Sustainable Renewable Energy Planning in the Alps

A handbook for experts & decision makers

recharge green
BALANCING ALPINE ENERGY AND NATURE

Alpine SPACE
EUROPEAN TERRITORIAL COOPERATION
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Executive summary

The Alps, with their long cultural history and unique geographic and geological particularities, are a biodiversity hotspot. This extraordinary biodiversity, and the ecosystem services resulting from it, is being threatened by various anthropogenic pressures, including climate change. Climate change mitigation measures such as the increased use of renewable energy can have both positive and negative effects on the Alpine region. Siting decisions for new renewable energy production facilities, whether hydropower, biomass, wind, or solar power, have to be carefully evaluated, taking into account not only technical and economic potential, but also ecological sustainability and social factors. But how can decision-makers make better land-use planning decisions?

The recharge.green project concerned itself with evaluating both the potentials and the trade-offs involved in expanding renewable energy production in the Alps. 16 partners from 6 Alpine countries, including members of national parks, local government, academia, civil society, and the private sector, have jointly developed a set of tools to facilitate decision-making on renewable energy extraction in the Alps. The tools can help to evaluate the ´renewable energy carrying capacity' of the biodiversity-rich Alpine ecosystems.

Chapter 1
provides a brief overview of historic and current developments in the Alps and presents a summary of the recharge.green project. It outlines the economic and political dimensions of land-use decisions and introduces established methodologies for calculating the social costs of public investments. It briefly introduces the concept of ecosystem services and the complexities associated with valuing these services. It then presents a cursory introduction to the decision support tools developed by recharge.green, which are explained in more detail in later chapters. The tools are useful for obtaining an overview of renewable energy production siting options, insights into the potential environmental costs these will engender and ultimately provide a basis for implementation of plant siting decisions.

Chapter 2
introduces the role of social sciences in land use planning and renewable energy planning. It goes into some detail on ecosystem services approaches, including valuation methods, with particular reference to the services provided by Alpine ecosystems. Soil ecosystem services are highlighted as an example of the complexity of ecosystems and the impacts renewable energy may have on them. The chapter discusses the potential conflicts that may develop between nature conservation and ecosystem services, and among different types of ecosystem services. The chapter then relates the participatory process needed to involve stakeholders and to integrate their perspectives into planning processes to avoid social conflict. Such a process was implemented in the recharge.green pilot regions in relation to the valuation of ecosystem services and stakeholder preferences for different renewable energy development scenarios. Some of the implemented stakeholder involvement exercises are highlighted in the form of "best practice" examples.

Chapter 3
explores the role of decision support systems in renewable energy planning. There are different kinds of decision support systems, but in general they are computerized tools that help users to identify solutions

for complex situations. recharge.green developed four such systems, each targeted at different levels and pilot regions in Austria, Italy, and Slovenia. One of the principal challenges for all computerized systems is obtaining sufficient and accurate input data. Such data are often not available or costly to obtain. DSS can be extremely powerful tools, and in recharge.green they have helped to foster discussions, highlight conflicts and possible solutions. They are relatively easy to run, but may still require experts to operate them properly. They should also not be thought of as providing one-stop solutions. They can bring science into decision-making processes, but still require careful reflection, planning and ultimately implementation.

Chapter 4
homes in on the impacts renewable energy production can have on ecosystem services in greater detail. It differentiates between forest biomass, hydropower, wind power, and solar power impacts on provisioning, regulating and maintenance, and cultural ecosystem services, using the Common International Classification of Ecosystem Services. Most impacts depend on particular management regimes and additional measures, but we have highlighted the major conflicts and their dimensions, which require trade-off decisions.

Chapter 5
goes into the specific results produced by recharge.green. It presents the protection constraints that IIASA´s decision support system includes according to different scenarios of protection levels. Depending on the protection level chosen, different recommendations will be made by the system. This highlights the importance of properly defining protected area management objectives for each area under consideration, before applying the model to evaluate siting decisions for different types of renewable energy. The chapter then zooms into the project´s pilot regions and presents the systems and approaches used in the Veneto region (Italy), Piedmont region (Italy), Triglav National Park (Slovenia), Altusried (Bavaria, Germany), and Leiblachtal in Vorarlberg (Austria). Each of these regions had its own special focus and applied various tools in different ways. All regions, however, placed great emphasis on participatory approaches, which are key to creating social support for decisions and projects, in the domain of renewable energy planning and elsewhere.

We invite you to also read our additional publications, which are available for download on the recharge.green website http://www.recharge-green.eu/downloads/. In the download links you will also find a link to the online Decision Support Tool "JECAMI", where you can find some geographically explicit visualization tools that recharge.green has developed.

Photo © Karin Svadlenak-Gomez

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Balancing Alpine energy and nature – the project recharge.green

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„As fossil fuel-based energy sources are phased out, new decentralized energy production patterns must be supported by social and environmental tax reforms and policies that promote energy efficiency and minimise ecosystem impacts. The regional scale seems appropriate to elaborate sustainable energy concepts. A "sustainable energy vision for the Alps" is needed and should ensure that energy production is harmonised with the goals of nature and landscape protection." (CIPRA , FIWI, UIBK)

Interview:

A view from outside the Alps

Luis Gomez-Echeverri, MSc., Senior Advisor to Sustainable Energy for All (SE4ALL) initiative

Luis Gomez-Echeverri is a Senior Advisor to the Executive Office of the UN Secretary General on the "Sustainable Energy for All (SE4ALL)" programme. He spearheaded and led the start up of the SE4ALL programme in over 70 developing countries. Before coming to IIASA in 2007 to work on the Global Energy Assessment, he had a long career working on sustainable development, energy, environment and climate change issues with the UNDP and UNFCCC.

Question: The EU needs to decrease its greenhouse gas emissions and has launched ambitious plans to increase renewable energy production across its entire territory. The European Council has also asked the Commission to elaborate an EU Strategy for the Alpine Region , which aims to ensure that the region retains its Alpine natural (biodiversity) and cultural heritage while seizing opportunities for sustainable and innovative development in a European context. The production and use of energy in the Alps is not happening in a vacuum. What global patterns do you see affecting developments in Alpine countries?

Answer: *Global demands will increasingly put pressures on the region´s natural resources, unless stringent protection measures are in effect. One of the major global trends that will also affect the Alpine region is of course climate change, with impacts across several areas: Changing weather patterns may have an effect on energy demand and potentials in the region and on linked sectors such as water, food production and health. Ecosystem changes may lead to migration patterns that could affect energy demand and have effects on fragile ecosystems. On the positive side, renewable energy technology improvements, particularly in the area of storage, and decreasing costs of this technology, will allow the region to make the use of renewable energy more efficient. The Alpine region may also benefit from scientific knowledge and adaptation approaches in other regions.*

Question: The recharge.green decision support tools can help to analyse trade-offs between new renewable energy plants and the need to protect biodiversity and ecosystem services in the Alps. They could be adapted for any region where sufficient land-use and other data exist. Given your experience with policy negotiation processes, do you think such tools could in fact be helpful to reach better decisions?

Answer: *Certainly. One of the most serious problems that we have globally is the fragmentation of decision- and policy-making across sectors. This is both an institutional problem and a problem created by the lack of tools for policy makers to allow them to analyse the trade-offs and impacts of their decisions. We need better tools for policy analysis and to promote synergies across sectors. But the tools need to be backed up by sound analytical frameworks that allow us to make projections even when there is a lack of data (for example modelling tools that use the most relevant science for the region to which they are applied). Tools that clearly identify the trade-offs will definitely facilitate and improve policy dialogue.*

Question: You are involved in a project that aims to dramatically expand energy access for people living in developing countries. Are issues such as those we looked at in recharge.green at all a concern in this process?

Answer: *Despite the fact that we are dealing with totally different conditions, there are some common features in the challenges that we face. Providing energy access is not simply about linking people to an electric transmission line. A large number of factors come into the question how to provide that energy in the most sustainable way: what is the cleanest and most affordable way to provide it, are any ecosystems being disturbed by a particular option, is the type of energy being provided suitable for the energy services needed. We are not just talking about light bulbs, but about all kinds of energy that enhance productive capacities and livelihoods in a community. So in fact we are looking at the potential trade-offs.*

Question: In general, what do you see as the greatest barrier to sustainable development?

Answer: *One of the greatest barriers is fragmentation in policy- and decision making, which we see all over the world. Rather than close coordination among sectors, what we observe is competition. The international community is not helpful in this regard. It actually exacerbates this competition by working in a fragmented way.*

Background

The Alps are many things to many people. Settled since prehistoric times, the Alpine region features a rich cultural and industrial heritage that now extends across eight national borders and is of great benefit to numerous sectors. From the 19th century onward the region, with its abundant water resources and steep slopes, benefited economically from the exploitation of hydropower for primary industrial production (e.g. iron ore and steel) and subsequently electricity production. Multiple-use forest management also continues to be an important type of land-use in the Alps, and due to natural re-growth and afforestation, forests are now increasing in the region, having experienced a gradual decline until the end of the 19th century 1. Because of their geographic and geological particularities, the Alps are also a biodiversity hotspot – their richly diverse ecosystems provide habitats for a multitude of plant and animal species. This extraordinary biological diversity is at the same time the foundation of what today is referred to as "ecosystem services", the benefits nature provides to people.

Biodiversity has increasingly been coming under threat from multiple sources. Alpine biodiversity is no exception in this regard, even if on the surface through protected areas and nature protection policies, it appears well protected. The indirect global toll of anthropogenic climate change also affects Alpine biodiversity and ecosystems negatively and is projected to continue to do so [2,3].

Climate change mitigation and biodiversity

One of the principal strategies to reduce carbon dioxide (CO2) emissions in order to mitigate climate change is the expansion of renewable energy, which is promoted both by the Alpine Convention [4] and by the European Union [5]. While in principle the use of renewable energy over fossil-fuel based energy sources allows for a reduction in CO_2 emissions, it is also important to examine the impacts that renewable energy production and use will have on natural ecosystems and their functions. Although reducing climate change impacts is expected to benefit biodiversity, these benefits could be limited by additional adverse impacts from energy developments, a fact that is acknowledged in the Alpine Convention [4]. For example, the total economic value of energy produced by very small hydropower plants may well be negative, given their ecological impacts and insignificant production capacity [6]. The Convention´s Energy Protocol contains a number of clauses demanding the conservation of natural areas as habitats for wildlife. This implies that siting decisions for new renewable energy production facilities in the Alps, whether hydropower, biomass, wind, or solar power, have to be carefully evaluated, taking into account not only technical and economic potential, but also ecological sustainability and social factors. Decision making processes are, however, often flawed. Amongst many issues, they may lack frame control, rigour and focus and not assess all aspects of an issue. In particular, despite legal obligations to undertake environmental impact assessments for all major infrastructure projects, impacts on biodiversity and trade-offs between different ecosystem services tend to be insufficiently taken into account in decision making[7].

This is where the EU Alpine Space recharge.green project can be of help. 16 partners from 6 Alpine countries, including members of national parks, local government, academia, civil society, and the private sector, have jointly developed a set of tools to facilitate decision-making on renewable energy extraction in the Alps. The tools can help to evaluate the ´renewable energy carrying capacity' of the biodiversity-rich Alpine ecosystems.

Economic foundations – A caveat concerning ecosystem services valuation

It is beyond the scope of this chapter to discuss details, but the overarching issue, which drives all others, is human behaviour: Short-term economic priorities that trump nature conservation goals are exacting a direct toll, such as the disruption of ecological connectivity through growth-oriented infrastructure development or through unsustainable agricultural methods. The transformation of natural landscapes has been called a "side-effect" of all socio-economic activities [8]. Landscapes are managed based on context-driven decisions, influenced by factors such as the policy environment, historical traditions, and institutional or personal interests. Management decisions are often political and not necessarily rational from an economic point of view and even less from a sustainability perspective.

One of the older techniques that is often used to weigh up the divergence between private and social costs of public investments is cost-benefit analysis (CBA), which has its roots in welfare economics [9]. CBA calculates increases or reductions in human wellbeing arising from a project or policy. It uses the notion of total economic value (TEV), which measures the economic values of an environmental asset (such as an ecosystem), deconstructing it into use and non-use values. Economists have developed various ways of estimating the intangible values of environmental assets, which we cannot go into here. In recent years the concept of valuing biodiversity for the ecosystem services it underpins has been promoted and at times hotly debated [10,11]. Practical implementation, however, has remained a challenge [7]. Markets and public accounting systems (GDP) still fail to trade and capture ecosystem service values.

Part of the problem is the difficulty of understanding all the complex linkages between ecosystem functioning, biodiversity, the impact of human activities, and the intricacies of differential impacts across time and space [12]. Efforts to further the understanding of ecosystem service values have been ongoing across Europe [13–15]. Market-based instruments, such as green accounting, payment for environmental services, and mitigation banking have been proposed as effective conservation tools , but there is also a great deal of discomfort among some with these approaches because it is perceived as a "commodification" of nature [16,17]. In a recent expert survey we undertook for greenAlps, a related Alpine Space project, 42% of respondents felt that not all ecosystem services should be assigned a market value[18]. Some argue that focusing on ecosystem services as a conservation tool risks detracting from overall conservation agenda, which is to protect nature for its own sake [19].

The authors of the widely quoted TEEB study propose various valuation techniques, but also point out that valuation techniques have limitations, and that the inadequacies of monetary valuation should be borne in mind in view of the possibility of irreversible ecosystem change [12]. They advise, as have economists before them, the use of a precautionary approach in situations of high uncertainty or ecological thresholds [9,12]. This is also a general principle for decision-making in the EU - the precautionary principle is detailed in Article 191 of the Treaty on the Functioning of the European Union. It aims at ensuring a higher level of environmental protection through preventive action in the case of risk of environmental damage. The World Business Council on Sustainable Development, a private business association and think tank, points out in its Guide to Corporate Ecosystem Valuation, that values of biodiversity and ecosystem services do not equal price lists, and that context is important [20]. They go on to say that even estimated values can be useful for decision-making, and that valuation should be seen as complementary to other tools, such as life cycle assessment and multi-criteria analysis.

What we take from the diversity of approaches and opinions in the literature and within our own project team is that there is still a lack of a consistent and practical definition of ecosystem services "units" that could be compared to those used to value conventional goods and services that are used in national accounting. On the other hand the definition of ecosystem services at a regional or local scale can be a very useful awareness-raising tool to draw attention to the full value of ecosystems to people. Recharge.green has demonstrated this through a practical approach in the pilot areas of Vorarlberg and the Veneto region. Attempts to use a generic ecosystem services model without regard to contextual variations could yield very misleading results. Moreover, focusing only on a pure cost-benefit calculation could muddy the waters and prevent us from seeing the major institutional changes that are needed to safeguard our natural environment.

Science-based decision-making support

Scientists are often accused of working in an ivory tower, detached from on-the-ground reality. Nevertheless, policy makers often ask for scientific information to help them devise policies. Even if ultimately many decisions have to be judgement calls, having robust tools at hand to inform judgement can be very useful. The recharge.green team has made efforts to bridge the perceived gap between scientific knowledge and real-life implementation. The project has produced guidance and tools to enhance the decision-making process with respect to the four most common types of renewable energy sources in the Alps: biomass, hydro, solar, and wind, and has tested them in various pilot regions.

One component of the recharge.green toolkit is a model that can support siting decisions at an Alps-wide scale and, provided that data are available, can be programmed to zoom in to a regional or even municipal scale. To analyse economic and ecological trade-offs, a 'marginal protection cost curve' was developed, which the model uses when calculating the per-unit costs of renewable energy production. Theoretical potentials for renewable energy production were calculated and fed into the model. In areas with higher levels of protection, energy production is inherently more costly (or not possible), and so the tool allows decision-makers to gain insights into the trade-offs involved when planning energy facilities. While areas may have theoretical energy production potential, they are potentially economically unsuitable when integrating environmental impacts and costs into the decision making process. To facilitate the use of the tools by lay-persons, the various models were integrated into the map-based online visualisation tool Jecami (http://www.jecami.eu/), which was developed within the ETC Alpine Space project ECONNECT. Different components of the recharge.green toolkit, including various model scenarios were field-tested in four pilot regions in Austria, Germany, Italy, and Slovenia. In addition, participatory methods were developed and tested to raise awareness on landscape values and on the benefits of ecosystem services among residents of individual regions. Taken together, the various components of the recharge.green toolkit support integrating biodiversity and ecosystem costs with economic and carbon reduction benefits to enable rational and all-inclusive energy implementation decisions.

The recharge.green models are not perfect, stand-alone tools that can provide a one-stop decision. Careful reflection, planning and ultimately implementation is still necessary. The models are only as good as the datasets and information that flows into them and can only function within the clearly defined contextual framework of the decision making process. We have found that adequate data are often hard to obtain – even when these should be readily available, as, more often than not, acquisition has been previously publicly financed. Lack of data sharing among institutions is a major issue in many projects. Furthermore, the inputs to our models are of necessity fed by proxy indicators for biodiversity "hotspots", which may not necessarily provide a complete picture of the real situation on the ground. For example, for the Alpine-scale spatially explicit r.green model, indicators included the level of protection of an area and the theoretical potential for different types of renewable energy. However, protection status alone is a poor indicator of biodiversity in the area. Bearing these caveats in mind, the tools are imminently useful in obtaining an overview of renewable energy production siting options, insights into the potential environmental costs these will engender and ultimately provide a basis for implementation of plants.

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2 Social science and ecosystem services

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"Where land-use is the issue, conflicts result from diverging demands on landscape and nature. Balanced, professionally moderated governance processes are very important to deal with these conflicts. Stakeholders, including the media and NGOs, should be able to expect transparent processes, and access to all relevant information, right from the start and throughout a project. The considerable time and effort needed for this would yield long-term benefits, including for energy producers who may guard against objections to their projects late in the game by involving stakeholders from the planning stage." (CIPRA)

Interview:
The importance of valuation of ecosystem services

Prof. Davide Pettenella, University of Padova

Davide Pettenella is full professor at the University of Padova (Italy) where is teaching Forest economics and policy. He has published more than 500 papers in the field of forest economics and wood products marketing as a result of his research activities and field works carried out within programmes financed by the European Commission, FAO, European Forestry Institute, World Bank, and by Italian national and regional institutions.

Question: What is the role of social science in land use planning (renewable energy planning)?
Answer: *It is an essential role: economics can be used for defining the net benefits (both from a public perspective and a private point of view) of the investment, like a new power plant. In the case of a public approach, not only market but also non-market impacts should be evaluated and this can make the assessment quite complex. Moreover, the evaluation shouldn't just be a neutral, technical operation made by outsiders: local stakeholders have to be involved in the process, and this implies the use of special approaches in stakeholders' involvement where sociologists and experts in communication and local governance systems should play a role. Sometimes renewable energy has to be sold on the market like a normal commodity, and here experts in (green) marketing may play a role. Finally, on a macro scale, when dealing with issues of national or regional planning, again economists and experts in political science may have a role in forecasting demand and supply development, prices and in setting the proper system of market regulation.*

Question: What are the strengths and weaknesses of a participatory approach in the development of renewable energy?
Answer: *Adopting a participatory approach in the local development of renewable energy is not a strengthening factor in decision making but a basic requirement! It is not only a matter of reducing risks, preventing conflicts and getting public support for the investments. It is connected with the idea that normally renewable resources are linked to the supply of public or common goods (environmental services), i.e. goods that – by definition – are not private and should be managed through public consultation.*

Question: Why is the economic valuation of ecosystem services in land use planning (renewable energy planning) important?
Answer: *An economic assessment, as already mentioned, can be a powerful tool for understanding the creation of value, the distribution of benefits and costs, the trade-offs among various alternative services (e.g. biomass used for energy vs. timber). When an investment can be measured in economic terms it can be compared to other investments (e.g. is it more profitable to build a hydropower-plant or some infrastructure to prevent avalanche damages?) and to define the optimal size of an investment (e.g. the proper size of a biomass plant?).*

Question: In your opinion how could the use of renewable energy in the Alps develop in the future?
Answer: *Technology applied to renewable energy generation has seen huge progress and we no longer face problems of energy scarcity in mountain areas. Not only are the Alps able to satisfy the internal demand for energy, they can also provide energy to areas outside the region. The real issue that we are facing in the future is political: how much and what type of compensation should be paid for this role of energy provider? How to distribute the costs and benefits of theses energy services? How to find a balance among the different renewable energy sources? What is the carrying capacity of the Alpine system, what are the environmentally and socially acceptable thresholds for power generation? These are all answers that need a multidisciplinary approach by policy makers and an advanced system of good governance.*

2.1 Introduction of the ecosystem services approach

The concept of ecosystem services was first proposed in 1983 by Paul Ehrlich and Harold Mooney, and since then its use in the scientific literature has grown rapidly. Ecosystem services are defined in the Millennium Ecosystem Assessment (MEA) as the "benefits people obtain from ecosystems".

These ecosystem services include a large variety of aspects such as food and fodder production, provision of raw materials, pollination, climate- and water regulation, water supply, erosion control, soil formation, nutrient cycling, carbon sink, green-house gas cycling, biological control, genetic resources, recreation and cultural values. Over the years, several classification schemes of ecosystem services have been elaborated, for instance the classifications used by the above-mentioned MEA, by TEEB (The Economics of Ecosystems and Biodiversity), or by CICES (Common International Classification of Ecosystem Services). These classification schemes differentiate ecosystem services on the basis of their function:

- **1. Provisioning services:** material or energy outputs from ecosystem such as food production (e.g. fish, meat, honey, mushrooms and berries), provision of raw materials (e.g. timber, wood for bioenergy), water supply;
- **2. Regulating services:** benefits obtained from the regulation of ecosystem processes such as water and climate regulation, pollination, hydrogeological protection, soil erosion control;
- **3. Cultural services:** non-material benefits that people obtain from forests through spiritual enrichment, cognitive development, recreation and aesthetic experience;
- **4. Supporting services:** necessary for the production of all other ecosystem services such as natural diversity, plant production, soil formation and nutrient cycling.

There are some differences among the different classification schemes. For example, in contrast to the TEEB and MEA classifications, CICES regards "biodiversity" as total sum of life and a basis for all (biotic) ecosystem services and not as an ecosystem service itself. Despite the problems related to an exact categorization and definition of ecosystem services, the importance of ecosystem services for human life as well as wildlife is widely recognized by both the scientific community and political decision makers. Simply put, preserving ecosystem services means preserving the life of terrestrial ecosystems. Human wellbeing depends on ecosystem services, and most of them cannot be replaced artificially, so their preservation and maintenance is a crucial challenge for the future.

However, current management practices often lead to a loss of ecosystem function. This trend is particularly visible in mountain areas, including in the Alps. The development of renewable energy is one of several anthropogenic pressures that threaten Alpine ecosystems, putting at risk the region´s high levels of biodiversity, fragile ecosystems, recreational value and the diversity of cultural identities. Alpine ecosystems provide several goods and services such as protection against natural hazards (i.e. landslides, avalanches and rock falls), carbon dioxide sequestration, fodder, timber, renewable raw material for energy production (bio-energy), tourism and recreation (hiking, biking, hunting, etc.), freshwater, and biodiversity.

Potential conflicts may and often do develop between nature conservation and renewable energy development. The development of the different renewable energy sources (i.e. hydropower, wind power, solar thermal energy and forest biomass) could have an effect on ecosystems and biodiversity, with negative consequences on the quality of the benefits provided by ecosystem services. In particular, renewable energy development may cause soil loss and degradation and a loss of biodiversity. In addition it may have a negative effect on the landscape´s aesthetic beauty. Notwithstanding the above, the ef-

Figure 2.1.1
Ecosystem services examples from Vorarlberg - Hoher Reschen. 1 Provisioning Services, 2 Regulation and Maintenance Services, 3 Cultural Services. (Source UIBK – HASTIK, Richard)

fects of renewable energy development on the environment are not purely negative. On the whole, it is necessary to balance the positive impact (reduction of the dependence on fossil fuels through the use of renewable energy sources), with other aspects of nature conservation, which leads to a trade-off situation.

Unsustainable practices are driven by a market logic that does not take into account the social and environmental costs. Generally speaking, the value of ecosystem services is often not included in the political decision-making process because many benefits supplied by natural ecosystems have no market prices. So-called "negative externalities" (the external costs of economic activities that impose a negative effect on third parties, often society at large) of unsustainable production or consumption practices occur because natural resources tend to be public goods (such as air, which people may use freely without paying for such use). Because public goods are perceived as "free for all", their real value is not as obvious to users as that of private and marketable goods. In the absence of a market price the economic value of these benefits is not clearly defined, and it could happen that the cost of conservation appears higher than the benefits, when in reality the benefits of conservation could be quite high if properly accounted for.

In order to overcome this limitation, many economic valuation methods have been developed and applied for the assessment of the values of different ecosystem services. The economic valuation methods - such as contingent valuation (CV), the travel cost method (TCM), the replacement cost method, choice experiments, and the benefit transfer method - allow assigning a total value to ecosystem services, even in the absence of a market. Benefits might include, for example, climate and water regulation, protection against natural hazards, or landscape amenity and recreation (See Science: Total Economic Value (TEV) of ecosystem services).

Recharge.green evaluated both market and non-market ecosystem services in some of the project´s pilot regions. Based on information from these evaluations, decision makers may now formulate effective strategies and choose optimal locations for renewable energy that can preserve the environment and at the same time produce renewable energy efficiently. A list of nine final ecosystem services was developed (see Chapter 4). In the present study the ecosystem services are divided into three main groups: provisioning services, regulating and maintenance services and cultural services as proposed by the CICES classification.

Science:

Total Economic Value (TEV) of ecosystem services

The Economics of Ecosystem and Biodiversity (TEEB) study emphasizes that ecosystem services are closely linked to economics. The main goal of TEEB is to define a reliable methodology for valuing ecosystem services, trying to understand the environmental costs and benefits of exploiting natural resources and loss of biodiversity. The underlying idea of TEEB is that the value of an ecosystem is not only related to exploitable goods, there are several other benefits whose value is less clear because they have no market price. If the non-market benefits were included in planning, the damages connected with the exploitation of the environment could be assessed more comprehensively. This idea is strictly linked to the total economic value (TEV) approach, stating that the value of natural resources is composed of several components:

- **Direct use value:** the benefit obtained from a direct consumption of the resource;
- **Indirect use value:** the benefit derived from an interaction between users and nature but without consumption of the resource (e.g. recreation in a forest);
- **Option value:** the value of conserving resources unused today in order to obtain higher benefits in the future (mainly derived from the current rate of interest);
- **Quasi-option value:** the value of leaving resources today in order to obtain benefits due to alternative -and still undiscovered - uses in the future;
- **Non-use values:** values of the resources themselves, without considering the interactions with humans (i.e. existence value, intrinsic and bequest values).

The TEV approach focuses on the fact that the value of nature is more complex than the mere consumption of goods. Managing resources based only on harvestable quantities of goods may considerably deplete the total benefits people obtain from ecosystems. Including conservation-related and non-use values in the planning phase of decision-making is fundamental to predicting the real effects of development projects on the environment.

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2.2 Participatory processes and social impact assessment

Social acceptance is an important issue that shapes the development of renewable energy and the implementation of new technologies needed to achieve the EU energy policy targets (Renewable Energy Directive 2009/28/EC). It is necessary to understand stakeholders' perspectives on the use of renewable energy technologies and their impacts on natural resources. The site-selection process for the development of renewable energy facilities (siting) and the choice of renewable energy technologies are potential causes of social conflict [9]. This kind of social conflict could be called "green on green" conflict because renewable energy development generates global environmental benefits on the one hand, and potential negative local impacts on visual landscape, nature conservation and wildlife on the other hand. In order to address these conflicts and to increase the social acceptance of decisions, a possible solution is to use a participatory approach in decision-making processes [1]. Public participation can be defined as a voluntary process whereby people, individually or through organized groups, can exchange information, express opinions and articulate interests, and have the potential to influence decisions or the outcome of the matter in hand. Public participation in the decision-making process implies the involvement of different interest groups (interest group participation approach) and/or the involvement of people (direct citizen participation approach) [3]. The interest group participation approach refers to the principles of representative democracy where citizens' interests are represented in groups (i.e. associations, private organizations, public administrations). Inversely, the direct citizen participation approach refers to the concept of direct democracy that assumes that such groups cannot represent the complexity of society's interests and therefore can be an obstacle to real democracy [2].

A four-step participatory process

In the recharge.green project **a four-step participatory process** for renewable energy planning on the local scale (pilot regions) was developed to integrate both the interest group participation approach and the direct citizen participation approach. Consequently, the participatory process involved experts, stakeholders representing interest groups, and citizens. The four steps of the participatory process were: (1) expert consultation; (2) stakeholder analysis; (3) valuing and mapping of ecosystem services; and (4) stakeholder involvement.

Expert consultation

The first step of the participatory process was an expert consultation aimed at gathering information about the status quo of renewable energy in the recharge.green pilot regions. The main pieces of information collected during this step were: (1) potential development of renewable energy sources (i.e. hydropower, wind power, solar thermal energy and forest biomass); (2) potential impacts of renewable energy development on ecosystem services and local socio-economic characteristics; (3) map of the stakeholders to be involved in future steps of the decision-making process (stakeholder analysis). All this information was collected with specific reference to each pilot region.

The experts were identified by the partners of the recharge.green project taking into account three main criteria: (1) expertise on ecosystem services and/or renewable energy, (2) knowledge of the local context, (3) no direct stake in the activities of recharge.green.

The required information was collected through semi-structured questionnaires in face-to-face interviews with the identified local experts. The positive and negative impacts of renewable energy development on the baseline scenario were evaluated by the experts using a 5-point Likert scale (from very negative to very positive impacts). This was done for eight ecosystem services belonging to three categories (provisioning, regulating and cultural services). In addition, the impacts of renewable energy development were assessed taking into account ten socio-economic indicators related to a standard Social Impact Assessment (SIA) procedure, such as local market diversification, local entrepreneurship, waste management system, resource efficiency, employment of local workforce, income growth per capita, social and community aggregation, political stability, human health and property rights and rights of use (Box 4.2).

All information collected through questionnaires was useful for assessing strengths (development potential) and weaknesses (environmental and social impacts) of the development of renewable energy in the pilot regions.

Stakeholder analysis

The term "stakeholder" refers to any individual or group of people, organized or unorganized, who share a common interest or stake in a particular issue or system. Stakeholder analysis is aimed at identifying and classifying the stakeholders in order to determine the extent of their future involvement in the decision-making process. This stage is particularly delicate because on the one hand a large number of stakeholders can delay the decision-making process, while on the other hand the exclusion of relevant stakeholders may compromise the process, delegitimise the decisions taken and increase conflicts between interest groups.
In the recharge.green project the stakeholder analysis was performed by experts in three phases: (1) in the first phase all the stakeholders who affect and/or are affected by the policies, decisions, and actions of the system were recognized and listed (brainstorming session); (2) in the second phase stakeholders previously identified were classified considering some personal characteristics (i.e. power, legitimacy, urgency and proximity); (3) in the third phase the stakeholders´ professional relationships were analysed (social network). During the second phase the stakeholders were divided into three main categories: key stakeholders, primary stakeholders and secondary stakeholders.

- Key stakeholders are those who can significantly influence or are important for the success of the project.
- Primary stakeholders are those who are affected either positively (beneficiaries) or negatively by the results of the project.
- Secondary stakeholders are those who have a marginal effect on the results of the project.

In addition, the stakeholders were also analysed from the relational point of view using the social network analysis (SNA) approach. SNA is a formal theory to define and analyse the relationships that stakeholders have with each other. This technique is crucial to address a diverse set of issues that are important to society and can facilitate conflict resolution among the users, increase opportunities for peer-to-peer learning and collective actions, and foster the dissemination of information. In this context, SNA was applied to identify which key stakeholders are in a central position in the social network, at local level, for each pilot region. In particular, the network was analysed considering professional relationships in the management of natural resources and renewable energy development, and the strength of these relationships (strong tie and weak tie). Stakeholders with a strong tie tend to have a similar background, they share similar views and, due to ease of communication, their communication is effective even with complex information. Conversely, weak ties are generally characterized by low emotional intensity and sporadic communication among different actors, not structured to transmit complex information.

Stakeholders - identified through the stakeholder analysis and classified using the SNA approach - were invited to participate actively in the last step of the process (round tables).

Science:
Social Impact Assessment (SIA)

The European Commission introduced an integrated Impact Assessment (IA) system in 2002 defined as "a tool to improve the quality and coherence of the policy development process. Impact Assessment identifies the likely positive and negative impacts of proposed policy actions, enabling informed political judgments to be made about the proposal and identify trade-offs in achieving competing objectives". The importance of IA as a process more than a simple tool is further emphasized in the revised version of the European Commission's IA guidelines: "Impact assessment is a set of logical steps to be followed when you prepare policy proposals. It is a process that prepares evidence for political decision-makers on the advantages and disadvantages of possible policy options by assessing their potential impacts".

Social IA (SIA) can be defined as the application of the IA process to the identification and analysis of the social impacts of a given policy or action. The benefits of SIA approach are: (i) the application of social issues to other policy areas; (ii) the transparency of the process (which involves stakeholders), (iii) the increased awareness of social context among decision makers, (iv) the potential of avoiding costs related to unforeseen social problems that could arise after policy implementation.

The main **indicators** of the SIA can be summarized as:

1. Local market diversification: allocation of resources over a large number of markets in an attempt to reduce the risks of concentrating resources and to exploit the economies of flexibility.
2. Local entrepreneurship: propensity of the local population to initiate business enterprises' and the effects on business opportunities and productive diversification of the area.
3. Waste management system: a service to collect, transport, and treat waste from a certain area in an adequate manner.
4. Resource efficiency: use of natural resources, with the main purpose of minimising their input when producing a product or delivering a service.
5. Employment of local workforce: the installation, operation and maintenance of renewable energy technologies are often of modest scales, so they create more employment, for the local workforce.
6. Increasing income per capita: income per capita is a positive variable of social welfare, and is often an effect of technical progress.
7. Social and community aggregation: impacts on the capacity to improve local people´s participation (i.e. social and political empowerment, participative decision-making, participatory integrated assessment).
8. Political stability: citizens' acceptance of the system or, in other words, the potential of conflicts induced by energy systems, and the citizens' participation in the decision making process.
9. Human health: health hazards for the local population linked to renewable energy production (potential health impact due to severe accidents; health consequences of normal operations).
10. Property rights and rights of use: land and resource tenure, dependencies on foreign sources (e.g. financial investments, knowledge), customary rights.

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Valuing and mapping ecosystem services

In the third step of the process the ecosystem services were assessed in each pilot region and the relationship between ecosystem services and stakeholders was analysed through the lens of economic evaluation and spatial distribution of the benefits to society.

In each pilot region three categories of ecosystem services were evaluated from an economic point of view using the total economic value (TEV) approach (see Box "Total Economic Value (TEV) of ecosystem services"): provisioning services (e.g. wood and non-wood products), regulating services (e.g. carbon sequestration and protection against natural hazards) and cultural services (e.g. recreation).

In addition, the economic values of ecosystem services were made spatially explicit using a Geographical Information System (GIS) approach, and taking into account the ecological characteristics of each ecosystem service. The spatial distribution of ecosystem services could provide useful information for decision makers, allowing them to better define and implement renewable energy development strategies.

Stakeholder involvement

The last step in the participatory process was the consultation of stakeholders (individual citizens and interest groups) to highlight their opinions on and preferences for scenarios of renewable energy development and the potential impact of renewable energy development on ecosystem services and the local economy.

Public administrations, associations and non-governmental organizations (NGOs), private companies and citizens can add value to decisions. Participants can improve decisions with their local knowledge and opinions.

Science:
Challenges of the participatory approach

In the last few decades participatory approaches in decision-making processes linked to natural resources management have become an alternative to traditional top-down approaches. Participatory approaches are based on the consideration of stakeholder preferences and opinions in decision-making processes. The main advantages of the participatory approach compared to the traditional approach are: increasing public awareness, generation of knowledge useful to improve the quality of decisions, rapprochement between authorities and citizens, prevention and solution of potential conflicts between users, and legitimization of the decision-making process. Conversely, the application of a participatory process may run into some barriers and limits, such as lack of influence on the final decision, inability or unwillingness to participate in making decisions, inability or unwillingness to share and create a debate and two-way communication.

Representativeness: Decision-makers usually choose to decide on the basis of representative democracy principles. A good decision should be speedy and specific. However, in many cases linked to environmental issues it would be better to involve stakeholders in the decision-making process: more viewpoints, better decisions, and fewer environmental conflicts about controversial issues.

Structure of participatory process: A participatory process includes different actions: information, consultation, interaction between actors. Each kind of action is important. Care has to be taken to communicate transparently in the information phase, as citizens and stakeholders could lose trust in the organizers and the institutions. An impossibility to influence important issues could result in unresolvable conflicts, lack of trust in decision-makers and, above all, lack of collaboration in the implementation phases. The goals of every participatory process must be made clear from the start.

Presence: it is often difficult to convince the stakeholders to participate. Facilitators can invite, inform and listen, but people are often difficult to engage. The active and individual seeking out of people is a useful tool to involve local stakeholders and residents.

Conflict: Early involvement of stakeholders and residents is an instrument to gain trust and it requires a timely discussion about a project (main objectives, ways to obtain them, people to involve, important issues). The inclusion of stakeholders only in later phases could lead to conflicts, because viewpoints and goals of decision-makers were not made clear from the onset.

Trust: Trust is a concept that includes several aspects linked to the relationship between institutions and citizens and it might influence (positively or negatively) individuals' willingness to engage in participatory efforts. Participatory methods act through a mechanism that places all participants on an equal level. It is very important to discuss about an issue without communicative barriers. When the level of trust in a local context is low it is preferable to involve a facilitator who can create a trust relationship with and between participants.

Participatory processes should be organized depending on the features of each case. One should consider the main goals, involved actors, important issues, ways of communication, and modes of participation.

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The most important element of participatory techniques is paying attention to people through the creation of mechanisms of trust and mutual listening. Discussion is an instrument through which it is possible to understand the reasons and feelings of participants. Round tables are an appropriate means for considering all points of view of the participants. Consequently, during the organization of a round table the following key aspects were taken into account: (1) stakeholders to be involved in the process, (2) tools to be used, (3) issues to be addressed, (4) objectives to be achieved.

The choice of **stakeholders to be involved** in round tables is of crucial importance because they play a key role in the definition of priorities and in data collection. In this project all stakeholders - previously identified during the stakeholder analysis - were invited to participate in round tables, with project leaders trying to persuade them of the importance of their collaboration in the decision-making process. The involvement of all the important residents and groups of interests created a local map of viewpoints and goals (e.g. production vs. environmentalism).

With regard to the **tools to be used** in the participatory process, it was decided to invite local stakeholders, facilitators and partners of the recharge.green project to round tables. Normally, these round tables lasted from 90 to 120 minutes and were repeated many times (two to four times) depending on the number of issues discussed. During these meetings, many instruments were used (maps, colours and posters) to collect information and preferences from participants, with the facilitator playing an arbitration role.

When organizing a round table there are many aspects to be considered. First and foremost are the **issues to be addressed** during the participatory process. In our case, it was decided to address general issues related to renewable energy (e.g. "What are positive/negative aspects of renewable energy in the pilot region?"), and then focus on the results of the decision support system. Clear objectives and language are important to collect results from a round table. Second, related to the **objectives to be achieved** and the definition of a shared scenario of renewable energy development and the social perception of impacts of different renewable energies on ecosystem services and economy, it is key to pay attention to the characteristics, viewpoints and language of participants. The agreed scenario should be clearly described at the end of the round table or in a follow-up paper.

Finally, the competencies, knowledge, and cultural background of participants are fundamental elements of the participatory process. The involvement of as many essential local residents and interest groups as possible is important for the success of the participatory meeting.

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Best practice example:

Stakeholder involvement in the Maè valley pilot region

The participatory process adopted in the Maè Valley pilot region can be considered a best practice example. The methodology adopted for the participatory process was divided into three steps.

The first step was an informative meeting with the aim of presenting the whole project to citizens of the valley, public administrations and technicians and local associations. The second and third steps were based on round tables, organized with the support of an external facilitator to help people make suggestions focusing on the specific issues of hydropower and forest biomass development. Stakeholders involved were selected from categories suggested by experts, participants to the first meeting, and interested people "captured" through advertising material (i.e. flyers, posters) displayed at the information points of the valley.

A first information round table was organized at municipal level. During this meeting, participants were presented with the framework of the project and the first results, and how they could be involved in the following activities. The meeting was an opportunity to collect comments on and suggestions for a decision support system (DSS) and for the analysis of ecosystem services. At the end stakeholders were provided with materials, such as ecosystem services maps, and some "blank" maps, where they could draw their own inputs and suggestions, to complete the analysis of the ecosystem services of their valley.

A second meeting was organized at the valley level, one month after the first meeting: this allowed people to elaborate information and to have discussions among the various stakeholders. They could put their inputs on the "blank" maps or send them directly to a specific mail address. This second meeting was focused on evaluation. Stakeholders were asked to provide information about their valley, in particular they were asked to fill in a questionnaire to rank a selected number of values of their territory (i.e. ecological value, touristic value, social value, economic value, historical and cultural value, personal and family value, landscape). People's choices were shared among the participants and justified, also providing new information for the categories of ecosystem services, simply drawing them on a "blank" map in A0 format. The final result was a ranking of the ecosystem services in the pilot region that reflected the personal opinions of the stakeholders.

Maè valley mirrors the situation of many Alpine valleys: partial isolation from the valley floor, depopulation, needs to provide a connection to infrastructure and technological networks. The ranking showed that the social, personal and economic values were considered most important by stakeholders, who stressed the need to maintain people in the valley and give them job opportunities and services, and social gatherings. All these aspects are the basis for the development of the valley, and consequently they represent an opportunity to define a sustainable future.

Further Reading

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2.3 Ecosystem services and soil functions

Various ecosystem services defined by CICES strongly correlate with soil functions (Table 2.3.1). They are defined for instance, by the soil protocol of the Alpine Convention and by the Austrian standard for evaluating soil functions (ÖNORM). Depending on the energy source, soil resources are affected to a different extent by expanding renewable energy (see chapter 4). Unfortunately, soils and respective soil functions are as yet rarely considered or are under-valued in the planning process. This is even true for larger projects that require a strategic environmental assessment. Therefore, chapter 4 not only presents ecosystem services impacts from expanding renewable energy production, but also discusses possible consequences for soils and soil functions.

Table 2.3.1: Soil Functions linked to ecosystem services. (Source GEITNER, Clemens & HASTIK, Richard 2015)

Important soil functions (Functions prov. by soil resources)		**Linked ecosystem services (CICES)** (Benefits humans obtain)		**Linked final ecosystem services** (ES the context of expanding RE)
(Functions prov. by soil resources)	➔	(Benefits humans obtain)	➔	(ES the context of expanding RE)
Habitat for soil organism	➔	Lifecycle support and maintenance, habitat and gene pool protection	➔	Habitat for flora and fauna
food Biomass production (food, timber, energy plants)	➔	Soil formation, provision of nutrients materials & energy	➔	Provision of forest- and agricultural products
Water flow regulation	➔	regulation of water and mass flows	➔	Natural hazard protection
Filtering, buffering and decompositionof pollutants	➔	Immobilization of waste, toxics and other nuisances by ecosystems	➔	Water provision and filtering

Renewable energy sources and their relations to soil functions – possible impacts based on expert knowledge and literature review

Table 2.3.2: Renewable energy sources and their relations to soil functions. (Source: GEITNER, Clemens & HASTIK, Richard 2015)

	Soil as a livelihood resource and a living environment (1a) and as a genetic reservoir (1e)	Soils as a location for agricultural use including pasture farming and forestry (3a)	Soils as an integral part of the ecological balance (mainly water and nutrient cycles) (1c) and as filtering, buffering and storage medium (1d)	Soils as a characteristic element of nature and the landscape (1b) and as an archive of natural history and the history of civilisation (2)	Soils as a space for human settlement (3b) and other activities (tourism, transport, commercial usage, etc.) (3b/3c)
Forest biomass	Loss of soil biodiversity in case of inadequate forest management	Loss of soil nutrients in case of full tree harvesting	Soil compaction and humus degradation in case of inadequate forest management (e.g. use of heavy harvesters)	Soil erosion in case of inadequate forest management	Competition for forest resources with other industries (e.g. paper or wood processing industry)
Agricultural biomass	Loss of soil biodiversity in case of intensified agriculture (e.g. due to pesticide use)	Soil erosion, compaction and humus loss in case of inadequate agriculture management	Soil erosion, compaction, humus loss and water eutrophication in case of inadequate agriculture management	Soil loss and loss of wetlands in case of intensified agriculture (e.g. due to drainage of hydromorphic soils or earth movements)	Competition for agricultural land between energy crop cultivation and food production
Hydropower run-of-river and reservoir	Soil habitat changes (e.g. in case of riparian forests and flow alternations)	Loss of productive land in case of inundations and/or construction measures	Soil water balance change due to inundations and groundwater alteration close to water reservoirs	Depending on individual project (e.g. impacts on alluvial soils as landscape element and archive)	Depending on individual project and possible conflicts of use (e.g. with agriculture)
Photovoltaics ground mounted	Regeneration of soil habitats due to agriculture extensification	Regeneration of soil productivity due to agriculture extensification	Organic matter enrichment, small-scale changes in water budget and increase of groundwater recharge	None or only minor impacts are assumed but impacts during construction phase are possible	Competition for agricultural land
Hydropower drinking water supply	None or only minor impacts are assumed but impacts during construction phase are possible				
Wind power	Only minor impacts are assumed (soil sealing) and impacts during construction phase are probable				
Photovoltaics building mounted	None impacts assumed				

Soil functions according to the Protocol on the implementation of the Alpine Convention of 1991 in the field of soil conservation, CIPRA 1998: Chapter 1, Article 1, Objective 2, 1-3)

A literature research helped to reveal various areas where soil functions can be impacted by expanding renewable energies (Table 2.3.2). In the context of agricultural and forest biomass, a large range of impacts has to be balanced within management plans. For hydropower many impacts are related to the habitat function of hydromorphic soils while further impacts strongly depend on the individual project. For other energy sources, soil function impacts can occur primarily during the installation phase.

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3

Decision support systems

Authors:
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"Identifying the "real" potentials for renewable energy in the Alpine Space is a matter of finding an optimal compromise between the right technology/renewable energy type applied to the right place, and at the same time protecting the environment and ecosystem services (considering the various protection zones and levels). Equally important, such measures of optimisation have to be accompanied by corresponding supporting policies (e.g. introduction of tariffs/appropriate renewable energy subsidies, lifting of fossil fuel subsidies." (IIASA)

Interview:
The role of social science and decision support systems

Eva-Maria Nordström, PhD, Swedish University of Agricultural Sciences

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Eva-Maria Nordström holds a PhD in Forestry and works at the Department of Forest Resource Management at the Swedish University of Agricultural Sciences (SLU). Her research presently focuses on forest management planning and policy situations with multiple objectives and involvement of stakeholders. She has expertise in forest decision support systems, multi-criteria decision analysis (MCDA), participatory planning and future studies methodologies.

Question: What is the role of social science and decision support systems (for stakeholders and experts) in land planning and renewable energy planning?
Answer: I think both decision support systems and social science are essential for good planning. Decision support systems based on sound models and relevant biophysical data are needed to help us explore the consequences of various land management options and define appropriate strategies for the future. For instance, advanced decision support systems have been developed for forest planning during the last 10 years that can help us to analyze complex problems. However, with increasingly advanced decision support tools the need for social science and "soft methods" also grows, at least if we want to avoid a technocratic and expert-based approach to planning. Decision support tools may assist in involving stakeholders in the planning but interdisciplinary approaches including social science will in many cases be necessary to be successful.

Question: What might be the strengths and weaknesses of a participatory approach for development of renewable energy strategies?
Answer: A successful participatory approach will most likely increase the stakeholders' understanding of the issue of renewable energy and of other stakeholders' perspectives on this issue. Thus, it may assist in defusing conflict among stakeholders and facilitate the implementation of the strategy selected in the end. Participation will also bring multiple perspectives and new information from stakeholders into the process, which may lead to more innovative and better strategies from an overall societal point of view. However, a successful participatory approach is often demanding, both for planners and stakeholders. Usually it takes time to build trust among stakeholders, to agree on objectives and to explore various options.

Question: In your opinion what can be the future development of renewable energy in the Alps and how can decision support systems contribute to it?
Answer: The future is hard to tell, but I think it is likely that we will need to use our natural resources very efficiently in the future to support a sustainable development under global climate change. Decision support systems will be essential to explore different options and make sound choices that will not only optimize the resource use today but also ensure that we will have different options in the future.

3.1 Short general introduction to decision support systems

A decision support system (DSS) is a computerized tool that helps a user to identify a simple solution to a complex system and enforces the decision making process. A DSS has three core components, (1) the input data or database, (2) the model and (3) the user interface. The user has an important role in the overall architecture of the DSS, and can provide useful feedback regarding the objectives of the DSS (see Figure 3.1.1).

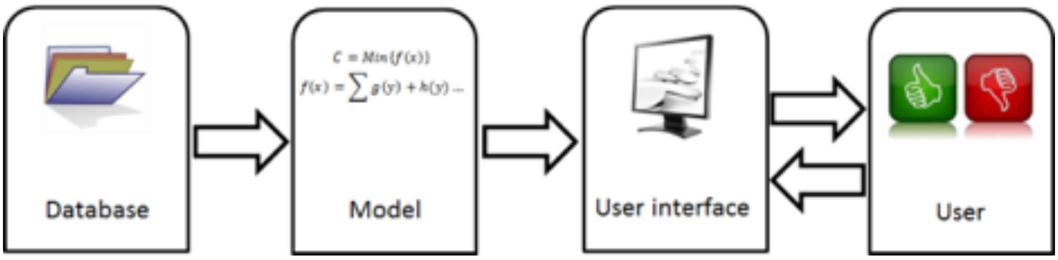


Figure 3.1.1: Overview of a Decision Support System architecture

The recharge.green project has developed four decision support systems. One is dedicated to the Alpine Space developed by the International Institute for Applied Systems Analysis (IIASA), the second one to specified case studies developed by the European Academy of Bozen/Bolzano (EURAC), one for the optimal use of biomass in the Triglav National Park coordinated by the University of Ljubljana, Slovenia, and finally one for the implementation of renewable energy systems in Leiblachtal, Austria.

The Alpine Space DSS focuses on the whole Alpine arc and identifies the potential and cost of increasing renewable energy production as well as protecting ecosystem services such as biodiversity. The development of solar panels, windmills, hydropower stations and combined heat and power plants are the four technologies studied for the Alps. Regarding the localization of the areas where it is allowed to set up such technologies, their number, capacity and location are identified.

Besides the Alpine space DSS, other specialised DSS dedicated to some of the pilot areas have been developed to answer specific questions that are characteristic of each of the case studies. These were designed for the following tasks:

- Identifying the sustainable use of woody biomass in Triglav National Park (Slovenia)
- Hydropower station development and biomass energy use in Maritime Alps Nature Park (Italy)
- Comparing the potential of different renewable energy sources and assisting stakeholders in making land use decisions regarding renewable energies in Vorarlberg (Austria).

For each DSS case study a different methodology was used. The cooperation between the local authorities and/or industries and the project partners played a key role in the successful implementation of the four local DSS. This interaction increased the value of the DSS with regard to access to more accurate input data, as well as defining the problems the region is willing to address for its own renewable energy planning.

The results of two of the computer based DSS (Alps-wide and Maritime Alps Nature Park) were uploaded to a user-friendly interface called JECAMI (www.jecami.eu). The users can vary the key parameters (e.g. intensity of protection restriction) and see what would be the consequences, for instance, for renewable energy potential, production cost or emission reductions. This General User Interface (GUI) does not allow users to run any of the DSS themselves, but rather allows them to observe the results from pre-selected scenarios. Users can see the consequences of each parameter and can refer to a detailed manual for further information, where all assumptions are listed and described. The JECAMI interface presents the results geographically, for the Alps or for the "zoomed-in" pilot region case studies.

When establishing a DSS the challenge is to collect the largest possible amount of data. Interaction with the stakeholders or local partners is crucial for the accuracy of the input data, and thus the results. The final users have an important role in interacting with the developers of the DSS tool in order to define the purpose and the key questions a decision support system has to answer. Table 3.1.1 below presents an overview of the key parameters that have been collected for the different case studies:

The integration of a large amount of input data on a wide spectrum of areas such as resources, technologies, environment or local policy at a very detailed level increases the complexity of the system. Therefore it is important to delimit the boundaries of the problem. A good integration of the problems and thorough consideration of multiple criteria will lead to more informed and better established decisions. The decision resulting from the multi-criteria approach is based on the various alternatives for producing a certain amount of power while balancing renewable energy development and the protection of the environment. For each set of parameters, the modelled optimization will lead to different solutions. From a sample of results from plausible scenarios, the user can then make an educated decision on the optimal solution that he or she judges least risky or most valuable for the region in question.

Table 3.1.1: List of major parameters needed for the setup of the DSS.

Category	Sub-category	Resolution	Unit
	Resources		
Biomass	Location of biomass	1*1 km	
	Biomass available	1*1 km	m^3/ha
	Cost of harvest	1*1 km	EUR/m^3
Solar	Solar radiation	1*1 km	kWh/km^2
	Slope	1*1 km	degrees
Wind	Wind speed	1*1 km	m/s
Hydro	Precipitation	1*1 km	m^3/year
	Height differences	1*1 km	m
	River map		shp file
Existing industries	Pulp and paper mills	Exact location	m^3biomass/year
	Sawmills	Exact location	m^3biomass/year
	Hydropower stations	Exact location	MW
Network	Road map		shp file
	Railway map		shp file
	High voltage power grid map		shp file
	Power stations	Exact location	
Transportation cost	Biomass transport		EUR/m^3
	Power distribution		EUR/kWh
Demand	Heat demand	Cities	PJ/year
	Power demand	Cities	MWh/year
Reference systems	Heat price	Cities	EUR/MJ
	Power price	Cities	EUR/kWh
Protected areas	Map of protected areas		shp file
	Policy in place per country for each protected area category		

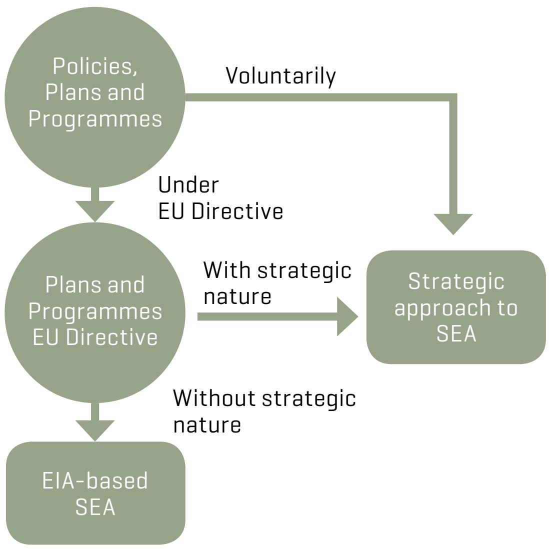
3.2 Introduction to strategic environmental assessment

Strategic is an attribute which qualifies ways of thinking, attitudes, actions related to strategies. The Alps need a strategy to balance renewable energy production and ecosystem services preservation.
For this reason the recharge.green project adopted the concept of Strategic Environmental Assessment (SEA) as a methodology to link the project's outputs to the decision making processes and development planning actions in the Alpine territory.
SEA relates to highly complex issues, at multiple spatial and temporal scales, engaging a variety of stakeholders and consequently, multiple perspectives and expectations. It is a flexible framework of key elements, acting strategically in a decision process to enable a facilitating role, ensuring an added-value to decision-making.

The SEA methodology was introduced in 1989 as a voluntary approach in the elaboration of development plans. In 2001 an EU Directive (2001/42/EC) enforced the use of the SEA methodology as a legal procedure in the assessment of plans and programmes, which set conditions for certain types of project development [1].

The SEA, which has a legal procedure similar to the Environmental Impact Assessment (EIA), provides a more holistic and comprehensive view of development strategies (Figure 3.2.1). It may be argued that the environmental assessments suitable for policies, plans and programs of a more strategic nature are different from those applicable to individual projects in several important respects [3].

Figure 3.2.1: Flowchart of the relations between SEA methodology, EIA and SEA Directive (Source: Partidario, 2012)



Interactions between recharge.green and the SEA methodology

The recharge.green project´s objectives were compatible with the SEA procedure and Directive. The following project objectives are shared with the SEA Directive:

- Mitigation against climate change;
- Enhancement and maintenance of biodiversity values and human well-being;
- Social and territorial cohesion;
- Promotion of regional development potential;
- Innovation of the population;
- Promotion of environmental quality, landscape and cultural heritage and sustainable use of natural resources.

Some of the recharge.green project´s technical outputs were designed to connect to the SEA methodology. In particular the spatial Decision Support System (SDSS) called “r.green” supports the SEA procedure by:

- Positioning itself flexibly in relation to the decision-making process (for renewable-energy production), ensuring strong interaction and frequent iteration from earliest decision moments, and following decision cycles;
- Integrating relevant biophysical, social, institutional and economic issues, keeping a strategic focus on very few, but critical, themes;
- Assessing environmental and sustainability opportunities and risks of strategic options to help drive (renewable energy) development towards sustainability pathways;
- Ensuring active stakeholder engagement through dialogue and collaborative processes towards conflict reduction (between energy production and ecosystem services preservation) and win-win achievements.
-

The interactions between the phases of the SEA and the tools of the r.green SDSS are explained in Table 3.2.1:

Table 3.2.1: Interactions between the phases of the SEA and the SDSS (Source: IIASA)

SEA steps	SEA outputs	R.Green capabilities

screening	State of the art analysis
	Data collection
	Stakeholders involvment
		• Review of current environmental and social conditions and likely changes in these conditions in the absence of the development 'plan' (or development trends) – OPTION ZERO (do nothing).
		• State of the art analysis for:
		  • *RE production: current production, maps, potentials, energy plans*
		  • *ESS: values, locations, conflicts*
		• Stakeholders involvment:
		  • *ESS values definition*

scoping	Defines the context, extent, conflicts	• Identification of changes in environmental and social conditions if the proposed plan (or existing trend) is implemented • Theoretical, legal, technical, reccomended, economic criteria are considered • The „impact“ module supports in evaluating multifunctional and corss-cutting issues (soil protection, CO2 emissions, etc..)
alternatives	Scenarios development Stakeholders involvment Alternative comparison; Iteration of modelling exercise and multicriteria evaluation	• Scenario development and discussion with local stakeholders; • Alternative comparison • Iteration of modelling exercise and multicriteria evaluation
monitor	Able to update the state of the art during the scenarios implementation	• Able to update the state of the art during the scenarios implementation • Incremental construction of the database / update • Easy reiteration of the modelling exercises to update the SoA • Framework and platform for the discussion with key stakeholders

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Science:
The use of GIS as a tool for Strategic Environmental Assessment

The use of Geographical Information Systems (GIS) can be considered at various key stages of the Strategic Environmental Assessment (SEA) regarding energy planning. The use of GIS facilitates the preparation of the baseline and helps to illustrate data by means of maps. GIS enhances the display of key information related to the location of a plan or programme and to the location and proximity of protected areas, touristic or recreational zones and heritage areas. It can increase the understanding of environmental and planning considerations.

The SEA practice not only needs a visualisation tool but also robust spatial data analysis. For this reason, the GRASS GIS add-on r.green was developed in a GIS environment. The r.green add-on is a set of tools for transforming and analysing spatial data starting from the availability of natural resources. In particular, the r.green set of tools can support the SEA at the following stages:

- **Development of reasonable alternatives with a series of indicators regarding natural resource exploitation.** The integration of the r.green add-on in a GIS environment facilitates the spatial representation of possible alternatives that can be compared with the baseline information and, consequently, evaluated. The alternatives can be diverse energy source uses (wind, solar, forest biomass and hydropower) and different degrees of exploitation (only legal and technical constraints or several sets of "recommendation" measures).
- **Determination of the cumulative vulnerability and the proximity of environmental resources.** r.green facilitates a more robust spatial analysis that can be integrated with various datasets. The combination or cumulative nature of different impacts can consequently be visualized. Furthermore, the tool evaluates the energy exploitation by removing areas with special protection and by computing the surface area of lands vulnerable to impacts. Vulnerability maps can be inserted into the model by considering levels of protection, ecosystem services evaluation, etc.
- **Testing scenarios during the planning process.** The test phase and the continuous assessment of users' opinions and needs were improved thanks to the transformation of renewable energy exploitation models into a spatial format. The tool can stress potentially conflicting energy exploitations against vulnerability maps and identify potential conflicts (e.g. hydropower against agricultural use of water, energy exploitation against biodiversity or landscape value, etc.). Thus the tool facilitates the identification of potential trade-offs and possible quantifiable mitigation measures (e.g. buffer zones around highly vulnerable areas, minimum distance between plants, decreasing the percentage of prescription for forest biomass, etc.). The results obtained by a participatory approach can then be easily integrated into a new scenario.

In conclusion, the GIS environment and the r.green add-on enhance the delivery of information and improve the effectiveness of the SEA process with a clearer and more understandable visual communication towards the general public. The tool could also be used for monitoring energy planning implementation. Of course the information that r.green can provide depends on the availability of spatial data. The software r.green is available as add-on in GRASS (http://grass.osgeo.org/grass7/) and plugin for QGIS (www.qgis.org). It works on different Operation Systems (Linux, Windows, Mac).

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3.3 An Alpine wide DSS model for optimal plant location decisions

The Alpine Space analysis comprises the whole Alpine arc stretching from the south of France up to Vienna and Northern Slovenia. The Alpine arc is characterized by a rather low energy demand within the Alps, but the demand in both power and heat increases drastically right outside the region due to the close vicinity of big cities such as Vienna, Zürich, München, Lyon or Milan, to name a few.

The Alpine wide DSS approach was developed by the International Institute for Applied Systems Analyses (IIASA), Austria. The DSS combines information on resources, engineering, economy, environment and policies that are all integrated in one model. The DSS is based on the existing techno-engineering model BeWhere (www.iiasa.ac.at/bewhere) that identifies the optimal location of renewable energy systems (see Science: The BeWhere model for more details).

The model considers both the energy demand from the cities within the Alps and the major cities outside the Alps. Heat is considered to be delivered to the local communities within a radius of maximum 25 km around the bioenergy production plant. Power is sent to the power grid if the power lines are located in the vicinity of the production plants, otherwise the power line can be extended and a power transformation station can be set up.

For each renewable energy system (i.e. photovoltaic solar, windmills, hydropower stations or bioenergy production plants), the optimal location is identified based on the minimization of the cost of the supply chain. The identification of the optimal location varies a lot from the technical parameters (setup costs, operation and maintenance costs, overall efficiency) of the energy systems, resource availability (e.g. access to biomass and cost of collection), the distribution of power, and environmental constraints (e.g. restriction on biomass use). The production costs of power are determined for each energy system, and therefore the average power cost in the Alps can be presented. Emission substitutions from building new energy systems are calculated the same way.

There are restrictions for the setup of the energy systems and the extraction of biomass. In order to ensure nature conservation and avoid conflicts regarding the expansion of renewable energy, the diversity of protected areas was considered to assess the potential for renewable energy. Some strict protection categories limit any human use in order to ensure nature conservation. Other models of protection promote a flexible integration of social, economic and environmental objectives, relying on the interaction between nature and more or less traditional lifestyles as a means of achieving nature conservation. Many of these areas allow the use of local renewable energy sources that are compatible with nature conservation objectives, and so serve as model examples of the sustainable integration of local use of renewable energy with safeguarding the ecosystems services.

However, definitions of protected areas vary among countries and even among provinces of the same country. Despite similar designations at national level (national parks, nature reserves, nature parks, regional parks, landscape protection areas, etc.) there is no consistency across countries in the management objectives within a given protected area category. Given the complexity of protection designations, it was necessary to harmonize protection constraint assumptions for transboundary decision making. Increased coherence between protected areas across national boundaries would provide a better basis for good management practice. In an attempt to harmonize the different protected area management approaches, the International Union for Conservation of Nature (IUCN) has provided a global system of protected area categories (Figure 3.3.1).

The seven different protected area categories (categories I to VII) are based on the primary management objectives, although this classification does not imply a simple hierarchy regarding degree of intervention or naturalness. This unified system of protected area categories is independent from national designations.

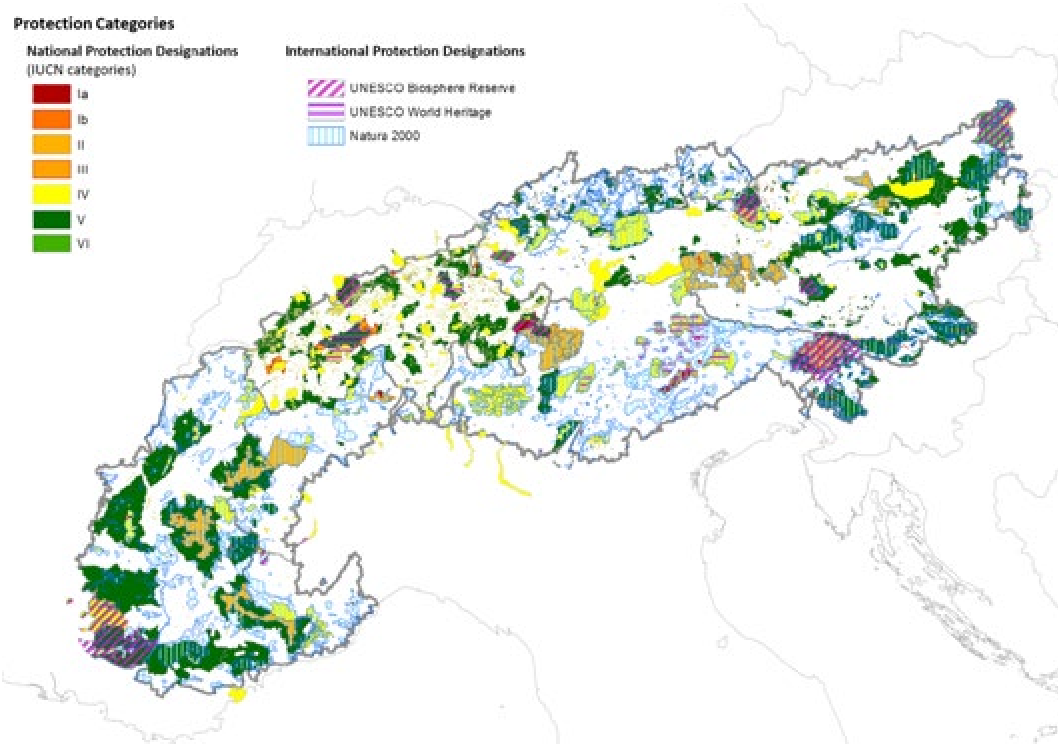

Figure 3.3.1: Overview of the protected areas and IUCN categories (adapted from EEA 2014, UNEP-WCMC 2014b and SIG ALPARC 2013)

Each protected area designation was reclassified for each scenario according to the different levels of renewable energy production. See chapter 5 for more details on the scenarios for protected areas. The protected areas are divided into 3 categories: low, medium and high protection. New energy systems can be set up with some restrictions within those areas, ranging, for example, from installation of a small hydropower plant in areas with low levels of protection to a total restriction to biomass intake in a very strictly protected environment. In addition to protection constraints, the elevation is another constraining factor for the setup of windmills or solar photovoltaic plants. Even with low environmental constraints, it is assumed that no wind mills and solar photovoltaic plants can be set up above 2,000 m, whereas in a high constraint scenario, it is assumed that the same energy systems cannot be set up above 1,200 m. On the other side, hydropower stations can either be set up in a low protection scenario (except for highly protected areas) or be completely prohibited in a high protection scenario. Finally, the biomass collected can be harvested to a certain threshold in each type of protected area. The environmental protection measures are different for each technology and for each category of protected area (Table 3.3.1).

Table 3.3.1: Overview of the assumptions about the level of protected areas for each of the technologies.

Type of protected area	None		Low		Medium		High	
Protection scenario	Low	High	Low	High	Low	High	Low	High
Solar PV 1	0.1	0.05	0.05	0.025	0.05	0	0	0
Wind mills 1	0.1	0.05	0.05	0	0.05	0	0	0
Hydro power station 2	1	1	1	0	1	0	0	0
Biomass production plants 3	0.75	0.5	0.5	0.25	0.25	0.1	0.1	0

[1] share of the area that may be dedicated for solar PV or wind mills.
[2] 0 means no hydro power station should be built, 1 means that a hydro power station may be built.
[3] share of the yearly biomass increment used for bioenergy production.

Due to the difficulties non-expert might face when running the existing model, and trying to correctly interpret the results, the DSS is not available online for private use. From the huge number of available scenarios, a few (the ones differing most from each other) were selected and their results are presented on the JECAMI interface. The results from the DSS are presented in such a way that the user can run the DSS for either one renewable energy system (i.e. solar photovoltaic, wind mills, hydropower stations or bioenergy production plants) or for all four renewable energy systems. The user can vary three parameters: (1) the cost of fossil fuel, (2) carbon cost, and (3) environmental protection level. The fossil fuel cost is the reference system, and if the cost of setting up new production plants is competitive enough when compared to the cost of fossil fuel based power, new renewable energy systems will be selected. The carbon cost is applied to any emission occurring along the supply chain. The higher the emission, the higher the cost would be. Regarding protection level, a low and a high environmental protection level can be selected.

The final results visualized on the JECAMI interface present the final calculated renewable energy potential, including the theoretical, technical, environmental and the economic potential. On the JECAMI interface, different layers can be superimposed (e.g. paths of species or occurrence of species) with the results from the pilot areas or from the Alpine level.

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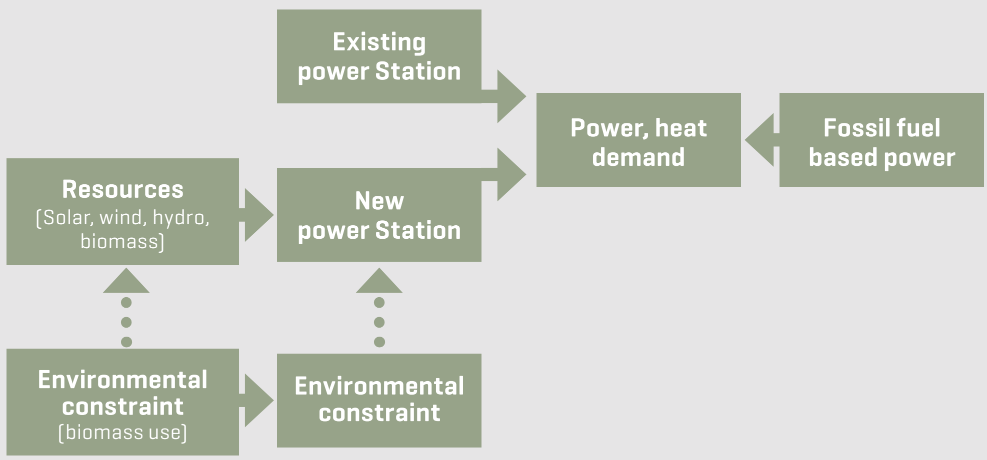
Science:
The BeWhere model

The Alpine space DSS was built based on the optimization model BeWhere (www.iiasa.ac.at/bewhere), developed at the International Institute for Applied Systems Analysis (IIASA), Austria. The model is a techno-economic, geographically explicit model that aims at identifying the optimal location and combination of energy systems in a defined region. For the case of the Alpine arc, the model optimized the locations of windmill parks, solar plants, hydropower stations and bioenergy production plants. The heat and power demand has to be met by the existing industries, the new optimized production sites, and fossil fuel based heat or power. This location optimization is derived from the minimisation of the cost of the supply chain (e.g. in the case of bioenergy, it includes harvesting of feedstock, transport of feedstock to the production plant, processing of the feedstock into power and heat, delivery of power and heat to the consumers as well as fossil fuel based heat and power delivery) for the welfare of the region studied (i.e. the Alps). New production energy systems will be selected once their production cost is competitive enough against the cost of fossil fuel based power and/or heat (see figure 3.3.2).

Figure 3.3.2
The supply chain studied in the optimisation model BeWhere (Source: IIASA)



The model is dependent of spatially explicit data that have to be as detailed as possible for the resources (i.e. solar radiation, wind speed, hydropower catchment or biomass resources), for the energy demand (e.g. heat and power) and the logistical infrastructure (i.e. road and railway networks, power grid and power stations). If the identified location of the renewable energy site is remote, an additional power station can be set up and the power grid can be extended to that location. An environmental constraint can be added to the above supply chain, both on the resources and the production sides: regarding the environmental constraints for the protection of ecosystem services the extraction of biomass can be limited, and/or the setup of a renewable energy production site can be allowed or not. For example, in a core region of a national park, no biomass can be collected, and no production site can be set up, whereas in the buffer zones, some biomass can be extracted, and solar panels, but not windmills, can be set up.

The model keeps track of the costs, emissions and the energy quantities of each segment of the supply chain. Therefore for each scenario produced, the renewable energy potential, the power production cost and the emissions avoided can be derived. Those three outputs are the final results that are provided on the JECAMI interface, as well as

the locations and types of the renewable energy systems.
Regarding international protection designations such as UNESCO Sites (Biosphere Reserves, World Heritage sites) and the Natura 2000 network, the relationship with the IUCN protected areas is not straightforward. For UNESCO Sites, it was assumed that they were assigned a highly protected core zone similar to categories I–IV to ensure the long-term conservation of the sites values. Each core area is surrounded by a sustainable management buffer zone corresponding to category V or VI. The Natura 2000 network is formed by the Sites of Community Importance and Special Protection Areas designated under the Birds and Habitats Directives of the European Union. The main objective of Natura 2000 is the conservation of targeted species and habitats of European interest, which would correspond to the PA category under IUCN categories I to IV. However, the Habitats Directive also provides the opportunity for area management following sustainable development principles in participation with local communities and other stakeholders, which corresponds to the approach of the IUCN categories V and VI.

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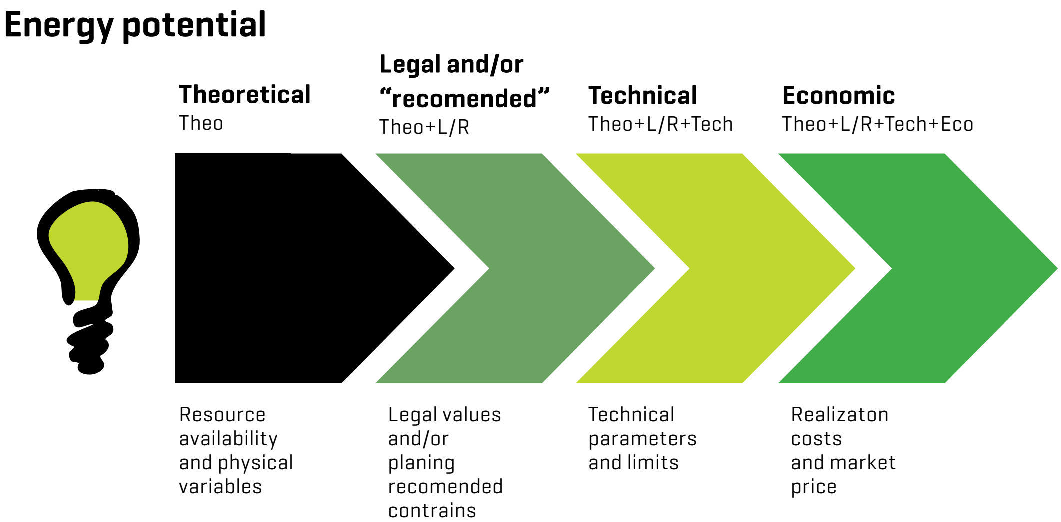
3.4 An Alps-wide spatially explicit DSS for assessment and planning of renewable energy potential

The spatially explicit Decision Support System (DSS) r.green aims at assessing the residual potential of renewable energy in the Alps according to criteria of sustainability and nature conservation. It creates maps of the studied regions that show the potential power for each kind of renewable energy according to the chosen level of potential. The approach is multi-disciplinary. Starting from the availability of the resources and going through different levels of energy potential (theoretical, legal, technical, financial and recommended) different scenarios can be compared. The latter aim at helping decision makers to deal with renewable energy planning. Indeed, r.green allows identifying the energy potential that can be concretely and sustainably exploited and the most suitable places for constructing new power plants.

The r.green model

r.green can be used through the Open Source software GRASS (v7) and QGIS (v2.8, more user-friendly than GRASS), which can be downloaded for free from the internet. They are GIS whose source code is available with a license in which the copyright holder provides the rights to study, change, and distribute the software to anyone and for any purpose. This choice was made to encourage further development and to spread and share knowledge and science. Indeed, r.green is available for everybody downloading the corresponding add-on for GRASS or plugin for QGIS. In GRASS, r.green is available by installing the add-on using the command "g.extension r.green" from the GRASS Command Console or Terminal. In QGIS, one has to choose "Manage and Install Plugins..." in the Plugins tab and install r.green, which is listed there. There are help manuals for each module.

Figure 3.4.1: Sub-modules of r.green to assess energy potential (inputs detailed on the left). (Source: EURAC)



r.green is composed of four modules corresponding to the main kinds of renewable energy : r.green.wind, r.green.hydro, r.green.solar and r.green.biomassfor (forest biomass). It also includes the module r.green.impactess which gives feedback of the impacts on ecosystem services.

Each module is composed of five sub-modules: theoretical, legal, recommended, technical and financial. They calculate energy potential taking into consideration different levels of analysis, as explained below and in Figure 3.4.1. From theoretical to financial potential, more and more parameters are considered that make the analysis more precise.

- **Theoretical** calculates the maximum power that could be exploited, considering only the amount of resources available and some physical parameters.
- **Legal** introduces legal constrains derived by plans or guidelines. There is already much legislation reducing the potential power in favour of biodiversity conservation.
- **Recommended** introduces recommendations that are not legal constrains but expert or personal opinions on the exploitation of a particular area. Some areas may be excluded because they should be protected for some reason (e.g. high aesthetic value, preservation of ecosystems, etc.).
- **Technical** takes into account technical limits, among others the compatibility between potential power and possibility to build an accurate system, energy losses and efficiency of the electro-mechanical system.
- **Financial** considers the economic dimensions of the intervention. It provides a financial analysis, calculating realisation costs and profits for each potential plant to assess economic feasibility.

The sub-modules contain required and optional variables. The more complete and accurate the list of provided variables, the more specific and precise are the results. Even if the purpose is the same, these sub-modules are really different for each kind of energy. The following paragraphs explain how the levels of potential (sub-modules) are defined for each renewable energy module. The modules for hydropower and forest biomass are in the most advanced stage of development and were applied and improved in pilot regions.

r.green.hydro considers discharge data along the rivers and digital terrain elevation model as main inputs to calculate the theoretical power potential. Then, providing the position of existing plants and protected areas and information about the legislation, the sub-module legal calculates the potential power considering water legislation. It takes into account especially the value of the minimal flow discharge, which is the residual water necessary to preserve ecosystem health. The sub-module recommended allows excluding some area from the analysis, which can be created from points or only boundaries in an input raster map. The technical part includes the head losses, the efficiencies of the turbine and of the electro-mechanical systems. It creates a map with the optimal position of the plant(s), including their potential powers and their intakes and restitutions of water. Providing economic parameters, we can then rank the feasibility of the plants on the basis of the realisation cost thanks to r.green.hydro.economic.

r.green.biomassfor calculates the theoretical potential considering the periodic or yearly forest increment. The legal potential takes into account forestry plans that prescribe an ecological availability. Through r.green.biomassfor.recommended, the user can choose to define a potential destined for civic use or exclude some areas in order to create scenarios that modify the level of protection of the territory. The technical aspect considers the possibility of extraction based on the level of accurate mechanization (e.g. cable crane, forwarder). It concerns above all road accessibility and slope. The economic sub-module excludes areas where there would not be a net profit for the whole production chain. Moreover, there's also a sub-module called r.green.biomassfor.impact, which provides an estimate of CO_2 emissions and other parameters, such as fire risk and recreational value.

r.green.wind computes the wind energy potential starting from wind distribution functions and the power curve of available turbines. The theoretical sub-module considers the maximum limit to the amount of energy that can be converted in power (Betz limit). The technical sub-module needs the features of the wind-turbine (e.g. rated power, rotor diameter, hub height). The other sub-modules again add legal and recommended constrains as well as the financial analysis.

r.green.solar considers a thermodynamic cycle (Shockley-Queisser limit or Carnot limit) as limit for the theoretical potential. A required input of the model is the irradiation map, which can be computed by the sub-module r.sun. The legal sub-module is based on the European norms (EN 15316-4-6). The technical aspect includes the efficiency of the solar cells. Different land uses can be considered in r.green.solar.recommended in order to exclude areas of particular interest. Also in this case, the financial sub-module performs a cost-benefit analysis.

r.green.impactess estimates the economic impact of energy withdrawal on select ecosystem services. It considers timber and other wood products, carbon sequestration, hydrogeological protection and recreation. The fundamental input of the module is a vector file with the spatial definition of ecosystem services economic values. The module automatically creates a raster map for each ecosystem service and calculates the change of the ecosystem service value considering a percentage of variation.

r.green was developed and applied in four pilot areas in the Alps (Figure 3.4.2): Gesso and Vermenagna Valleys in the Piedmont region (Italy), Mis and Maè Valley in the Veneto region (Italy) and Triglav National Park (Slovenia). For each region we analysed the most suitable sources of energy for the territory. The module for forest biomass was applied in all pilot regions, whereas the one for hydropower was deployed only in the Italian pilot regions. The results were discussed and the modules (particularly the recommended module) improved in focus groups with experts and local authorities.

Figure 3.4.2: Localisation of the pilot regions. (1) Gesso and Vermenagna Valleys (Piedmont, Italy) - (2) Mis and Maè Valley (Veneto, Italy) – (3) Maè Valley (Veneto, Italy) – (4) Triglav National Park (Slovenia). (Source: EURAC)

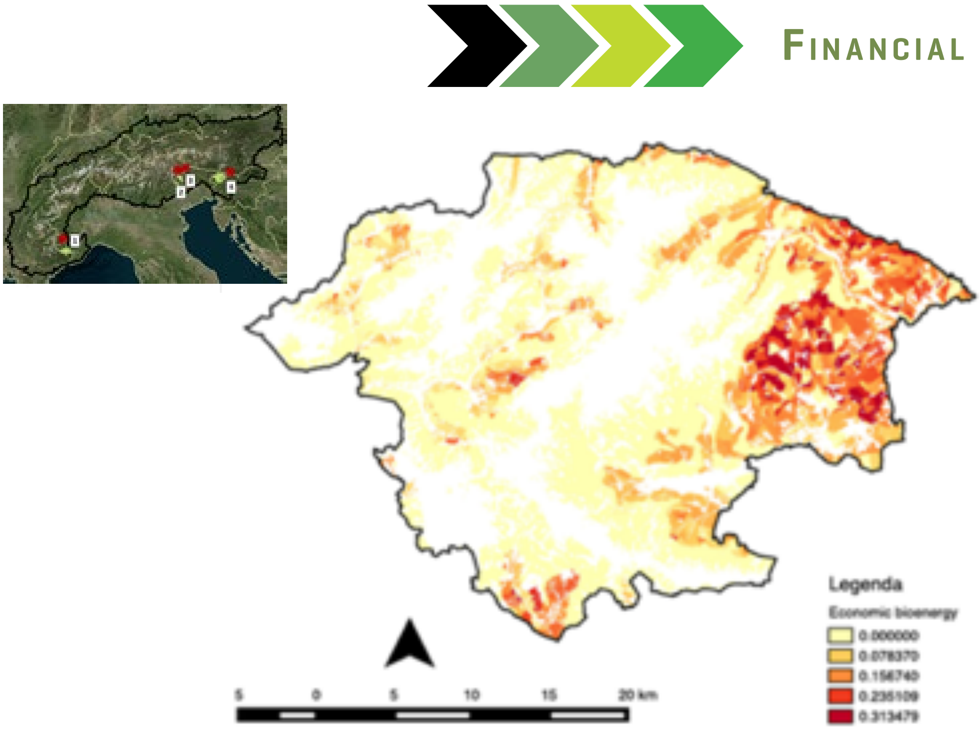


Figure 3.4.3: Results of r.green.hydro. economic (in MWh/year) for forest biomass in the Triglav National Park. (Source: EURAC)

In Figure 3.4.3 the smaller map presents the location of the pilot region, and the larger map summarizes the results for forest biomass in Triglav National Park. These results were computed by r.green.hydro.economic, which has calculated the potential energy (in MWh/year) considering wood prices and other costs. It only shows the areas with a positive net profit and the legal and technical constraints are also included. The results of the economic module yield more complete scenarios that include the financial feasibility of potential plants.

The JECAMI platform gathers different scenarios for each pilot region. Through this user-friendly interface, users can choose a region and a level of potential (theoretical, legal, technical and financial) and view the maps with the visualised corresponding power potential.

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3.5 The DSS biomass-energy-biodiversity-landscape management system (BEBL) in Triglav National Park

Background – situation and reasons for DSS development

Triglav National Park (TNP) is a governmental institution responsible for management and maintenance of the protected area situated in the core part of the Julian Alps. Among others, the important task of TNP is to control the sustainability of forest production systems as well as agricultural production. Additionally, TNP is responsible for the maintenance of traditional landscapes, natural and cultural heritage and preservation of scenic values of the park area. The strategic concern in relation to the traditional landscapes and diversity is to preserve an adequate proportion of agricultural land uses in the TNP area. The agricultural land uses, mainly pastures at high (90 – 1,200 m.a.s.l.) and medium (700 – 900 m.a.s.l.) altitudes as well as other types of grassland are interlaced with modest patches of arable land. The climax vegetation at the high plateau of Pokljuka is mixed forest. Agricultural land use, a few villages, and isolated farms are a part of the traditionally managed landscapes in the Park and represent its cultural heritage. The mixture of agricultural land and densely forested areas significantly contributes to the diversity of the park. Semi-natural grasslands managed in traditional and extensive ways are rich in floral vegetation and are of high biodiversity value. In some places the plateau shows a rough micro-relief. Such areas were cultivated and grazed in the past (Figure 3.5.1), but nowadays they are abandoned due to the inaccessibility for agricultural mechanization. Consequently, spontaneous afforestation is a process that threatens to change the traditional landscape to forest and decrease the landscape and the (bio)-diversity values of the area. On the other hand, the transitional vegetation of different stages between grasslands and mature forest shows highly diverse of flora as well as fauna. In addition to their biodiversity value, bushes and shrubs can represent an interesting source of woody biomass that can be used for energy production.

The main strategy to preserve the traditional landscape and an adequate proportion of agricultural land uses is to stop the further spread of spontaneous afforestation and to maintain selected areas in different transitional stages of vegetation. The latter requires significant effort and cost.

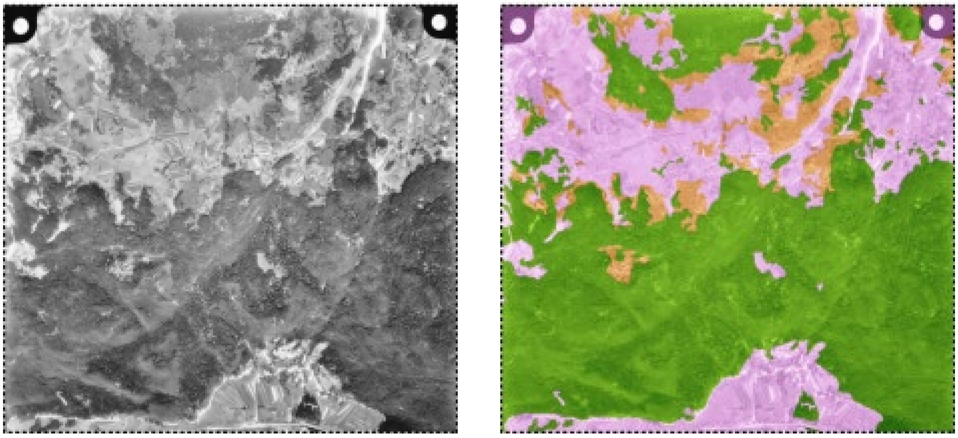

Figure 3.5.1: Analysis supply of woody biomass from marginal agricultural land on Gorjuše area (TNP) The historical aero photo image from the late fifties (left) was analysed and classified regarding land use (right) (Source: TNP)

The above mentioned processes and goals require a management strategy that will efficiently stop or decrease afforestation, increase biodiversity, and preserve traditional landscapes. An important consideration that influences the design of management measures is the cost. Management activities have to largely pay for themselves and should not require additional financial resources.

Land management for energy production, biodiversity and landscape

The land management system that was designed was focused on the production of biomass for energy production, to increase and maintain the biodiversity of the protected area and to preserve traditional landscapes of the Pokljuka plateau. The biomass-energy-biodiversity-landscape management system (further abbreviated as BEBL) aims, in the first stage, to identify marginal agricultural lands (Figure 3.5.2) that cannot be cultivated with the agricultural machinery or that are difficult to access. In a second stage, it is used to assess the suitability and the sustainability of the system in such areas. In real situations within the TNP area marginal agricultural lands usually show a high proportion of surface rockiness or stoniness, frequently have shallow or acidic soils, or are situated on steep slopes and/or rough micro relief. Such areas are unsuitable for modern agriculture that fundamentally depends on the use of machinery. Generally, such land is located close to the forest margins and frequently remote from villages.

The BEBL management practice keeps such areas in different development stages of transitional bushy vegetation from its initial stages to mature bush. Each area is divided in five to seven sections, of which one is harvested each year. Within a few years a rotation is established that keeps the extent of the area stable and in different development stages. Such areas differ by plant species and composition, height and density of the canopy and contribute to the diversity of landscapes. Mature shrubs are a source of significant quantities of wood biomass, which can be harvested, processed to wood chips and used for energy production. The diversity of such structures is rich in plant species and has a varied canopy that represents a habitat for different animals. The BEBL management practice enables the co-existence of biodiversity rich transitional vegetation with biomass production. The management costs of the BEBL areas are compensated by earnings from woody biomass that is harvested for the production of wood pellets.

Figure 3.5.2: Marginal agricultural land in Triglav National Park (Photo TNP)

The DSS for BEBL identification and assessment

The key information that was initially required was the extent of marginal agricultural areas that are potentially suitable for BEBL management, as well as information on the quantity of woody biomass that can be produced in these areas. The GIS analyses revealed several areas usually bordering on forest (e.g. Figure 3.5.3).

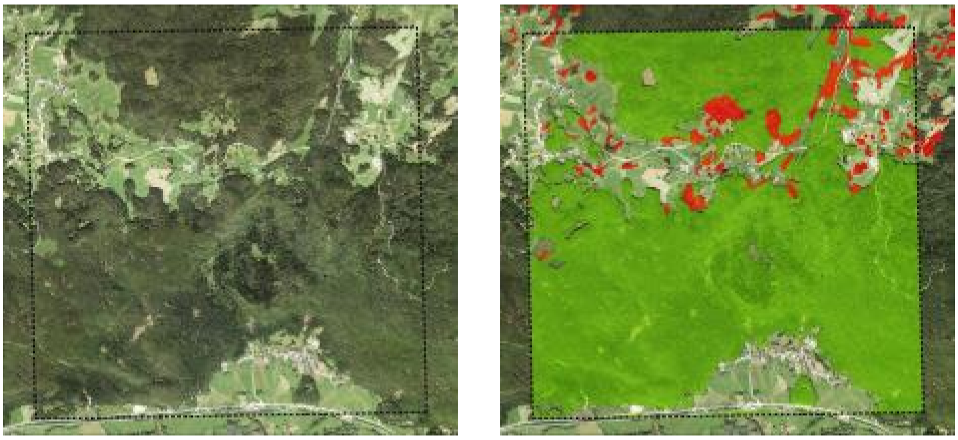

Figure 3.5.3: Analysis of the supply of woody biomass from marginal agricultural land in the Gorjuše area (Source: TNP)

The DSS that informs land use management

To introduce the BEBL management system the area was analysed and evaluated on suitability. The core set of information is mainly based on land use, relief and soil data. Since the large area of TNP has to be frequently checked for BEBL suitability, a DSS was designed and merged with the web-based GIS. The DSS is based on spatial information consisting of raster soil data (soil quality, soil depth), surface rockiness, surface stoniness, altitude and derivates of the 12.5 m elevation data (slope, curvatures), a rasterised agricultural land use map (1:5,000) and expert knowledge-based polygons showing areas of marginal agricultural land. The model was developed and applied in the Gorjuše test area, which extends over 718 ha at an elevation of 490 to 1,142 m.a.s.l.

Nr	Land use		Area (ha)		Area (%)	
	ID	**Name**	**1954**	**2015**	**1954**	**2015**
1	2000	FOREST	413,64	519,8	57,57	72,4
2	1410	OVERGROWING AREAS		4,7		0,7
3	1500	BELTS OF TREES AND BUSHES		8,5		1,2
4	1600	ABANDONED AGRICULTURAL LAND		1,5		0,2
5	1800	MEADOWS WITH TREES		3,4		0,5
		SUM 2-5	**63,9**	**18,1**	**8,9**	**2,5**
6	1100	FIELDS		2,0		0,3
7	1222	EXTENSIVE ORCHARD		4,0		0,6
8	1300	PERMANENT MEADOW		152,2		21,2
9	3000	URBAN AREA		22,1		3,1
10	6000	BARREN LAND WITH GRASSES		0,1		0,0
11	7000	WATER BODIES		0,1		0,0
		SUM 6-11	**240,9**	**180,5**	**33,5**	**25,1**
		SUM	**718,4**	**718,4**	**100,0**	**100,0**

The results of the DSS BEBL model (Figure 3.5.4) were integrated into the TNP web GIS, which enables users to combine and additionally evaluate the BEBL information with other data collected for management and protection of the TNP area.

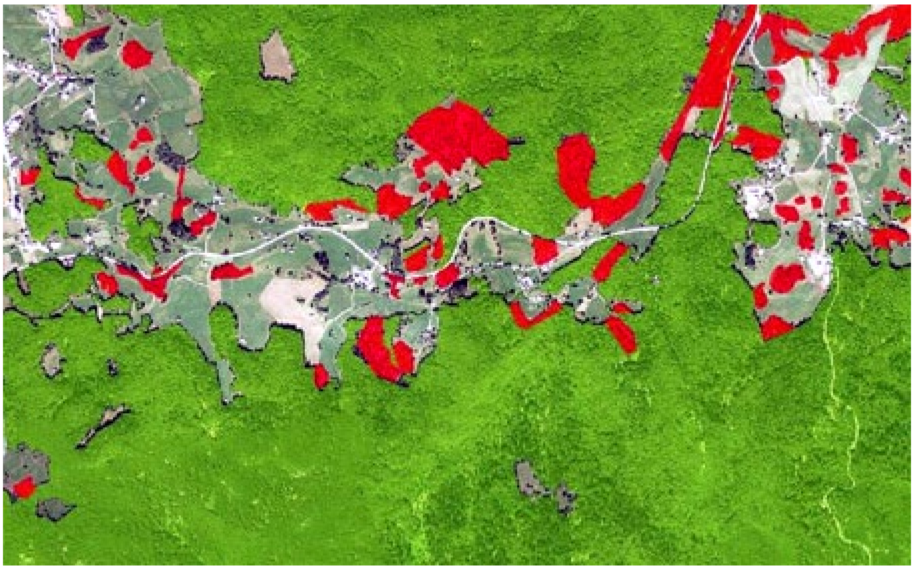

Figure 3.5.4: The BEBL areas presented by the DSS – Gorjuše test case study. (Source TNP)

Being sub-ordinated to the Slovenian Ministry of Environment and Spatial Planning (MESP) and the Ministry for Agriculture, Forestry and Food (MAFF), TNP is in favour of using compatible information systems. That is why the DSS was embedded into a newly developed TNP- recharge.green GIS web page (Figure 3.5.5), which builds on the software platform that is used by MAFF and other governmental intitutions.

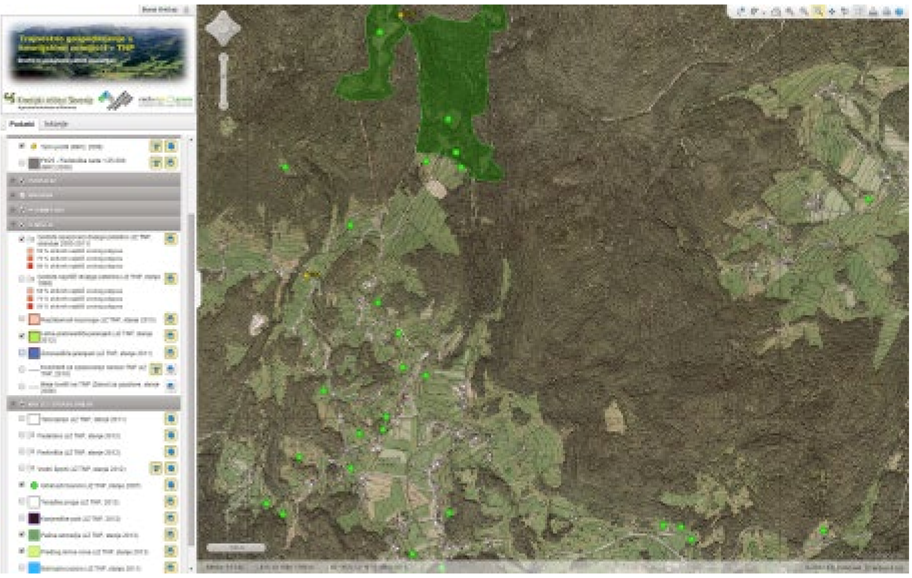

Figure 3.5.5: DSS web GIS of Triglav National Park developed within recharge.green. (Source: TNP)

3.6 The spatially explicit DSS "WISDOM" model in Triglav National Park

Another DSS used by TNP, but for a different purpose, is the WISDOM (Woodfuels Integrated Supply/Demand Overview Mapping) model. The WISDOM methodology was developed by the Wood Energy Programme of the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the University of Mexico [5]. WISDOM is a spatially-explicit method oriented to support strategic wood energy planning and policy formulation through the integration and analysis of existing woodfuel demand and supply-related information and indicators [2]. It allows a holistic vision of the wood energy sector. A national-level aggregation of key parameters constitutes the main inputs of the Wood Energy Information System. Rather than absolute and quantitative data, WISDOM is meant to provide relative/qualitative values such as risk zoning or criticality ranking. It highlights, at the highest possible spatial detail, the areas deserving attention and, if necessary, additional data collection needs. WISDOM is based on:

- the use of geo-referenced socio-demographic and natural resource databases integrated within a geographical information system;
- a minimum spatial unit of analysis at sub-national level;
- a modular, open, and adaptable framework that integrates information of relevance to wood energy from multiple sources; and
- a comprehensive coverage of fuelwood resources and demand from different energy users.

WISDOM is a powerful tool intended also for external users such as municipalities, entrepreneurs, and other individuals who want to improve renewable resource management and planning. The basic parameters, which assist end-users in decision-making, are also published on the Web.
The WISDOM methodology uses the following steps for data analysis (Figure 3.6.1):

1. Setup of a national GIS to integrate all available datasets;
2. Preparing a wood energy geo-referenced database;
3. Preparing methodologies for the development of wood energy maps and other planning tools, using wood energy production and consumption information.

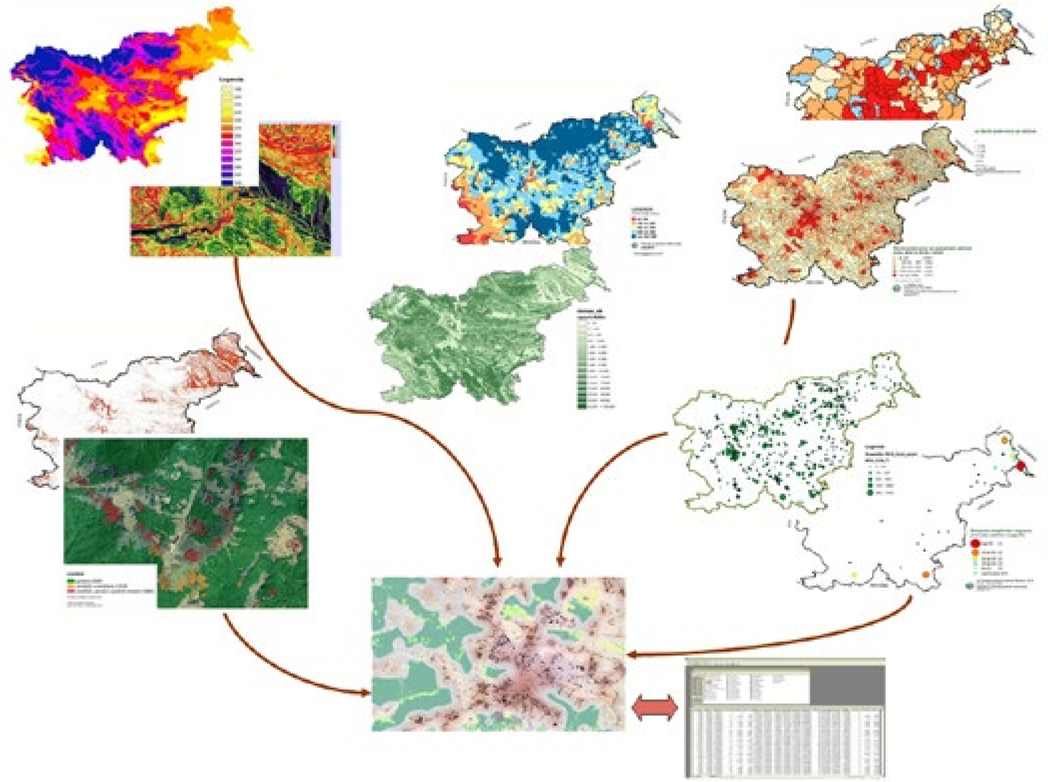

Figure 3.6.1: WISDOM - Wood fuels Integrated Supply/Demand Overview Mapping steps. (Source: University of Ljubljana)

The data needed for the WISDOM methodology are grouped into four sets that cover administration and management, physical stock (related to the supply of wood fuels), market- and consumption-related data, and a market balancing dataset. The first three datasets are comprised of recalculated data collected from the field, while the fourth dataset is derived from comparative analysis. The data needed to run the model are grouped into several modules,

1. BASIC: Digital elevation model (DEM), vector data on administrative units (municipality borders, provinces), urban areas (spatial extend, population), transport infrastructure (roads, railways), etc.;
2. SUPPLY: Data related to potential, divided into direct and indirect sources: Forest supply; total standing volume and increment; annual allowable cut and its structure; standing volume from the agricultural sector, timber residues from the wood processing industry, import;
3. DEMAND: Wood fuel demand/consumption-related data: percentage of households using firewood/wood fuel, estimated annual consumption of fuel wood (in households, public and commercial sector), export;
4. INTEGRATION: Data integration - results: Balance raster maps between consumption and supply.
5. PRIORITY AREAS: Woodshed analyses for current biomass consumption, planning locations for new plants /distance heating systems, priority areas for new road infrastructure).

All data and results are integrated into an ArcGIS geodatabase and updated annually.
The main value of WISDOM as a planning tool lies in its ability to present the results spatially. Its fine spatial and thematic resolution make it a flexible tool for the representation of the fuelwood production/consumption situation in different locations and, in synthesis, for the definition of priority areas under a wide variety of perspectives.
In Slovenia the WISDOM methodology was introduced in 2004-2005 with FAO assistance [2]. The geostatistical database produced at that time provided the first outlook of the wood energy sector and its potential in Slovenia. The analysis was carried out at the most detailed administrative unit level (Kadastral municipality).
The upgrade and update of WISDOM Slovenia (SWEIS - Slovenia Wood Energy Information System) was carried out in the framework of the IEE Project MAKE-IT-BE, with specific reference to the scope of the Work Package 4: Development of supporting tools for bio-

energy initiatives.
Today the Slovenian Forest Service is in charge of upgrading and updating SWEIS, i.e. updating its geo-referenced database by including new reference data, expanding the study object by including non-wood sources of biomass, and developing the spatial analysis component to allow woodshed analyses [3].
The WISDOM methodology is used in many other countries, provinces and cities all over the world: Argentina, Brazil, Central Africa Republic, Chad, Croatia, El Salvador, Italy, Kosovo, Mexico, Montenegro, Mozambique, Rwanda, Senegal, Serbia,, Sudan, etc. The FAO have already prepared new projects to extend this approach to other countries, such as Albania, Bosnia and Herzegovina, and Macedonia.,
The WISDOM methodology is also a suitable tool for global climate impacts estimations of the use of traditional woodfuels. Furthermore, it can be used to assess the pan-tropical woodfuel supply and demand, to calculate the degree to which woodfuel demand exceeds regrowth, and to estimate woodfuel-related greenhouse-gas emissions [1].

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3.7 A visual DSS approach that captures complexity – the Sample Hectare method in Leiblach, Vorarlberg

Introduction to the Sample Hectare

The government of Vorarlberg, Austria plans energy independence by 2050. Therefore it is necessary to compare the potentials of different renewable energy sources for this limited area. “Sample Hectare” assists stakeholders in making decisions about the use of landscape for renewable energies. “Sample Hectare” reflects the complexity of renewable energies. It considers the energetic potential of renewables per area combined with the existing use of areas, ecosystem services, and socio-economic aspects. The tool reflects the trade-offs between different solutions.

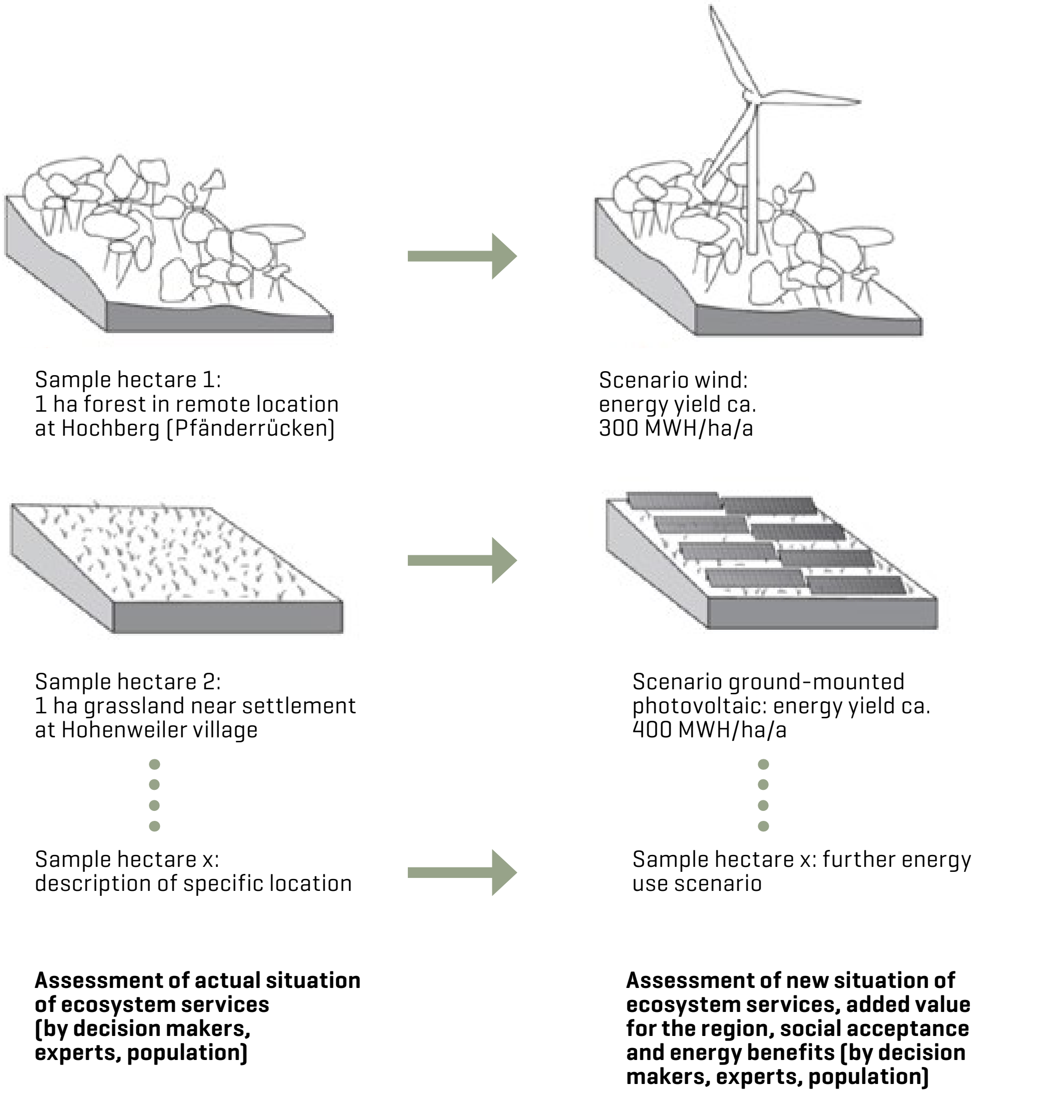

Figure 3.7.1: Sample Hectare method in Leiblach, Vorarlberg. (Source: Richard Hastik)

The tool "Sample Hectare" was tested by about 50 experts, politicians and local citizens in the course of three events in the years 2013 and 2014. The reference region was the Leiblachtal in Vorarlberg.
The tool which is easy to use provides the testing group's frame of mind within minutes. Further it delivers a contemporary survey of the consulted people's estimations. It therefore offers a fruitful contribution to the integration of public interest in spatial planning processes. The development of the "Sample Hectare" will continue after the ending of the project recharge.green.
The decision support tool "Sample Hectare" was developed by Regionalentwicklung Vorarlberg eGen (Markus Berchtold-Domig, Franz Rüf, Peter Steurer, Phillip Meusburger) in co-operation with the University of Innsbruck (Clemens Geitner, Richard Hastik) during the project recharge.green. The principles of the tool "Sample Hectare" are being presented and explained below.

Selected Sample Hectares

Representative areas of regions with "medium-value" were selected for a comparative evaluation. Natural monuments, nature reserves, biotopes, designated recreation areas as well as other protected areas were excluded. As well as:

- Dense settlement area
- Grassland with good yields (slight slope)
- Grassland with low yield (steep slope)
- Good accessible Forest
- Bad accessible Forest
- Unused brownfield site (forestation)
- Mountain plateau with forest and meadow

Selected measure-scenarios respectively forms of renewable energy production

The examination is carried out only for the production of energy from renewable sources. Due to the relatively low spatial effect the use of air heat, combined heat and power generation, energy imports were not considered. The Sample Hectare uses the following exemplary pattern hectares and scenarios:

- Photovoltaic roof surfaces
- Use of grassland to livestock, exploitation of liquid manure in biogas
- Energy maize and energy grass recovery in biogas plant
- Open landscape photovoltaic
- Planting energy wood
- Maximizing the timber harvesting
- Plantation energy wood
- Construction of wind power plant

Figure 3.7.2: Sample Hectare method: Visual example of different uses. (Source: Regionalentwicklung Vorarlberg eGen)

Calculation of the energy yields per Sample Hectareand per measure-scenario

Each hectare landscape has the potential to generate renewable energy. Only the primary energy use is considered in the context of the Sample Hectare and possible double uses are not observed. The production of electricity is preferred against heat production.

The description of the energy output (primary energy) per Sample Hectare or the action scenarios takes place on the basis of existing energy yield gross, energy production per scenario gross, input of grey energy (used for the new production of energy on the sample hectares), energy yield net (the energy yield scenario minus the use of grey energy lead to the actual energy output).

Selection of the ecosystem services to be evaluated

The pre-selection of the ecosystem services to be evaluated refers to the situation in the pilot area Vorarlberg and in accordance with the criteria related to the production of energy from renewable energy sources as well as their practicability for an assessment.
The final selection was done by the vote of the regional project team of recharge.green as well as the responsible of the state departments of planning and building law; agriculture; agrarian district authority; forestry, hunting, fishing; nature and environmental protection; environmental and food safety; water management; and economics, energy and climate protection.
The six selected ecosystem services are assessed in the present and in the potential perspective.
(1) Landscape and recreation, (2) Basis of life for water, air, soil, (3) Habitat and diversity of plants and animals, (4) Protection against natural hazards, (5) Production of raw materials, (6) Reduction in greenhouse gases and global warming.

Socio economic integration to be evaluated

Each Sample Hectare has an effect on the habitat, the people and the system of habitat and people. These effects are recorded in six socio-economic integration factors.
For the evaluation of local socio-economic integration factors the level of individual involvement of the test person is relevant. If the stakeholder is from the site community, the assessment based on the community is relevant, if the stakeholder is from the region, where the site is located, the assessment based on the region level is relevant, if the stakeholder is from the province where the site is located, the assessment based on the provincial level is relevant.

The following socio-economic integration factors are considered in Sample Hectare

1 Creating win-win situation
2 Political will and openness of society
3 Backup of the local value creation
4 Security of energy supply
5 Warranty of operation and waste disposal
6 Meaningful large-scale application

Further Reading

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2. Amt der Vorarlberger Landesregierung (2010): Energiezukunft Vorarlberg – Ergebnisse aus dem Visionsprozess.
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3.8 The benefits and drawbacks of DSS

DSS have been used in the recharge.green project at two main levels, at the Alpine scale and at the local scale in the pilot areas. Both approaches and scales have provided important general and numerical, spatially-based results. These results are immediately available for spatial planners, decision makers, stakeholders, citizens, and scientists via the JECAMI platform. The use and spread of DSS tools in energy planning should be encouraged, but data availability and quality are major issues that must be taken into account, since they affect DSS applicability and results.

DSS are extremely powerful tools that have helped during the project to foster discussions, highlight conflicts and possible solutions. During implementation the DSS provided results that can be useful to speculate at an Alps-wide level, or to address political and planning issues at a sub-national level, but DSS have also demonstrated their effectiveness at a local level, where they can help local planners, decision makers and stakeholders to identify a path towards sustainable solutions.

The ability to create on-the-fly alternatives and scenarios have been used both as a tool to foster discussion, and as a tool to propose acceptable alternatives. Nevertheless, sometimes printed maps are more communicative than scenarios visible only on a computer screen, because some of the decision makers and stakeholders may consider printed maps more tangible and easier to understand. The choice to use one approach (printed maps) or the other (on-the-fly projections and scenarios), or both, has to be adapted to the preferences of stakeholders and decision makers and to case-specific conditions. Whichever approach is chosen, the introduction of DSS into the planning process is definitely positive and helps to define objectives and to reach a better consensus among stakeholders. This was true for all the pilot areas, even considering the different experiences during recharge.green implementation.

The real applicability of DSS and the quality that can be obtained from them, however, definitely depends on data availability and quality. The advantages and disadvantages of DSS can be summarised as follows:

The **benefits** of DSS:

- DSS may help to support difficult decisions since they can provide a holistic or at least a broader vision than that of individual experts.
- DSS are suitable to be used in a participative process as a tool to incorporate the fruits of discussion, but they can also give hints and ideas to refresh and foster discussions.
- As shown in the recharge.green project, DSS can give a global and local perspective and can support planning at different scales.
- DSS can produce on-the-fly highly communicative and informative projections and scenarios, taking advantage of the visual approach and of the spatially based information. Such visual scenarios can easily be examined for errors, misinterpretations or unrealistic results.
- DSS can help to highlight and sometimes solve or at least soften conflicts between stakeholders.
- DSS are relatively easy to run, and even non-specialists can take advantage of them (with some limitations highlighted in the drawback section).

The **drawbacks** of DSS

- DSS need reliable data, following the general rule of garbage in garbage out, thus data quality must be checked before they are run.
- Data input may be a painful process, since data format may appear coherent but may lack fundamental pieces of information. Thus metadata (data describing the data) are fundamental to put DSS together, and this aspect requires expert knowledge (See Section 3.9 for more on data).
- Even if DSS may be relatively simple to use, to obtain the best results they must be run by experts (or at least with the help of experts) who know what the right settings are.
- DSS need computers and, especially if the amount of data to process is quite large, they need highly performing machines.

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3.9 Some notes on data requirements

Decision Support Systems are extremely efficient software applications that can significantly contribute to help managers and decision makers to take decisions in complex situations. DSS have been used in different situations with a surprisingly wide field of applications, from urban contexts to environment conservation, energy planning, and forest management. Nevertheless, one of the most important issues -which are often underestimated - is that the quality of the results is extremely dependent on the quality of input data. This is particularly true for spatially explicit DSS, which rely on spatially based information.

Various factors influence the data quality. Data quality depends primarily on the source of the data. For example in the case of forest biomass, this information can be obtained from detailed forest management plans based on field sampling or derived from remote sensing detection and transformation into biomass using algorithms that calculate quantity rates. Both approaches are valid. The first is generally more accurate, if management plans are redacted professionally. In other situations remote sensing data, for example from LiDar or high resolution multi-spectral images can be comparable to, if not better than, field data. Sometimes remote sensing data are the only available data. Data quality also depends also on the resolution of the information and on the scale of the analysis. For example Digital Terrain Models (DTM) are crucial for calculating a set of derived information such as slope or aspect or basin extension, and the base resolution of Terrain Model data strongly affects all derived results. In other words, DTM resolution fixes the resolution limitation for many analyses. If the original DTM is available at 500 meters resolution, all the slope and aspect calculations will be processed accordingly. This means that all the terrain discontinuities that are smaller than 500 meters (small valleys, small river beds) will be lost. If the calculation is carried out at a wide scale, for example for a whole country or for the whole Alpine arc, a resolution of 1 km may be sufficient, since results are relative approximations. If the calculations are carried out at a local scale, like a watershed or a municipality, resolutions of 10 to 1 meter are needed to produce more reliable results.

The recharge.green project worked at two different scales that represent very diverse perspectives. The first one was at Alpine level with a broader resolution of 1 km, and the second one at local level for the pilot areas reaching in some cases a resolution of 5 meters.

It is certainly true that a compromise between data quality and processing efficiency is often achieved for a DSS when it comes to choosing scale and resolution of analysis. Even if an Alpine DTM at 1 meter resolution were available, it would be very unwise to process the calculations for the entire Alpine area at a 1 meter resolution, since there are many other information uncertainties that limit the general results of DSS modelling and processing time would be extremely long. On the other hand, at local level it would be unwise to process data at a 1 km resolution, since all the advantages of detailed data sets, including local conditions and peculiarities would be lost and results could be too poor to be used at a local level.

Data should always be provided in the best actual available format without transforming them. For example, if the original data are in vector, they should be provided in a vector format and if original data are in raster they should be provided in a raster format. Eventually, the DSS operators will decide how to treat and transform the data.

Data quality also depends on data reliability. A detailed description of good practices regarding this can be found on the website of INSPIRE (Infrastructure for Spatial Information in the European Community) (http://inspire.ec.europa.eu/index.cfm).

Nevertheless a short reminder of what is important and must be checked in your data before they are given to a DSS could be useful especially if seen in the light of the recharge.green experience:

- Data must be consistent in their structure and should not contain information repetitions or information encoded in a wrong format. We frequently encountered data bases containing fields with numerical data encoded as text or text data mixed with numerical data. Of enormous importance in geo-referenced information are primary keys, data base fields that are crucial to join table values with geographical objects. The fields that can be used as primary keys should always be checked for inconsistencies or repeated values. It helps, in this case, to archive your data in a Relational Database Management System, like Oracle or PostgreSQL, which can manage this kind of problem respecting the ACID (Atomicity, Consistency, Isolation, and Durability) protocols.

- An essential part of data is metadata, the information that describes the data. For example, a detailed database containing many data regarding forest yield or a very detailed 1 meter resolution DTM have no value if there is no information on how they were created. Does the forest database or the DTM contain data from the current year or from twenty years ago? What is the meaning of some cryptic field names in the forest data base? Is forest yield value calculated at a parcel level or at the hectare level? These are just some of the questions that may arise. Metadata should always be provided in digital format together with database and geographical information, but in some cases metadata can be provided also in paper format if digital format is lacking.

- If data are provided with field names in original language (German, French, Italian, Slovenian…) a translation of fields name into English should be provided.

- On the geographical side, data must always be provided with the projection and reference system adopted by the creator. A spatial reference system (SRS) or coordinate reference system (CRS) is a coordinate-based local, regional or global system used to locate geographical entities. A spatial reference system defines a specific map projection, as well as transformations between different spatial reference systems. Providing geographical data without this information creates a risk for all data processing and jeopardises result consistency. It may also happen that data is created using peculiar national or regional reference systems. In this case it might be impossible to re-process this data into a more commonly used projection if no specifications are provided. Most GIS easily provide this information in the form of text files; moreover they can be included in the export data formats, such as the widely used "shape" .shp file format that can store projection and reference system in a file with .prj extension. Once the information is stored in a .prj file, any kind of GIS is able to retrieve these data and, if necessary, to transform data coordinates in a different reference system. Thus using simple but effective precautions it is easy to provide enough information to allow a correct geographical data treatment.

Experience suggests that data must always be re-adjusted and retuned before they can run in a model, it does not matter where they come from, but if their general structure is well built and documented through metadata this operation is much easier and more effective. The lack of this information generates a painful process of interpretation that generally drives the operator to trash the problematic data and use other, maybe less precise but better documented, information instead.

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4

Ecosystem services and biodiversity scenarios

Authors:
Authors: GEITNER, Clemens[7]; HASTIK, Richard[7]; VRSCAJ, Borut[2]

"The ecosystem services concept is very important for understanding the entirety of benefits nature provides to humans. We need to recognize that nature and biodiversity protection are crucial for people´s wellbeing. The ecosystem services concept is one way to express this idea. Valuing and mapping both marketable and non-marketable ecosystem services can help to assess the trade-offs between nature conservation and renewable energy production and to undertake effective development strategies. Both monetary and non-monetary evaluation methods are available. However, a context-less use of poorly defined ecosystem service models could blind us to the ecological, economic and political complexities we face and could potentially obfuscate the necessary major institutional changes we must make." (EURAC, FIWI & UIBK)

Interview:

Renewable energy development in Vorarlberg

Franz Rüf, Regional Development of Vorarlberg

Franz Rüf deals in his professional career with topics of factory planning and site development. Over the past 18 years he has been working with his team for the Regional Development of Vorarlberg, an association of 50 municipalities. A key concern for him is the careful handling of processes in nature and society. Public planning processes to address the issues of sustainability are in his opinion the foundation for local development work.

Question: What is the role of social science in renewable energy planning?
Answer: *Science has to communicate the social benefit of spatial planning and renewable energy planning. Research has to be based on the feelings, expectations and needs of the residents and society. It is necessary to discuss the different development scenarios, critical matters, and possible paths towards acceptable solutions.*

Question: What are the strengths and weaknesses of a participatory approach?
Answer: *Participation is essential to enable changes that are broadly accepted. We need a change towards sustainability. We must not wait until a catastrophe forces us to act. It is crucial that we act with foresight and avoid a disaster.*

Question: What about the Sample Hectare tool?
Answer: *The Sample Hectare helps us to understand and communicate the energy resource challenge. It is an instrument that allows us to compare different scenarios, and different renewable energy sources. The Sample Hectare helps us to de-emotionalise the debate. A broad application test must be the next step.*

Question: The application is planned?
Answer: *Yes. We will apply the Sample Hectare tool in the "Energiekonzept Leiblachtal" (energy concept for Leiblachtal). The energy scheme for this region will be an important model for the whole province of Vorarlberg.*

Question: Why is it important to evaluate ecosystem services in renewable energy planning?
Answer: *Renewable energy is not micro-economically justified everywhere. Therefore we have to bring in welfare arguments as well. The growing application of public-welfare balances shows the importance of social added values. The true values of ecosystem services must be made more transparent. In addition, we should not forget the desire for self-sufficiency and the need to pay attention to social science aspects, not just the natural sciences..*

Question: How can renewable energy be developed in the future in the Alps?
Answer: *The Alps have great potential for renewable energy and we should address this challenge. With the Sample Hectareapproach, communities in Vorarlberg can take a step forward towards sustainable renewable energy planning..*

4.1 Renewable energy impacts on provisioning services

Forest biomass

This chapter first discusses ecosystem services impacts caused by expanding renewable energy production (forest biomass, hydropower, wind power, solar energy) based on the CICES ecosystem services classification (provisioning, regulating and maintenance, cultural services). After outlining the main impact dimensions we will develop a baseline scenario for renewable energy expansion and the consequences for ecosystem services.

Although the aim of Alpine forest management strategies is sustainable harvesting, the increased use of forest residues for energy generation facilitated by new harvesting machines may create new challenges.

Soils as three-dimensional components of ecosystems fulfil various functions, for instance as living space, as regulator in water and element cycles, as reservoir, buffer and/or filter, but also as an archive of natural history and the history of civilization. Given the negative outcomes during previous centuries (e.g. degradation of forest soils resulting in a reduction of net primary production), these residues are now traditionally left in the forest to ensure long term soil fertility. Biomass guidelines promote a "sustainable" removal of residues, but the quantification of threshold levels is challenging. Various long-term experiments highlight the impact of residue removal, suggesting subsequent reductions in forest growth ranging from 5 to more than 20 percent. Additionally, pure forest monocultures (spruce stands) can have significant adverse effects on soil quality (Figure 4.1.1). These impacts occur particularly on shallow soils and/or nutrient-poor soils as well as in specific soil types (e.g. Podzols). High fuelwood prices might promote intensified forest management. This might stimulate pre-commercial thinning of lower quality timber, increasing stand stability and tree species composition. Impacts on the provision of non-wood forest products, such as wild plants and wildlife, are more difficult to evaluate as these are strongly reliant on habitat quality and function.

Figure 4.1.1: Two Alpine soils on the same parent material (carbonate moraine), excavated at the Pokljuka plateau, Slovenia, almost at the same altitude and a few km apart. Podzolised soils under pure spruce stands (left) show strong podsolization processes in comparison to weakly leached Luvisol under pasture (right) (Source: VRŠČAJ, Borut, AIS).

Hydropower

Hydropower reservoirs are a particular source of socio-economic conflicts and conflicts with various provisioning services due to a forced shift in land use and subsequent human and livestock displacements. Furthermore, water diversions can affect the provision of fresh water. On the other hand, hydropower systems can also create benefits such as a more constant provision of water for irrigation purposes or flood control.

Wind power

Wind power rarely has an impact on provisioning services, as most adjacent areas can still be used for agriculture or forestry. Soil sealing and a loss of productive land only occur at the construction site and in case of additional infrastructure (e.g. construction of access roads).

Solar energy

Although some concerns have been raised about loss of agricultural land from ground-mounted photovoltaic systems, modern installations can reduce soil sealing to less than 5% of an area. Furthermore, the remaining areas can still be used for extensive forms of agriculture, such as grazing. Soils might even benefit from extensive land management regimes, e.g. from addition of organic matter. On the other hand, soil functions might be impacted during the installation phase (e.g. reduced water buffer function due to compaction).

4.2 Impacts on regulating and maintenance services

Forest biomass

The impacts on regulating and maintenance services resulting from the intensification of forest management are manifold. Particularly biodiversity impacts are difficult to assess as some species might benefit from altered forest structures while the habitat for others deteriorates. In general, intensified forest management decreases deadwood ratios or stands of old wood. Deadwood is an important habitat for fungi, beetles, amphibians, birds or small mammals. In this context, the monitoring of key species can help to estimate biodiversity impacts. On the other hand, the removal of old trees and residues might also decrease the potential for pest infections due to the removal of breeding substrate and help to prevent fire hazards.

Natural hazard protection is regarded as a key function of Alpine forests. Therefore, forest activities need to be evaluated with respect to various regulating services such as protection from avalanches, landslides, erosions, mudflows, rock falls or floods. However, most of the current problems regarding the protective function are not related to over-extraction of wood but rather to inadequate rejuvenation and excessive wildlife browsing. Higher prices for forest biomass can stimulate cost-prohibitive management and consequently improve the protective function of forests.

Forest soils and the geological setting play a key role in water filtration and fresh water provision as they both depend on physical, chemical and biological properties. Water-related ecosystem services may benefit if an increased use of bioenergy favours a shift towards more diverse forests, particularly more broad-leaved species. Full tree harvesting has an impact on soils and water quality through physical soil damage such as compaction and erosion, reduced interception, infiltration and increased runoff with augmented turbidity.

Air quality impacts caused by combustion present themselves specifically in the form of particle matter and NOx. Alpine valleys are particularly affected during the winter months due to increased particle matter emissions from residential wood burning while large scale facilities with sophisticated combustion and filter systems can decrease air pollution significantly.

Last but not least an increased use of forest biomass reduces the carbon sequestration rates of forests. This could be compensated with sound forest and land use management, by balancing long rotation periods aimed at maximising carbon sequestration against short rotation periods targeted at biofuel harvesting.

Hydropower

The use of hydropower can result in a loss of biological diversity and create barriers to fish migration and can also lead to impacts on downstream river ecosystems (e.g. alternation of hydrological cycles, loss of areas exposed to regular inundation), reservoir impoundments, altered sediment transport patterns and water quality modifications. The nature and the size of these impacts depend on management procedures such as maintaining in-stream flow, reducing hydro peaking, reservoir management, bed-load management and power plant structures. Recent concerns are particularly related to the impacts caused by hydro peaking, a scheme used to provide more flexible energy production and thus higher revenues. However, numerous efforts have been undertaken during the past decades to improve upstream fish movement (e.g. fish passages) and decrease turbine related mortality (intelligent turbine design). The potential resulting from small hydropower is estimated to be limited while the ecological impacts can be substantial. Therefore, small hydropower will not be discussed here.
Besides these ecological impacts that an expansion of hydropower generation entails, the consequences for water regulation and flood protection also need to be discussed: On the one hand, experience from the past decades has demonstrated the ability of man-made reservoirs to defuse extreme flood events, but on the other hand these reservoirs can cause additional damage through mismanagement of water flow and breaching. Besides flood hazard protection, hydropower reservoirs may be important for the mitigation of droughts caused by regional climate change in the future.

Wind power

Impacts of wind mills on wildlife habitats can take the form of rotor collisions, displacements due to disturbance, migration barriers and habitat alterations. However, impacts on birds and bats vary strongly, depending on site-specific factors (positioning of power station with respect to topography, winds and migration routes), species-specific factors, diurnal and seasonal factors (yearly migration movements). The death rates associated with wind turbine collisions are generally lower than other anthropogenic causes of death, such as collisions with communication towers, windows, and power lines, entanglement in fences, cat predation, and mortalities related to pesticide use. Nevertheless, impacts on endangered species or species with low reproduction rates may be a matter of serious concern.

Solar energy

Ecosystem services impacts associated with ground mounted photovoltaic arrays strongly depend on former land uses. Impacts might be positive in the case of selective agricultural extensification or renaturation of former military or industrial zones while negative impacts are likely to occur in ecologically sensitive areas. Avoidances by wildlife or bird collisions have not been reported, but the fences required around ground mounted photovoltaic facilities are a potential barrier to the movement of various species.

4.3 Impacts on cultural services

Forest biomass

Recreational activities in forests have been shown to have several positive effects on human health. There seem to be only a few conflicts between recreational and economic forest functions. Moreover, the perception of landscape changes with the development of the vegetation under forest management activities (new formations of open areas, different forest type successions). Additionally, managed forests are often perceived as more attractive than purely natural forests from an aesthetic point of view. Temporary impacts of forest operations might be offset by an increased availability of infrastructure (roads) for visitors.

Hydropower

Historically, hydropower projects have proved a major draw for (mass) tourism in the Alps due to their "spectacular" infrastructure. However, the compatibility of hydropower projects with present-day tourism strategies, which are not focused on mass tourism but on lower impact eco-tourism, remains uncertain. Conflicts might arise if hydropower projects affect elements of natural or cultural heritage, such as rare landscape characteristics.

Wind power

Wind energy potential is particularly high on exposed terrain, at higher altitudes and on mountain ridges. However, these high-lying Alpine landscapes are strongly associated with untouched nature, cultural identity and space for recreational activities. Many parts of the Alpine area are characterised by historic cultural landscapes, a factor which must be considered when implementing wind park developments. Therefore, both physical/tangible (e.g. lines of sight) and intangible dimensions (e.g. personal attitudes towards the environment, cultural ideals and past experiences) of landscapes have to be taken into account.

The co-benefits arising from combining wind energy and tourism are traditionally referred to by wind energy proponents. Besides, numerous efforts have been made to attenuate the mechanical noise (e.g. of gear hubs) and aerodynamic noise that occurs due to wind shearing (low ground wind speed but high wind speeds at hub height). Nevertheless, the acceptance of wind power projects by local residents and visitors is essential for the future exploitation of wind energy.

Solar energy

In terms of aesthetic impacts, solar energy plants are similar to wind power due to their both physical/tangible and intangible dimensions. Therefore, highly treasured landscapes (e.g. sites of cultural or natural heritage) should not be impacted by ground mounted photovoltaic systems.

Interview:

The importance of considering soils when valuing ecosystem services

Prof. Franco Ajamone Marsan, University of Turin

Prof. Dr. Franco AJMONE MARSAN is full professor of agricultural chemistry at the University of Torino, Department of Exploitation and Protection of the Agricultural and Forestry Resources (Turin, Italy). His main research interests and teaching subjects are soil environmental chemistry, soil contamination, soil quality evaluation. He published more than 100 research and conference papers and supervised a number of MSc and doctoral students.

Question: Soil was considered as an 'agricultural topic'. Such thinking is gradually changing especially when ecosystems functions are discussed. What are the main functions and services the soil provides within an ecosystem?
Answer: *Soil is a non-renewable ecological component that provides food, biomass and raw materials; it is a platform for human activities and landscape, and an archive of heritage, and plays a central role for habitat and gene pools; it stores, filters and transforms many substances, including water, plant nutrients and carbon.*

Question: In contrast to air and water the land or soil is a true property, a real estate. A simple conclusion would be that the ecosystem services the soil or land provides are private and can be marketed?
Answer: *Historically, the most required among the soil ecosystem services have been biomass production –agriculture, forestry - and platform for human activity. These have generated the necessity of imposing a right of property on the soil, except for limited experiments of common management of the land. However, while concrete services can be private, there are a number of indirect ecosystem services that are of general, common importance, such as landscaping or regulating CO_2 emissions.*

Question: So, the traditional thinking on land production is changing? Are these indirect soil ecosystem services in any way in conflict to 'traditional' land uses such as food production or housing?
Answer: *Pressure is now increasing on the provision of indirect services and, for example, the use of land for infrastructures is being negatively depicted as land consumption. The allocation of energy infrastructures (e.g. solar panels, wind turbines) is perceived as an impact on the aesthetical value of the landscape, of which the soil is the main component.*

Question: Can we measure ecosystem services? What would be a first step to preserve indirect soil ecosystem services?
Answer: *Along with the political decision, better planning instruments are needed that can take all the direct and indirect soil ecosystem services in consideration. Estimating or measuring those services is not straightforward but it is the only way by which the provision of services can be optimized while minimizing the impact on the soil resource".*

4.4 Scenario discussion

Conservation strategies do not necessarily have to imply trade-offs between ecosystem services and economic interests. Both the negative impacts and the positive co-benefits need to be balanced against each other and scrutinised in order to discover the endogenous development strategies that are particularly important for Alpine regions. However, most of these impacts depend on particular management regimes and additional measures. It is thus not possible to view these impacts a priori as positive or negative. Nevertheless, it is possible to highlight major conflicts and their dimensions that require trade-off decisions as described in Table 4.4.1. Global climate change mitigating goals need to be balanced against local nature protection requirements, which are particularly important in biodiversity hot spots such as the Alps. Furthermore, industrial landscapes and energy production need to be balanced against the need for "pristine" mountain environments. However, tourism and energy generation can also create co-benefits, depending on the project in question and the tourism strategies applied. Natural hazard protection, crucial in areas of extreme topography, can be impacted both positively and negatively by expanding renewable energy generation for local settlement areas (roof-mounted photovoltaic systems, near-surface geothermal energy), which are generally of less concern from an environmental point of view.

Table 4.4.1: Main ecosystem services impact dimensions for different types of renewable energy. (Dark green = main impacts, light green= further impacts, grey = side aspects) (Source UIBK)

	Provisioning Services	Regulating and Maintenance Services				Cultural Services
	Provision of forest-/ agricultural products	Water provision and filtering	Climate regulation	Habitat for flora and fauna	Natural hazard protection	Recreational and aesthetic values
Forest biomass	Impacts on forest products and soil productivity, wood competition with industry	Impacts in case of inadequate management	Trade-off between the replacement of fossil energies and changed forest carbon sequestration rate	Loss of natural forests, habitat disturbances, reduced dead wood values	Benefits or negative impacts depending on forest man-agement	Temporary impacts related to logging activities, long term benefits of infrastructure
Hydropower run-of-river	loss of productive land possible	Only minor impacts for human use assumed	Impacts in case of inappropriate land-use changes	Riverline altera-tion, limitation of migratory routes, downstream impacts, collisions	Positive and negative impacts depending on side-measure-ments	Positive and negative impacts depending on side-measure-ments
Hydropower reservoir	Loss of po-ductive land possible	Changed water availability in case of derivations, mitigate of droughts possible	Impacts In case of inappropriate land-use changes	Habitat loss through inundation, temperature shifts, introduc-tion of species	Reservoirs can help to defuse extreme flood events	Positive and negative impacts depending on side-measure-ments
Hydropower drinking water supply	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed
Wind power	None or only minor impacts assumed	None or only minor impacts assumed	Impacts in case of inappropriate land-use changes	Alternation of habitats/ migratory routes of birds and bats, collisions	None or only minor impacts assumed	Visual impacts on landscape composition, emission of noise/flicker effects
PY ground mounted	Competition for agricultural products possible	None or only minor impacts assumed	Impacts in case of inappropriate land-use changes	Only minor impacts assumed, avoidance of important habitats required	None or only minor impacts assumed	Visual impacts on landscape composition
PVbuilding mounted	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	None or only minor impacts assumed	Only minor im·pacts assumed in case of natural and cultural heritage sites

Based on these insights, we assumed the following constraints (based on ecosystem service constraints) for a baseline scenario for an expansion of renewable energy generation in the Alps:

Forest biomass baseline scenario for ecosystem service constraints

An intensive use of forest biomass might result in a deterioration of biodiversity, for instance due to reduced deadwood levels. Therefore, we assume a reduced usage rate of 70% in protected forest areas. Besides habitat and biodiversity impacts, an increased usage of forest biomass for energy generation might result in resource competition with wood-processing industries. However, optimised cascade use can help to reduce resource conflicts. Based on data available for Austria we assume that half of the industrial wood can be acquired for energy production. Furthermore, natural hazard protection is regarded as a key function of many Alpine forests requiring adapted forest management strategies. Therefore, only 33 percent of the natural regrowth rate is used in hazard protection forests. Finally, we assume that most forest residues are left in place to ensure long term soil fertility.

Hydropower baseline scenario for ecosystem service constraints

For the sample plot analysis discussed in the next chapter we assume, based on the Water Framework Directive, that new hydropower plants cannot be installed in protected river basin areas and should not deteriorate existing river courses. Therefore, the theoretical potential assumed for the Alpine area of 180 TWh per year needs to be reduced by 35TWh.

Wind power baseline scenario for ecosystem service constraints

To preserve important habitats and cultural landscapes we assume that no wind energy is used within 1 km of protected areas and settlement areas. Additionally, wind energy is not used in high-lying and as yet untouched Alpine areas above 2500m.

Photovoltaic baseline scenario for ecosystem service constraints

Many Alpine regions strongly limit the use of ground-mounted solar energy systems but promote building-mounted solar energy systems. Therefore, we focus on building-mounted photovoltaic systems which are mainly limited by technical and economic constraints rather than ecosystem service impacts.

Figure 4.4.2: Ecosystem service impacts and resource competition of selected renewable energy sources [Source: UIBK]

Energy source	Possible Ecosystem Services impacts and resource competitions	Assumed energy potential reductions
Forest biomass	*Impacts on natural habitats*	*Exclusion of protected natural forests, usage rate reduced by 30 % in other protected areas*
	Impacts on the provision of other forest products, competition for wood resources with other industries	*Limited proportion of fuel wood (40 %) besides timber wood and wood used in industries (60 %), 50 % of industrial wood available for energy generation due to use cascades (residues and waste)*
	Impacted hazard protection function of forests	*Strongly limited harvest rate (33%) in hazard protection forests*
	Impacts on soil productivity	*Retention of harvest residues (17 %) in forests*
	Source: (Hofer & Altwegg 2007, Österreichischer Biomasse-Verband 2013, Katzensteiner & Nemestothy 2007)	
Hydro-power	*Impacts on habitat function of aquatic and river adjacent ecosystems, recreational use of rivers and adjacent areas*	*Exclusion of protected and remaining natural river courses. (Potential reduction: approx. 20%)*
Wind energy	*Impacts on endangered bird and bat populations*	*Exclusion of nature conservation zones, exclusion of habitat areas and migration routes of endangered bird and bat species with a minimum buffer distance (1 km)*
	Visual impact on landscape aesthetics	*Exclusion of other protected areas, minimum distance to settlements (1 km), maximum height of 2500 m (pristine high Alpine areas), maximum distance to existing road infrastructure (500 m)*
	Source: (Regio Energy 2015, Suisse Eole 2015)	
Solar energy	*(Temporal) loss of productive land or potential settlement areas, visual impacts*	*Focus on building-mounted solar energy, limitation of ground-mounted solar energy*
Biogas	*Habitat and water quality impacts of intensive agriculture, competition with food production*	*Limited proportion of energy crops (max. 10 %)*

Further Reading

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5

Renewable energy exploitation and ecosystem services: Alpine region and pilot area analysis

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"In pilot areas, the exploitation of renewable energy should involve local people, assuring that they share decisions in energy planning. The successful integration of participatory principles into decision-making processes necessitates a willingness to make real use of stakeholder contributions. The proper recognition of contributions from the participatory process (solutions, opinions, knowledge) in decision-making can help to reduce conflicts. Alpine residents must be given a stronger role in the management and use of renewable resources of their home region." (Veneto & FIWI)

5.1 The recharge.green approach: results and best practices

Scenarios on the protected areas

When identifying the sustainable potential for renewable energy in the Alps, protected areas need to be considered to ensure nature conservation and avoid conflicts that might arise from the expansion of renewable energy production. Three scenarios were created, with different limitations and access to protected areas according to the methodology described in chapter 5. Under the general levels of protection assumed (Figure 5.1.1, centre), the available area for renewable energy production is considerably limited given the high constraints applicable in strictly protected areas and the marginal levels of production to be achieved in less strictly protected areas. Another scenario considers a context with greater emphasis on renewable energy production, assuming lower restrictions on renewable energy production or higher compatibility levels with conservation management objectives (Figure 5.1.1, left). Under a less restrictive scenario, the potential area for renewable energy production increases significantly. In this reduced scenario a high proportion of the protected area is considered suitable for renewable energy production. Categories I-IV are maintained as strictly protected areas. Inner zoning, where small-scale renewable energy production is considered to some extent to support compatible tourism, is assumed for the categories II (National Parks) and IV (Habitat Management Areas). In addition, the assumption of no restrictions on renewable energy production at Natura 2000 sites reduces the conservation constraints in large areas.

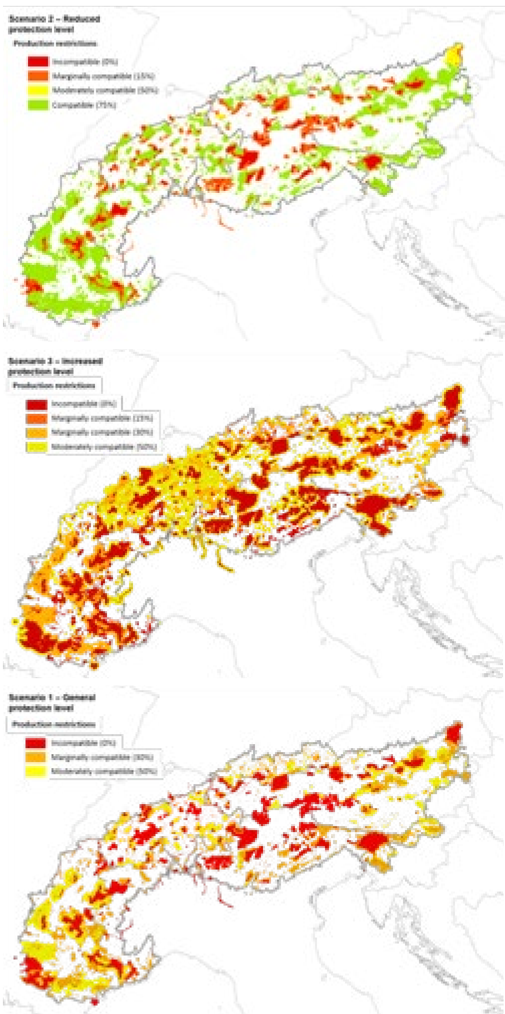


Figure 5.1.1: Spatial distribution of the protection constraints for the potential production of renewable energy considering an increased protection level (Source: IIASA).

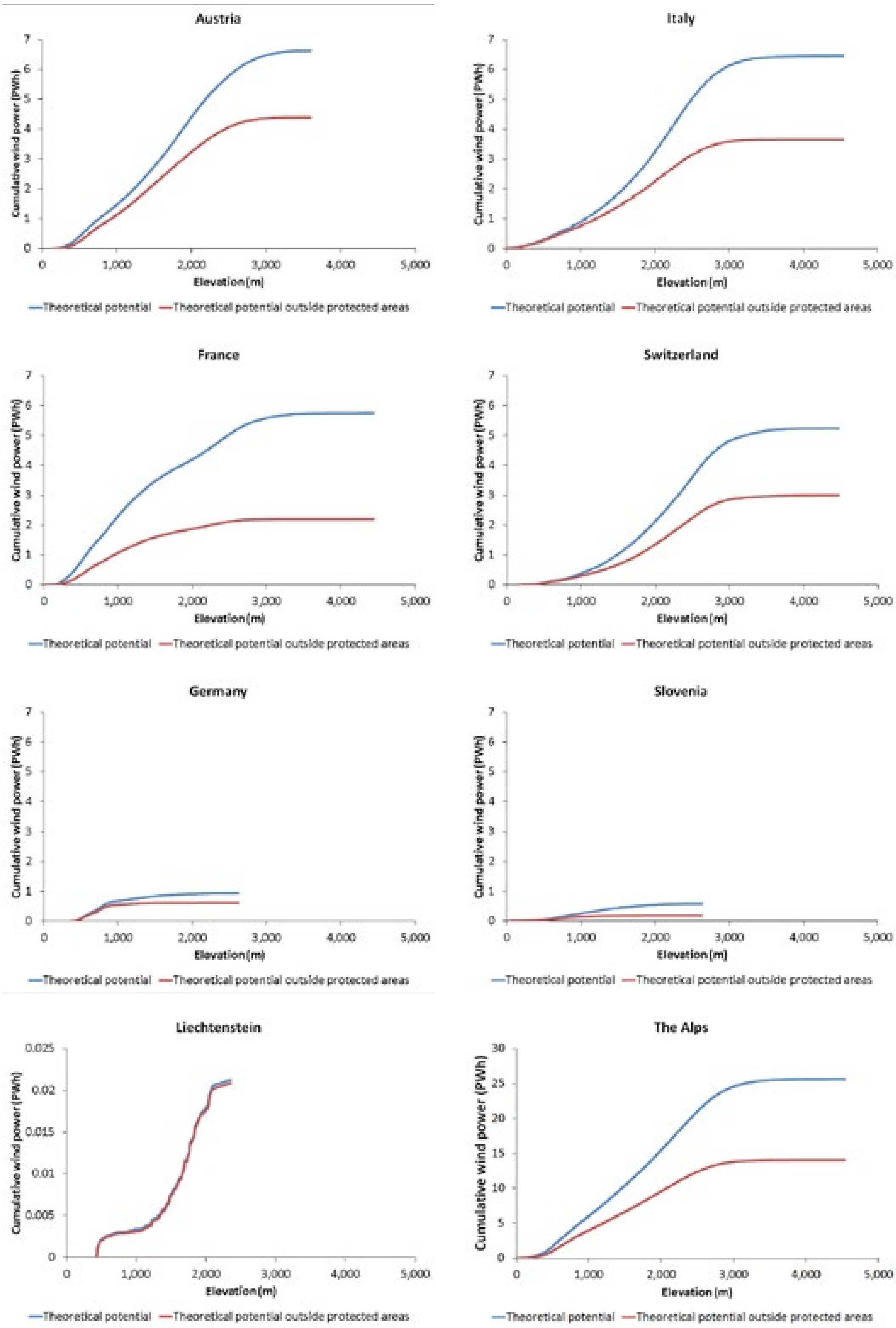
Under an increased level of protection scenario (Figure 5.1.1, right), high restrictions on renewable energy production and lower compatibility levels with the conservation management objectives were assumed. A focus on the strict conservation of habitats and species in the area of the Natura 2000 sites significantly reduced the area for compatible renewable energy production. Furthermore, the potential area for renewable energy production without restrictions is considerably smaller when assuming an external buffer zone for the strict categories I-IV in order to ensure the protection of whole ecosystem processes.

From these scenarios, we can see the importance of defining management objectives for each individual protected area. Large differences in the potential area for renewable energy production depend on management considerations. It is important to note the potential role that the Natura 2000 network has in the extension of the biodiversity conservation area and the limitations to the potential area for renewable energy production. Nevertheless, the actual management of these sites differs between regions. Therefore, the focus on biodiversity conservation or sustainable development would depend on a particular area.

Wind power potential

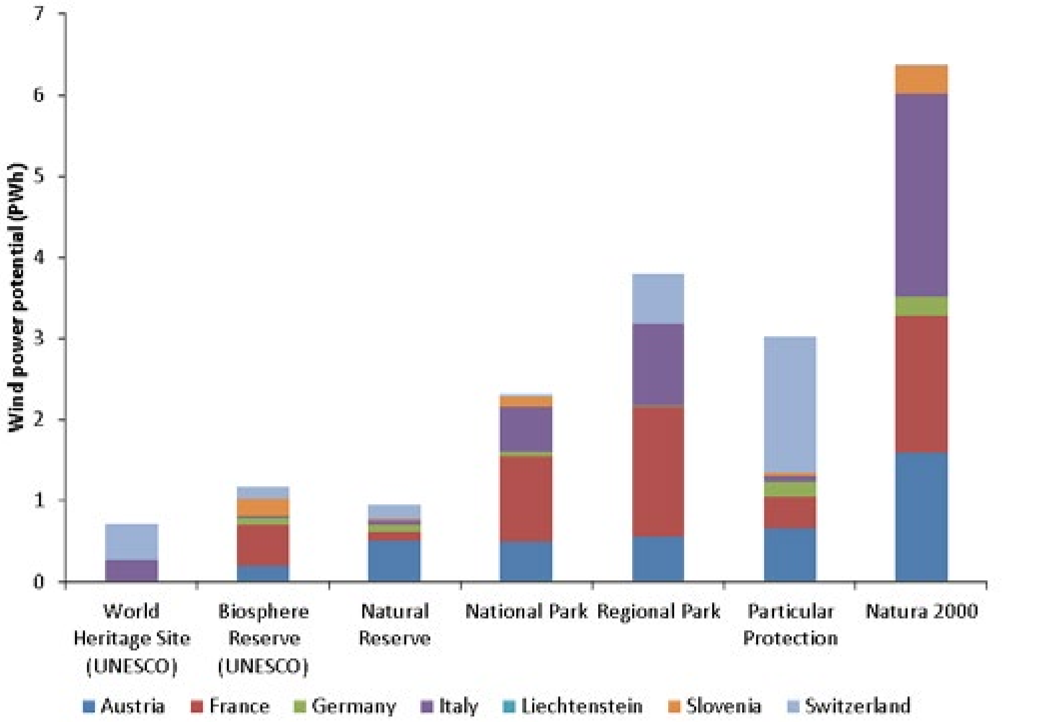
The location of wind mills on crests or on mountainous plateaus is a very sensitive topic for local communities and power manufacturers. Figure 5.1.2 presents aggregated results for a theoretical potential. It is of interest to note that the potential is divided by a factor of two if the protected areas are excluded from the set-up of windmills. Nevertheless, it should be noted that there are some disparities between countries, with France having very limited wind power development (the potential in protected areas covers more than two thirds of the total potential) compared to Austria, where one third of the potential is to be found in protected areas. Moreover, the potential for wind power generation outside protected areas is mainly found at relatively low altitudes.

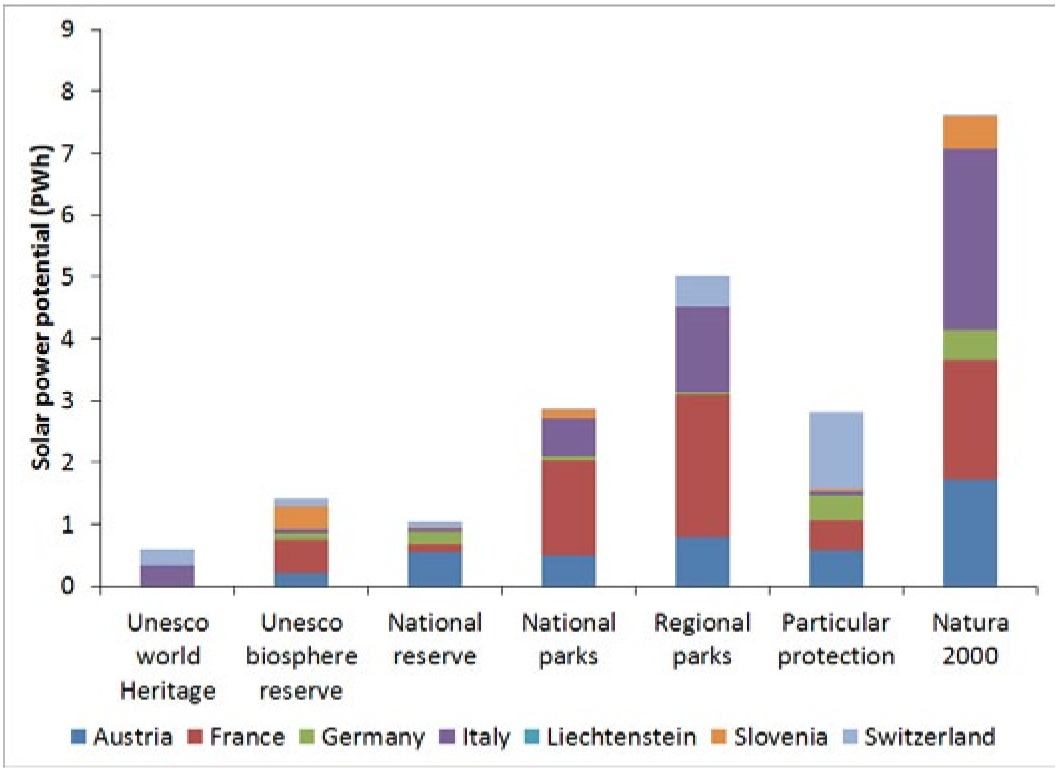
Figure 5.1.2: Profile of the theoretical cumulative wind power potential with regard to elevation for the countries of the Alpine Space and the Alps as a whole. (Source: IIASA)



The protected areas are classified into different categories (i.e. UNESCO World Heritage, UNESCO Biosphere Reserve, Nature Reserve, National Park, Regional Park, Particular Protection and Natura 2000). Each of the categories may overlap with each other in some areas, but it has to be noted that a fourth of the total theoretical potential in the Alps is covered within the Natura 2000 category (see Figure 5.1.3) for both wind and solar power production.

Figure 5.1.3: Theoretical wind (left) and solar (right) power potential in the Alps by country and type of protected area, energy potential data provided by EURAC. (Source: IIASA)





Hydropower stations

The potential of hydropower was investigated through an analysis of the potential of the catchments. The potential of each catchment was determined by EURAC. Starting with the full potential, it is assumed that no hydropower plant can be set up in a catchment where a hydropower station is already up and running. Figure 5.1.4 presents the theoretical hydropower potential in the Alps without constraints, without existing power stations and without protected areas.

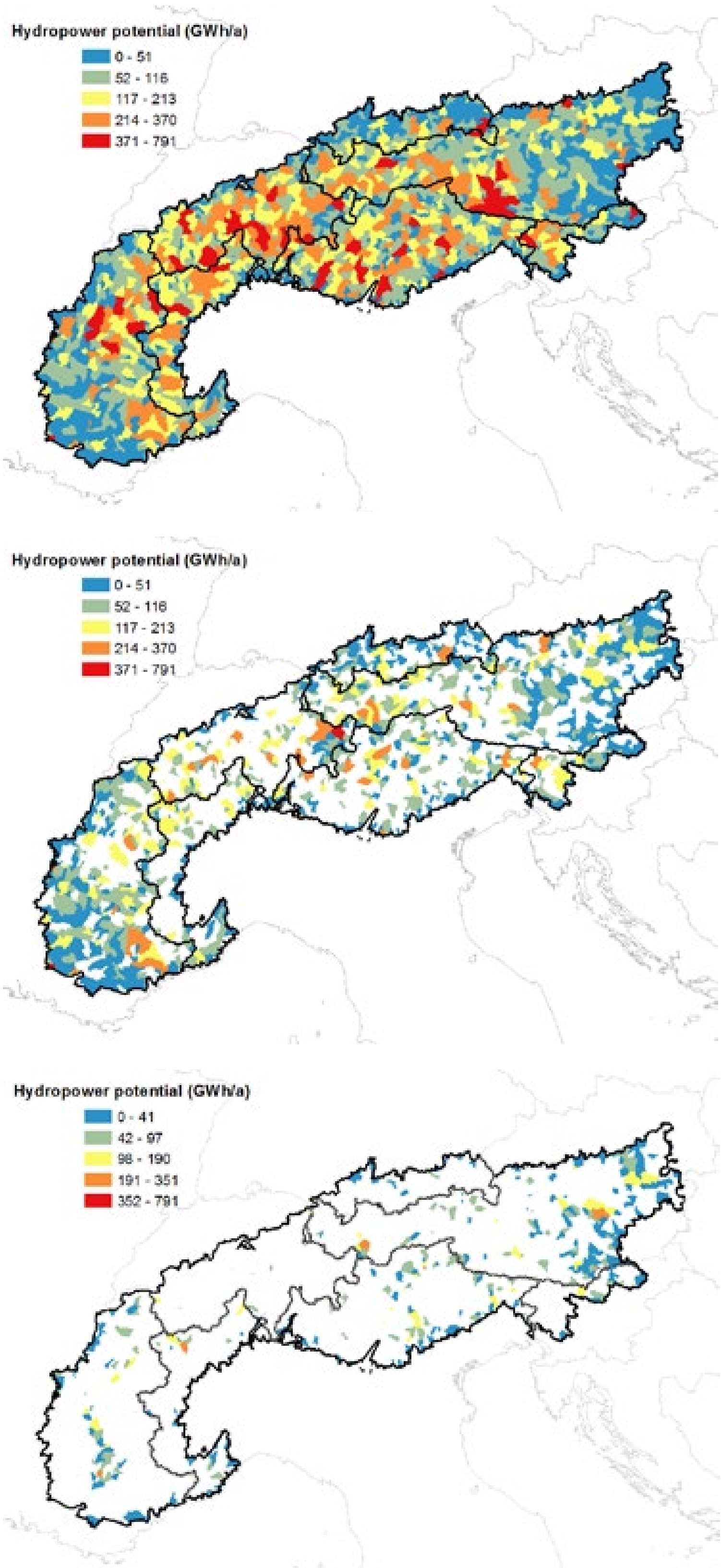
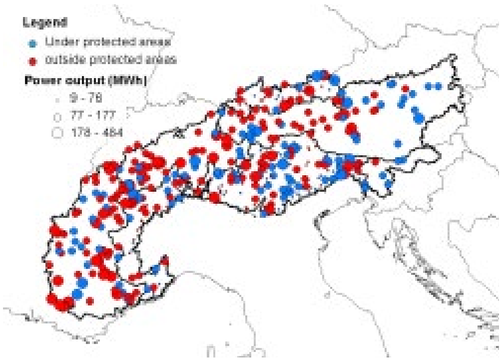


Figure 5.1.4: Hydropower potential of each catchment: left, full theoretical potential. Middle, theoretical potential without catchments with hydropower plants. Right, theoretical potential without existing stations and outside protected areas. [Source: IIASA]

A DSS was applied to identify the economic potential of hydropower plants. A business-as-usual scenario would contribute to increasing the capacity of hydropower stations by 10% up from the actual capacity, with new power stations being set up across the Alps. With a view to cost minimisation and optimisation, most of the plants are located in protected areas. Assuming a strict regime of environmental conservation, the power generated by the hydropower stations would increase the Alpine power capacity by some 10%.



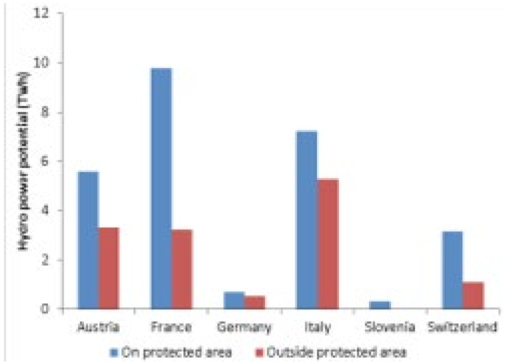


Figure 5.1.5: Optimal location of hydropower plants in the Alps (left) following a business-as-usual scenario and aggregated power generation by country (right). (Source: IIASA)

Bioenergy

It is assumed that woody biomass is used for power and heat purposes. It is shipped mainly by truck and additional power and production plants can be built either in- or outside the Alps where the heat demand is suitable for large facilities. residual heat is assumed to be delivered to local district heating systems, which brings extra income for the production plants, avoids spillover of valuable energy commodities and increases fossil fuel substitutions. From all protected areas biomass can be selected with some restrictions regarding whether it is an area with a high, medium or low level of protection. Figure 5.1.6 presents how restrictions on the collection of biomass from protected areas would impact the power and heat potential under two different fossil fuel price scenarios. Under the first scenario (low fossil fuel cost) a potential of 6.8 and 4.1 TWh/a would be reached for a low and high level of environmental restrictions respectively and under the second scenario (high fossil fuel cost) a potential of 8.8 and 5.6 TWh/a for a low and high level of environmental restrictions respectively.

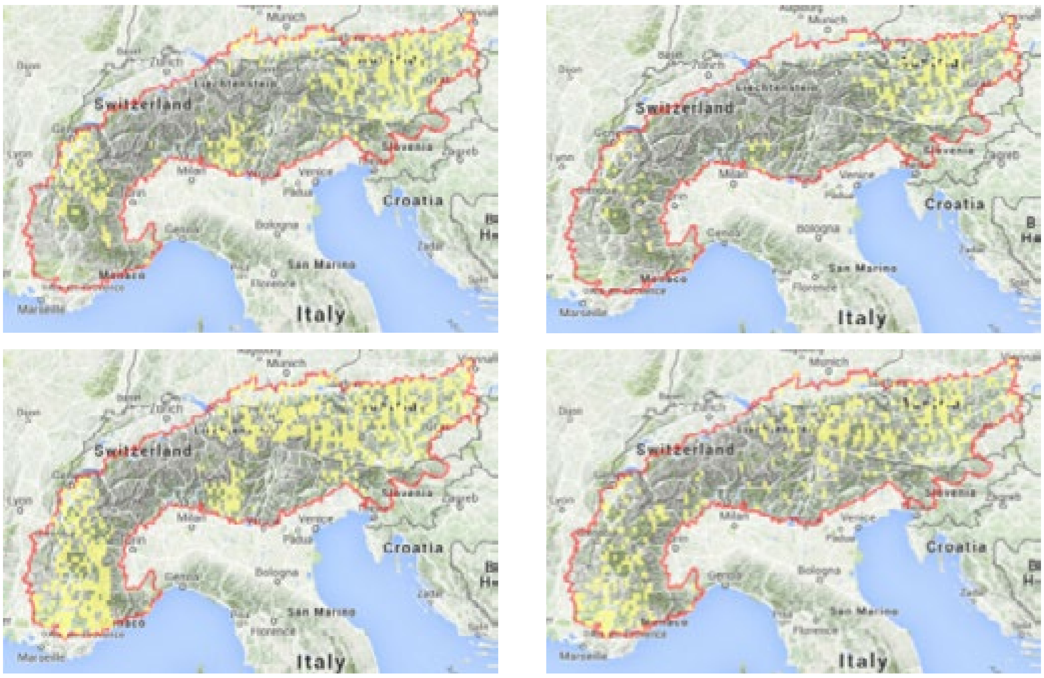


Figure 5.1.6: Overview of biomass used for power and heat production under 4 scenarios: (1) low fossil fuel cost and no environmental restrictions, (2) low fossil fuel cost and a high level of environmental restrictions, (3) high fossil fuel cost and a low level of environmental restrictions, (4) high fossil fuel cost and a high level of environmental restrictions. (Source: IIASA)

Combining the technologies

The model was also set up to identify an optimal mix of renewable energy production in the Alps which takes the protection of the environment into consideration. Two scenarios have been developed, a low protection scenario and a high protection scenario (see chapter 5). The protection constraints of course have some impact on the final potential, which drops by a factor of 4 to 6 depending on the policy in place (factor of the fossil fuel that can be interpreted as a subsidy. The cost is also impacted by the limitations on the use of the protected area. Assuming the same policy remains in place and the production levels remain the same, the production cost would increase by a factor 3. Figure 5.1.7 presents an overview of both the potential and the cost when fossil fuel prices rise (costs being the main driver of the decision-making process for the implementation of renewable energy systems).

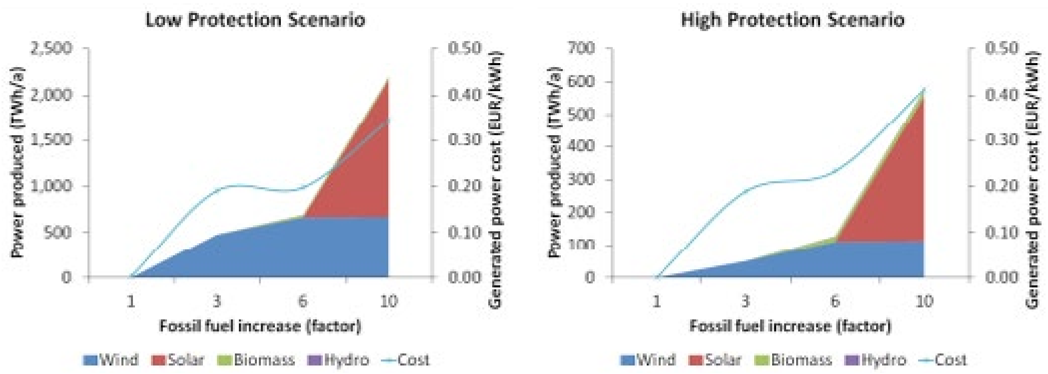


Figure 5.1.7: Potential and cost of renewable energy production in the Alps. (Source: IIASA)

Further Reading

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Interview:
Alpine Convention: towards "Renewable Alps"

Markus Reiterer, Secretary General of the Alpine Convention

Markus Reiterer has been Secretary General of the Alpine Convention since 1 July 2013. He is an Austrian diplomat and lawyer. During his term of office he is putting special emphasis on promoting and implementing the Alpine Convention on international, European, national, regional and local level. He strives to build good cooperation and partnerships with the regions, local communities and civil society organisations.

Question: What role would the Alpine Convention like to play in increasing the production and use of renewable energies under a potential energy transition ("Energiewende")?
Answer: *The environmentally sound development of renewable energies is very important in terms of climate change mitigation. The Alps are affected by European and national polices and targets. In an overall approach towards energy efficiency and a decrease in the use of energy, the Alpine Convention with its energy protocol and climate action plan supports the development of renewable energies and emphasises the necessity of ensuring the compatibility of this development with nature and landscape protection.*

Question: What are the strengths and weaknesses of a participatory approach towards the development of renewable energy?
Answer: *One of the main issues is how compatibility of renewable energy development with nature and landscape protection can be achieved and how, more generally, competition over land use can be dealt with. This can only be addressed with planning and participatory instruments. Of course, sometimes time and persuasions are needed, but only in this way can the various projects be effectively balanced.*

Question: How can the Alpine Convention help to pave the way for a progressive 'renewable energy vision'?
Answer: *In the years 2013 and 2014, experts from the Contracting Parties and from the Observers met in order to determine a "Renewable Alps" vision and collected information and data on the current status of energy development in the Alps – in terms of production, consumption and networks. Currently a report on progress towards the Renewable Alps vision is under preparation. The German Presidency has launched initiatives for energy efficiency and renewable energy generation that are compatible with nature and landscape protection. The Alpine Convention is also supporting initiatives from Contracting Parties such as the Constructive Alps Prize awarded by Switzerland and Liechtenstein.*

Question: In your opinion, what will be the future of renewable energy development in the Alps?
Answer: *I really think the Alps can be a laboratory for more sustainable and effective energy production and consumption. Substantial Alpine experience can be shared between the different Alpine regions and countries and be a motivation for collective improvements.*

5.2 The decision support system and the participatory approach in the Mis and Maè Valleys

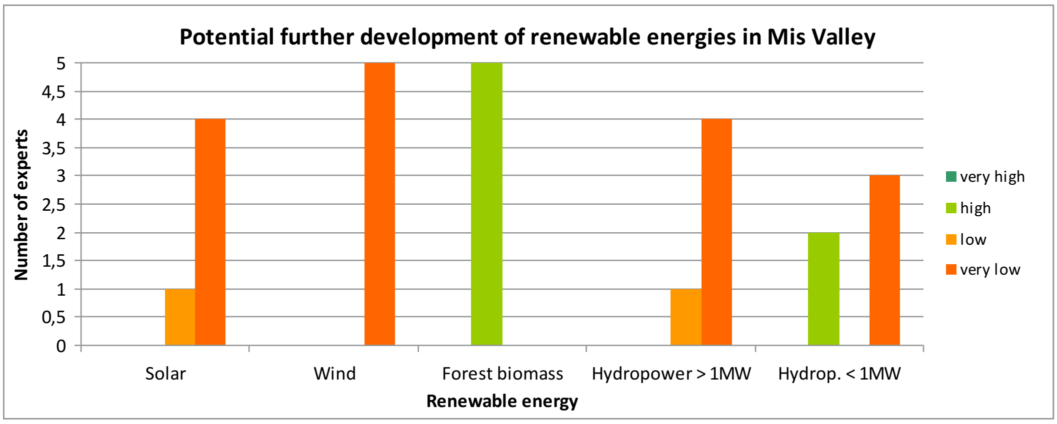
The Mis and Maè Valleys are the two pilot areas in the Veneto Region, in the Province of Belluno, and they are representative of the Italian south-eastern part of the Alps. They are covered by Natura 2000 Network and Dolomiti Unesco sites. Both of the two areas are characterised by the presence of small local communities that manage forests and pastures collectively. Like most of the province of Belluno, both areas have experienced depopulation in recent years.

The Mis Valley (Figure 5.2.1) covers an area of 11,800 hectares and is crossed by the Mis Stream, which is 22 km long. It includes the Sospirolo and Gosaldo municipalities with a total of nearly 4000 inhabitants in 2009, and is characterised by small villages in the northern and southern part. The central part has been abandoned, partly because of the creation of the artificial Mis Lake in 1962, partly because of the great flood events in 1966, and now it off the electric grid. The lake is used for hydropower generation but also for the irrigation of the plains. This central part is also part of the Dolomiti National Park, as it has interesting geological and botanical features.

Figure 5.2.1: The Mis Valley boasts great landscape beauty and many streams and lakes (Photo © Regione Veneto - Mis Valley)

The Maè Valley (Figure 5.2.2) is an area of 23,300 hectares around the Maè Stream (33 km long). It includes the municipalities of Longarone, Forno di Zoldo, Zoldo Alto and Zoppè di Cadore (with a total of 7974 inhabitants in 2009). The valley is important for winter and summer tourism. In former times it was characterised by traditional use of wood for rural building structures, which has now strongly declined; nowadays a considerable amount of wood is still being used for traditional household heating purposes.

Figure 5.2.2: The Maè Valley is popular with tourists for its scenic beauty [Photo © Regione Veneto - Maè Valley]



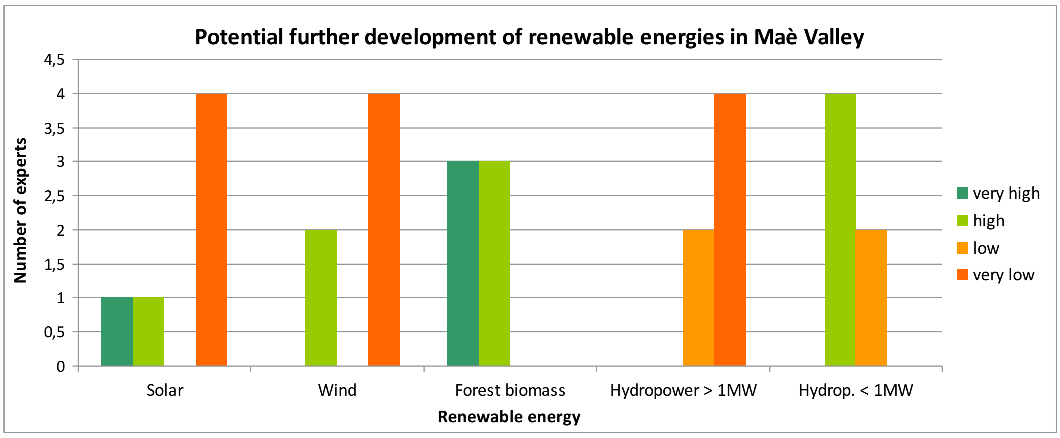


Figure 5.2.3: Potential for further renewable energy development in the Mis and Maè Valleys [Source: EURAC]

Concerning hydropower, the majority of experts underlined that small and large power plants exist already, with licensing schemes for the small ones, so a further development of this source of energy is not an option. Especially for the Maè Valley, experts have suggested some "limitations" on new power plants, for example regarding the maximum distance between intake and restitution. On the other hand, the Mis Valley has recently been affected by a judgement (Corte di Cassazione a Sezioni Unite, n. 19389/2012) regarding an authorisation granted for a hydropower plant inside the Park area. For this reason, the experts have been more careful with their statements regarding this energy source, and have suggested less "invasive" solutions such as hydropower on existing check dams or aqueducts.

Regarding the social and economic aspects evaluated in the questionnaire, the experts underlined how small hydropower could represent a possible source of development for local economies by providing financial support to local communities and through their own involvement with the companies that manage the plants.

Particular attention was given to forest biomass. Experts argued that it could represent a possible alternative as a source of energy that would also guarantee the conservation of open areas such as pastures and meadows which, in the last decades, have been subjected to spontaneous afforestation, causing problems such as loss of landscape variety, fires, tick abundance and so on. The use of forest biomass for energy production is considered important also from an economic point of view: it can represent an opportunity to recover the local tradition of wood cutting, and also be a benefit for landscapes – in terms of the management of forests and open spaces – and, consequently, for tourism.

The DSS r.green was tested in the two valleys for hydropower and forest biomass.

The following parameters were used in the model to produce the first results. Scenarios were hypothesised, together with inputs from experts.

Small hydropower

- Minimum environmental flow, calculated with a formula determined by the Basin Authority. This formula uses a prescribed value for a specific discharge for some specific segments of the streams: this value is used as a basis to calculate the stream's discharge (no direct continuous measurements of the natural discharge are available for the two pilot areas).
- Buffer of 300 m from the Park area.
- Technical aspects of turbine efficiency.
- Existing hydropower plants (for the Maè Valley also the position of small hydropower plants under a licensing scheme was considered).

Scenario determined by the following parameters

- Buffer of 300 m from the Park area.
- Maximum distance between the intake and restitution of a power plant: 100 m.
- Minimum distance between restitution and intake of the next power plant: 200 m

Forest biomass

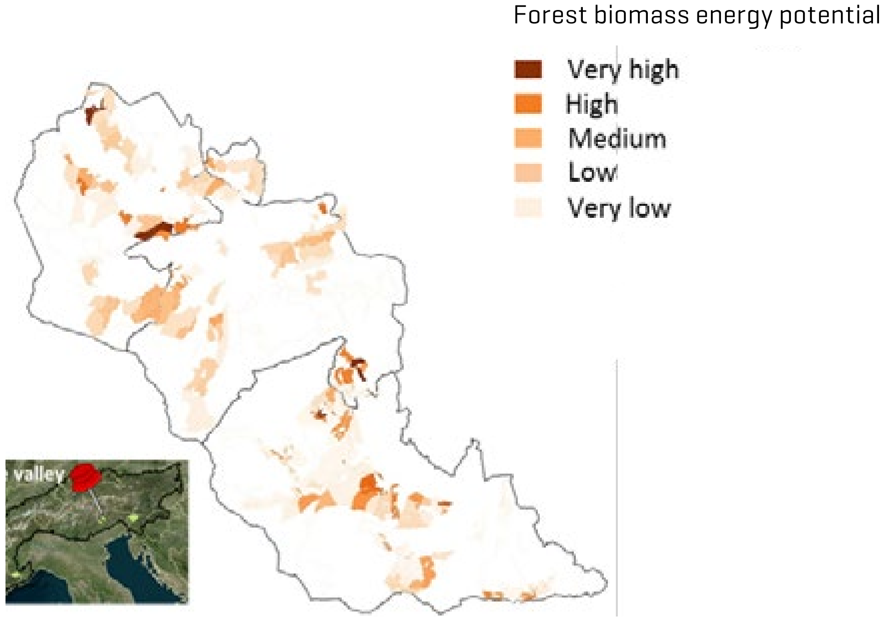
- Forest plans: for the Mis Valley, only the municipality of Gosaldo has a plan; on the other hand, all the municipalities of the Maè Valley have a forest plan. Compartments with a productive function are considered in the model.
- Increment and yield data from the forest plans.
- Mechanisation levels for extraction.
- Costs.
- Collective ownerships.
- ·Evaluation of CO2 savings.

For forest biomass, some scenarios were analysed with respect to the existing power plants in both areas (one in the Mis Valley in Sospirolo, and one in the Maè Valley in Zoppè di Cadore) and with respect to some hypothetical plants (Figure 5.2.4).

The results were discussed with the stakeholders during roundtable discussions.

Figure 5.2.4: Map of forest biomass energy potential in the Maè valley (Source: University of Trento)

Financial



An important step was made with the participatory approach, developed with local communities. The methodology is summarised in chapter 2.1.

The participation of local people (see Table 5.2.1) was useful for evaluating some of the ecosystem services that are related to water and wood, as the experiences and knowledge of residents helped to produce more realistic and detailed maps, which were initially only based on scientific data. At the same time, the stakeholder dialogue provided an opportunity to collect suggestions and comments on the results of the DSS and on resource management in general in the two areas.

Table 5.2.1: Local stakeholder participation in focus group discussions

Focus Group	Category
Mis valley Tot. number of participants to the meetings: 30	Local administration
	Environmental associations
	Local Associations
	Sport and recreational associations
	Other associations
Maè valley Tot. number of participants to the meetings: 38	Local administration
	Collective ownership “Regole”
	Environmental associations
	Sport and recreational associations
	Citizens

The main results from this participatory approach are summarised below.

1. Suggestions implemented in the DSS r.green

The stakeholder discussion provided interesting suggestions and adjustments of the first results from r.green and the hypothesised scenarios.

In particular, it was suggested that hydropower should not be regarded as a potential energy source that needs to be investigated, except in the case of small off-grid power plants in specific areas. For example, the stakeholders suggested that an analysis should be carried out to determine what could be obtained from the DSS that would help to supply an "info point" in the Park area in Sospirolo with electricity. Figure 5.2.5 shows the map that was produced. Starting from an evaluation of the average annual amount of electricity potentially required by the "info point" (about 10 kW), the analysis was focused on a stream near the Mis lake where a small hydropower plant had already been in place and used for energy production until the 1960s. With the DSS it was determined which parts of the stream could be used to produce the required energy, as well as the length of the segments. The aim was to "choose" the shortest segment with the required production potential. It should be noted that the results strongly depend on the accuracy of the river bed profile and on the resolution of the digital elevation model.

Recomended

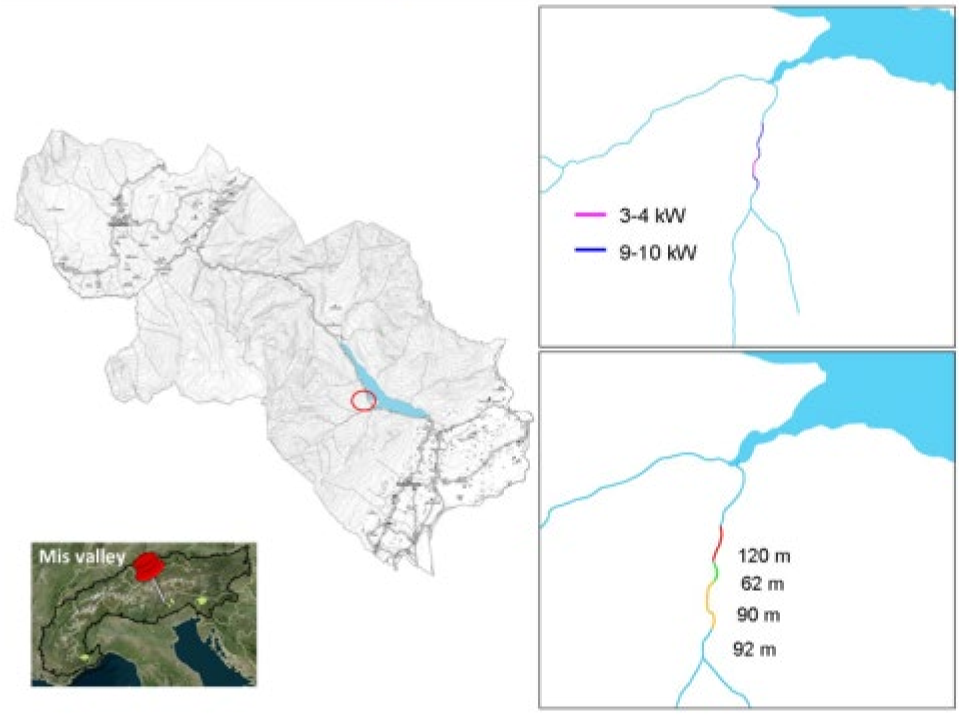


Figure 5.2.5: Map showing the hydropower potential of a stream near Mis lake (Source: Regione Veneto and EURAC)

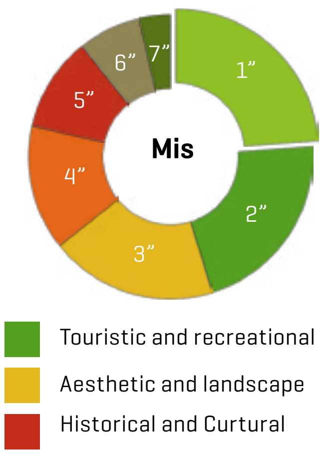
For forest biomass some interesting suggestions were provided. In particular for the Mis Valley, stakeholders suggested that of the amount of energy that could be produced from material obtained from cleaning near roads and electric power lines should be analysed. As the forest plans could not be used, data were gathered from the project NESBA (Interreg IV Italy – Austria 2007/2013), referring not to forest compartments but instead to forest typologies.
The results are described in more detail in the report Progetto recharge.green: equilibrio fra energia e natura (publication in Italian by Regione del Veneto, available on the recharge.green web site).

2. Ranking of values

Stakeholders were asked to rank ecosystem services values:

- Environmental value
- Economic value
- Touristic and recreational value
- Social value
- Emotional-sentimental value
- Historical and cultural value
- Aesthetic and landscape value.

Then they were asked to justify their choices: all the collected information, especially the data put on maps directly were used to define new input files for the DSS. In particular, emotional-sentimental, historical-cultural, and social values were used to produce a map showing the intrinsic value of the respective areas. The map was used for a module ("recommended") of r.green in an analysis where areas were defined that were to be excluded from the production of energy because of their intrinsic value.
Figure 5.2.6 shows the ranking for the two valleys. As one can see, the priorities are quite different. Because the Dolomiti National Park makes up a large proportion of the Mis Valley (the entire central part), the environmental value comes first. In the Maè Valley, on the other hand, due to its specific features and its recent depopulation, the stakeholders felt that the need to increase opportunities for work and services was most important there, to enable people to live in the valley. As someone reported during the meetings, "first technological networks and then environmental networks" meaning that if people can stay and live there, then they will also be interested in environmental issues and do something about them.



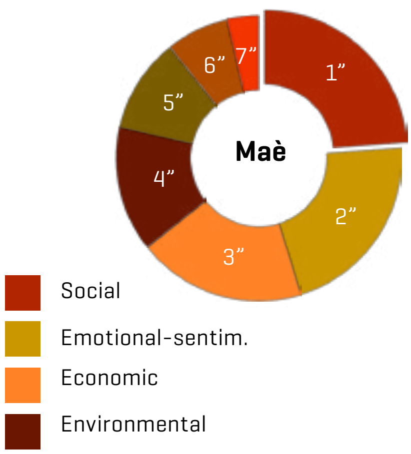


Figure 5.2.6: Classification of values. The two graphs show the rankings of the values for the Mis and Maè valleys. The areas have different colours depending on the values represented and different sizes depending on the importance placed on them by the stakeholders (Source: Regione Veneto)

3. Local, social and political suggestions

The involvement of stakeholders was extremely fruitful. Many suggestions were collected concerning a variety of different topics and aspects of the project and the methodology adopted. These can be summarised as follows:

- It is important to evaluate energy savings and efficiency measures as part of the 20-20-20 goals. Before analysing the potential for renewable energy, especially where energy independence is at stake, it is important to have an idea of the real energy consumption in the valleys;
- Local people should be involved right from the beginning of the process of energy planning;
- In the case of hydropower, it is necessary to preserve the last untouched streams; minimum environmental flows should be evaluated in a wider sense;
- Forest biomass can represent a source of energy and support local economies, and its use can be favourable for the maintenance of open spaces and for controlling spontaneous afforestation. However, simpler laws are needed, especially regarding the management of private/public forest areas.
- High value woods should be preserved for other economic activities;
- Local authorities ask for the opportunity to plan the use of natural resources at the medium scale (within the province), to identify areas that need to be preserved, and to be able to express a binding opinion on authorisation procedures.

Interview:
What makes a DSS useful for public administrations?

Dr. For. Sergio Zen, Regione del Veneto, Parks Biodiversity, Forest Planning and Consumer Protection

Dr. For. Sergio Zenis a civil servant at the Regione del Veneto Section for Parks, Biodiversity, Forest Planning, and Consumer Protection. He is responsible for the forest planning office and has been working on procedures regarding the management and monitoring of the Veneto forest areas for many years.

Question: : Considering your experience in technical aspects of public administration, what are the features/characteristics of a DSS that would make it really useful and applicable for natural resource management in mountain areas?
Answer: *Information must be relevant and updated to build a useful database, at several levels – with "hierarchical" information. A DSS can be easy to understand in technical and sector-based fields; however, if it is also applied for non-sectorial fields, the information must be defined in a hierarchical way, from a level that is more general to a more specific one.*

Question: How can a DSS help to use resources from forest areas in a better way and to guarantee ecological sustainability in the use of these resources themselves?
Answer: *To guarantee both an economically and ecologically sustainable use of forest resources, it is important to have detailed and coherent information on the dynamic evolution of the area of interest, and to update this information. For example, the structure of forests changes slowly, while other habitats can change more rapidly, for both natural and human-made reasons.*

Question: What are the advantages that a participatory approach involving the local population can have for the use of forest resources for energy purposes?
Answer: *IIt is important to pay attention to the communication with stakeholders and local communities to make it more efficient and continuous, rather than sporadic. This can help to avoid controversies and conflicts with management and planning choices. On the other hand, communication provides opportunities for including suggestions, as well as historical and territorial knowledge that only the local communities can provide.*

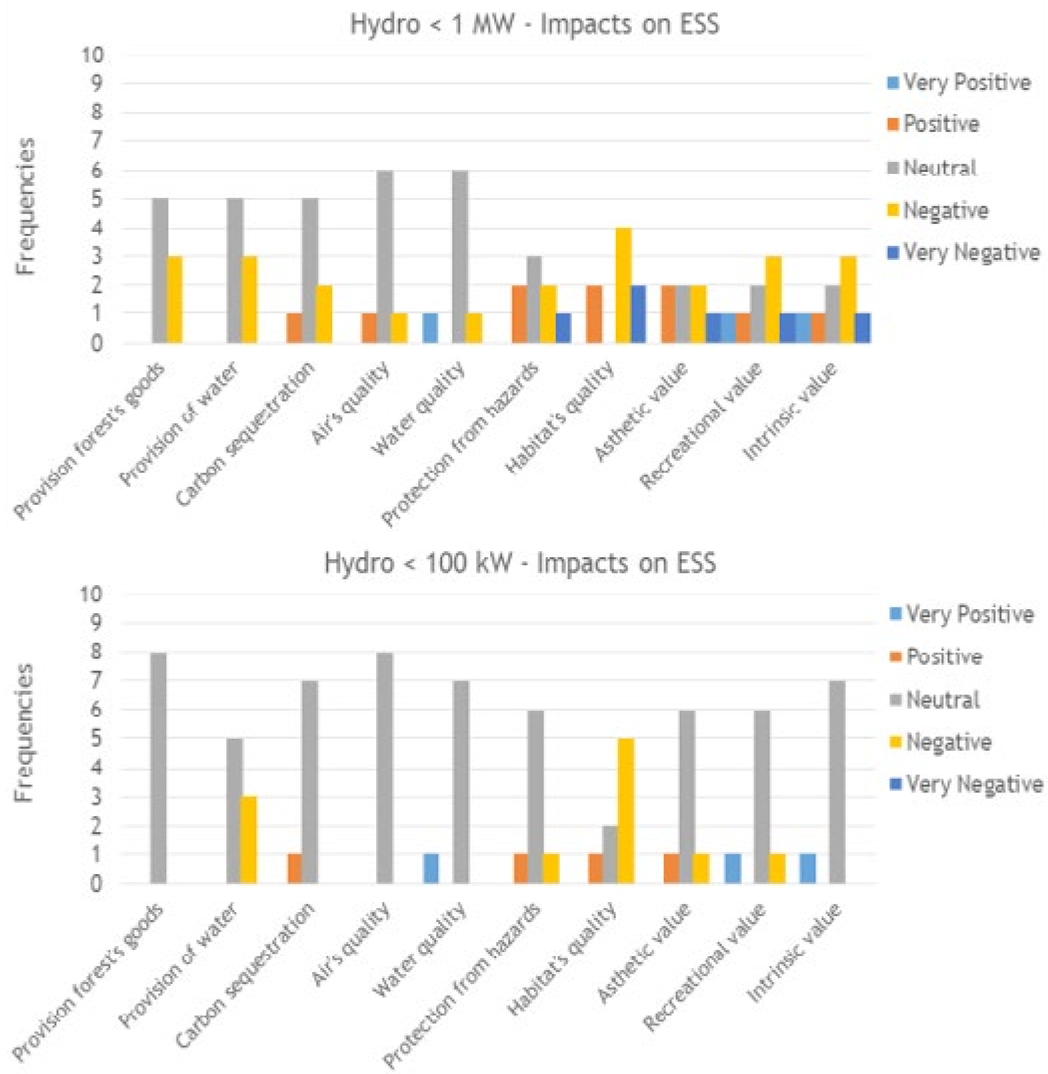
Question: Considering your experience, what could be the future of renewable energy development in the Alps?
Answer: *Renewable energy sources, by nature, are spread over a wide area; their use involves collecting, planning and redistributing. The challenge will be to find the best and lowest impact solutions for these three activities, from an Alpine mountain perspective.*

5.3 Trade-off between energy exploitation and ecosystem services in Gesso and Vermenagna valleys

The Gesso and Vermenagna valleys are located in north-western Italy, in the Piedmont Region. The two valleys include seven municipalities (Valdieri, Entracque, Roaschia, Roccavione, Robilante, Vernante and Limone Piemonte), with a surface area of approximately 51,500 ha. In 2010 the population was about 10,000 inhabitants with a density of 0.194 inhabitant/ha. The Maritime Alps Natural Park and Natura 2000 sites of the Maritime Alps are the most important protected areas of the two valleys. The principal renewable energy used is hydropower. In the study area, there are 21 hydropower plants and the total installed power is 1137.37 MW. The most powerful power plants are sited in Entracque (1065 MW) and in Andonno (65 MW) and represent more than 99% of the installed capacity. These big plants were built before the establishment of the Natural Park of the Maritime Alps and the Natura 2000 sites. The power plant in Roccavione is also significant (1420 kW). It should be noted that in Robilante there is an intake that derives water for the hydroelectric plant located in Borgo San Dalmazzo, which is outside the boundaries of the study area. This hydropower plant has a capacity of 2630 kW. The local economy is based mainly on tourism (about 121,000 tourists per year) and secondarily on agriculture and forestry. In this pilot area we have analysed the possible use of forest biomass, which was identified as the most exploitable renewable energy source, and the current and future development of hydropower. In this section, we provide an overview on the trade-off and conflict analysis, starting from the opinions of technicians (experts) and citizens and ending with a spatial evaluation produced by the decision support system.

We interviewed eight experts belonging to different branches such as hydraulics, forest management and environmental protection, who provided their different points of view about the renewable energy potential and impact. Qualitative analyses of relevant impacts on ecosystem services, society and the economy were carried out for two cases: a “high”/“very high” and a “low”/“very low” renewable energy potential, so as to collect more feedback on the experts´ perceptions. More details about the experts’ perceptions can be found in the project report on Renewable energy and ecosystem services in the Alps: Status quo and trade-off between renewable energy expansion and ecosystem services valorisation, which is available for download on the recharge.green website. Hydropower in particular is perceived to have a negative impact on ecosystem services overall, but this negative perception changes slightly if the capacity of a run-off plant decreases from one MW to lower than 100 kW (Figure 5.3.1).

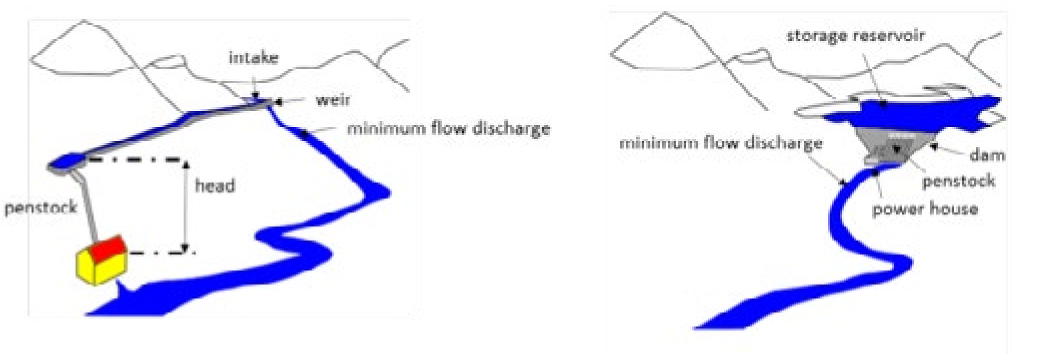
Figure 5.3.1: Expected impacts on ecosystem services of a run-off plant with different capacities in the Gesso and Vermenagna Valleys. (Source: EURAC)



Experts' opinions do not always correspond to citizens' views. For this reason, and to collect information about the preferences of the residents in the Gesso-Vermenagna pilot region, we used a structured questionnaire composed by 27 closed-ended questions. The structured questionnaire was administered face-to-face to a sample of residents in the two valleys. The questionnaire was structured to gather information on renewable energy in general, and about the local development of solar photovoltaic power, windpower, hydropower and forest biomass more specifically. The respondents assessed - using a 5-point Likert scale - the current level of development and the potential future development of renewable energy in the Gesso-Vermenagna valleys, and the impacts of renewable energy development on ecosystem services (Figure 5.3.3).

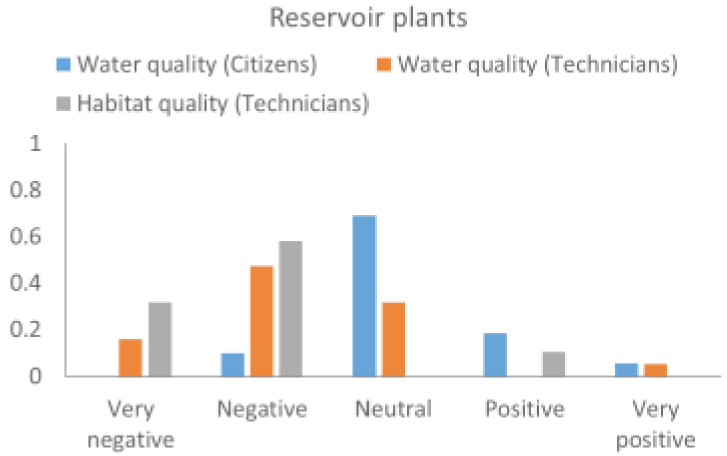
Figure 5.3.2: Run-off plants (small hydropower) classified on the basis of the plant's capacity for the expert survey and reservoir plant (large hydropower). (Source: EURAC)

Run-off plant (Small Hydropower) **Reservoir plant (Large Hydropower)**



The perceived impacts of renewable energy development on ecosystem services were evaluated only for hydropower, distinguishing between reservoir plants (large hydropower) and run-off plants (small hydropower) (Figure 5.3.2). It should be noted that the citizen's perception can disagree with the experts' opinions. For example in the case of large hydropower plants, citizens of the two valleys do not feel negatively about the impact of hydropower development on water quality, while the experts agree that it would put negative pressures on wildlife habitats and on water quality.

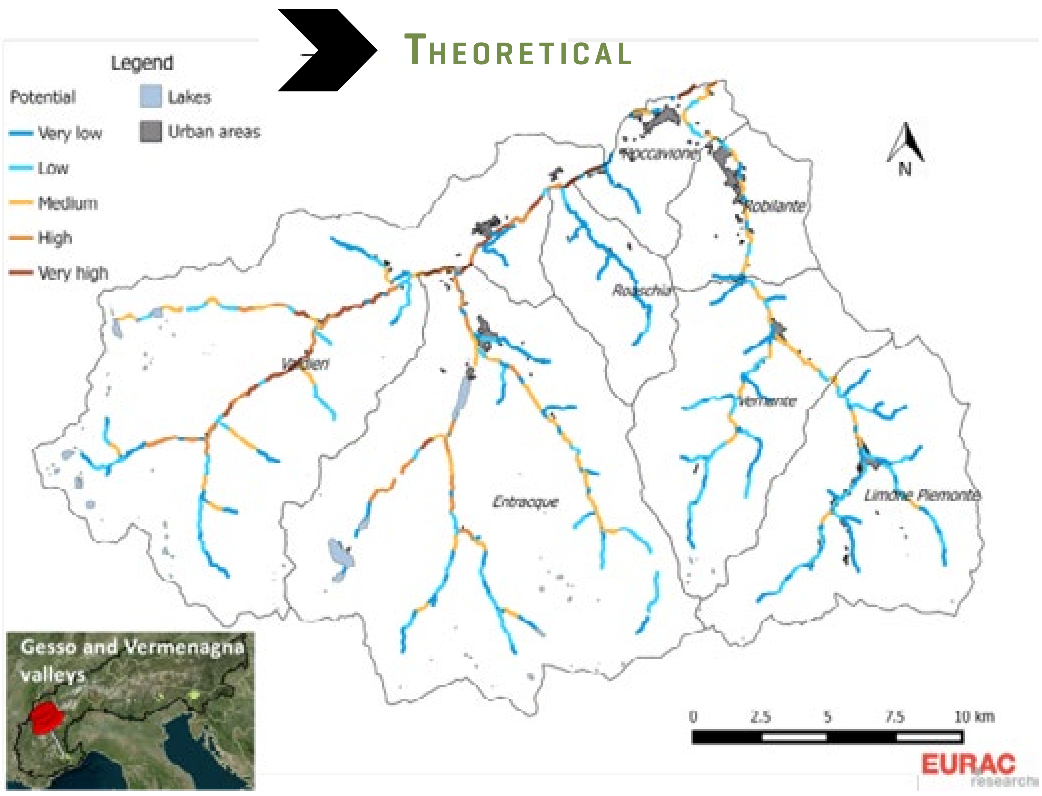
Figure 5.3.3: Perceived impact on water quality: citizens´ and experts´ perceptions. [Source: EURAC]



The survey among experts and citizens was only the first step of this analysis. Possible conflicts on the use of the water resources were identified during consultations with a focus group composed of local stakeholders. By integrating the stakeholders' opinions into the r.green decision support system, we were able to analyse possible trade-offs and existing conflicts between renewable energy exploitation and ecosystem services.

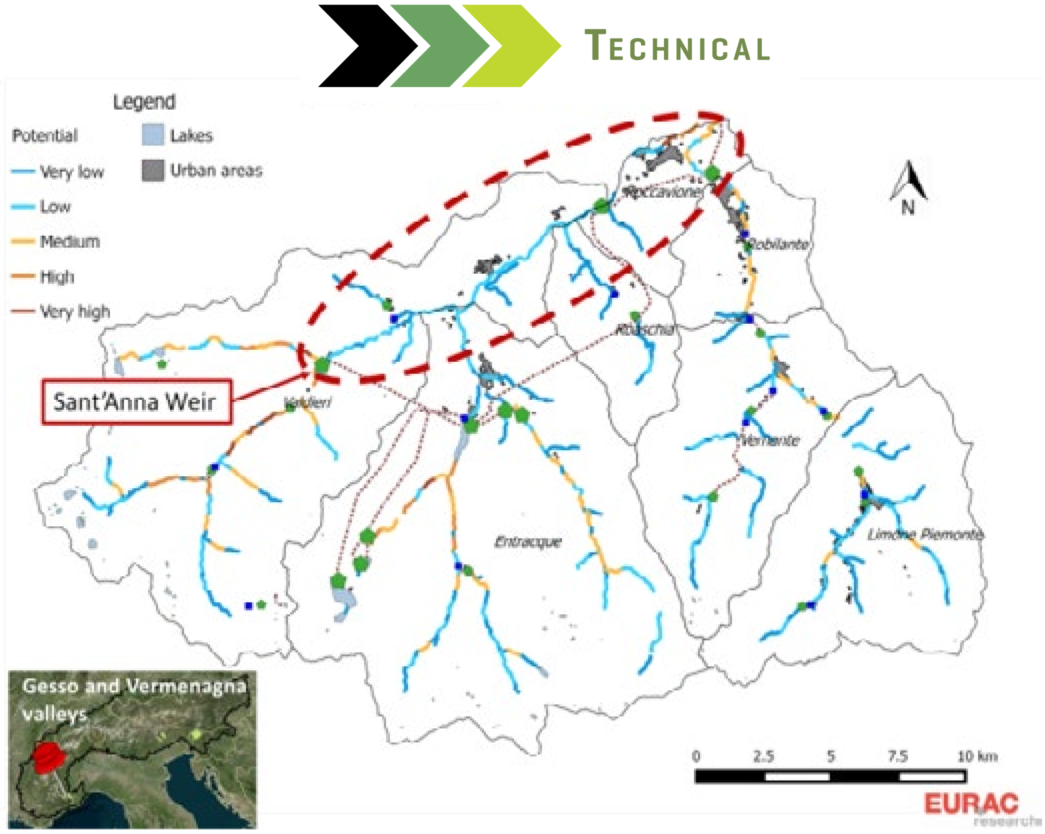
Starting from the r.green.hydro.theorethical module, we considered the energy potential in the case of run-off plants. The theoretical potential is quite high in the two valleys as shown in the map (Figure 5.3.4), where the segments are classified into segments with very high (dark brown) to very low (dark blue) potential.

Figure 5.3.4: Theoretical hydropower potential in the Gesso and Vermenagna valleys [Source: EURAC]



Currently, the hydropower reservoir of Entraque is used to store water not only for energy purposes but also for the irrigation of agricultural plains; consequently, it changes the water availability downstream from the Sant'Anna weir. In fact, downstream from the Sant'Anna village the water quantity in the river is about 500 l/s and decreases to about 180 l/s during the summer period as a result of irrigation as provided for in the regional law (Art. 9, D.P.G.R. 17 luglio 2007, n. 8/R).The priority is the use of water for provisioning services, i.e. irrigation, which is held to be more important than possible hydroelectric uses downstream from the weir or other ecosystem values (biodiversity, habitat, etc.) (Figure 5.3.5).

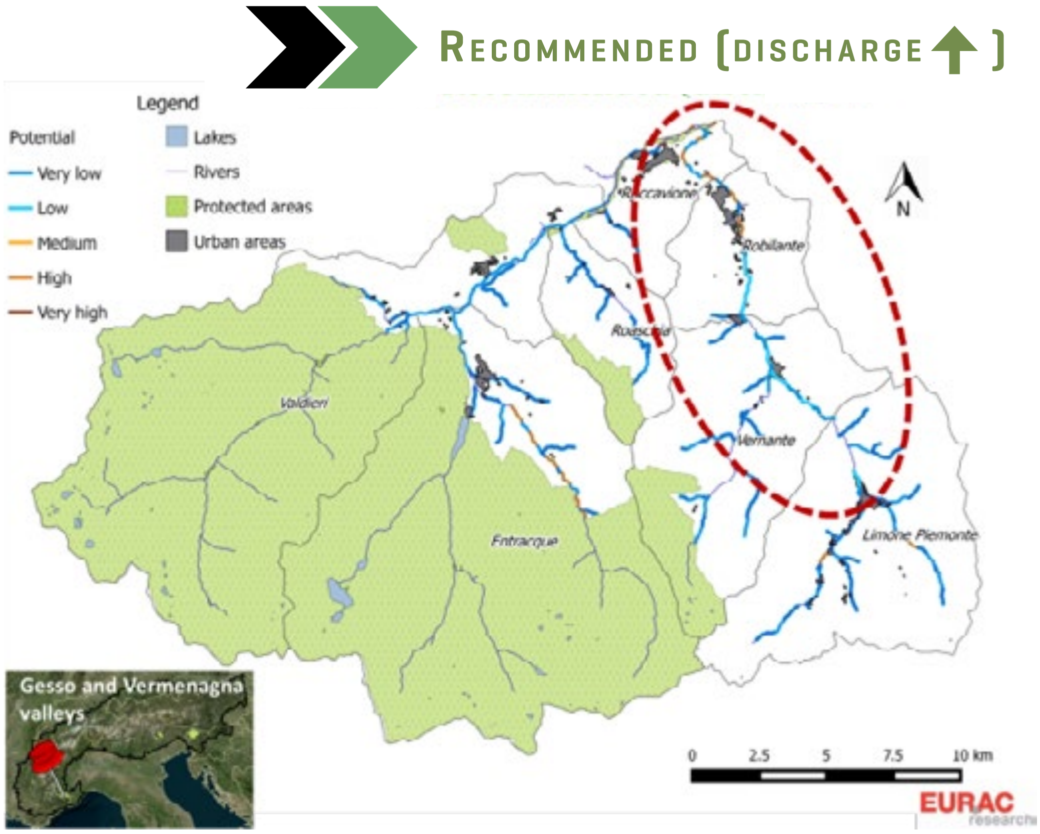
Figure 5.3.5: Decrease of hydropower potential downstream from S. Anna due to the current use of water not only for hydroelectric but also for irrigation purposes. (Source: EURAC)

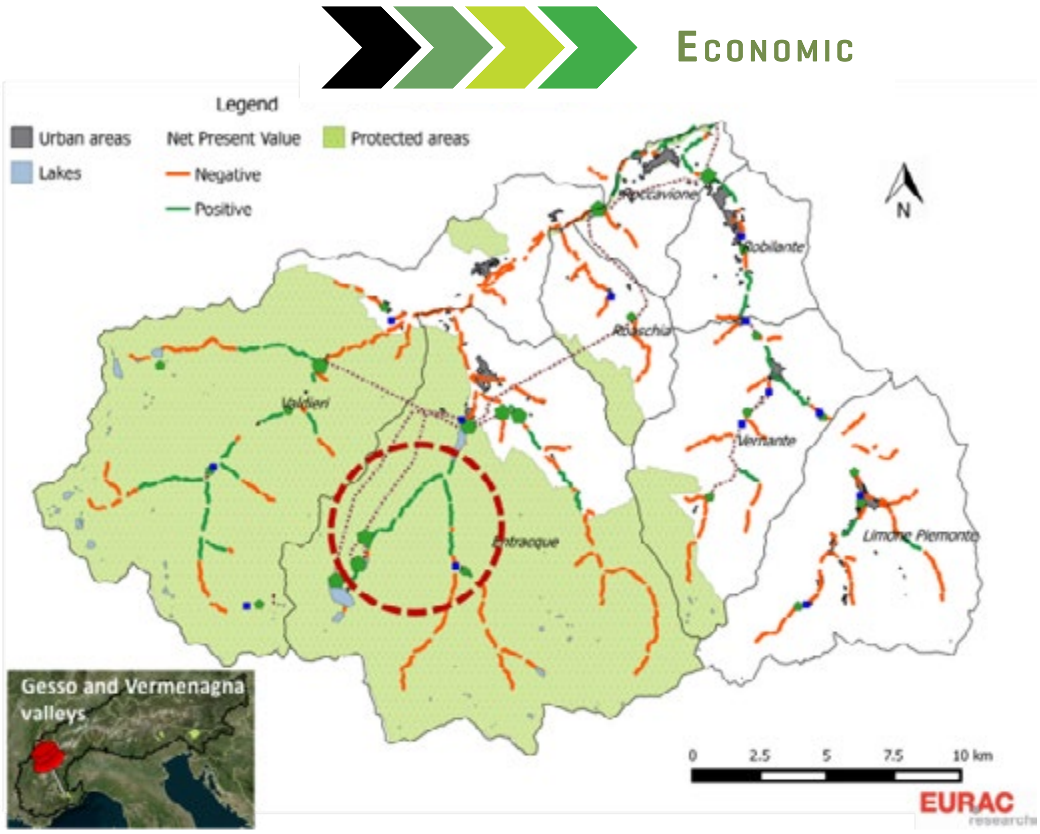


Secondly, during the focus group meetings we asked the stakeholders to identify river zones with a high recreational or aesthetic value. The stakeholders identified a cycle path along the river close to Vermenante. In order to maintain or increase the aesthetic value of the river, a greater quantity of water should be assured. In this case, we set the minimum flow discharge equal to 50% of the natural discharge computed, referring to the local plan ("Piano di tutela delle acque", introduced in 2007). The energy potential changes from medium to low in several river segments in the highlighted area.

Finally, local energy producers identified areas with a high energy potential and where the financial feasibility of hydropower can be assumed within the protected area of the Natural Park of the Maritime Alps. The r.green.hydro.economic module was run by setting the price of energy equal to 0.1€/kWh. The map (Figure 5.3.6) shows the river segments with a positive net present value in green, with the sites suitable for new hydropower plants only selected on the basis of economic criteria. These sites are at the heart of the protected area, where new artificial water flows cannot be designed. This is a clear trade-off between energy production and existing plans for biodiversity preservation. The protected area has a high biodiversity value that should be preserved. Only plants in secondary networks or aqueducts are therefore allowed.

Figure 5.3.6:
Economic feasibility of run-off plants in the Gesso and Vermenagna valleys. (Source: EURAC)





The results of the decision support system r.green confirm that the tool has the potential to enhance the understanding of planning considerations and to increase the objectivity of trade-off and conflict evaluations. In fact, the first results were a starting point for the discussion with local stakeholders. By integrating the stakeholders' needs and expert knowledge in the r.green GIS tool, a spatial analysis of existing and potential conflicts has been possible.

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   Download: http://www.recharge-green.eu/wp-content/uploads/2015/06/WP5-Recomendation_kompr.pdf
4. Website of the Maritime Alps Natural Park http://www.parcoalpimarittime.it/

5.4 Strategic environmental assessment in the bioenergy sector: the natural capital concept and the environmental impacts

When the expansion of renewable energy production is planned without careful investigation of the potential consequences of the envisioned production and management strategies, the intensification of land use often leads to the depletion of natural resources. The strategic environmental assessment (SEA) procedure is a useful tool for anticipating the potential effects of new power plants.

In the case of forest biomass use for bioenergy the interactions between the human energy need and natural resources are particularly important. Harvesting forest biomass produces both positive and negative effects. On the positive side, using wood for energy rather than fossil-fuel based energy sources, contributes to the reduction of $CO2$ emissions. Wood collection can also reduce forest fire risks. Some people also perceive forest paths that are "clean" of dead wood and other plant residues as more aesthetic. On the other hand, forest biomass withdrawal depletes forest soil fertility with negative consequences on resilience and biodiversity. In addition, the protection function of the forest against natural hazards such as landslides and rock falls may be adversely affected by extensive wood collection.

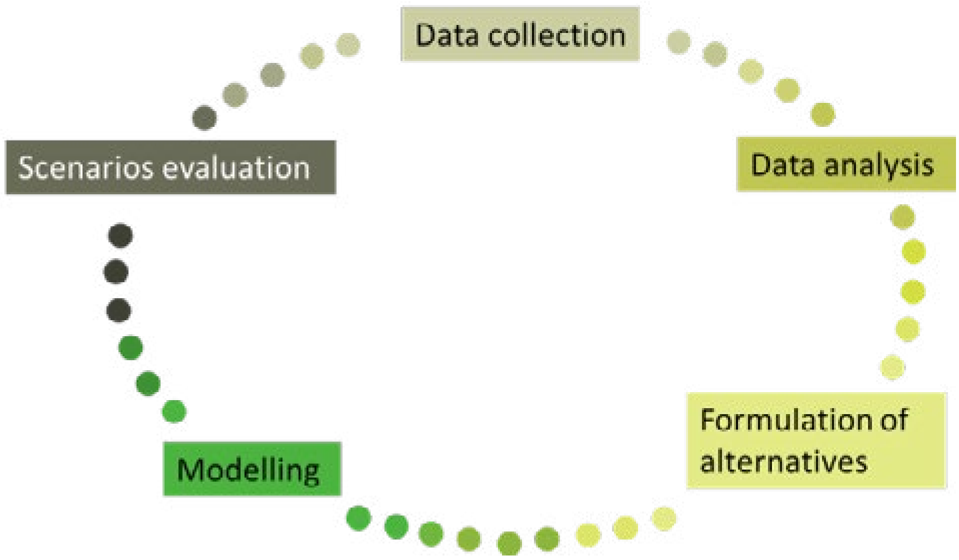
An SEA represents an important tool to take into account these and other possible effects. Although the environmental aspects of plans and programmes are of particular concern, these are not the only areas of concern in an SEA. The SEA procedure also deals with the impacts of planned activities on society, on human health and on social factors concerning the affected territory. The European Directive 2001/42/CE foresees a series of criteria that the SEA procedure should consider:

- the probability, duration, frequency and reversibility of the effects;
- the cumulative nature of the effects;
- the trans-boundary nature of the effects;
- the risks to human health or the environment (e.g. due to accidents);
- the magnitude and spatial extent of the effects (geographical area and size of the population likely to be affected);

- the value and vulnerability of the area likely to be affected due to:
- special natural characteristics or cultural heritage;
- exceeded environmental quality standards or limit values;
- intensive land-use;
- the effects on areas or landscapes which have a recognised international, national, or local protection status.

The Directive requires the indicators to be considered, but it does not suggest a specific procedure. Thus both in theory and in practice the applied methodologies vary significantly from case to case. Despite the difference of approaches and considered variables, all implementations of the SEA procedure share the same objective: They are aimed at comparing alternatives for the identification of the most viable and effective pathway for future development. Against this background, a decision support system (DSS), such as r.green, represents a useful tool for the implementation of an SEA in the energy sector by accounting for the environmental impacts of new power plants including all the ancillary activities involved.

Figure 5.4.1:
The steps for implementing an SEA procedure
(Source: EURAC)



We implemented a 5 step SEA procedure (Figure 5.4.1) for addressing the prescription of the Directive:

1. Data collection
2. Data analysis
3. Formulation of alternatives
4. GIS modelling
5. Evaluation of scenarios

A case study from the Gesso and Vermenagna valleys (Italy) serves as an example of this procedure. The study area of Gesso-Vermenagna (44° 15' 00" N, 7° 32' 00" E) is located in the north-western part of Italy (Piedmont Region) close to the French border. 32,000 ha of the area are protected areas (Maritime Alps Natural Park and Natura 2000 sites). The main land uses are forests (42%) and pastures (33%). Regarding ownership about 45% are public forests while the remaining 55% are private forests. The main forest types are European beech forests (11.500 ha) and chestnut forests (2.700 ha). There are also smaller extents of mixed forests with maple, linden and ash. The average standing stock is 183 m3/ha with some important differences among forest types: 245 m3/ha in chestnut forests, 156 m3/ha in mixed broadleaved forests and 149 m3/ha in European beech forests. The average annual increment is 7.73 m3/ha/year. The harvesting rate varies depending on the forest type: 45% of the annual increment is in European beech and mixed broadleaved forests, and 80% in chestnut forests.

The environmental impacts of increasing biomass energy use were assessed by considering changes in the natural capital value. Since removing biomass from forests has an impact on several ecosystem services, we implemented the SEA procedure by assuming that removal of more biomass for energy results in higher impacts on the environment. The underlying idea for implementing the SEA procedure is that the more biomass is used for energy, the higher is the impact on the environment.

Data Collection

Data collection was supported by representatives from the Alpi Maritime Natural Park. In order to apply an SEA, spatially explicit forest data were needed. In particular, we required and collected data on forest annual increment, forest types, forest roads and main local typologies of forest mechanization. In addition, data were compiled for estimating the economic value of selected ecosystem services. In this way we were able to assess the current value and project how this value may change after the withdrawal of forest biomass for energy purposes. Finally, we conducted a questionnaire with local experts to gain a better understanding of their perception about the impact of exploiting biomass for bioenergy.

Data analysis

The focus of data analysis was on i) assessing current local energy consumption; ii) the local potential for further development of biomass energy; iii) the expected impact of increased biomass use for energy, both on the ecosystem services and on local socio-economic development. The data on the expected impact on ecosystem services are particularly important because they facilitate an assessment of the changes in natural capital following removal of biomass for energy from the forest. In the Gesso and Vermenagna valleys, we interviewed eight experts in the fields of renewable energy and nature conservation who estimated the following impacts of increased biomass removal on ecosystem services:

1. A negative impact on protection against natural hazards (e.g. landslides and erosion). The average impact on the value of protection was assessed to be around -15%;
2. A negative impact on the carbon sequestration service. Forests and forest soils are an important carbon sink counteracting negative effects of increased greenhouse gas emissions. Removing biomass from forests reduces future quantities of sequestered carbon. Such impact was assessed to be around -14%.
3. A slightly positive impact on the recreational value of the forests. A positive relationship between recreation and forest biomass withdrawal is justified because, after collecting wood, forest seems to be much more clean and well-kept. The positive impact was estimated to be around 8%.

The cited percentages are used to model the variation of the natural capital stock following the withdrawal of forest biomass for bioenergy. We´ve generated maps depicting ecosystem services to gain a better understanding of the spatially-explicit impacts of biomass removal and highlight the areas most affected.

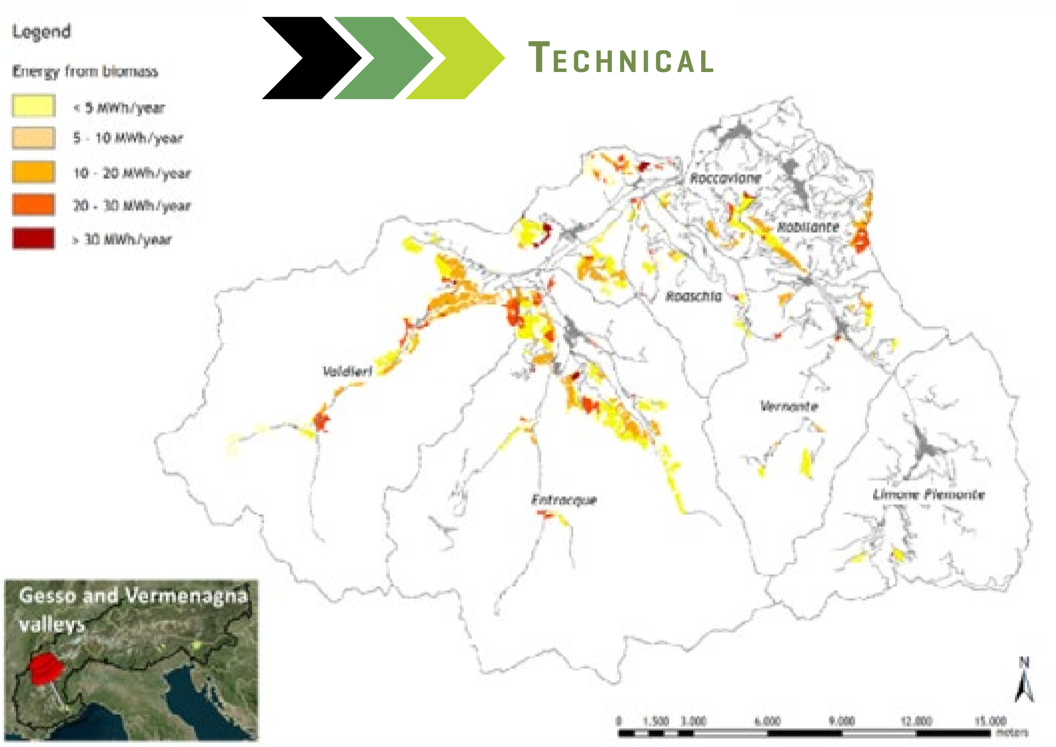
Formulation of alternatives

The formulation of alternatives is a crucial step in an SEA, as it highlights the impacts of defined alternative pathways. In the Gesso and Vermenagna valleys we agreed with the representatives of the Alpi Marittime Natural Park to define two scenarios. The first one foresees the exploitation of public forests, the second one both public and private forests.

GIS Modelling

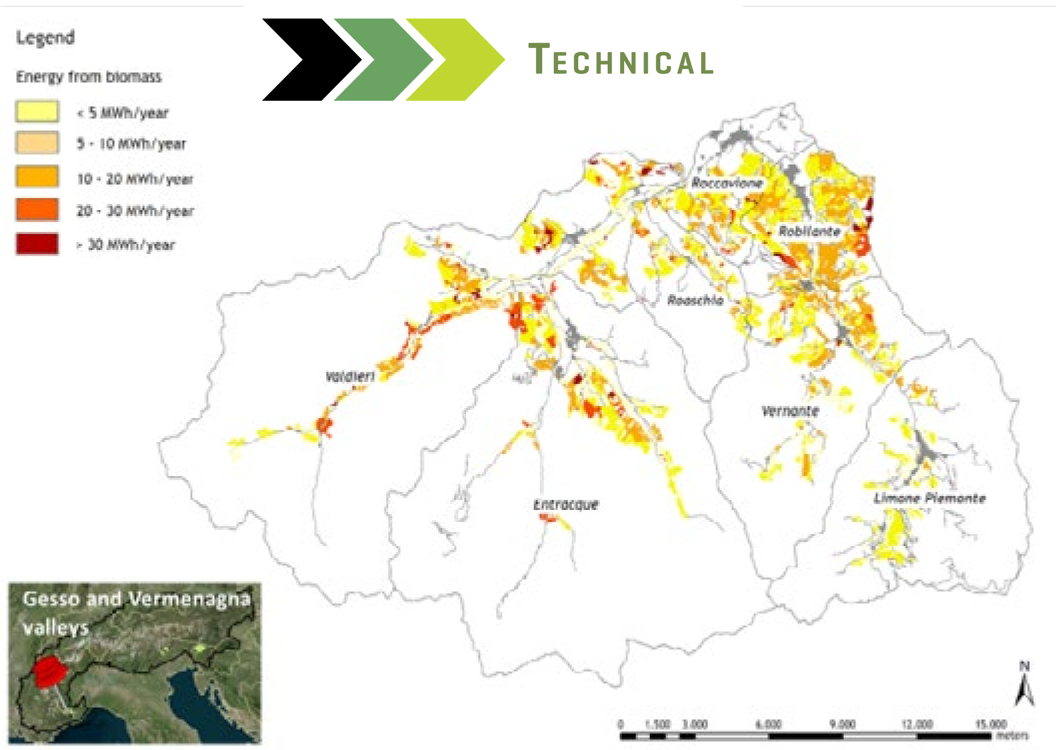
r.green.biomassfor calculates the energy potential from biomass sources using a modular structure. Each module calculates the energy potential for each of the following assumptions: theoretical, legal, technical, recommended and economic potentials (see Chapter 3.4). The technical potential represents the amount of forest biomass that can technically be extracted from the forest, i.e. with the existing technology. We analysed the impact on selected ecosystem services based on an extraction level derived from the calculation of technical potential. Although it is unlikely to be recommendable to extract the entire technical potential, we showed this map during the focus group because it is more flexible and to produce scenarios under different assumptions. The technical potential was then integrated with stake-holders comments to derive the economic potential. GIS modelling allows the creation of a potential map showing the quantity of bioenergy that can technically be extracted, as shown in Figure 5.4.2 for the first scenario and Figure 5.4.3 for the second scenario.

Figure 5.4.2: Scenario 1: Potential of the forest biomass for bioenergy from public forests, exploitable with technical parameters calculated by r.green.biomassfor. technical. The outputs of the model were provided by the University of Trento who developed the module r.green.biomassfor. [Source: University of Trento and EURAC]



The economic potential foresees the construction of a (hypothetical) biomass plant in the valley. The location is important because the transport costs from the forest to the plant may change significantly depending on location.

Figure 5.4.3: Scenario 2: Potential of the forest biomass for bioenergy from both private and public forests calculated by r.green.biomassfor.technical. [Source: University of Trento and EURAC].



For both scenarios we assumed construction of a biomass plant. The location, between the two valleys, was chosen with the aid of a local expert with the rational to allow easy and efficient collection of wood biomass from the different extraction sites. Note that the chosen location is hypothetical and no economic feasibility studies have been conducted. The location is only justified by the efficiency in gathering the collected wood.

The expected impacts of Scenario 2 (Forest biomass removal for bioenergy from both public and private forests) on the ecosystem services is represented in Figure 5.4.4 (before extraction of biomass for bioenergy) and 5.4.5 (after extraction). The two maps highlight how the value of the natural capital changes when the wood is extracted.

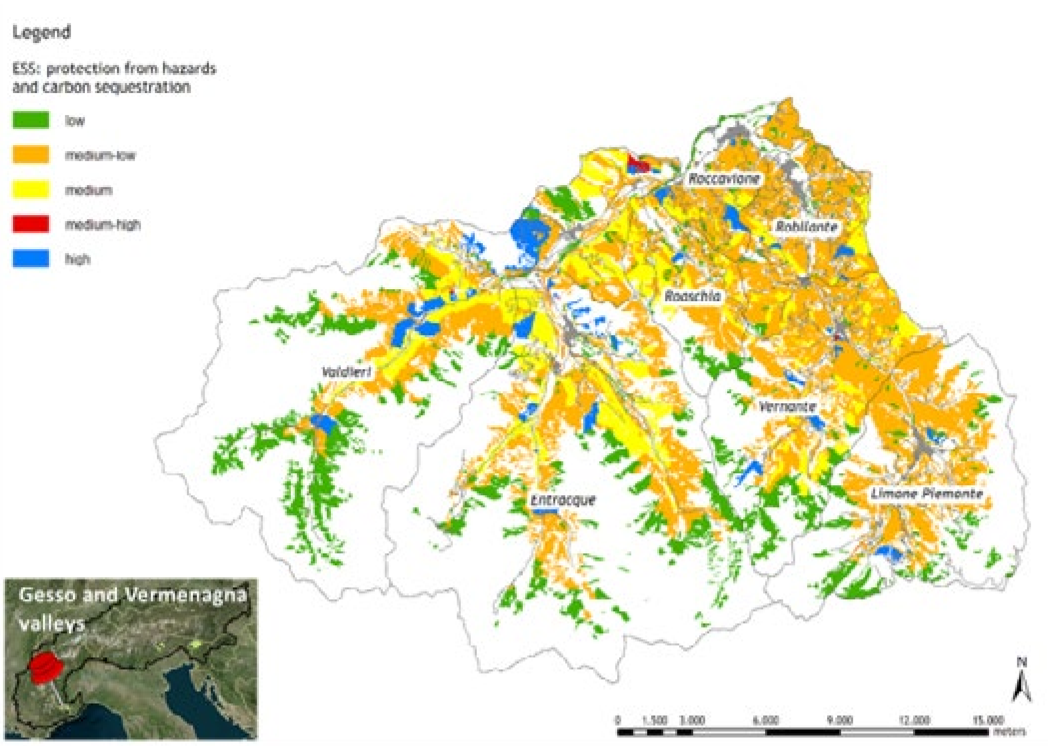


Figure 5.4.4: The value of ecosystem services before the extraction. (Source: EURAC and CRA-MPF)

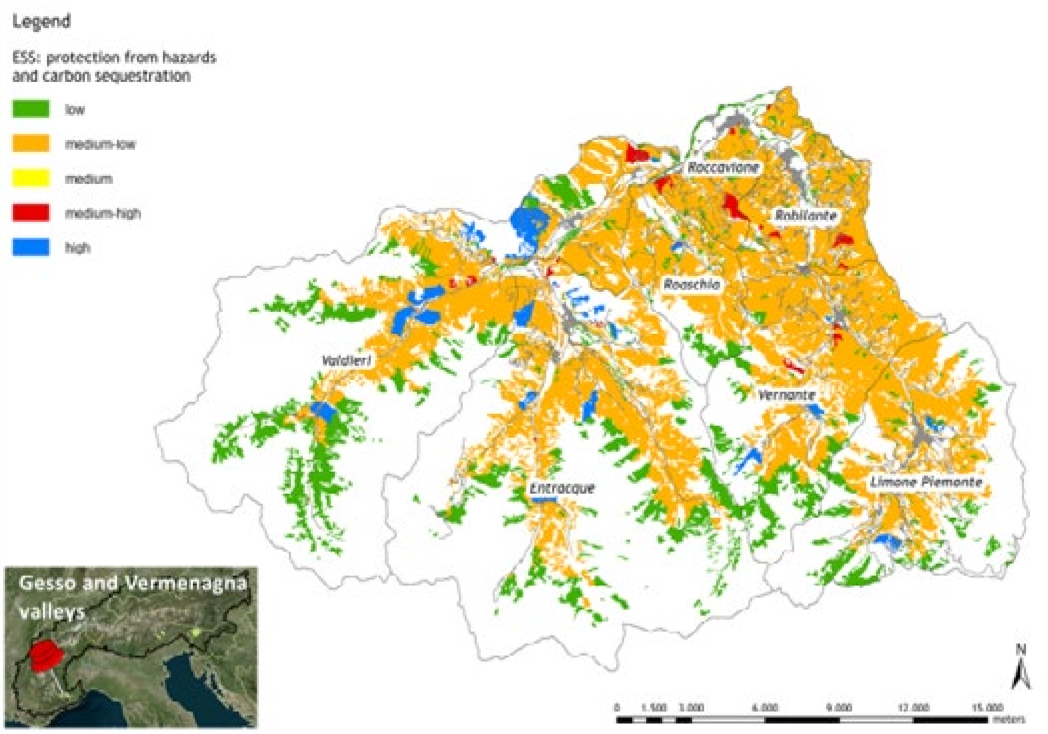


Figure 5.4.5: Expected value of ecosystem services after the collection of wood biomass for energy (Source: EURAC and CRA-MPF)

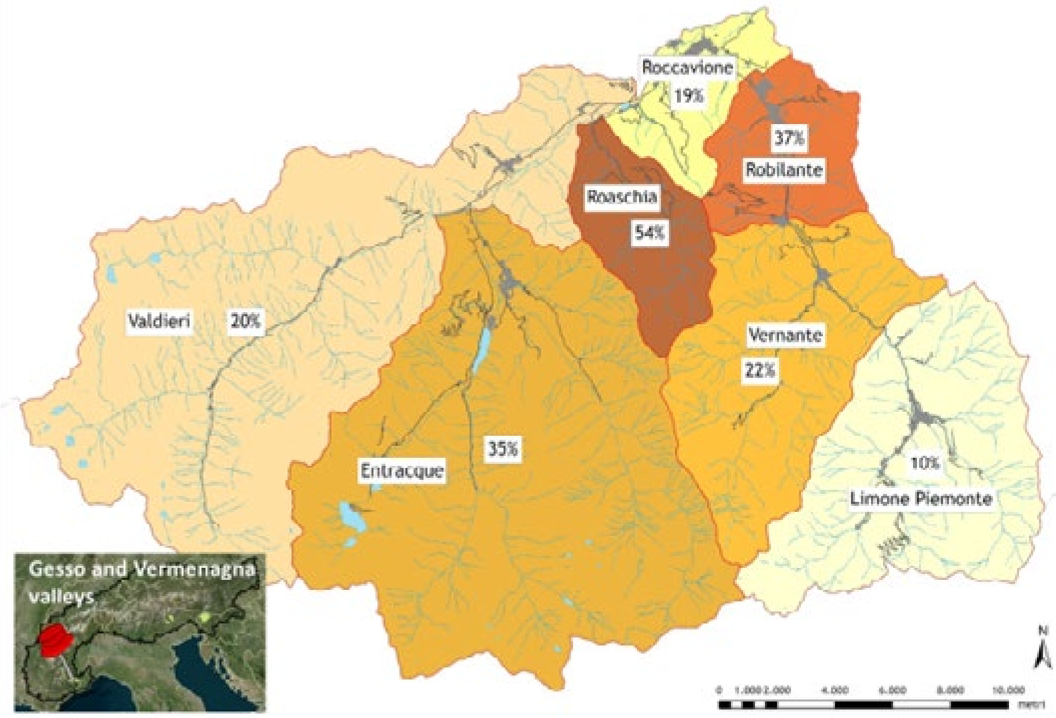
As a general trend, the economic value of ecosystem services is expected to decrease. In particular, before wood extraction for biomass energy, large areas in the category medium level value (yellow color) change to the medium-low category (orange colour) after biomass has been removed. Other changes are visible in other part of the map. The usefulness of this approach relates to the spatial dimension of the impacts. For example, forests assessed as having high ecosystem services value may be preserved for conservation purposes, while less important areas may be exploited further. Such scenario analysis together with assessments on local energy supply potentials are an important tool for decision making.

Scenario evaluation

The spatial visualization of the effects of biomass extraction on the environment allows an optimal identification of areas for biomass extraction. Areas where energy exploitation would have no or only small effects on the environment may be explored further for potential biomass extraction. In contrast, areas where such activities would have high impact areas should be avoided.
An important feature of the SEA is the participation of local stakeholders. All proposed development plans should be shared with the people who could be affected, in order to avoid conflicts and facilitate the local acceptance of projects. In the Gesso and Vermenagna valleys case study, the results of the potentials and the expected impacts on the environment were presented in three focus groups. Participants were invited to select the preferred development alternative. Stakeholders in general showed an overall preference for further development of the wood-energy supply chain, but they were highly critical of the construction of only one medium or large biomass plant as opposed to several smaller sized plants. This is due to people´s opinion that local biomass availability is highly unpredictable and may change significantly from year to year. In such a situation, a single large (or medium-sized) power plant for the seven municipalities may be too expensive and the return on the investment too uncertain to justify the construction. Apparently, participants think that more than one plant, i.e. one in each municipality, could be more beneficial for the local economy (Figure 5.4.6). This outcome of the stakeholder involvement was not predictable for someone from outside the Gesso and Vermenagna valleys and provides strong evidence that the involvement of local stakeholders is important during decision making. A participatory SEA procedure may yield unexpected results.

In conclusion, it is important to highlight that SEA deals both with environmental and socio-economic aspects of plans. It has to integrate concerns about people´s health, future expected incomes and the effects on local socio-economic developments.

Figure 5.4.6: Preferred solution for bioenergy development according to local stakeholders: Percentage of energy consumption covered by biomass plant based on short-chain principle. The discussion during the focus group was managed by CRA-MPF, Trento. (Source: EURAC)



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Interview:
Ecosystem services in the Gesso and Vermenagna valleys

Luca Giraudo, Natural Park of the Maritime Alps

Luca Giraudo is an ornithologist and environmental tour guide. He works in the Maritime Alps Natural Park The Park and Luca Giraudo collaborated with EURAC Research in the recharge. green activities. He provided important support to the researchers.

Question: In your opinion, what are the most important ecosystem services for the territory of Gesso and Vermenagna valleys? Could you list them in order of importance? Does the presence or absence of a protected area affect this order?

Answer: *In my opinion, the order of importance of the most important ecosystem services in our territory is:*

a. *Recreational services, i.e. sports and tourism activities related to nature*
b. *Provision of drinking water and the use available water resources for irrigation and energy purposes*
c. *Potential for firewood collection*
d. *Cattle breeding and derived products*
e. *Fishing and related economic income*

Definitely, there are some positive and negative influences on ecosystem services due to the protected area designation. Especially, the Alpi Maritime Natural Park increases the value of recreational services. Besides, it positively affects the local economy by increasing job opportunities in the valley and decreasing commuter numbers. On the other hand, I would like to underline also some negative impacts, i.e. the increasing air pollution linked to unsustainable tourism, as well as the greater impact on some complex and delicate ecosystems due to a high population concentration.

Question: The exploitation of renewable energy sources (forest biomass and hydropower) can decrease the efficiency of the ecosystem services that you have previously identified. If yes, how?

Answer: *Yes, we have already experienced the overexploitation of some natural resources due to the presence of hydropower plants and irrigation systems: the return of water downstream of weirs and dams, i.e. the minimum vital discharge, is insufficient to maintain the habitat and the vitality of the stream ecology.*
Currently forest wood is not widely and significantly exploited. In my opinion, a future use of forest biomass can hardly affect large areas of the park due to the inaccessibility of many forest sectors.

Question: What is the level of exploitation of renewable energy in Gesso and Vermenagna valleys? Do you think that there might still be room for future development? If so, what measures can be put in place to minimize negative impacts on ecosystem services?

Answer: *In the case of hydropower, the only option is to exploit the conducts of the aqueducts; otherwise, according to the current legal framework, the potential is zero. In the case of aqueducts, the impact should be minimal.*
In my opinion, for the use of forest biomass, the area that would be workable for exploitation is too small to meet the demand of an economically feasible plant. The impact of an intensive use may affect the air quality and the traffic, especially if a power plant were located at the bottom of the valley.

Science:

Mapping ecosystem services

When planning an environmental intervention, such as renewable energy development, an important challenge is the understanding how ecosystems, and ecosystem services, may be affected by the planned activities. The renewable energy sector plays a key role in the context of climate change mitigation. In order to assure sustainable management, it is important to foresee and anticipate the possible effects of decisions to expand the share of renewable energy. Within the environmental decision-making process, assessing and mapping ecosystem services is becoming a more and more common practice. The concept of ecosystem services stresses the attention on the interaction between humans and ecosystems, so an effective mapping should include both environmental and social considerations. Providing a spatial map of the ecosystem services allows the investigation of how ecosystem services vary across space and the identification of the areas with high or low values of the ecosystem services. As a general rule, ecosystem services analysis consists of two main processes:

- valuing ecosystem services through quantitative measures, and
- spatial mapping.

The valuation of ecosystem services is essential for providing a measure of the importance of an ecosystem service. There are plenty of techniques for the quantification of ecosystem services including multi-criteria analysis, economic valuation, technical and ecological assessments. Spatial mapping, on the other hand, is fundamental to provide a clear overview of the share of ecosystems under pressure and to avoid further depletion of the environment.

There are many methods of ecosystem services mapping. The simplest method consists of establishing binary links between land use and the value of ecosystem services. A more sophisticated, but still simple, approach is to ask experts to rank useful environmental variables based on their know-how. Similarly, literature-review-based mapping is also popular, as are field survey-based approaches. In addition, there are several useful software packages, such as AIRES and InVEST that may help in the challenge of mapping ecosystem services. To produce an effective and reliable map of ecosystem services, human-ecological relationships should be clearly identified. For example, the importance of mountain forests for hazard protection could be mapped based on the potential risks for human activities and settlements, while the recreational values could be made spatially explicit by looking at the areas with the highest concentration of tourists. More generally, a large number of environmental data and thematic layers may be integrated into a spatial analysis.

Providing a general mapping framework would be extremely complicated, each pilot area has its own specific features and should provide the best inputs for mapping its territory. Even though in the literature there are examples of mapping ecosystem services at very large scales (for example for all of Europe), these kinds of evaluations are extremely general and may not reflect the real situation at the local scale. It is therefore recommended to use an approach such as the one of the recharge.green project, which combined the opinion of the representatives of the local study area with expert knowledge, as described in this chapter.

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5.5 Forest biomass use and biodiversity in the Triglav National Park

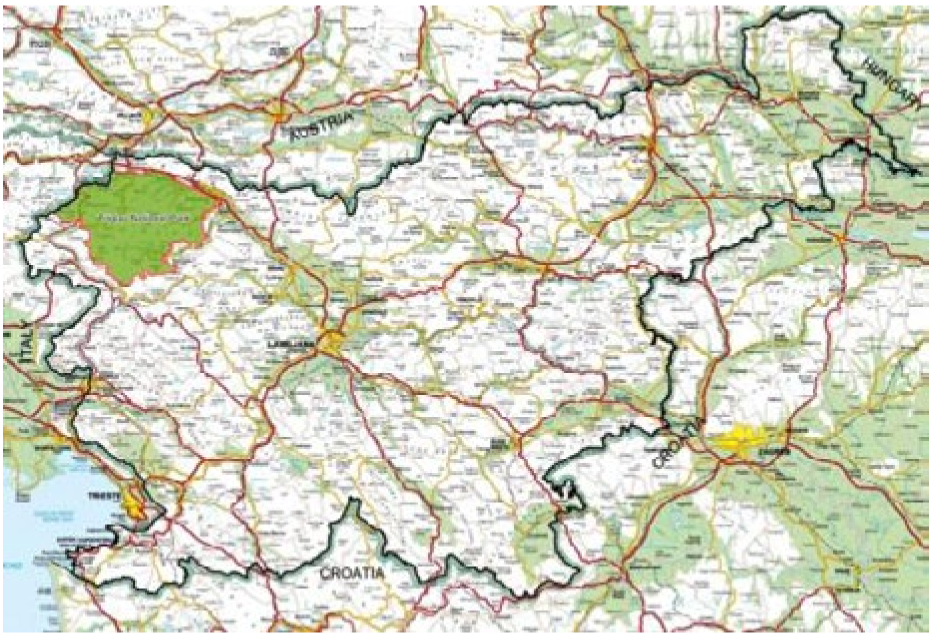
Introduction

Landscapes in the Alps reflect centuries of human activities. In the past, traditional activities such as timber production and livestock grazing considerably changed natural landscapes in the Alps [4]. Today, these traditional activities have become important for the preservation of cultural landscapes and local development. Therefore, forest management and agricultural land use are still practiced in some protected areas such as the Triglav National Park in Slovenia. In the last decades, there has been an increasing demand for wood biomass for energy, mainly due to the high productive potential of forests within the park, but also due to increasing fuel prices and the expected transition to renewable energies. Biomass production is a promising opportunity for forest owners to earn additional income. However, increasing demand could also lead to the overuse of forest resources, which might represent a threat to biodiversity and increase the conflict between the use of natural resources and nature protection objectives in the Park. Successful management of biomass potentials and balancing potential conflicts between forestry exploitation and nature protection calls for an understanding of the spatial patterns of biomass supply and demand and the impact of biomass exploitation on biodiversity. To achieve these complex tasks, we have employed a mixed assessment using both ecological and socio-economic approaches and supplemented those with the use of GIS. The analysis includes three steps: 1) Stakeholder analysis; 2) Modelling of forest biomass potential; and 3) Assessing the impact of forest biomass use for energy on ecosystem services and biodiversity.

The Triglav National Park pilot area

Triglav National Park (TNP) (Figure 7.18) is the only national park and the largest protected area in Slovenia [1]. TNP extends along the Italian border and close to the Austrian border in the north-western part of Slovenia. Its territory occupies almost the entire area of the Slovenian part of the Eastern Julian Alps. It covers an area of almost 840 km2 (4% of the Slovenian surface). TNP has been among the first European national parks and was established in 1924 as the first protected area in Slovenia.

Figure 5.5.1: Study area: Triglav National Park, Slovenia (Source: TNP)



The Park's landscape is characterized by glacier-shaped valleys, mountain plateaus and steep mountain ridges above the tree line. It is a typical mixture between unspoiled nature areas and a cultural landscape. Forest covers two thirds of the park's territory. The main forest types include: Montane, altimontane and subalpine European beech forests on carbonate and mixed bedrock (28,237 ha), dwarf mountain pine forests (11,336 ha), silver fir-European beech forests (4,925 ha), and silver fir-Norway spruce forests (3,676 ha) [8]. All forests in the Park are under forest management plans elaborated by the Slovenia Forest Service. The Park is divided into three protection zones. In the first zone, the core zone, forests are left to natural processes and only minor protection measures are allowed. In the second and third protection zones, sustainable and close-to-nature forest management is practiced regularly.

The Park provides a variety of ecosystem services such as nature conservation (habitat for fauna and flora), various environmental protection functions, conservation of cultural heritage, and recreation and tourism [11]. Agriculture and forestry are important economic activities for people living in the Park [7]. Among the various renewable energy sources, wood biomass has the greatest potential for sustainable use.

Stakeholder analysis

Before the analysis of forest biomass potential, a stakeholder analysis was performed to identify all (formal and informal) groups of people who share a stake in renewable energy, forest management and nature conservation. In addition, according to the analysis of the stakeholders' interests, the conflicts between different users, and the relationships we've classified the stakeholders into groups with different levels of interest (e.g. key stakeholders, primary stakeholders and secondary stakeholders). A three step method [1] based on expert assessment was applied: (1) Identification of the experts by brainstorming among the partners of the recharge.green project; (2) Identification of local stakeholders based on experts' opinions and information, gathered through semi-structured questionnaires; and (3) An analytical categorization (classification) of the stakeholders into a professional relationship network using Social Network Analysis (SNA).

In the first step, experts identified 31 stakeholders belonging to the following categories of interests (Table 5.5.1): Public institutions (51.6%), local associations/non-governmental organizations (19.4%), and private organizations (29.0%). All 31 suggested stakeholders were considered in the future stages of the project. Stakeholders were involved at different levels according to their role in the network. Key stakeholders were involved for cooperation and consultation; primary stakeholders were consulted, while others were only informed about the decisions.

Table 5.5.1: List of stakeholders in TNP identified by recharge.green experts

Name of stakeholder	Category	Nº preferences
Public institution of Triglav National Park (TNP)	Public institution	9
Slovenia Forest Service	Public institution	8
University of Ljubljana	Public institution	7
Association of forest owners	Private organization	5
Municipality of Bohinj	Public institution	5
Institute of the Republic of Slovenia for Nature Conservation	Public institution	4
Agrarian community Dovje Mojstrana	Private organization	4
Company EL-TEC Mulej (Society for Energy and Environmental Solutions)	Private organization	4
Agricultural/Forest Cooperative	Association-NGO	3
Ministry of agriculture and the environment	Public institution	3
Forest company GG Bled	Private organization	2
DOPPS - Birdlife Slovenia	Association-NGO	2
Slovenian Environment Agency	Public institution	2
CIPRA Slovenia	Association-NGO	2
Slovenian Forestry Institute	Public institution	2
Bled-Tourist Association	Private organization	1
Alpine Association of Slovenia	Association-NGO	1
Institute for the protection of Cultural Heritage of Slovenia	Public institution	1
LEAG - Local Energy Agency of Gorenjska	Public institution	1
Fisheries Research Institute of Slovenia	Public institution	1
Municipality of Gorje	Public institution	1
Municipality of Kranjska Gora	Public institution	1
Municipality of Bled	Public institution	1
GOLEA - Goriška Local Energy Agency	Public institution	1
Chamber of Commerce and Industry of Slovenia	Association	1
RAGOR - Upper Gorenjska development Agency	Private organization	1
Regional Development Agency of Gorenjska	Public institution	1
Association of hoteliers	Private organization	1
Archdiocese of Ljubljana	Church association	1
Company Lip Bohinj d.o.o.	Private organization	1
Machine club Bled	Private organization	1

In the second step, we identified and categorized the local stakeholders by asking two questions: First, respondents (i.e. experts) were asked to indicate local stakeholders that should be involved in the participatory decision-making process, assessing four key attributes for each stakeholder: power, legitimacy, urgency, and proximity. Second, experts identified the stakeholders with whom they maintain a professional relationship in the field of renewable energy. The stakeholder with the greatest power and ability to disseminate information is the Institute of the Republic of Slovenia for Nature Conservation, who represents a "bridge" between the rest of the network and four stakeholders: Slovenian Forest Institute, Municipality of Kranjska Gora, Fisheries Research Institute of Slovenia and Ministry of Agriculture and the Environment (Figure 5.5.2).

Other stakeholders with high power and the ability to disseminate information are the Bled-Tourist Association and the forest enterprise GG Bled. There are some other stakeholders in an intermediate position, such as the public institution of Triglav National Park and the agrarian community Dovje Mojstrana. These stakeholders have substantial decision-making power, but lower ability to spread information compared to the above-mentioned powerful stakeholders. The opposite is true for the company EL-TEC Mulej, which is able to disseminate specific information on renewable energy sources to a group of four stakeholders (Municipality of Bled, Goriška Local Energy Agency, Local Energy Agency of Gorenjska and Alpine Association of Slovenia), but has low power in the decision process.

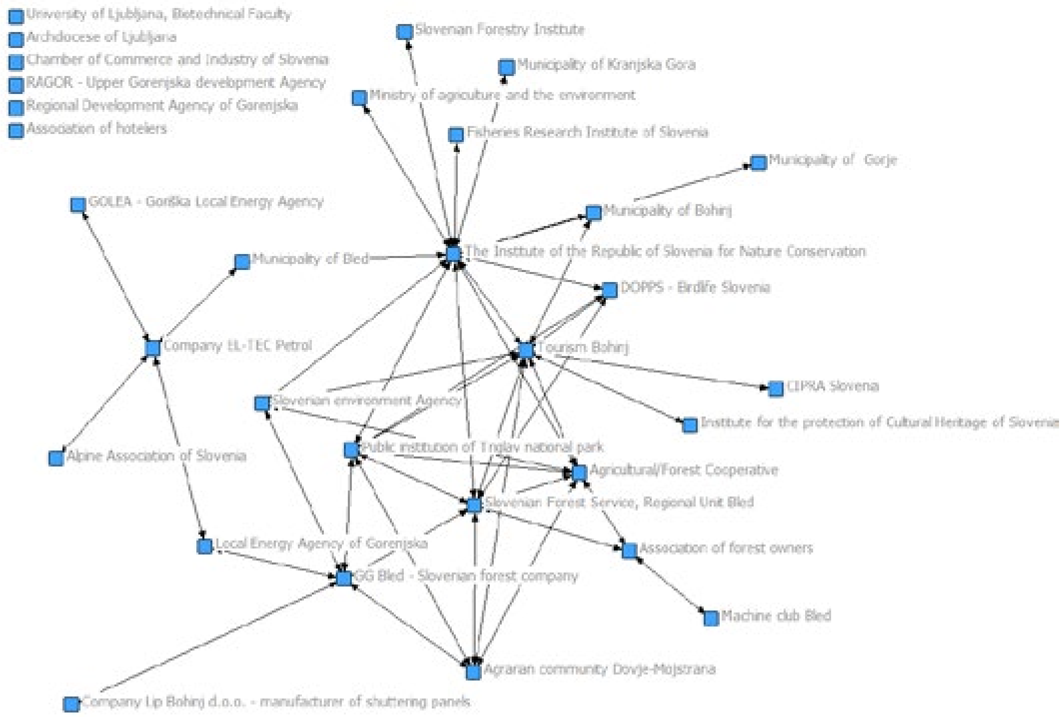


Figure 5.2.2: Social network of Triglav National Park's stakeholders (Source: University of Ljubljana)

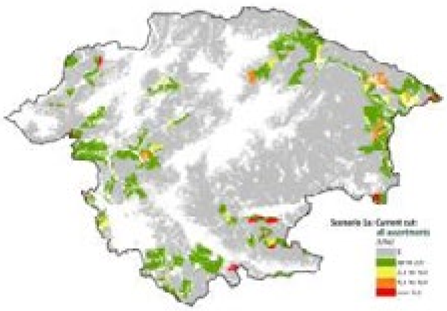
Furthermore, a classification of stakeholders on the basis of their position in the network led to the identification of eight key stakeholders: the Institute of the Republic of Slovenia for Nature Conservation, the Bled-Tourist Association, the forest enterprise GG Bled, the Slovenia Forest Service, the company EL-TEC Mulej, the Agricultural/Forest Cooperative, the public institution of Triglav National Park (TNP) and the Slovenian Environment Agency. The network analysis of TNP shows that the key role in the decision process related to renewable energy is not in the hands of one central stakeholder, but in said group of eight key stakeholders. Therefore their involvement in decisions related to renewable energy planning is crucial for the success of the participatory process.

Modelling forest biomass

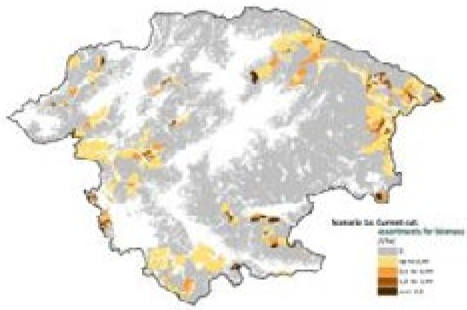
We used the WISDOM tool to evaluate the potential for biomass use in the study area. WISDOM is a planning tool that allows users to integrate data from various sources and to conduct multi-scale spatial analysis [5] (see also chapter 3.6). For modelling purposes, three hypothetical scenarios were developed, as shown in Figure 5.5.3:

- Scenario S1 (business as usual), where current (S1a) and planned (S1b) cut was considered;
- Scenario S2 (nature protection scenario), where we hypothesized no harvesting in the core protection zone, harvesting in the second protection zone only where the naturalness of forests is strongly modified, and harvesting in the third protection zone only where the forests are changed;
- Scenario S3 (biomass production scenario) where we assumed that in the third, second and core protection zones 100%, 70%, and 30% of the annual increment respectively is harvested.

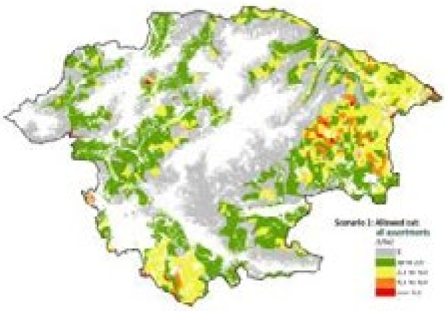
Figure 5.5.3: Spatial distribution of available wood potential including industrial timber and biomass for energy (left) and forest biomass for energy (right) according to: a.) business as usual scenario, b.) nature conservation scenario and c.) biomass production scenario (Source: TNP)



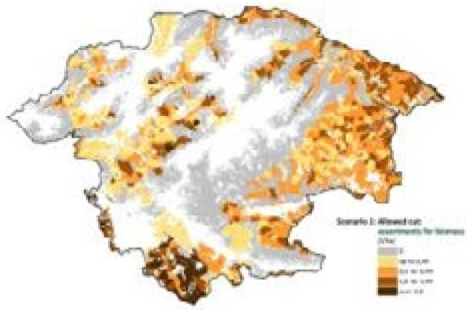
S1a: Current cut – wood potential



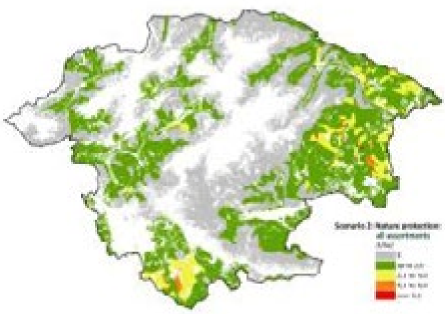
S1a: Current cut – biomass for energy



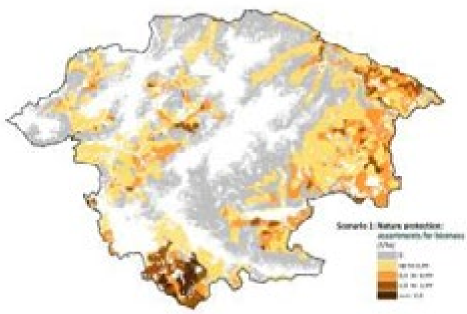
S1b: Allowed cut – wood potentia



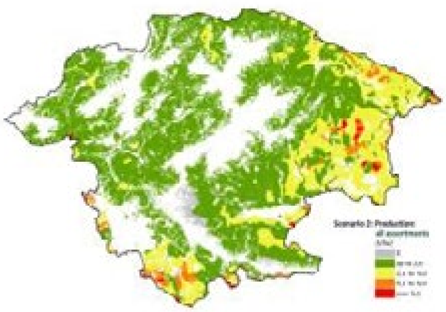
S1b: Allowed cut – biomass for energy



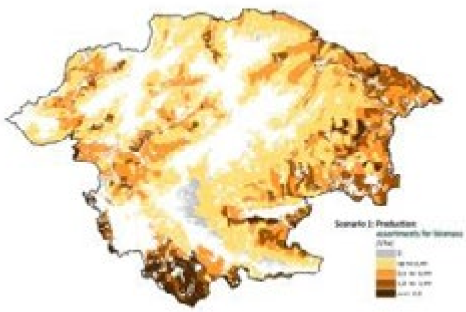
S2: Protection scenario – wood potential



Protection scenario – biomass for energy



S3: Production scenario – wood potential



S3: Production scenario – biomass for energy

The current cut presents only one third of the maximum allowable cut in year 2012. The highest cut is on the Pokljuka and Mežakla plateaus, in the valleys and in better accessible forests opened with more forest infrastructure. A maximum allowable cut has been defined for all production forests. It is higher in the more productive sites such as spruce forests (e.g. Pokljuka). Scenario 3 emphasizes wood production and assumes harvesting in all forests. However the maximum cut could somewhat decrease in areas where the current cut is currently relatively high (e.g. on Pokljuka). The most wood for biomass use is found in forests in the southern part of TNP below the mountains Krn and Vogel (e.g. Čadrg, Tolminske Ravne).

The energy demand in TNP is relatively low. The population density in the Park is low with 21 settlements and 2,444 inhabitants [10] and there are no large energy consumers such as industry. The results of forest biomass supply modelling show that current demand for woody biomass energy within the Park is relatively low (2.940 t/year). Each of the three scenarios could supply sufficient biomass for the current demand within the Park. When considering additional demand for energy from bordering towns and cities, which are highly related to land use in the park, then the estimated demand becomes much higher (19,940 t/year). This could still be covered with planned cuts in the management plans (Scenario 1b; 30,290 t/year) or assuming increased use of forest resources (Scenario 3; 40,859 t/year). The current cut (Scenario 1a; 9,932 t/year) and nature conservation scenario (Scenario 2; 15,365 t/year) covers more than 75 % of energy needs.

The assessed wood potential is high (high productive forests, increasing forest stock) and it represents income opportunities for the forest owners. On the other hand, over-exploitation might represent a threat to biodiversity and to the sustainable use of TNP´s forests [6].

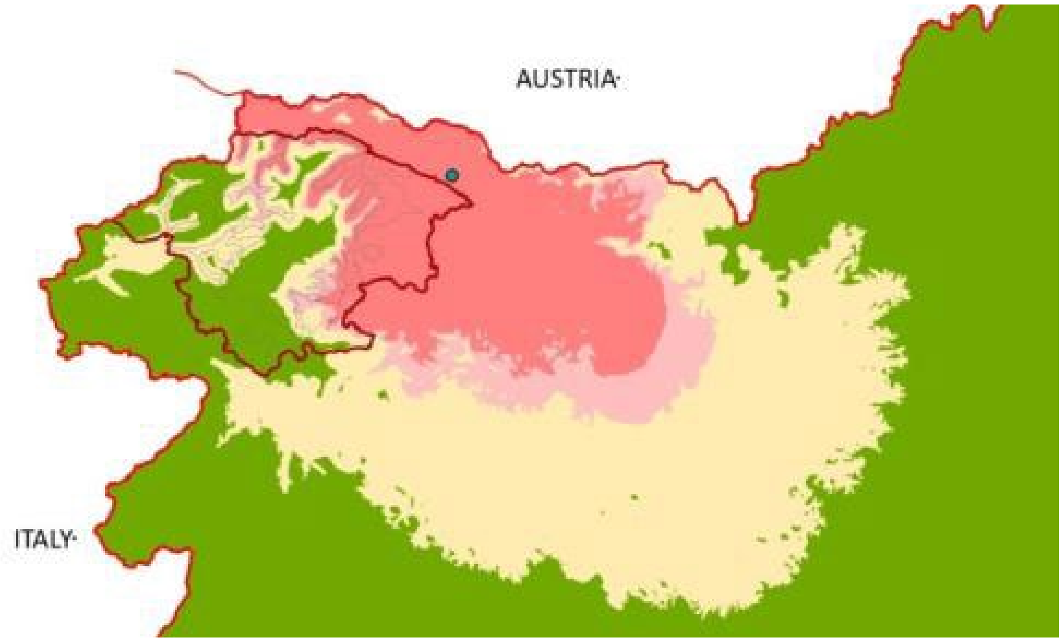


Figure 5.5.4: Supply areas corresponding to increased demand for woody biomass in case of establishment of a new biomass plant in Jesenice with an annual consumption of 5000 tons (dark red), 20000 tons (light red) and 30000 tons (yellow) (Source: TNP).

Additionally, we considered increasing demands for biomass use by simulating a new biomass plant in Jesenice city with annual biomass consumption of 5,000 t, 20,000 t, and 30,000 t. Such increased demand could be supplied by biomass originating from much broader regions including areas outside the Park (Figure 5.5.4). Alternatively, increased demands for biomass could be covered by increasing production in the nearby area, which however may result in conflicts with the conservation goals of the Park.

Impact of forest biomass harvesting on ecosystem services

The potential impact of forest biomass harvesting on ecosystem services was quantified by asking local experts to complete a questionnaire. Thirteen experts were identified taking into account their expertise and local knowledge on ecosystem services and/or bioenergy. The sample of experts is small, because we had to find respondents who have both an extensive knowledge of bioenergy and/or ecosystem services and a detailed knowledge of the study area. Respondents were asked to express their opinion on the potential impacts of forest biomass harvesting on the above mentioned ecosystem services using a 5-point-Likert scale (from -2=very high negative impact to +2=very high positive impact). The expected impacts were aggregated on the basis of three categories of ecosystem services: provisioning services, regulating services and cultural services. For each category, the mean value was calculated in order to obtain a synthesis indicator of the impact. The mean value of the indicator was then converted into a percentage, expressing the share of economic loss or benefit following the use of forest biomass for energy.

The results show that forest biomass harvesting leads to different positive and negative impacts depending on the characteristics of ecosystem services in the local context of TNP. As expected, provisioning services are the most positively affected group of ecosystem services (+ 32% of value). The increase of biomass withdrawal implies an increase of income generated by the sales. Regulating services shows a decreasing trend. A highly negative impact of forest biomass harvesting was identified for habitat quality (-0.62). Biomass extraction usually lowers the amount of deadwood in the forests, which decreases habitat suitability for saproxylic insects and other deadwood-dependent organisms [2]. We also recognized a negative impact of forest biomass harvesting on natural hazard protection (-0.23) and on carbon sequestration (-0.15). The negative values of the indicator for natural hazard protection are unexpected. The silvi-cultural measures applied under the current forest management practice in TNP [7] has been found to have a positive influence on natural hazard protection [3]. The negative values derived from the expert survey for natural hazard protection could be explained by the fact that the process of harvesting logging residues increases soil compaction and erosion in finely textured and moist soils, and this aspect is particularly relevant in protected areas [1]. Cultural services are likely not affected by biomass withdrawals – the values of this indicator were estimated around 0.

In conclusion, while the primary objectives of protected areas are nature conservation and protection of the environment and its cultural heritage, the use of forest resources for energy, if properly planned and if the potential exists (e.g. well-stocked productive stands) could nevertheless be aligned with the management objectives of protected areas. However, increase demands for energy use could have a significant negative influence on biodiversity and could cause conflict with nature conservation objectives in the Park. To reduce the risks of biodiversity loss and to avoid contradictory management objectives in the park, careful planning and an appropriate forest management system is needed. A systematic scenario analysis can help to evaluate possible interventions and support planning. Close-to-nature forestry and a rational approach, including constant monitoring, planning and evaluation of realized measures, could be the right way to deal with overlapping demands for various ecosystem services. In the study area (and in general in all Slovenian forests), close-to-nature forestry has been practiced for 50 years with no significant conflicts between forestry and nature conservation. Within the recharge.green project, the Slovenian partners supplemented current information on forests available on a 2×2 km permanent sample plot grid (maintained by SFS) with complementary additional information on soils, vegetation, birds, fungi, etc. This type of forest inventory allows us to gain better insights into the impacts of biomass use on biodiversity and thus improve the evaluation of forest management and biodiversity monitoring in TNP.

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5.6 A best practice example from Slovenia that considers ecosystem services

As has been previously stated, including ecosystem services in planning the use of natural resources is of paramount importance. Decisions on the use of a particular resource can strongly influence other resources and services that are connected. In the case of the use of forest biomass, maximization of the allowable cut could be most beneficial for energy production, but if the importance of other ecosystem services is considered, the sustainable energy potential would likely be lower. There are also other criteria beyond the amount of biomass extracted that can influence the ecosystem services in the region, such as the type of harvesting and skidding used, the technology for biomass production, whether or not a plant is buildt for local biomass use, and so on. Possible conflicts may arise between nature conservation and energy production, if for example dead wood is removed from the forest, or large diameter trees are no longer promoted by management decisions. Dedicated biomass plants may have a negative influence on recreation when operated in popular touristic and recreational spots. Skidding trails can interfere with recreational paths. However, many of these possible trade-offs can be prevented if conflicts are managed sufficiently early and all relevant stakeholders are included in the decision-making process.

In Slovenia, multi-objective forest management that considers a variety of forest ecosystem services (in forestry, these are called forest functions) is legally recognized. Forest planning is an important tool to practice multi-objective forest management. It is based on a participatory approach – different forestry stakeholders have the right to participate in the process of plan revision. However, this participation is mainly limited to providing different spatial layers or planning guidelines (e.g. for nature conservation agencies, hydrologists or for areas of cultural heritage), or for commenting on the final draft of a plan (e.g. for forest owners and the general public).

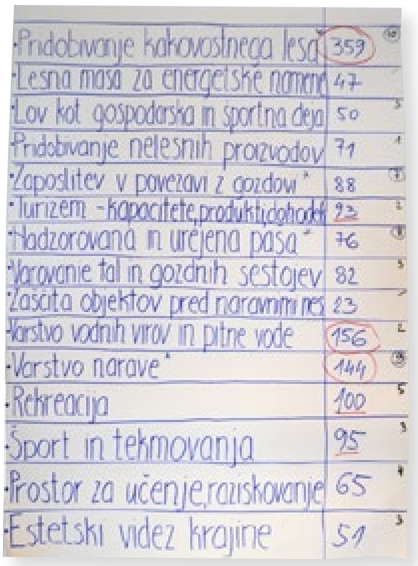
In recharge.green, we tested a new approach of including stakeholders at the first stage of plan revision – when management objectives are set and ranked, and priorities among forest functions/services are set and spatially allocated. Such an approach would help to 1) identify the main importance of forests in the region, 2) address possible conflicts among forest users and 3) find solutions for planning forest uses that minimise trade-offs between different ecosystem services.

A workshop for local stakeholders was organized in the heart of Pokljuka region. The aim of the workshop was to discuss the challenges for providing multiple ecosystem services on Pokljuka plateau in TNP including the provision of wood, biomass for energy, nature conservation, the protection of soil and water, and recreation and other cultural services. Thirty-one stakeholders participated, including participants from the TNP, the Forest Service (regional office in Bled), the Department of Forestry of the Biotechnical Faculty of the University of Ljubljana, from various local touristic and sport organizations, and representatives of forest owners and harvesting organizations, grazing communities, and some additional interested individuals. The workshop was also a step in the ongoing forest plan revision process of the forest management unit for Pokljuka plateau..

The workshop followed a four-step process:

1. **Ranking of management objectives**: Stakeholders were provided with a list of management objectives (e.g. wood production, energy for biomass, tourism, recreation, nature conservation, preservation of cultural heritage) and were individually asked to prioritize them by allocating 100 units among the listed objectives. The results showed that the production of high quality timber, nature conservation and tourism and recreation are the most important forest management objectives (Figure 5.6.1).

Figure 5.6.1: Ranked management objectives (left) and identification of conflicts regarding forest use (right). (Source: TNP)



2. **Identification of conflicts;**
   Stakeholders individually identified the main conflicts they face regarding forest use on Pokljuka plateau. Later, all identified conflicts were compiled and jointly returned back to the stakeholders who ranked the conflicts from the least to the most urgent one.

3. **Spatial allocation of ecosystem services:**
   Stakeholders were grouped according to their preferences (4 groups: recreationalists, environmentalists, forest owners, others – e.g. pasture communities). Each group received a map of the Pokljuka plateau and stakeholders were asked to indicate on the map where their interests for ecosystem services appear (e.g. mark hiking or biking trails, the most important places for tourism, quiet zones for habitats, etc.) (Figu re 5.6.2). The maps of the different groups were then compared in order to identify conflict areas.

Figure 5.6.2: Spatial allocation of ecosystem services (left) and finding solutions for conflict areas using H-method (right). (Source: TNP)

4. **Finding solutions**
   The H method is a participatory method to determine individual attitudes of stakeholders towards a certain problem (FAO). In our case, participants at the workshop were divided into four groups (three were related to specific conflict areas, and an additional one to conflicts that were not spatially explicit). Each participant had to estimate on a scale of 0 to 10 the consistency of land use in certain conflict areas, where 0 represented very poor consistency and 10 represented very good land use harmonisation. All participants then had to state up to three arguments why they had not given a mark of 10 or 0 (using sticky notes). Thereafter, the whole group sorted responses into similar opinions. The next step was a determination of the collective view, i.e. the entire group´s estimation was determined democratically. In the end, the group made suggestions (up to three) on how to move the group estimation towards a mark of 10, meaning how to improve the harmonisation between land uses, and between various stakeholder demands. Group representatives presented the main solutions, followed by a synthesis provided by forest planners. They assessed how to continue with plan revision and how to approach both spatially explicit and general problems regarding the use of ecosystem services on Pokljuka plateau. The results will be highly valuable for revising forest plans and balancing demands on multiple ecosystem services on Pokljuka plateau.

Interview:
A good forest management plan is the foundation for balancing energy use and nature

Mag. Janez Zafran, Head of Forestry Division, Ministry of Agriculture, Forestry and Food, Slovenia

Mag. Janez Zafran is Head of the Forestry Division of the Slovenian Ministry of Agriculture, Forestry and Food. He has over 20 years of experience in forestry. Before joining the Ministry, he worked for the Slovenian Forest Service and led the preparation, adoption and implementation of forest management plans. His expertise lies in forest management planning, forest inventory and monitoring, forest sector planning and forest policy.

Question: In Triglav National Park forest biomass is the most used renewable energy source. How do you see the potential for further forest biomass use in Triglav National Park?
Answer: *From a general point of view the use of different renewable energy sources itself is not problematic. Looking at forests and wood, there is a lot of potential in Triglav National Park and in Slovenia in general. When we talk about forest management we should not only focus on growing forests for energy use, but we have to talk about holistic forest management, based on the principles of sustainability and the protection of biodiversity, considering also the multi-functionality of the forest. Of course in sustainable forest management a certain part of wood biomass can be considered appropriate for energy use.*

Question: Triglav National Park is among the oldest national parks in Europe; the first protection designation dates back to 1924. Forest management also has a long tradition. Is a balance between energy and nature possible?
Answer: *The general contradiction between the exploitation of natural resources for energy and the protection of biodiversity has been discussed many times – at a political as well as at a professional scale. There are no unambiguous answers. The main direction is clear and also agreed upon at an international level: we have to halt the loss of biodiversity and the degradation of ecosystems and ecosystem services. In Slovenian forests and forestry we have a long tradition how to do forest management, which on the one hand considers economic aspects, such as the exploitation of forest resources, and which on the other hand respects biodiversity and its needs. We see forest management planning as the main instrument for the future.*

Question: How can we preserve the functioning of forest ecosystem services in Triglav National Park?
Answer: *A certain amount of attention and care is needed for any kind of change in Slovenia's only National Park. We have to be careful and ensure the acceptance of our decisions. For this we have to have a lot of basic knowledge on forest ecosystems services, we have to be able to communicate with each other and to invite accountable and public stakeholders. This is the only way to achieve long-term acceptance among the majority of people living in this area.*

5.7 A best practice example from Bavaria that benefits fish populations

The hydropower plant Altusried in the pilot region Bavaria is situated at the river Iller. Due to hydropower usage the Iller has a poor ecological status with regard to the European Water Framework Directive. The most important parameter in this context is the fish population. The main areas of interest are ecological connectivity at water-retaining structures and the protection of the fish population in accordance with the Directive. The objective of the project was the development of measures to improve fish populations in Alpine rivers in Bavaria (e. g. Iller, Lech, Danube) to alleviate the negative impacts of hydropower plants on river ecosystems.
The idea of the pilot activity was to carry out a special monitoring of fish fauna at hydropower plants and to optimize the construction and operation of existing hydropower plants and fish passages in order to minimize negative impacts on the fish population. In the year 2014 ecological surveys were carried out to determine the status quo and the deficits, and to gain a better understanding of what measures are needed to improve the situation.

Observed deficits:

- The local fish population is dominated by undemanding species (chub, stickleback and stone loach).
- There are severe deficits in the abundance of rheophilic (preferring flowing water) index species due to a low number of or a complete absence of juveniles.

Cause:

- There is a lack of functional spawning- and rearing habitats. In addition, hydropeaking degrades the quality and availability of possible spawning- and rearing habitats.

Based on a comparison of the historic with the current situation, a catalogue of measures was developed:

Package of measures directly referring to reference conditions

- Aim: optimization and creation of riverine habitats, especially rearing- and spawning habitats suitable for rheophilic species.
- Target Area: Head of the reservoir and riverine stretches downstream of the Altusried hydropower plant.

Proposed measures concern:

- gravel spawning grounds;
- vitalization of riverine habitats;
- connection of tributaries and backwaters.

Package of measures not referring to reference conditions

- Aim: optimization and creation of additional functional habitats inside the reservoir area (upstream of the hydropower plant) in order to create retreats during hydropeaking.
- Target area: From the Altusried hydropower plant to the head of the reservoir, area strongly influenced by hydropeaking.

Proposed measures concern:

- fish rearing habitats;
- fish retreat areas during floods;
- fish wintering sites.

With the proposed measures riverside habitats, which do not develop naturally due to the lack of dynamic flow in the river, can be newly created or restored. Since the situation at Altusried can be generally compared to other Alpine rivers the measures are suitable for other rivers as well. By realising and maintaining the proposed measures, the ecological potential of the water body can be significantly and sustainably improved.

A detailed description of the observations and the developed measures can be found in the (German language) report "Verbesserung des ökologischen Potenzials der Iller am Kraftwerk Altusried" (BNGF, June 2015). Subsequent to the recharge.green project the implementation of the measures took place in the course of two example projects and building activities of the BEW.

Stakeholder involvement

At the beginning of the project there was noticeable scepticism of nature conservation organisations whether such measures should be financed by a project, as this normally would have to be executed by the hydropower plant operator anyway. On the other hand, the participation of a private sector entity was felt to be desirable.

The following dialogue process took place:

- First, the intentions and questions of all involved parties as well as the course of cooperation within the project were discussed.
- CIPRA was integrated / included by BEW where the calls for proposals and allocations of fish ecological valuations were concerned.
- At the start of the evaluations and strategies a workshop comprising an excursion in the project area was held and the working program was discussed.
- Before finalising the work, intermediate results were presented at a meeting where interested stakeholders as well as involved authorities were given the opportunity to introduce their needs and to make suggestions for the completion of the project.
- The results of the project – suggestions of measures to improve the fish ecological potential of the Iller – were publicly presented at the final conference of recharge.green during an excursion.

Based on the experiences in the project it was found that the mutual understanding of each other's positions and aims was deepened and that faith in a dialogue based on fair and cooperative communication was promoted. The greatest difficulty in the execution of the project was the tight time schedule. The coordination of the individual project steps was considerably more time-consuming than expected. Enough time for a comprehensive and satisfactory exchange of content specific questions should be allowed in the future.

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Science:
The Water Framework Directive

One of the dominant conflicts between renewable energy production and environmental protection is the one between hydropower exploitation and the ecological status of rivers. Above all, protected areas are often rich in potential sites for hydropower generation, but fragile ecosystems and areas with high habitat values have to be preserved. It is obvious that increasing water diversions and uses can negatively alter the hydrological, biological and morphological quality of the river.

The European Water Framework Directive (WFD) (2000/60/EC) aims to achieve a good ecological status for rivers in terms of biological, hydrological and chemical characteristics. On the other hand, the Renewable Energy Directive (2009/28/EC) promotes the use of renewable energy, and in the European Alpine region the main renewable source of energy is hydropower.

Pressures altering the flow regime, e.g. hydropower uses and water diversions, affect the ecological status of a river. The water quantity plays an important role in maintaining and achieving the desired „good status" of rivers and in enhancing the conservation and the protection of habitats and species. For this reason, the amount of water required for aquatic ecosystems to continue to thrive and provide the services we rely upon, i.e. the environmental flow, has to be guarantee in rivers. As mentioned in the WFD guidance document n°31 on Ecological Flows and in article 4(1) of the WFD, environmental flow is defined as „a hydrological regime consistent with the achievement of the environmental objectives of the WFD in natural surface water bodies". The objectives of the WFD are the non-deterioration of the existing status and the achievement of good ecological status in natural surface body. Regarding protected areas, the WFD points out the achievement and maintenance of standards designated for the protection of water-dependent ecosystem. The case of heavily modified water bodies is different. Here the flow regime has to take into account the technical feasibility and the socio-economic aspects of water uses. In this case, the water flow has to be defined differently.

In addition, the WFD guidance documents contain several recommendations for implementing ecological flow. Note that a good implementation of ecological flow requires a significant amount of hydrological data.

To be able to find a trade-off between renewable energy exploitation and ecosystem services preservation, data related to environmental flow are a mandatory input for the r.green.hydro.legal modul (GRASS add-on). Starting from this module, the hydropower potential can be evaluated for both the delivery of new permits and the review of existing water rights.

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2. Collection of WFD Guidance Documents. Download: http://ec.europa.eu/environment/ water/water-framework/facts_figures/guidance_docs_en.htm

5.8 The potential for developing renewable energy in Leiblachtal, Vorarlberg

The pilot area Leiblachtal ("Leiblach valley") lies in the most north-western part of Vorarlberg (Austria) on the border to Germany. With a number of five municipalities (Lochau, Hörbranz, Hohenweiler, Möggers and Eichenberg), approximately 15,000 inhabitants and a size of 50 km^2, the Leiblachtal is the smallest pilot Area in this study. The main land uses are as follows: 48.9% forests (2,497 ha), 39.5% grasslands (2,017), 4.1% agricultural crops (208 ha) and 7.5% urban area (381 ha). With regard to forests, the main forest types are Norway spruce, silver fir and European beech mixed forests (75.3%), followed by pure Norway spruce forests (13.6%) and the mixed broadleaves coppices (4.5%). Considering the tree species composition, mixed forests cover 1,880 ha, pure conifer forests cover 429 ha, while pure broadleaved forests cover the remaining 188 ha in the lower valley area. Leiblachtal is socio-economically characterized by moderate tourism, work migration to the nearby urbanized area of Rheintal and forestry and agricultural activities in smaller villages. Like in many parts of the Alps, hydropower and biomass the most important renewable energy types in Vorarlberg. However, the Leiblachtal region has only limited hydropower potential (Figure 5.8.1). Therefore, alternative renewable energy sources such as wind power and forest biomass are under intense discussion to meet regional energy demands.

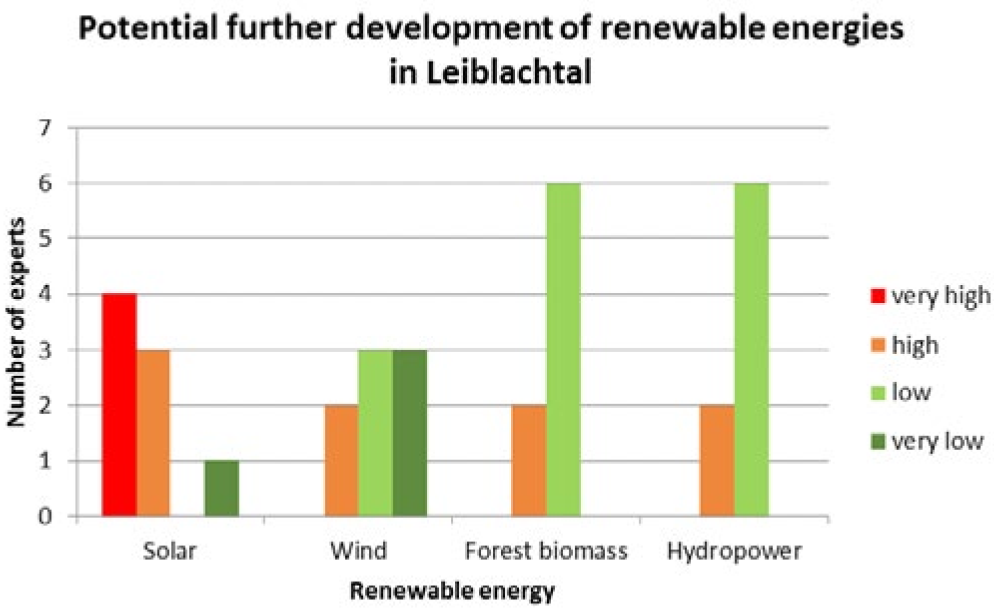


Figure 5.8.1: Potential further development of renewable energy in Leiblachtal (Source: EURAC)

The impacts of renewable energy on the environment for the most critical development scenarios were assessed with the Sample Hectare approach. (For further details see chapter 3.7 on the Sample Hectare method or "Musterhektar" booklet, available on the recharge.green website). The analysis was carried out only for the production of energy from renewable sources. The use of air heat, combined heat power generation, or energy imports were not considered due to their minimal spatial impacts. The Sample Hectare (SH) approach uses exemplary pattern hectares and the following renewable energy scenarios:

- Photovoltaic roof surfaces,
- Use of grassland for livestock, exploitation of liquid manure for biogas,

- Energy maize and energy grass recovery in biogas plant,
- Open landscape photovoltaic,
- Planting energy wood,
- Maximizing timber harvesting,
- Plantation energy,
- Construction of wind power plant.

Currently, the Sample Hectare approach does not consider energy saving or the following renewable energy sources:

- Hydropower plant
- Hydroelectric storage power plant
- Geothermal energy

Results

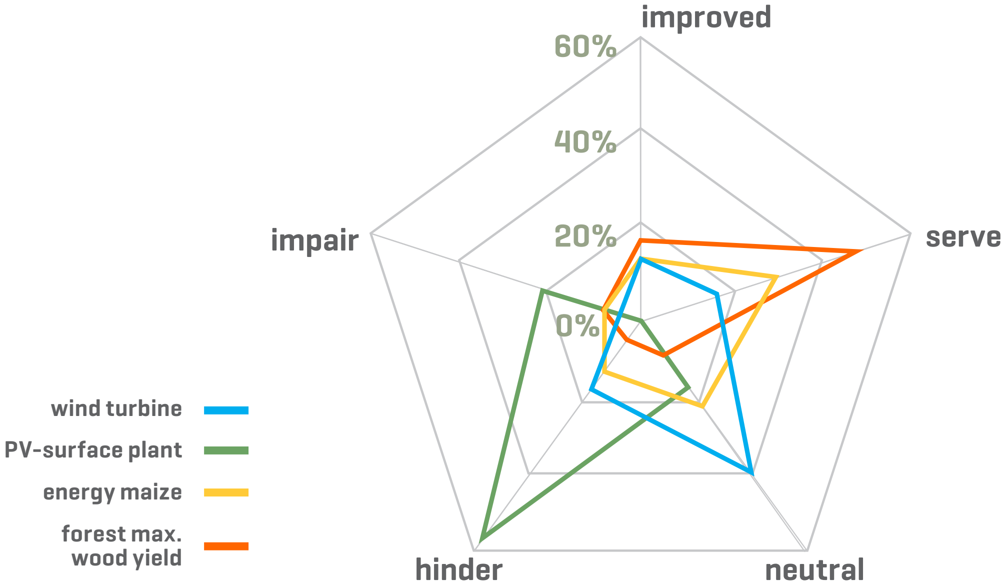
Decision makers and experts from public authorities such as government departments for urban and rural planning or agriculture were invited as "test persons" for the Sample Hectaremethod. Relevant stakeholders from district authorities responsible for agriculture, forestry, hunting and fishing; nature and environmental protection; environmental and food safety; water management; and economics, energy and climate protection were also invited.

The following sample hectares and scenarios were chosen because of actual relevance:

1. Good accessible forest combined with wind power plant
   (Wind turbine with a hub height of 140 m, due to the necessary clearances, eight more sample hectares of forest are affected around the site. The forest around the wind turbine runs without any additional restrictions - blue colour in figures 5.8.2 to 5.8.7)
2. Grassland with high yields combined with landscape photovoltaic.
   (A ground-mounted photovoltaic system on stilts that allows grazing for sheep, goats and cattle - green colour in figures 5.8.2 to 5.8.7)
3. Grassland with high yields combined with energy maize for biogas plants. (Yellow colour in figures 5.8.2 to 5.8.7)
4. Grassland with high yields combined with energy crop plants (wood) for biogas plants. (Brown colour in figures 5.8.2 to 5.8.7)

Figures 5.8.2 to 5.8.7 show the given feedback of test persons by pointing out the effect of each development scenario on given ecosystem services. Socio-economic effects were not analysed.

Figure 5.8.2: Perceived impact of different scenarios on landscape and recreation (Source: Regionalentwicklung Vorarlberg eGen)



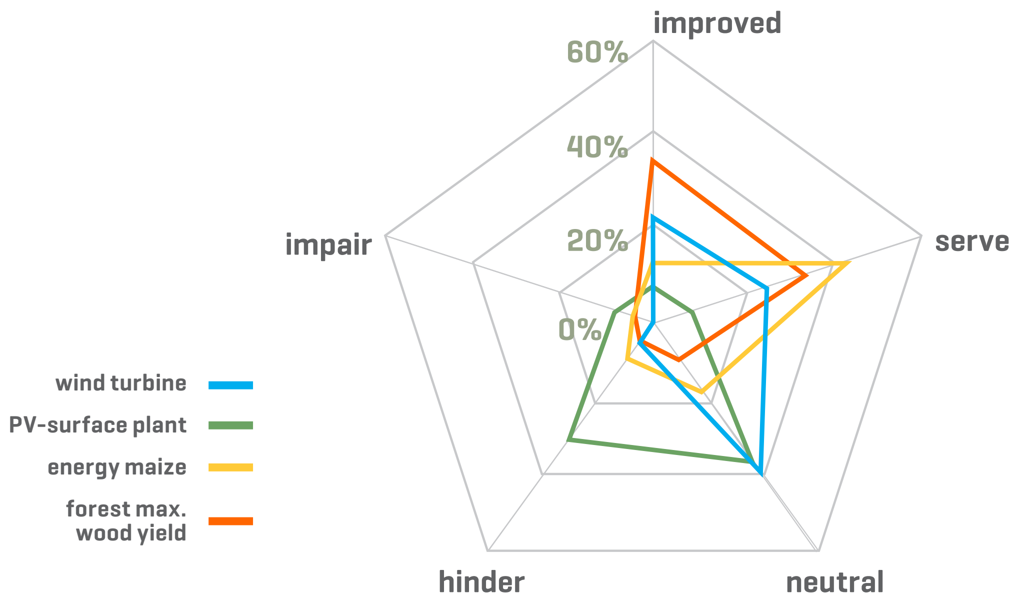


Figure 5.8.3: Perceived impact of different scenarios on basis of life for water, air (Source: Regionalentwicklung Vorarlberg eGen)

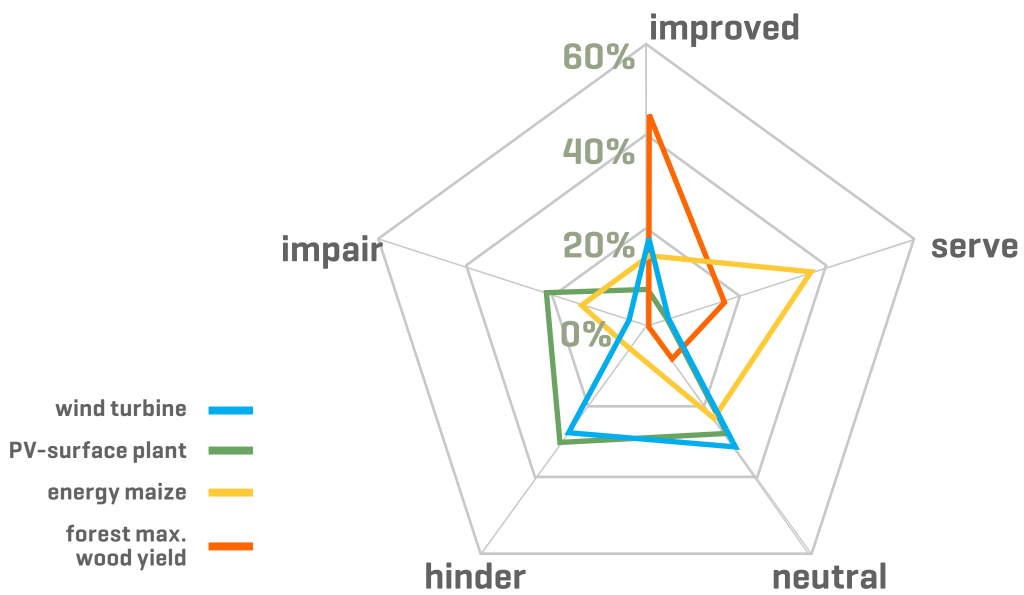


Figure 5.8.4: Perceived impact of different scenarios on habitat and diversity of plants and animals (Source: Regionalentwicklung Vorarlberg eGen)

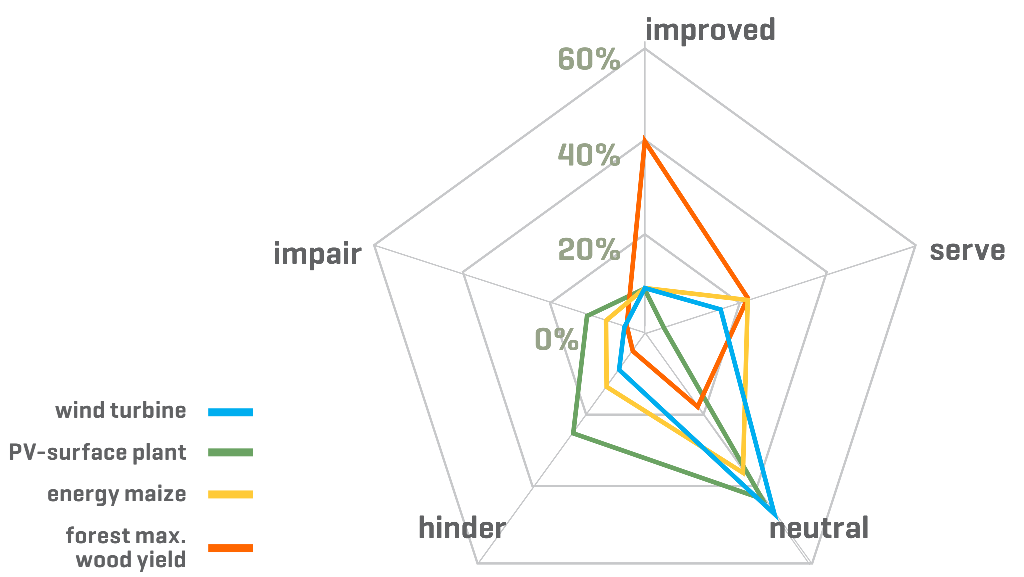


Figure 5.8.5: Perceived impact of different scenarios on protection against natural hazards (Source: Regionalentwicklung Vorarlberg eGen)

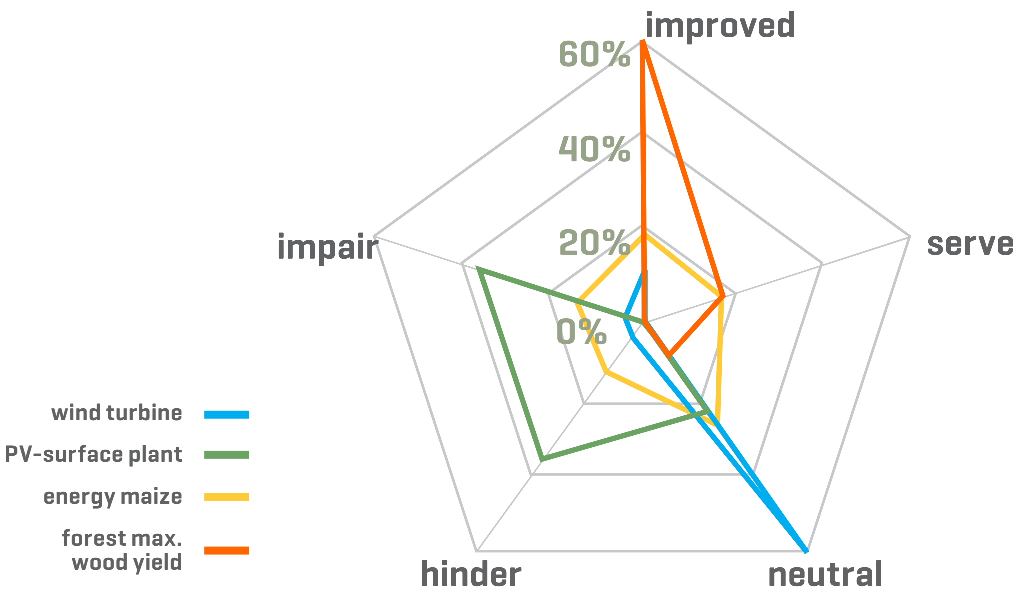


Figure 5.8.6: Perceived impact of different scenarios on production of raw materials [Source: Regionalentwicklung Vorarlberg eGen]

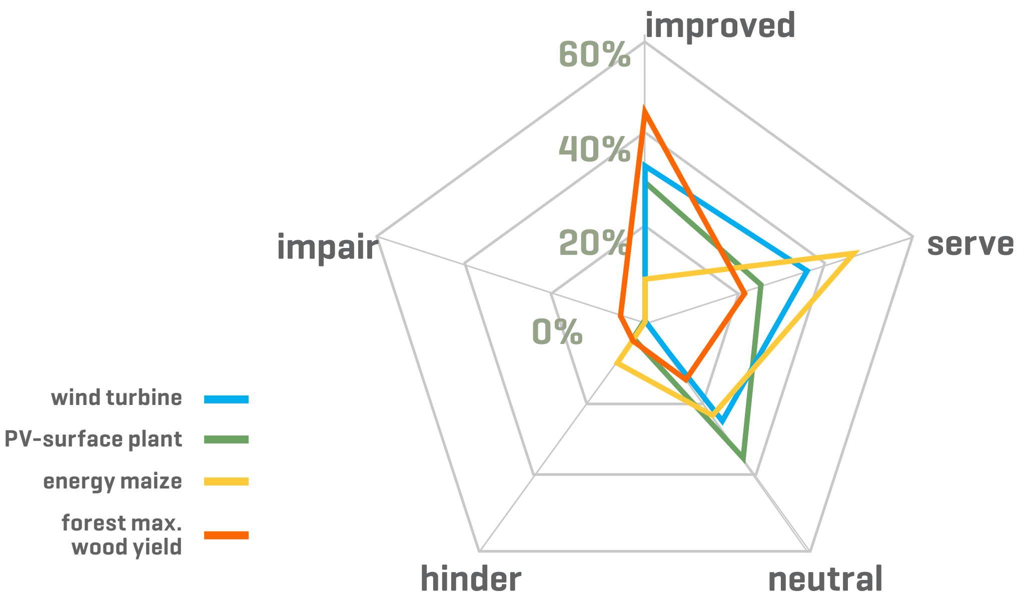


Figure 5.8.7: Perceived impact of different scenarios on reduction in greenhouse gases and global warming [Source: Regionalentwicklung Vorarlberg eGen]

Limitations of the approach and possible extensions

The Sample Hectare approach has clear advantages, but also some limitations.

- The consideration of the individual sample hectares in isolation from the surrounding environment does not correspond to the complex spatial reality.
- Landscape changes in the vicinity of settlements have to be assessed differently from those in remote areas.
- The ecosystem services of an area can't be considered in isolation from the neighbouring areas. E.g. the loss of one hectare of forest has a small effect when surrounding forest dominates the wider area.
- The positive impression of a landscape results from a mosaic of different landscape patches. Changes of landscape patterns often make an area attractive.

The relationships of sample hectares to neighbouring areas should be involved in the assessment, although this can't be standardized. One option might be to integrate a "scarcity value" for the sample hectares or a degree of diversity.

In addition to the impact of renewable energy to neighbouring areas, the so-called "long distance effect" of renewable energy should be considered. Currently this effect is not represented through the selective perception of the sample hectares. This “long distance effect” of renewable energy is extremely large for wind turbines, smaller for photovoltaic systems and hardly exists for biomass utilization.

The multiple use of a landscape is currently not considered in the assessment of the Sample Hectare approach: e.g. a landscape that combines the use of wind power, biomass and solar energy. In such an instance, the energy output and social benefits would be much higher.

Ecosystem services are in a reciprocal relationship in which they strengthen or weaken each other. The maximization of all the desired services is difficult in a highly complex system.
The Sample Hectare-approach has its limitations when it comes to energy sources with linear characteristics such as hydropower. In addition, the approach doesn’t consider the use of geothermal energy or groundwater heat.

Another point is the gap between the actual demand and the real price to be paid for ecosystem services. A forest near a settlement can be more valuable to people due to higher demand than an ecologically valuable forest further away. What we have left out of the discussion here completely are the limits of individual (economic) assessments of ecosystem services.

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Best practice example:
Free and open source software in research projects

Stallman provides a definition of free and open source software (FOSS) that is based on four main freedoms (GNU, The Free Software Definition, 2015). The freedom to run the program as you wish, for any purpose (freedom 0), to study how the program works (access to the code), and change it so it does your computing as you wish (freedom 1), to redistribute copies (freedom 2) and distribute copies of your modified versions (freedom 3).

The use of FOSS in science is considered a priority in science to fully guarantee the reproducibility of the research work. Software errors can undermine heavily the scientific results of a research. Things are even worst if we accept the idea that: "Data is code and code is data" (John D. Cook Data, code, and regulation, 28 May 2015) and this is why often release the software is not enough, it is also required to release an usable and testable data set (Open Data).

This approach provides many benefits also within a research projects such as recharge.green. The availability of the tools as FOSS guarantees the freedom to use and test the code in different contexts and areas and to adapt or enlarge the software capabilities to take into account different factors, algorithms and methodologies. Facilitating the adoption of these tools for future research projects.
The tools can be integrated in web-platforms to provide services to regional or local municipalities opening new business opportunities for start-ups or companies.

The openness of the software facilitates the link and collaborations with other institutes and stakeholders interested on the topic. Furthermore open the tools and data used to analyse a certain problem significantly improves the transparency of the whole process to the stakeholders. In case of conflicts between the stakeholders on interests, views and priorities we provide a neutral platform that can be used and improved by all the stakeholders involved in the decision making process. This process can help also the stakeholders to be conscious of the technical issues and can actively help to fill model gaps or refine input data. The tools can also be used inside an education program to help students to consider different aspects and impacts of the trade-off between Energy and Environment issues.

All the software that has been developed by EURAC and UNITN within the recharge.green project is available as a GRASS add-ons and it is available to be tested, scrutinized and improved. All the code has been written in a team with a peer-reviewed process to improve the readability, maintainability and quality of the code. Another important aspect to consider is that inserting this set of tools in the grass-add-ons repository we are enlarging our small team to an active and more wide community of user and developers that it is using, maintaining and developing the platform since 1982.

Open the tools developed within a research project improve the involvement and the participation of the stakeholders and increase the potential impacts of the project.
Make it easier to use the outcomes of this project as a starting point for others. For example, an early version of the tool was funded by the BIOMASFOR project co-funded by the CARITRO Foundation through grant No. 101. The first version was focused to assess the energy potential of forestry biomass residues. The recharge.green project helps us to extend the tools and to assess the energy potential of other renewable sources like: small/mini hydro, solar and wind power plants.
In conclusion if tools are released and published as FOSS, the end of the project could represent the beginning of a new process that involves several stakeholders and institutions.

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recharge.green – balancing Alpine energy and nature

The Alps have great potential for the use of renewable energy. Thereby they can make a valuable contribution to mitigating climate change. This, however, means increasing pressures on nature. What could be the impact of such changes on the habitats of animals and plants? How do they affect land use and soil quality? How much renewable energy can reasonably be used? The project recharge.green brought together 16 partners to develop strategies and tools for decision making on such issues. The analysis and comparison of the costs and benefits of renewable energy, ecosystem services, and potential trade-offs was a key component in this process. The project ran from October 2012 to June 2015 and was co-financed by the European Regional Development Fund in the frame of the European Territorial Cooperation Programme Alpine Space.

This handbook provides detailed insights about sustainable renewable energy planning in the Alps for experts and decision makers.

Together with other project publications, it can be downloaded from www.recharge-green.eu

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