Spatial planning related to Green Infrastructure

Training Module 1

Deliverable D.T4.2.1 Training module for GI oriented sustainable landscape planning

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Content

The LUIGI project

The Interreg Alpine space project LUIGI (Linking Urban and Inner-Alpine Green Infrastructure - Multifunctional Ecosystem Services for more liveable territories) brings together 14 partner institutions and 26 observers from Austria, France, Germany, Italy, Slovenia, and Switzerland with the aim of strengthening the link between mountain ecosystems and urban centres at the foot of the Alps through sound economic and social exchanges.

By recognising the pressures on Alpine ecosystems and the services they deliver to wider areas beyond mountain regions, the project aims to strengthen the link between mountain ecosystems and urban centres at the foot of the Alps. The project's objective is to recognise and valorise the joint benefits of a GI network between mountain/rural and urban areas, as well as their potential for sustainable economic development based on natural resources and ecosystem services, ensuring a higher quality of life and better urban environments for people living in urban centres.

Work Package 4 of the LUIGI project focuses on education and training for sustainable management of green infrastructure elements in LUIGI model regions, leveraging knowledge from the Alpine region and beyond.

Aims and objectives

The aim of this module is to provide information on the ecological aspects of movements of organisms and the importance of ecosystem connectivity for their long-term functioning. The aim is also to demonstrate to students and landscape planners the role of green infrastructure (GI) in ensuring ecological connectivity within landscapes. The module provides an overview of software tools for GI spatial planning, as well as proposed steps to take during its planning and development, including practical applications of the presented concepts such as ecosystem services and green infrastructure.

Who is this module for?

This module can be used by university professors and lecturers to prepare a lecture and a field trip for students taking biology, forestry, agronomy, spatial planning, or related courses. Lecturers may also use the module to provide training for professional landscape planners.

Suggested target knowledge end-users

Students taking biology, forestry, agronomy, spatial or regional planning and management or related courses; professional landscape planners on different administrative levels.

Suggested educational method

We propose two activities to achieve the aim of this module, which can be combined or conducted separately: an introductory 90-minute indoor lecture (activity 1) and a half-day field trip with students. This module contains suggested information and literature sources for activity 1, that can be used to prepare a 90-minute lecture. It further contains a description of a half-day field trip, as well as a proposed worksheet for students to fill in and discuss while visiting the GI elements in your region for activity 2.

Activity 1: 90-minute indoor LECTURE

The task and learning objective are to present a general overview of ecological aspects of movements of organisms and the importance of ecologicalconnectivity (EC) in ecosystems for their long-term functioning and biodiversity conservation. It identifies human behaviours that hinder EC and proposes green infrastructure (GI) to mitigate the negative effects of fragmentation. The module further explores different types of GI elements and the ecosystem services they provide, with a focus on orchard meadows. The module concludes by emphasizing the importance of GI spatial planning and explores available tools and methodologies that can be used to plan, design, or manage GI networks.

We've listed three main topics below (Ecological connectivity, Green infrastructure, and Integrating GI into landscapes), along with information and literature sources that can be used to prepare a 90-minute lecture for students taking biology, forestry, agronomy, spatial planning or related courses.

1 Ecological connectivity

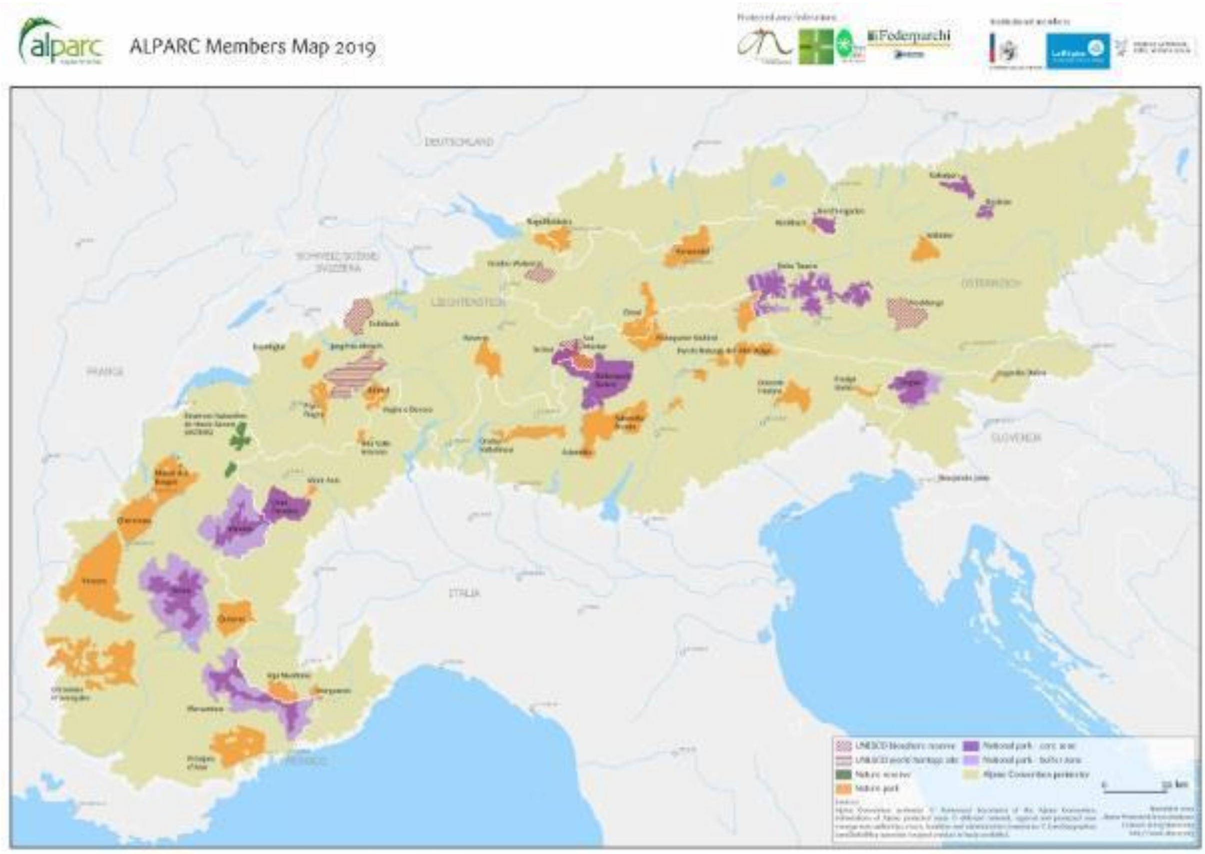
1.1 Ecological connectivity and why is it important

The following definition of ecological connectivity was given in the recently published IUCN Guidelines for safeguarding ecological corridors (J. Hilty et al., 2020): “The unimpeded movement of species and the flow of natural processes that sustain life on Earth”. Ecological connectivity is described as “The movement of populations, individuals, genes, gametes and propagules (pollen, plant parts, and seeds) between populations, communities, and ecosystems as well as non-living material from one location to another” in the IUCN Guidelines.

Ecological connectivity refers to the spatial and temporal extent to which organisms and related ecosystem functions can move between different habitat patches. It is critical to recognize that different species perceive a landscape differently, and so the level of connectivity varies between species and communities (Bennett, 2003).

Ecological connectivity is crucial for the long-term preservation of biodiversity and cannot be restricted to protected areas, separate mountain ranges, or regional or national perimeters. Since state borders are more political than ecological, ecosystems often expand across national or protected area borders. Therefore, efforts to conserve ecological connectivity must extend beyond national borders.

Several initiatives have been proposed to maintain and improve ecological connectivity on a large spatial scale. The Ecological Continuum Initiative was established in 2007 to conserve the high diversity of ecosystems and species found in the Alps. The aim of this initiative is to create a common Alps-wide framework for transboundary and trans-sectoral cooperation in order to raise awareness about ecological connectivity and protect or restore ecological networks that link flora and fauna habitats and protected areas (Plassmann et al., 2016). The Ecological Continuum Initiative has been promoted by the Alpine Network of Protected Areas (ALPARC), the International Commission for the Protection of the Alps (CIPRA), the WWF Alpine Programme, and the International Scientific Committee for Alpine Research (ISCAR).



Alpine protected areas in the ALPARC network in 2019 (Source: www.alparc.org)

1.2 Movement of organisms

The passive transport of plant seeds to the seemingly purposeful behaviour of many mobile animals are all examples of organism movement (Begon et al., 2006). Some species use several different habitat types during their lifetime, depending on their ecological characteristics, and they must be able to move between them either according to seasonal changes (e.g., birds), time of day (e.g., bat feeding habitats) or annual cycles (e.g., reproduction habitats for migratory fish species or frogs).

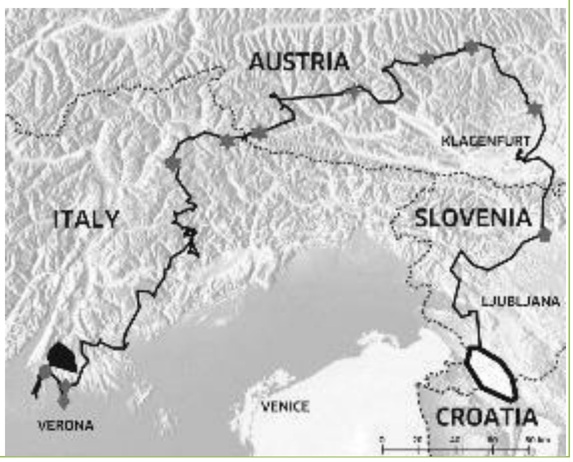
Here are some examples of different spatial movements of organisms:

- Movements of an animal within its territory in search of food and shelter, as well as to escape from predators, etc.
- A mass directional movement of large numbers of individuals of the same species from one location to another is referred to as migration. Frequently, migration enables animals to escape from temporarily unfavourable conditions such as winter cold, summer drought, and seasonal food scarcity (Cloudsley-Thompson, 1988). Birds, locusts, and coastal animals following the tidal wave are examples of migration.
- Dispersal is described as an individual’s departure from their immediate environment, which includes their parents and neighbours. Plant seeds dispersed by wind currents or attached to

animal coats are examples of passive dispersal. Animals engage in active dispersal by exploring and actively discovering new suitable sites (Begon et al., 2006). For example, young wolves disperse from their birth area to their new territory, where they can establish their own pack and breed (Ražen et al., 2016) **SEE BOX 1**.

BOX 1

Grey wolf populations in Europe have begun to recover in the last decade, though most populations remain isolated from one another. A team of researchers from Slovenia documented the long-distance dispersal of a radio-collared young wolf (nicknamed Slavc) in the Dinaric Mountains in 2011 as part of the SloWolf LIFE project. As a young adult Slavc had to leave the pack in which he was born to find his own territory and mate. Slavc was estimated to be 2 years old when he embarked on his journey in December 2011, and within 98 days he covered 176 km through Slovenia and Austria before settling in the Italian Alps, where he joined a lone female wolf (nicknamed Julia) from the Alpine population. With camera trapping, the first wolf reproduction in the area was documented in 2013, with two adult wolves and two pups. In this case, dispersal enabled recolonization of an area where wolves had been extinct for more than a century, as well as the mixing of genes between Dinaric and Alpine wolf populations.



Dispersal route of wolf Slavc (SOURCE: (Ražen et al., 2016)

1.3 Human activities affect ecological connectivity

Ecological connectivity is often hindered as a result of various human activities which that modify landscapes. Habitat destruction leads to fragmentation, which divides habitat into smaller, more isolated fragments separated by a matrix of human-transformed land cover (Haddad et al., 2015). Fences, roads, highways, railways, urban sprawl, river dams in freshwater ecosystems, wind turbine fields, and other physical barriers are common disrupters of ecological connectivity. Administrative barriers may sometimes occur due to significant differences in management approaches between neighbouring landscapes or countries, such as hunting rules. In such border areas, wild game populations are sometimes managed by two different hunting systems, which can an impact on the animals' spatial and temporal behaviour (Plassmann et al., 2019).

Human pressures have been increasing in the Alps as well. According to the Alps 2050 Atlas, the level of transport in the Alps has increased along all transit corridors (Chilla & Heugel, 2019). Similarly, soil sealing is a trend that can be observed in almost every part of the Alps 2050 perimeter (Chilla &

Heugel, 2019). Fragmentation caused by transportation infrastructure, land use change (urbanisation, agriculture, and forestry intensification), and human population density were all factors in a recent analysis of human pressures on ecological connectivity in the Alps using a Continuum Suitability Index (Plassmann et al., 2019). The ALPBIONET2030 project identified three categories of Strategic Alpine Connectivity Areas (SACA) according to the status of their ecological connectivity and the type of action required by adding indicators of environmental protection, altitude, and topography. Ecological conservation areas with low fragmentation levels were designated on only 8 % of the surface included in the analysis. Currently, 61% of these areas are located in existing protected areas, which highlights the importance of protected areas as the backbone of ecological connectivity in the Alps (Plassmann et al., 2019). The maintenance of ecological connectivity on the scale of the Alps needs cross-border connections between these protected areas.

Man-made barriers hinder ecological connectivity (Photo by form PxHere)

1.4 Ecological connectivity and climate change

Climate change will influence species physiology, phenology, and distribution (Bellard et al., 2012), resulting in extinction for those unable to adapt. The number of extinctions predicted due to climate change is alarming (Thomas et al., 2004). On the basis of mid-range climate-warming scenarios, 15-37% of species will be committed to extinction by 2050.

One of the ways species are adapting to climate change is by shifting their range (Hughes, 2000). Due to large differences in elevation in mountain regions, the obvious shift is expansion to higher elevations, as has been shown in models and confirmed in reality (Chen et al., 2009; Pauli et al., 2007). Ecological connectivity is crucial for enabling these shifts.

Models of climate change threats to European plant species showed a greater habitat loss for species distributed at higher elevations (Engler et al., 2011; Thuiller et al., 2005). Depending on the climate scenario, (Engler et al., 2011) found 36–55% of alpine species, 31–51% of subalpine species and 19–46% of montane species will lose more than 80% of their suitable habitat by 2070–2100.

2 Green infrastructure

2.1 What is green infrastructure

According to several studies, improving ecological connectivity within the landscape through the implementation of **corridors and steppingstones** is one way to mitigate the negative effects of fragmentation (Beier, P. & Noss, R. F., 1998; Gilbert-Norton et al., 2010; J. Hilty et al., 2020; J. A. Hilty et al., 2006; Rosenberg et al., 1999).

The so-called **GREEN INFRASTRUCTURE** was proposed with the aim of connecting protected areas with other natural and semi-natural areas (green and blue spaces) into a functioning network. According to the EU GI Strategy, green infrastructure (GI) is a "**strategically planned network of natural and semi-natural areas** with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation." The concept of GI includes several components: connectivity (e.g., between green areas); multifunctionality (e.g., areas with multiple functions), and enhancing the size and quality of the green and blue areas (Slätmo et al., 2019).

GI offers several opportunities for cross-sectoral cooperation and interdisciplinary thinking, as it merges nature conservation, spatial planning, and management aspects, where topics from agriculture and land use systems, climate change, and governance approaches can be merged and synchronized with one another.

2.2 Examples and current situation of green infrastructure

The EU GI Strategy's definition of GI is very broad, encompassing both natural and semi-natural areas. The Natura 2000 network of protected areas in the EU, which is rich in biodiversity, represents the backbone of GI. Other natural or semi-natural areas functioning as corridors or stepping stones between protected areas to form a coherent network is also considered GI. This can include groups of trees or hedgerows within an intensive farmland; wildflower-rich road verges; wildlife crossing structures over highways or eco-ducts; urban orchards or parks with mature old trees; riparian vegetation buffer strips along a river; fish ladders for crossing river dams; green walls or roofs of apartment buildings; etc.

Different types of GI elements in a landscape and the ecosystem services they provide (source: https://ec.europa.eu/environment/nature/ecosystems/benefits/index_en.htm)

Green infrastructure can be implemented at different scales, ranging from local to regional level to EU, and can provide both biodiversity conservation and socio-economic benefits (Nedelciu, 2013). Eco-ducts, green bridges and road verges, for example, are artificial connectivity features at the local level. Migration corridors, de-fragmented landscapes, and river continuum can all serve this function at a regional or national level. Finally, connectivity features at the EU level include supra-regional corridors, natural landscapes, and European-wide and transnational defragmentation actions (Nedelciu, 2013). **SEE BOX 2**

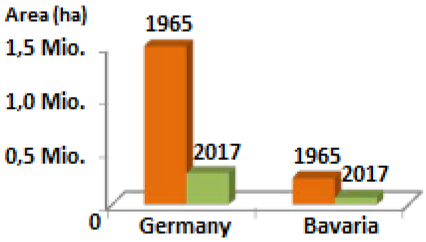
BOX 2

Orchard meadows are a form of GI cultural landscape that provides several ecosystem services and has the potential to connect rural and urban areas. Orchard meadows are key ecosystems with extraordinarily high biodiversity. Orchard meadows in Central European (also referred to as high-stem orchards or meadows with scattered fruit trees) are composed of scattered, tall fruit trees growing in semi-natural low-intensity grasslands. In agricultural landscapes, orchard meadows support high levels of farmland biodiversity and ecosystem services (Le Roux et al., 2018; Plieninger et al., 2015). In addition to biodiversity, orchard meadows provide high quality fruit for consumption, forage for livestock, are reservoirs of old tree varieties and cultivars, and provide recreational space (Bieling & Plieninger, 2013). Moreover, they also provide critical regulating ecosystem services including regulating local microclimatic conditions (such as temperature, humidity, and wind speed), reducing surface water runoff and increasing infiltration, and sequestering carbon (Smith et al., 2013).

Orchard meadows are an example of one of the GI elements on which the LUIGI project is focusing (Photo: I.Bertoncelj)

However, orchard meadows are threatened by agricultural intensification, urbanization, and land abandonment, with the most influential drivers of orchard meadow loss being those that reduce economic profitability and increase opportunity costs for orchards, providing incentives for converting orchard meadows to other, more profitable land uses (Plieninger et al., 2015). In Germany, for example, more than 70% of orchard meadows have disappeared in the last 50 years (see aerial photograph below).

Drastic decline of orchard meadows in the last 20 years – Example from Hetzles (Germany, Bavaria) in 2001 and 2020 (Source: Google earth).



Estimated loss of the area covered by orchard meadows in Bavaria and Germany between 1965 and 2017 (Kilian et al., 2020)

The current situation and challenges for key Alpine Green infrastructure were analysed in Work Package 3 of the LUIGI project (Schrapp et al., 2020), which focused on orchard meadows as a key GI in 7 out of 9 LUIGI pilot regions and was elaborated with contributions from 17 case study areas. Economically uninteresting for farmers; incompatibility with “modern” consumers’ preferences; inter-sectoral and interagency conflicts of interests; lack of awareness and non-valuation; land share vs. land spare conflict; loss of cultural and landscape values; settlement pressure where the main challenges for long-term persistence of orchard meadows in LUIGI pilot regions.

→ *For a comprehensive overview and maps of the GI situation in LUIGI pilot regions please see* ***LUIGI DELIVERABLE D.T.3.1.1*** (Schrapp et al., 2020)

2.3 Ecosystem services of GI

The aim of GI is to enhance nature's ability to deliver multiple ecosystem services by ensuring that its ecosystems are functional and in a healthy state. As previously mentioned, one of the GI's characteristics is multifunctionality, which entails making efficient use of space and resources while also providing cost-efficient, win-win solutions to several policy requirements and societal needs.

Different GI elements can offer **nature-based solutions,** which according to European Commission are defined as: "solutions inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions". Therefore, nature-based solutions must benefit biodiversity while also supporting the delivery of a range of ecosystem services.

For the development of the GI network, access to capital and funding is necessary, therefore identification of the economic value of GI can attract investors. However, we should not focus only on economic value when building the GI network because GI generates value through the **provision of ecosystem services** and contributes to a more sustainable and resource efficient economic development process (Giombini, Tasser, et al., 2020).

There are many systems for classifying ESS, however, in the LUIGI project, we followed the Common International Classification for Ecosystem Services (**CICES**), which has been endorsed and is used in EU research and policy. ESS is divided into three main categories by CICES :

- **PROVISIONING SERVICES:** such as food; water; timber, and fibres provision,
- **REGULATION & MAINTENANCE SERVICES:** such as climate, flood, waste, and water quality regulation, as well as soil formation, photosynthesis, and nutrient cycling,
- **CULTURAL SERVICES:** aesthetics information; recreation; cultural and artistic inspiration; spiritual experience; cognitive development.

Different GI elements provide different sets of ESS, and Work package 1 of the LUIGI project (Giombini, Tasser, et al., 2020) developed **factsheets for 13 GI components** that are common and/or important for GI networks in the Alpine's region urban, peri-urban, and rural areas: tree avenues, grass lawns, green roofs, urban parks, HNV farmland, hedgerows, HNV vineyards, orchard meadows, riparian areas, forests, Alpine meadows, mountains, and wetlands. This overview describes how each GI component delivers to ecosystem services and lists the most relevant groups of ecosystem services that are supported.

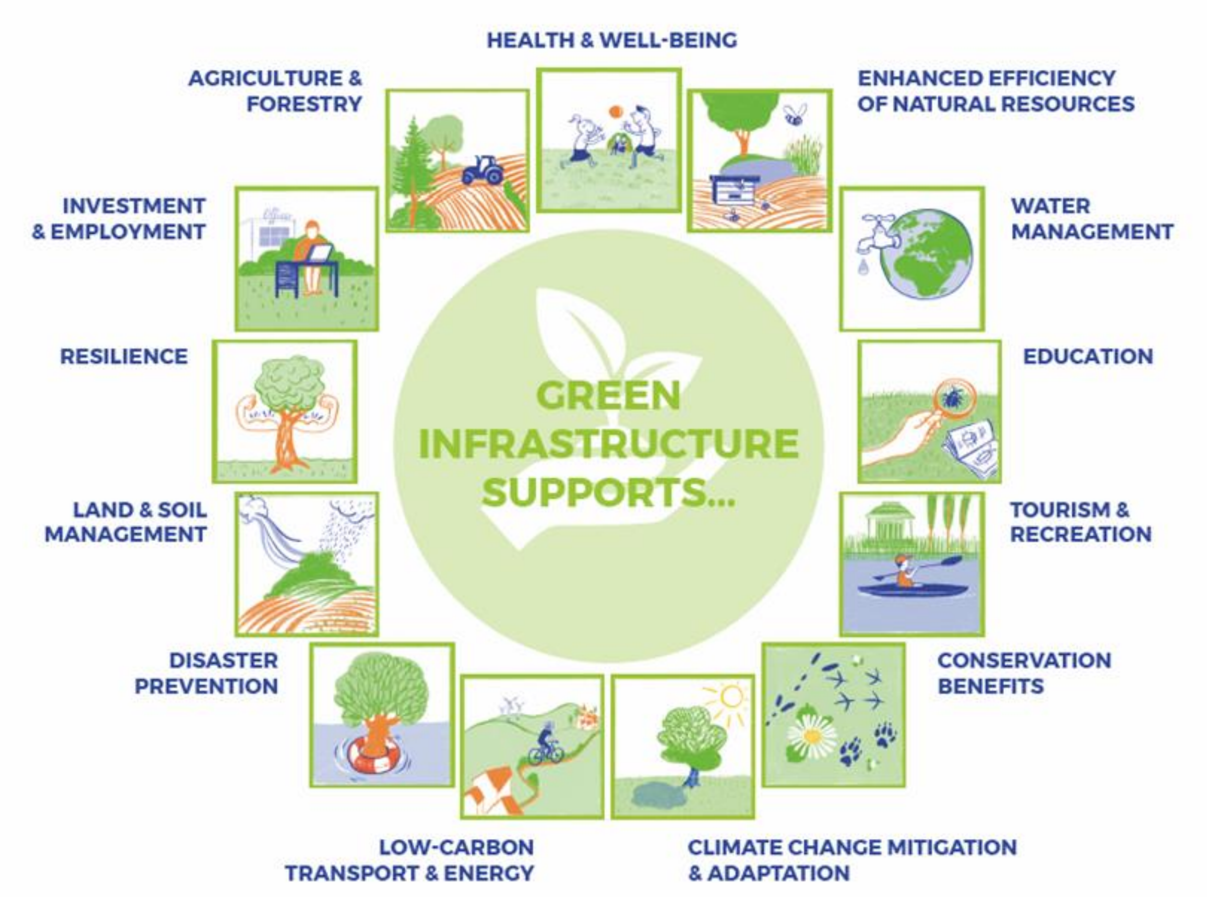
→ *For a comprehensive list of GI elements and related ESS in the Alpine region please see* ***LUIGI DELIVERABLE D.T.1.1.1*** *(Giombini, Tasser, et al., 2020)****.***

Different ecosystem services (Source: IUCN - https://www.iucn.org/news/commission-environmental-economic-and-social-policy/201702/step-sustainability-maes-mapping-and-assessment-ecosystem-services-european-cities-and-italy)

3 Integrating GI into landscapes

3.1 Spatial planning and green infrastructure governance

GI networks can be designed and managed to maximise the quality and quantity of the functions they support, as well as the multiple ecosystem services they provide (Giombini, Tasser, et al., 2020). GI is a spatial planning concept that aims to preserve non-built-up areas by highlighting the range of societal benefits associated with these green areas by following a systemic and holistic approach (Slätmo et al., 2019). Therefore, GI represents a solution-oriented, cross-sectoral approach to spatial planning, making it more sustainable (Slätmo et al., 2019).



The multiple benefits of Green Infrastructure in John, Neubertand Marrs (2019).

Green infrastructure implementation necessitates cooperative efforts from a variety of stakeholders, including governmental, non-governmental and the private sector. Conflicting interests and communication challenges through different alliances and agendas will, however, make implementation difficult.

Participatory governance for GI planning deals with the arrangements in which different actors make decisions and manage green space networks at different levels. Citizens, entrepreneurs, and NGOs may all play a role in GI governance, with or without the active involvement of government authorities and public agencies (review in Schrapp et al., 2020). They also vary in terms of resources, such as time, money, skills, and other tangible and intangible assets (e.g., political, and social relationships around those resources). Furthermore, there are differences in how relationships and actions are managed (including legislations, regulations, social and cultural norms) as well as discourses (beliefs, values, objectives and other motives and main drivers of action) (review in Schrapp et al., 2020).

Spatial planning aims to create a more rational organisation of land uses and linkages between them, as well as to balance the need for development with the need to protect the environment and to achieve social and economic objectives (Photo: I.Bertoncelj)

Spatial planning – as an instrument of nature conservation and management – strongly correlates with GI-governance on different vertical levels. Work Package 3 of the LUIGI project (Schrapp et al., 2020) analysed GI governance in 37 good practice areas across 10 LUIGI pilot regions (two in Austria, one in Switzerland, one in Germany, two in France, three in Italy, and one in Slovenia) in urban, rural, and peri-urban regions, as well as metropolitan regions within the Alps. Local public authorities dealt with the issue of GI (100 %) in all regions, significantly more than regional public authorities (71 %) and therefore clearly more than national authorities (6 %). In fact, national public authorities only played an important role in Slovenia. In Switzerland, the cantonal public authorities had responsibility for GI in all three case study areas in the canton of Grisons, which was regarded a different situation. A different situation was found, in which, in addition to classical government actors, grass-roots initiatives and the general public were taking part in GI governance. Local inhabitants and visitors were mentioned in almost all case study regions (94 %) together with non-governmental organisations and associations (88 %). Community groups were mentioned in almost half of the regions (41 %). Of greater importance was the role of education and research (76 %), somewhat lesser involved in the governance of GI seemed business partners and SMEs (59 %).

→ *For a comprehensive overview of vertical systems of spatial planning and of the most relevant formal and informal instruments of GI governance in the LUIGI project pilot regions please see the* ***LUIGI DELIVERABLE D.T3.1.1*** *(Schrapp et al., 2020)****.***

3.2 Examples of GIS tools for integration of GI into spatial planning

Several tools and methodologies have been developed by different institutions that can be used for the implementation of GI elements. One of the LUIGI project's deliverables is an overview of freely available tools for GI planning, design and management, which is listed below. The available tools were divided into 4 categories based on their purpose and focus:

ECOLOGICAL CONNECTIVITY ANALYSIS:

- Connecting Landscapes (http://www.landscope.org/focus/connectivity/)
- Jecami 2.0 (https://www.jecami.eu/)
- Condatis (http://wordpress.condatis.org.uk/)
- GUIDOS (https://forest.jrc.ec.europa.eu/en/activities/lpa/gtb/)
- Conefor (http://www.conefor.org/)

MAPPING AND ASSESSMENT OF ESS:

- AlpES WebGIS (https://www.alpes-webgis.eu)
- InVEST (https://naturalcapitalproject.stanford.edu/software/invest)
- ARIES (https://aries.integratedmodelling.org/our-mission/)

QUANTIFYING THE BENEFITS OF ESS:

- i-Tree (https://www.itreetools.org/)
- B£st (https://www.susdrain.org/resources/best.html)
- SolVES (https://www.usgs.gov/centers/gecsc/science/social-values-ecosystem-services-solves?qt-science_center_objects=0#qt-science_center_objects)
- Co$ting Nature (http://www.policysupport.org/costingnature)

PARTICIPATORY PROCESSES:

- USER PARTICIPATION (https://www.user-participation.eu/)
- World café (http://www.theworldcafe.com/)
- Conflict Management Toolkit (https://www.alpine-space.eu/projects/alpbionet2030/deliverables/eurac_alpbionet2030_toolkit_dic19_web.pdf)
- QUICKScan (https://www.quickscan.pro/)

→ *For a comprehensive overview and detailed description of available tools and methodologies used to plan, design, or manage GI networks please see the* ***LUIGI DELIVERABLE D.T1.1.2*** *(Giombini, Marsoner, et al., 2020)***.**

→ *See also the toolbox of 45 informal tools developed by the Alpine Space Project Los_Damas here.*

3.3 Steps of developing regional connectivity maps

The following 7 steps have been proposed for coarsely mapping regional linkages (Beier et al., 2011). Regional connectivity maps are the end result, and they can be used as decision-making tools and concise expressions of desired future connectivity. These steps are based on identifying "natural landscape blocks" which are defined as areas with high conservation value due to their content and are similar to core areas. However, the authors emphasize, that the rules for mapping natural landscape blocks and deciding which blocks should be connected should be based on technical criteria, as well as the values and priorities of stakeholders.

STEP 1 Identify the map's aim: the map's aim should be clearly stated and measurable so that its implementation success can be assessed.

STEP 2 Establish collaborations: consider which stakeholders should be involved in the process.

STEP 3 Define the region

STEP 4 Delineate natural landscape blocks: identify the entities (blocks) that must be connected based on expert opinion, optimization algorithms, existing protected areas etc.

STEP 5 Determine which pairs of blocks would benefit from connectivity

STEP 6 Depict connectivity areas

STEP 7 Provide end-user guidance: provide supporting documentation, including descriptive statistics for each natural landscape block and connectivity area, as well as recommendations on how to use the maps for managers.

Activity 2: Half-day field trip of GI elements in your region

In the second activity, we suggest that you translate theory into practise by organising a **half-day field trip to three GI elements in your region for the students**. We suggest that you select different types of GI elements that play different roles and provide different sets of ecosystem services (ESS) in the landscape.

You can invite representatives of institutions involved in the management of GI elements to speak to the students on the following topics. This will give you an excellent starting point for discussion:

- What is the main function of the GI element?

1.Protecting ecosystem state and biodiversity

2. Improving ecosystem functioning and promoting ecosystem services

3. Promoting societal wellbeing and health

4. Supporting the development of the green economy

- Who was involved in the planning of the location of the GI element?
- What was the source of funding for establishing this GI element?
- What actions are needed for its maintenance?

Following these presentations and discussions, students should fill in the following worksheet by listing and ranking the importance of different ESS provided by this specific GI element. At the end of the field trip, students should compare the three different GI elements and their respective worksheets and discuss the following topics:

- How and why does the number of ESS provided by the three GI elements differ, and what does the resulting value tell us from the spatial planning point of view?
- Do GI elements provide ESS from different groups (e.g., provisioning services, regulating services etc.)?
- Do the three GI elements have similar potential for supporting ecological connectivity?

FIELD TRIP WORKSHEET

Please evaluate the importance (1-least important, 5-most important) of the listed ecosystem services for your selected GI element.

GI ELEMENT:						
Ecosystem service		**1**	**2**	**3**	**4**	**5**
PROVISIONING SERVICES	Food					
	Water					
	Raw materials					
	Genetic resources					
	Medicinal resources					
	Ornamental resources					
REGULATION AND MAINTENANCE	Climate regulation					
	Air quality regulation					
	Water flow regulation					
	Water quality regulation					
	Waste treatment					
	Soil formation and soil fertility maintenance					
	Erosion prevention					
	Photosynthesis					
	Habitat and gene pool protection					
	Pest and disease control					
	Pollination					
CULTURAL SERVICES	Aesthetics information					
	Recreation					
	Cultural and artistic inspiration					
	Spiritual experience					
	Cognitive development					

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