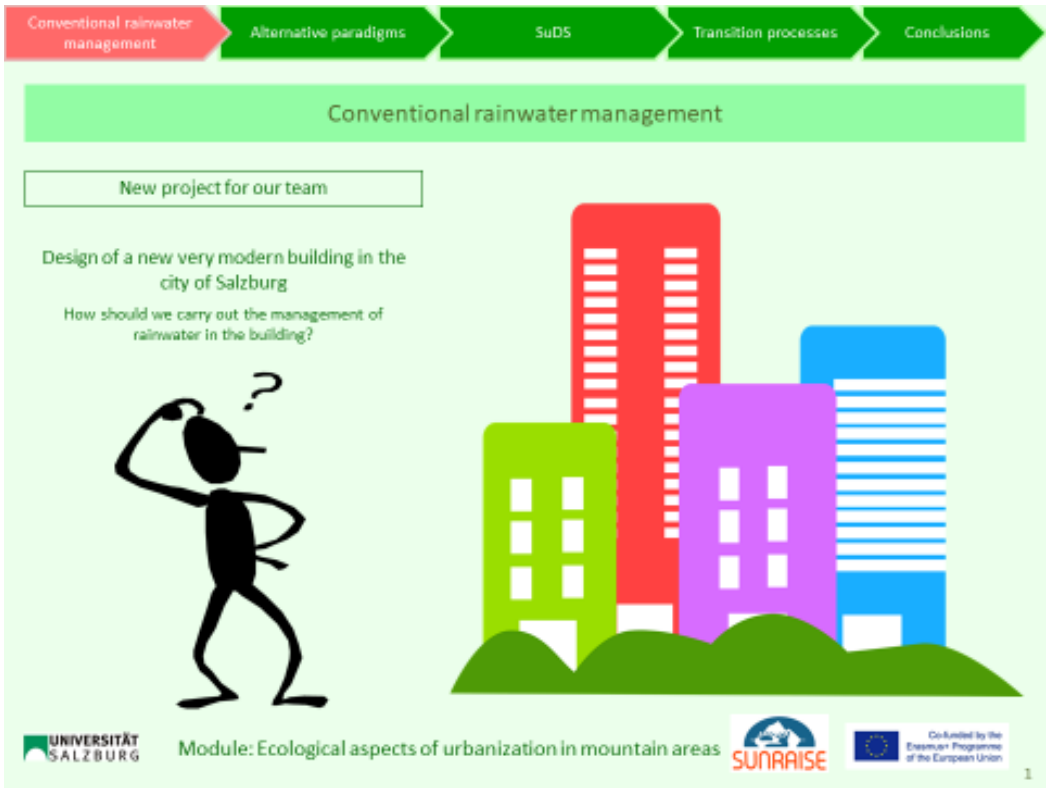
2. Urban rainwater management



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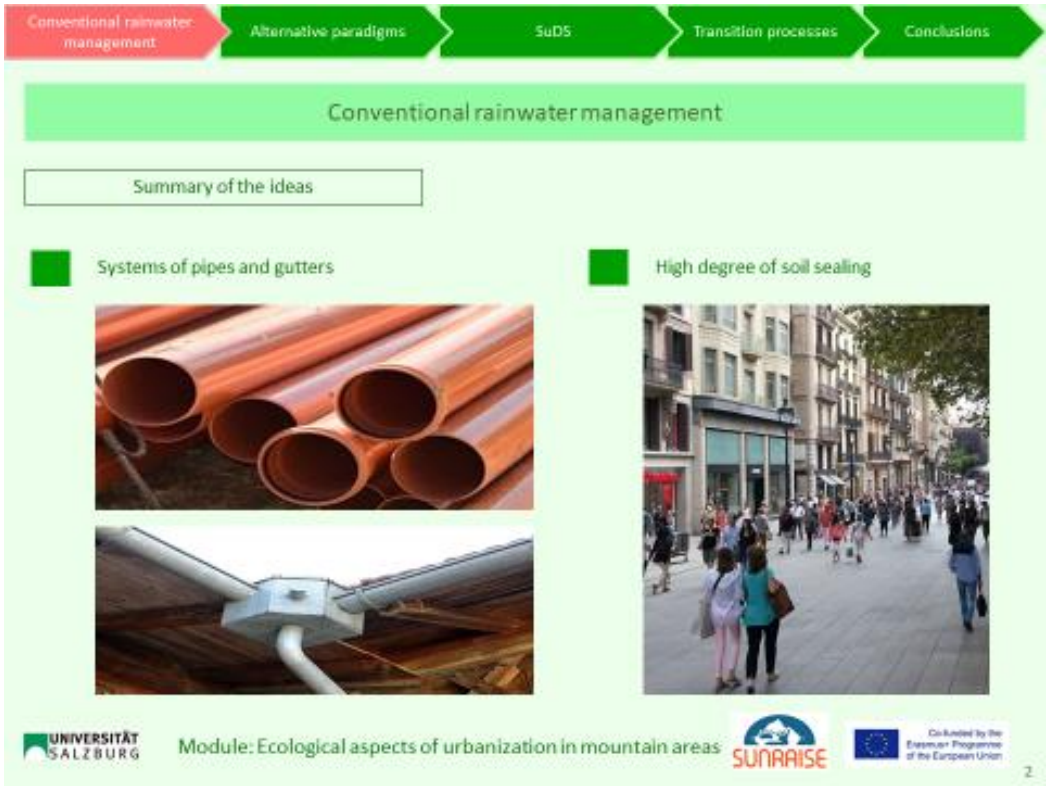

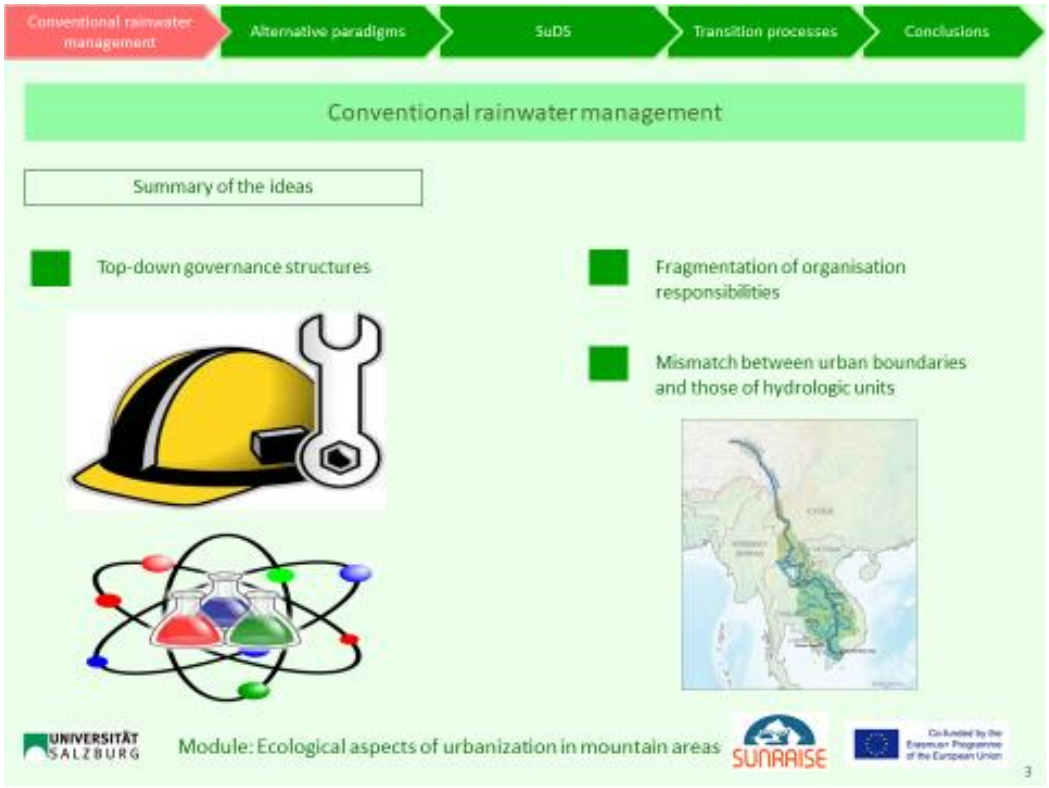

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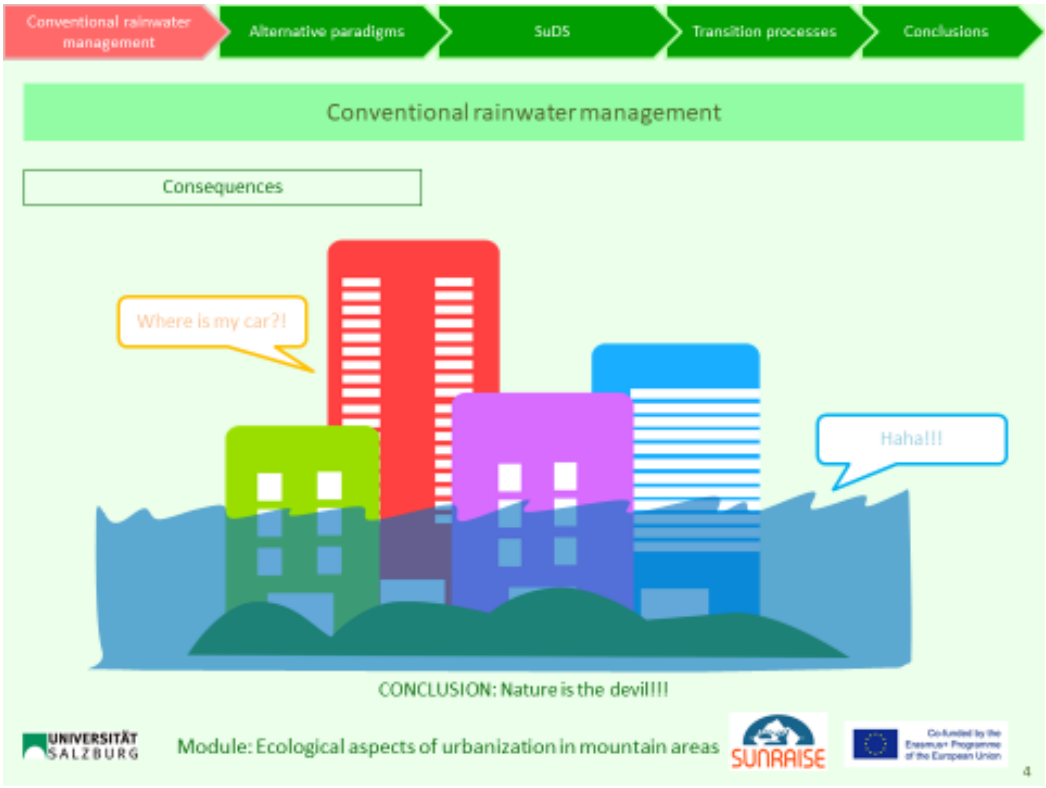

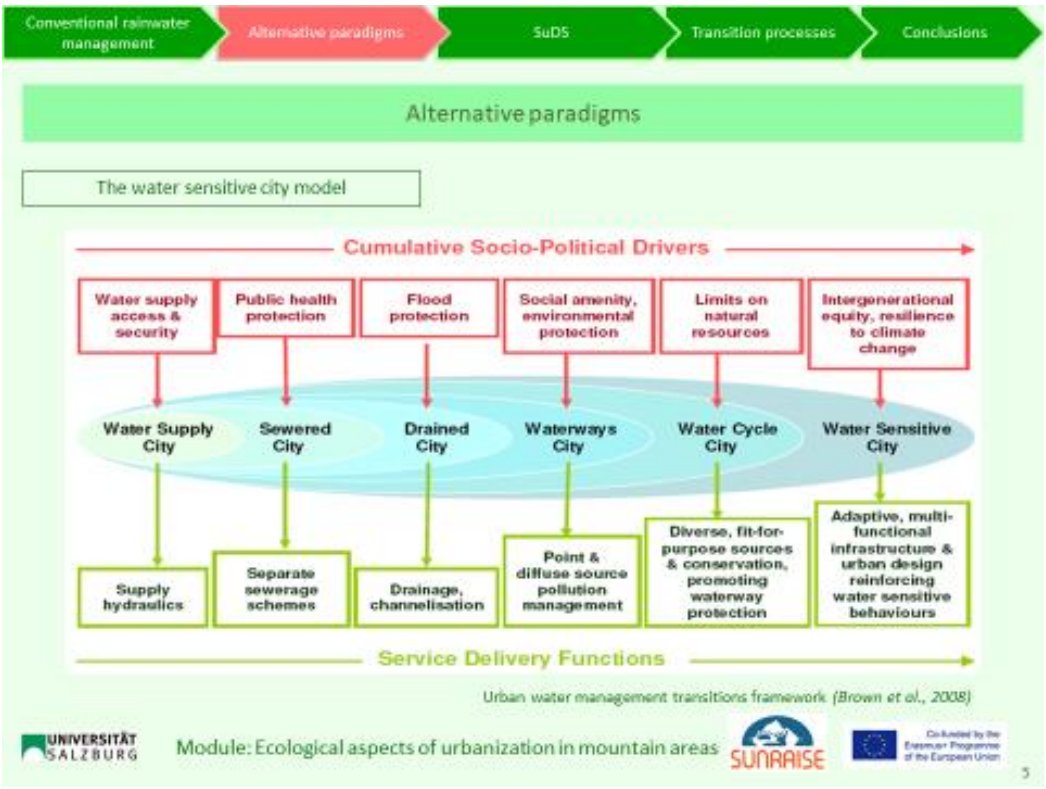

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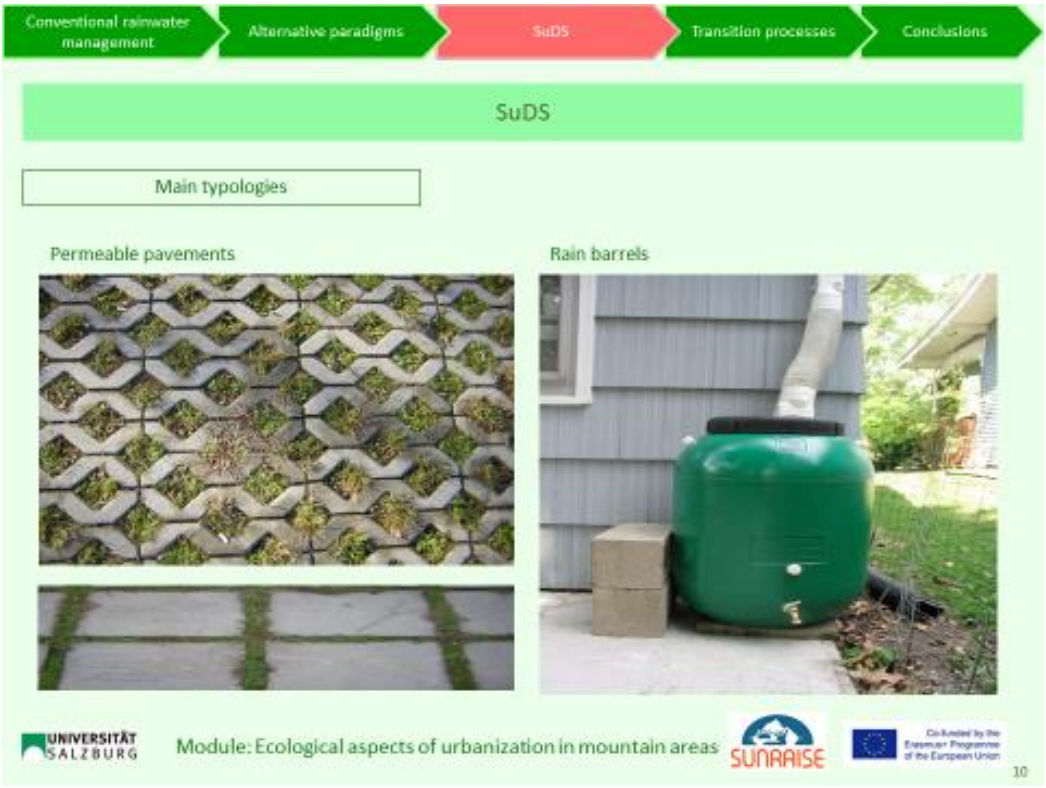

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